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

EGHD Position Paper (2022_Paper_1): Human dimension aspects associated with ADSPs and Virtual Centres

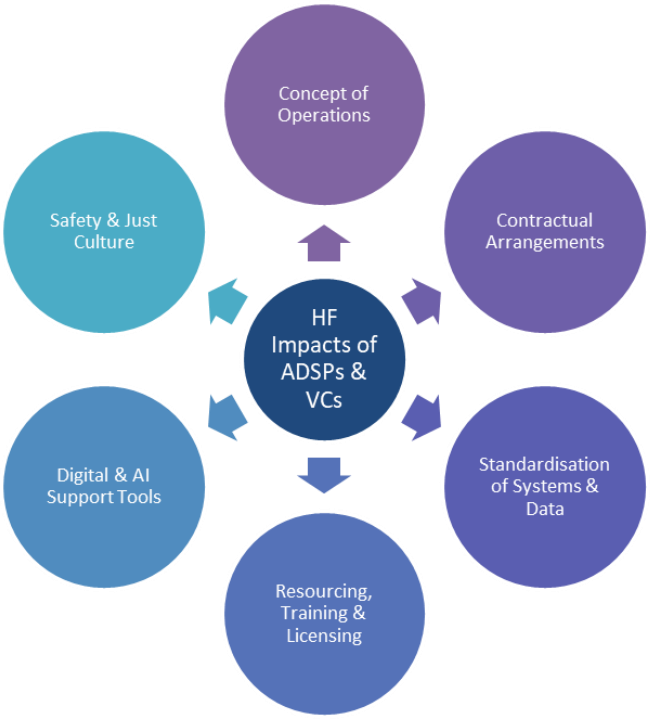
Issue | 27 October 2022

EXECUTIVE SUMMARY

In accordance with the EGHD Work Programme for 2021-2022, the EGHD developed this position paper with the objectives of:

1. Identifying Human Factors (HF) and Human Performance (HP) implications related to proposals in the draft SES 2+ and potential upcoming SES 3 legislation for the introduction of ATM Data Service Provision (ADSP) related concepts, including Virtual Centres (VCs); and
2. Deriving appropriate recommendations for National and/or European organisations, in order to promote the beneficial integration of human aspects in the introduction of ATM changes related to ADSP and Virtual Centres concepts.

This paper was developed taking into consideration the scope of the terms ADSP and VC, as defined by SESAR and EUROCAE, alongside both publicly-available and expert information about the state-of-play of both concepts. Potential HF/HP implications resulting from the expanded implementation of ADSP and VC concepts were identified and verified through a series of EGHD front-line expert workshop sessions and written exchanges.



The HF/HP implications thereby identified were grouped into six discrete categories, as in the adjacent diagram. Some implications were identified as being related to just one specific human front-line operator role, while others were relvant to multiple roles.

For every HF/HP implication, EGHD experts also identified relevant promotion and mitigation measures, following a human centric approach, to support the achievement of operational benefits in relation to the introduction of ADSP and VC concepts.

Further analysis of the implications and their related promotion and mitigations measures then informed the definiton of six pragmatic recommendations (one for each mitigation category), which were addressed to stakeholders including: the European Commission, EASA, SESAR (S3JU), EUROCONTROL, EUROCAE and Member States.

The *titles* of the six recommendations are:

1. The European Commission, EASA, EUROCONTROL and Member States should continue in its efforts to establish a Just Culture environment for all ATM-related stakeholders involved in supporting ADSP-ATSU ATM operations, including recurrent training for all actors of the ATM safety chain.

2. EASA should lead the development of adapted training, licensing and rostering schemes for professionals working in ATSU-ADSP environments. This work should be supported by SESAR 3 JU, as the entity presenting and validating the operational concept, and by the European Commissionas the entity responsible for its implementation, with potential delegation to EASA.
3. EASA should establish comprehensive requirements for ATM service provision involving ATSU-ADSP concepts, especially regarding service resilience and contingency.
4. The SESAR 3 Joint Undertaking should test, validate and update the operational concepts, responsibilities and ways of working defined for ATSU-ADSP ATM operations, including Virtual Centres, with the specific goal of improving the human-machine system.
5. The SESAR 3 Joint Undertaking should research and develop digital and AI-based human operator support tools specifically to support ADSP-ATSU operations, with the goal of delivering shared situation awareness, enhanced human capabilities in face of complex scenarios and balanced human workloads.
6. EUROCAE with support from EASA and SESAR 3 Joint Undertaking, should lead the research, development and standardisation of interoperable ANSP and ADSP systems on a European level, including associated principles for data processing and presentation.

The complete wording of each recommendation, prefaced by a summary of the EGHD's position and the stakeholders at which the recommendation is targeted, is included in section 3 of this paper. A more detailed analysis behind each recommendation (based on the identification and assessment of human implications by EGHD member experts) is included in section 2.

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1 INTRODUCTION

1.1 Purpose

The purpose of this position paper is to:

1. Identify Human Factors and Human Performance implications related to proposals for the introduction of ATM Data Service Provision (ADSP) related concepts, including Virtual Centres (VCs), in the draft SES 2+ and potentially in SES 3 legislation; and
2. Derive appropriate recommendations for National and/or European organisations, in order to promote the beneficial integration of human aspects in the introduction of the ADSP-related ATM changes.

1.1.1 Definitions of ADSP and VCs

The scope of the term ADSP and the definition of Virtual Centres that are applied in this paper will be taken from definitions used in SESAR and EUROCAE work, including in the SESAR JU Airspace Architecture Study. By such definitions:

- An **ATM Data Service Provider** (ADSP) is an entity that manages some or all of the data processing and associated support services needed by one or several Air Traffic Service Units (ATSUs) to deliver air traffic services to airspace users;
- A **Virtual Centre** is composed of one or more air traffic service units (ATSUs) which are using data provided by ATM data service providers (ADSPs).

Together, these two concepts encompass the decoupling of ATM data service provision from other air traffic services and the controller working position. Most of the analysis and recommendations made in this paper are intended to apply to both concepts simultaneously, except where the converse is explicitly stated.

This paper also employs the same definition of ANSP as has been used by the European Commission in other recent studies about ADSPs:

- An **Air Navigation Service Provider** (ANSP) is a public or a private legal entity providing Air Navigation Services, which supports the management of air traffic on behalf of a company, region or country. Depending on the specific mandate, an ANSP either *directly or indirectly* provides one or more of the following services to airspace users:
  - Air Traffic Services (ATS)
  - Communication navigation and surveillance systems (CNS)
  - Meteorological service for air navigation (MET)
  - Search and rescue (SAR)
  - Data (DAT)
  - Flow management (ATFM)
  - Aeronautical information services/aeronautical information management (AIS/AIM).

Logically, it follows that an ADSP and an ATSU are both examples of an ANSP (as for example, some independently-controlled meteorological services of today must and do have ANSP certification in order to provide meteorological information to a "front-line" ANSP).

More comprehensive definitons of these and other relevant terms are provided in the Glossary in annex.

1.2 Scope

This position paper focuses on the human dimensions aspects related to the *ATM Data Service Provider (ADSP)* and *Virtual Centre (VC)* solutions.

More particularly, this paper reports on the human factors and human performance implications related to the introduction of new ADSP solutions and Virtual Centres that are considered relevant from an EGHD perspective. Such implications may induce negative, neutral or positive impacts on human performance of the human operators involved in the production and use of ADSP and Virtual Centre solutions.

1.2.1 Scope clarifications

This position paper will focus on the following human operators affected by the change:

- End users of the data provided by ADSPs:
  - ATCOs, FMP staff (Flow Management Position), FISO, Pilots[1]
- Users involved in the data processing chain:
  - ATSEP, AIS/AIM personnel, Network Manager, MET Officers, FDA staff

It discusses two operational applications of these concepts, which may have distinct HF implications:

- Normal operations, meaning the regular day-to-day operations[2] for which ADSP/VC concepts have been proposed to offer efficiency-related benefits, and
- Contingency operations, meaning operations during a disruption of ATS and/or related supporting services, for which ADSP/VC concepts have in particular been proposed to offer enhanced service continuity benefits.

This paper has been written to take a total ATM system perspective. It considers the Joint Human Machine System, including interactions between:

- The human and other humans,
- The human and physical equipment and systems,
- The human and procedures, and
- The human and the physical and organisational environment.

1.2.2 Scope limitations

The following aspects are outside the scope of this paper:

- Methodological and process aspects related to the integration of human factors/end user aspects in ATM change management.
  - These fall instead within the scope of EGHD 2022 Paper 2: "Human Factors in ATM Change Management".
- ADSP-related technologies which are still under development or not yet clearly defined and understood.
  - For example regarding cybersecurity, data processing algorithms, data interoperability and standardisation.
  - These elements are in principle out of scope for the EGHD, although it may be important to mention some aspects considered to have practical HF-implications on the human actors.
  - For example, the theory and principles of cybersecurity for ADSP are out of scope for this paper, unless perhaps they introduce novel procedures that would impact the ability of an operator to do their job safely and efficiently.
- Legal aspects; although, some legal aspects related roles and responsibilities, training and licensing requirements are highlighted when there are direct HF implications.
- Proposed or potential business models for ADSP concepts and implementations are largely out of scope for this paper, but may be mentioned where they are relevant to human performance.

1.3 Problem Statement

ATM Data Service Provision (ADSP) and related concepts such as Virtual ATM centres are relatively new and potentially very broad in nature.

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[1] The European Cockpit Association (ECA) was consulted during the development of this paper and has informed they had no specific inputs to add at this moment in time. .

[2] Operation during which no accident, incident, or event takes place which would require contingency operations or stopping operations.

EGHD members identified the need to better understand ADSPs and VCs related concepts, as well as associated implications on human operators, including ATCOs, ATSEPs, Pilots, AIS/AIM staff and other human roles identified in the scope, and on whether their tasks can be carried out efficiently and safely. This understanding will be essential to ensure the delivery of the intended benefits of the operational change.

Implications on Human Perfomance (HP) and Human Factors (HF), associated with any change, must be adequately identified, at an early stage, and addressed. Such implications may include both negative impacts on human performance (HF issues) and positive impacts (HF benefits).

Regarding changes in the service delivery model introduced by ADSPs/VCs, EGHD members conducted a brainstorming activity across a series of scoping meetings to identify key potential Human Factors implications that are worthy of further exploration. These include:

1. Data reliability aspects and the potential related implications on end-users performance. For example:
    - Negative aspects such as lesser quality of data, potential for unsafe acts, management of degraded situations, and
    - Positive aspects such as more precise predictions, based on increased availability of accurate data sets, and increased system resilience;
2. Competence and HMI requirements for ATCOs and ATSEPs to operate across different or multiple sectors;
3. Shared situation awareness among the distributed actors involved in ATM data production, processing and use (e.g. ATSEP, AIS/AIM personnel);
4. Safety risks in degraded mode and fall-back operations, due to the decentralisation of integrated teams (for example, ADSP/VC concepts may increase some risks while simultaneously improving resilience and recovery aspects);
5. Other related human performance aspects (e.g. higher or lower workload) of all actors;
6. Changes in front-line operator roles and responsibilities.

1.4 Context around ADSP and VCs

In a context of fragmentation and capacity crunch, in which air traffic was outpacing the rate of capacity growth as well as the European ATM modernisation rate, the European Parliament invited the European Commission to launch a pilot project on the Single European Sky (SES) airspace architecture. The European Commission entrusted the SESAR Joint Undertaking in collaboration with the Network Manager to develop this study, the *Airspace Architecture Study* (AAS)[6] .

The AAS proposes a Single European Airspace System built on optimised airspace organisation, supported by progressively higher levels of automation and common ATM data services to deliver seamless air traffic services. The goal is to improve the resilience of ATM operations and introduce capacity-on-demand services. To achieve it, the AAS indicates that the continuity of air traffic service provision despite disruptions will be enabled by a temporary delegation of the provision of air traffic services to an alternate provider with spare capacity. This will require cross-border sharing of data.

Accordingly, two components of the proposed AAS service-oriented architecture are the ATM data service providers (ADSPs) and virtual centres (VC)[3]. Both the ADSP and VC components will act as enablers for a more collaborative management of the airspace, through remote provision of air traffic services, only possible if all needed ATM data is available to all ACCs. Ultimately these will contribute to increased resilience and improved capacity-on-demand of ATS.

The ADSP concept is also proposed in the *Wise Persons Group Report on the Future of SES* [12] "*Recommendation 4: Create a new market for ATM data service providers as recommended by the Airspace Architecture Study*".

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[3] *Definitions provided in section 1.1.1.*

With the introduction of ADSPs and VCs different new delivery models emerge and coexist. Elements that were previously co-located at an Air Traffic Service Unit (ATSU) could now be hosted at different locations. Several architectures are possible (depending on how services are grouped), images below illustrate some of the future options being investigated by the SJU.

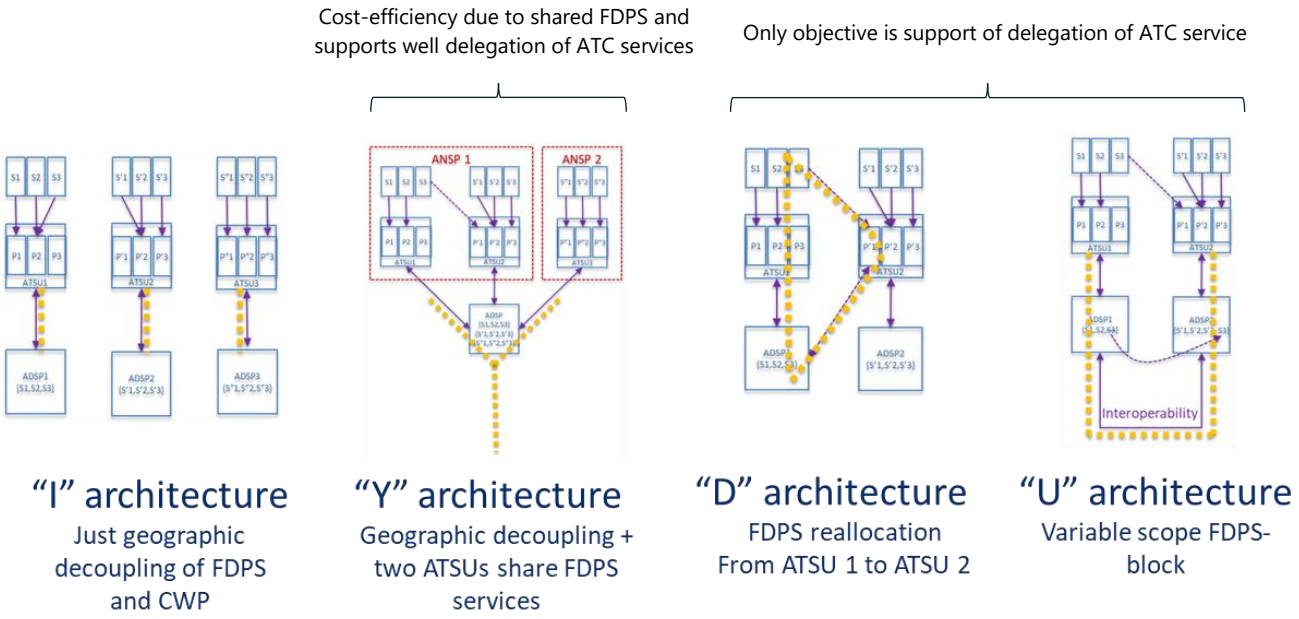

FIGURE 1: VIRTUAL CENTRE ARCHITECTURE OPTIONS (SESAR TARGET ACHITECTURES)

Source: EUROCAE 2021, SESAR JU 2022

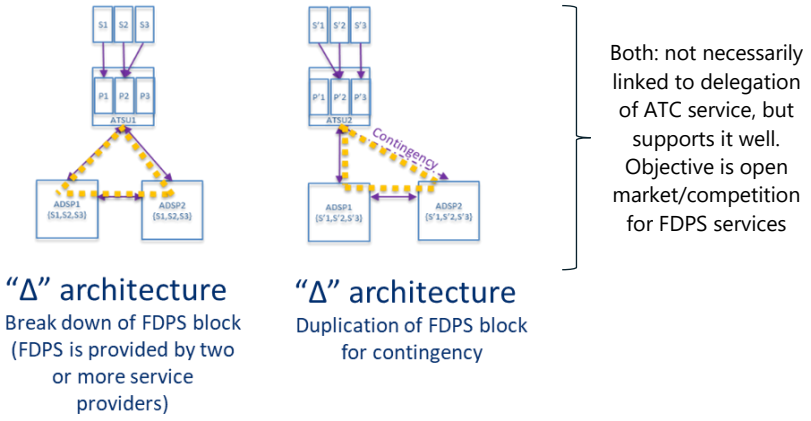

FIGURE 2: VIRTUAL CENTRE ARCHITECTURE OPTIONS (NOT YET IN SESAR)

Source: SESAR JU 2022

Until now, in most instances, the components of the ATM safety chain are all or nearly all integrated in the same company, whilst for the architectures above the structure of the safety chain will largely differ and this will likely lead to changes with important impacts if not mitigated by appropriate training and awareness of the humans involved in the delivery of safe air travel. The main risk, associated to this distribution of knowledge across multiple entities, is losing sight of the overall context, with each component managing individual risks instead of the risk of the whole ATM safety chain. Recurrent training is required as a means of mitigation.

The **motivation and expected operational benefits** associated with the introduction of a combination of ADSPs and VCs can be summarised as follows [7] :

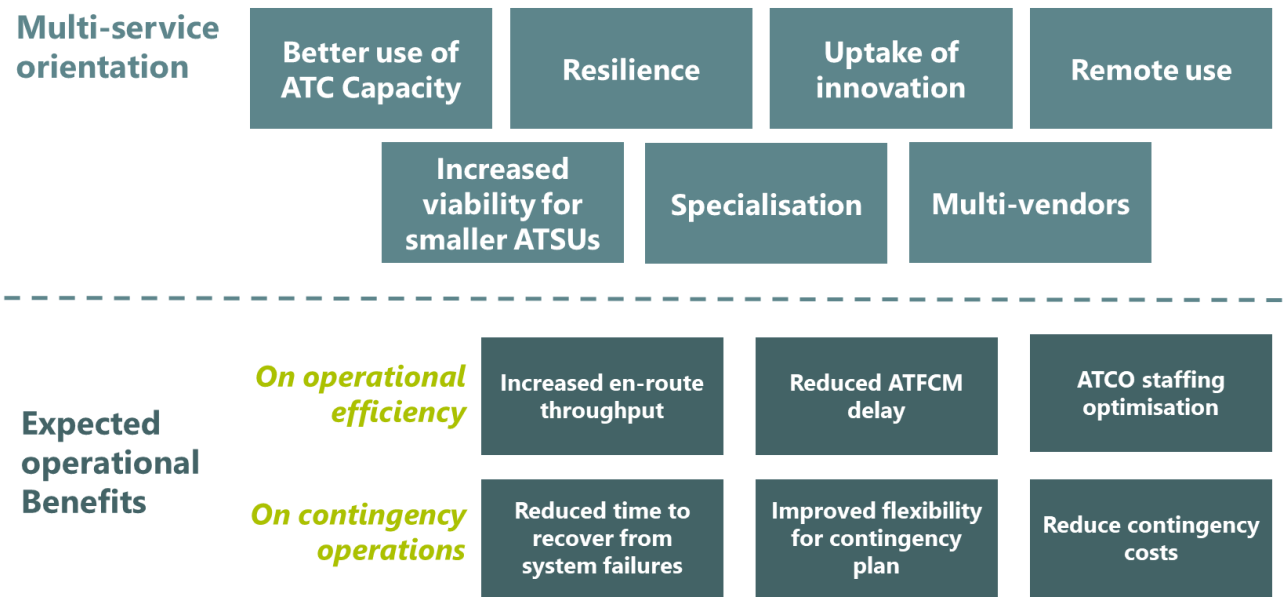

FIGURE 3: MOTIVATIONS AND EXPECTED OPERATIONAL BENEFITS ASSOCIATED WITH ADSP & VCS

In the EGHD's view, the AAS model is based on a conceptual scenario and some of the assumptions are not sufficiently developed or validated. For instance, there are already cases today where ANSP use data from other ANSPs (e.g. DSNA take raw data from Jersey). Notwithstanding, it is agreed that the AAS model is sufficiently mature to inform the development of the present position paper.

Since the AAS was released many follow-on activities were initiated to further explore the ADSPs and the VCs components. These are some of the most relevant activities, with further references available in annex:

The *ADSP Study* [4] , direct continuation of the AAS, taking economic, legal and regulatory analyses further;

Standardisation activities led by EUROCAE, such as *WG 122 on virtual centres*, that published in March 2021 an interesting report titled: "VIRTUAL CENTRE - STRATEGY FOR STANDARDISATION - PHASE 1" (not available to public).

- SESAR research and development activities such as:
  - Project PJ16-03 focusing on enabling rationalisation of infrastructure using virtual centre based technology. In this project was developed a concept for separating the Controller Working Position (CWP) from the datacentre where the data is produced.
  - Interface (HMI).
  - Project PJ10-W2-01 researching delegation of services amongst ATSUs;
  - Project PJ32-W3-01 researching delegation of ATC between ATSUs in a VC environment
- The *Strategic Research and Innovation Agenda (SRIA)*, that complements the European ATM Master Plan 2020 and the High-Level Partnership Proposal, details the research and innovation roadmaps to achieve the Digital European Sky, matching the ambitions of the "European Green Deal" and the "Europe fit for the digital age" initiative. This agenda includes two flagships in direct support to the introduction of ADSPs and VCs, which are transcribed below:
  - *Flagship 5 – Virtualisation and cyber-secure data sharing, which includes the need for an "ATCO environment that is prepared for dynamic location and independent operation", noting that an extract from the SESAR JU Strategic Research and Innovation Agenda (SRIA) states:*
    - *The establishment of a fully virtualised environment will need to be **coordinated with the ATCO licensing scheme** and will therefore also be people-centric. The active inclusion of the ATCO and ATSEP communities in the development phase is a prerequisite for successful implementation. Close collaboration in and input into the EU regulatory process is required so that, where necessary, the regulations can be adapted in a timely manner to allow for deployment.*

- *Flagship 8 – Artificial intelligence (AI) for aviation, which includes AI-based human operator support tools to increase human capabilities during complex scenarios or reduce human workload in their tasks, not to define the role of the human or to replace the humans, but to support them. This roadmap also stresses human-machine cooperation is enabled by human understanding: humans should understand what the systems are doing and maintain the right level of situational awareness in relation to them.*

- The *SESAR 3 JU Multiannual Work Programme (MAWP) for 2021 to 2031* that contains the core components of the work programme and budget allocation principles for the period. This programme includes SRIA's flagships, of which flagships 5 and 8 are potentially most relevant to human dimension aspects, and the Digital Sky Demonstrators which aim to accelerate the market uptake of breakthrough solutions. The demonstrators will include the testing in a live environment of concepts, services and technology supporting the achievements of the Airspace Architecture Study. Their goal is to foster confidence from the supervisory authorities and operational staff, by building further performance and safety evidence.

2 HUMAN IMPLICATIONS ANALYSIS

This section discusses potential implications to the work and activities of the changing human role in the whole ATM system, as well as overall human and organisational factors (HOF)[4] implications introduced by ADSPs and VCs.

By considering for the most part one front-line operator group at a time, this section provides the analysis and an initial and non-exhaustive list of potential implications to Human Factors and Human Performance, as well as potential direct benefits to operational performance and to shared awareness of the safety chain. In these analysis are also discussed measures to promote potential benefits and mitigate potential risks.

How to read this section

The approach followed in the analysis is summarised in section 2.1.

In section 2.2 is discussed the impact the implementation model can have on the range of HF/HP implications and their depth.

Section 2.3 presents the HF/HP implications which are common to all human ATM roles and following sections discuss aspects related to specific front-line operators ATCOs, FMP staff, ATSEPs, AIS/AIM, FISO and FDA.

Each analysis subsection includes one (at least) brief paragraph (highlighted within a text box) summarising relevant measures/mitigations identified. These measures are carried forward in the development of EGHD recommendations, discussed in the recommendations section of this paper.

2.1 Human Factors analysis approach

Potential HF/HP implications resulting from the expanded implementation of ADSP and VC concepts were identified and verified through several (7) EGHD brainstorm sessions[5] and written exchanges between an appointed group of EGHD member representatives, whose output therefore reflects their considerable operational experience and expertise in the domain. The focus of each brainstorm session was to identify member concerns and opportunities for a *specific group* of front-line operators (e.g. ATCOs, ATSEPS, AIM/AIS staff) in turn, and to consolidate and further group those implications agreed to be the most relevant and significant[6]. These HF/HP implications have been grouped into six discrete categories, as shown in Figure 4.

2.2 Range and depth of HF implications

Throughout the analysis process, the potential *range and depth* of an impact[7] on the human role was taken into account, in relation to the selected implementation model. For example:

If a small number of ATSUs were to participate in a limited regional cooperation focused on ATM Data Service provision between themselves, the impact might logically be relatively small (lower depth and range). Respective ATSUs might be impacted only mildly and transition could be gradual, planned over a longer period of time and with a high degree of ATSU control. Naturally, professions impacted by the change could be given enough time to evolve.

Conversely, procuring ATM Data Services on the open market from a commercial provider and discontinuing related some of the ATM data processing activities traditionally performed by ATSUs is likely to be a far more

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[4] HOF refers to the interactions among system components and humans, considering their behaviours, at all levels such as individual, situational, group, organisational or cultural. Examples of interactions, observable at several levels, can be found in: job design, workload, fatigue, procedures, competence management, working conditions, organisational and technological change, staffing, reporting culture, systemic investigations and audits, or the safety culture of the organisation. https://www.era.europa.eu/activities/safety-management-system/human-and-organisational-factors-hof_en

[5] Mainly, meetings on an every other week basis.

[6] This process was initiated on 27 January 2022 and besides the continuous interaction with the appointed group of EGHD member representatives, overall EGHD consultation took place at EGHD/28 and EGHD/29. The completeness and quality of this process was ensured by continuous review and verification of contents with EGHD members, with operational experience and expertise in the domain, at brainstorm sessions.

[7] Depth as synonym of intensity of impact and range as a measure of how many human dimension topics (e.g. roles and responsibilities, trust, training, etc.) impacted.

significant change (with higher depth and range). The procuring ATSU would be unlikely to have the same measure of control over the speed of any transitions, and implications on the human dimension for ATSU employees might result from the performance of the upstream third-party ADSP, over which the ATSU might have far more limited control.

For ADSPs, the level of change for the human role may be influenced by the chosen organisational model, for example:

An 'alliance model', with data production and service delivery vertically integrated in the same company;

A 'separate model' with an ADSP being a separate company providing data to ATSUs on a contractual basis.

Any vertically-integrated model implies less change in organisational design and therefore to subsequent roles and responsibilities of staff. Conversely, in a separated model the technical teams currently employed by ANSPs would be likely divided, with the majority of the technical roles (experienced in data processing and systems monitoring and control) becoming part of the ADSP, while other technical staff might remain under the ATSU.

Changes in teamwork and coordination and communication among technical/support staff will necessarily result from the geographical/organisational reorganisation introduced by the ADSP concept. While the potential this brings for an increased diversity of knowledge and skills may in some ways be useful, cultural and linguistic differences are also likely to introduce new operational challenges and risks.

Furthermore, if roles do move from ATSUs (or from those ANSPs which include both ADSP and ATSU functions) to external ADSPs, this may also lead to changes in work location, dependent on the specific local circumstances and strategic decisions. Employment conditions might be subject to change, as the external ADSP would be a separate employer with most likely different pay, benefits and provisions schemes, according to local contexts.

2.3 Potential HF implications common to multiple human ATM roles

In some cases, potential and relevant HF implications identified by EGHD members were clearly recognised to apply to multiple (or potentially to all) human ATM roles, including those both in ADSPs and in Virtual Centre for ATSUs. For the purposes of analysis, such common implications identified have been grouped together in this section according to the categories defined in Figure 4.

2.3.1 Concept of operations

2.3.1.1 Implications for systems situational awareness

The implications identified in this subsection apply to most human ATM roles except the ATCO. They are more relevant to ADSPs than to Virtual Centres, although some aspects may apply to both.

One of the most striking outcomes of the future service oriented architecture is the potential decoupling of ATSEPs, AIS/AIM & FDA personnel and ATCOs. For example: ATSEPs and Flight Data staff may no longer be collocated with the service consumer (the ATCO and AIS/AIM) which may lead to a functional separation between each of these human roles.

Overall, it is vital to ensure shared systems situation awareness amongst data and systems operators. Today, such actors usually all work for the same organisation (often a state ANSP which combines both ADSP and ATSU functions) and such proximity contributes to an understanding of each other's activities and needs. ATSEP and AIS/AIM personnel have close visibility of how data is being interpreted and used by the ATCO, for example, while ATCO and FDA staff have visibility and local insight into how the data has been generated and processed.

Such functional and physical separation may ultimately result in a decreased shared situation awareness among the operators involved in the data processing chain. For example:

The data production team may lose situation awareness on how a change to data (e.g. in format or structure) might impact operational teams such as ATCOs, FDA, FMP staff, the Network Manager and Pilots.

In cases where AIS/AIM, FDA and/or ATSEP personnel might need to generate or verify qualitative local or regional information, a lack of local knowledge might hinder their performance.

From an ATSEP & FDA perspective, unfamiliarity of ADSP staff with specific local circumstances and dependencies may result in extra workload in case of unforeseen circumstances when a technical problem occurs.

On the other hand, HF benefits may also arise:

In the case of having a large ADSP serving many ANSPs, there may be an increased understanding of different operational and technical contexts, sharing of best practices and increased shared awareness.

Situational awareness of distributed systems and data should be safeguarded through a detailed shared ADSP/VC concepts of operations, including the conception of appropriate tools to enable human delivery and performance. These CONOPS should carefully propose organisational and operational boundaries to safeguard systems situational awareness, set clear responsibilities, and account for cross-border operations as well as civil-military coordination.

2.3.1.2 Processes during contingency, backup, roll-back and last resort operations

In nominal operations, systems available to the ATCO today consist of a main system, a backup system and in some cases a last resort system and potentially a contingency location.

The main system is used in day to day business with full operational capacity.

The backup system is used when the main system in unavailable with reduced operational capacity, because no full functional backup system is available.

The last resort system is used when main and backup are not available, with the only purpose of clearing the airspace.

The main, backup and last resort systems are connected to the same ATCO working position. The backend systems are physically separated, but not necessarily geographically redundant.

Ideally, the main and backup systems are used with basically the same functionalities and HMI[8], to ensure ATCO proficiency on the backup system, which is not used frequently. In the use of backup systems a distinction has to be made between the FDP, surveillance and communication system. These are the most important functionalities available at the ATCO working position, main and backup system.

It is not necessary to go into full backup (i.e. FDP, SUR and COM) when a degradation takes place in one of these domains. As an example, when the main voicecom system is degraded, the main FDP and surveillance systems are still used, although with reduced operational capacity. To avoid a common failure in the main, backup and last resort systems, these have to be from different suppliers, or at least run on a different software version.

The contingency location is used when the main and backup systems are no longer available for a longer period of time. This includes a catastrophic event at the ATSU where a building is no longer usable and human casualties could be involved. Operational capacity is reduced and the intended use for the contingency solution is for an extended period of time (i.e. weeks or even months). The contingency locations in use today may not necessarily be equipped with a main/backup system configuration, a last resort solution however should be in place.

With the introduction of ADSPs and VCs, Collaborative Decision Making among all partners may be an important challenge which can be aggravated by the need to use a foreign language. This might be even more critical during high-stress contexts, such as contingency situations.

Comprehensive processes will be required, including reaction rules for each operator and organisation involved. These processes should also account for any regulatory or procedural differences/discrepancies between different impacted countries or organisms.

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[8] When functionalities are significantly different this usually results in reduced operational capacity (e.g. increased separation, reduction of traffic) at least during the transition from main to backup systems.

Comprehensive contingency processes should be developed specifically for ADSP/VC concepts, including reaction rules for each operator and organisation involved, and addressing potential regulatory or procedural differences/discrepancies between different impacted countries or organisms.

2.3.1.3 Cybersecurity

In a more digital scenario cybersecurity becomes increasingly critical. The human aspects of this relate primarily to the critical importance of front-line operators having a high level of confidence in the systems they depend upon, without which the potential negative HP impact must not be underestimated.

Clear overall responsibilities and accountabilities for cybersecurity are therefore essential. For example, it should be transparent to all operators (including those who are not directly responsible for systems continuity) who is accountable and responsible to avoid events of data corruption, identifying issues and risks, and resolving identified problems.

It is similarly crucial to define comprehensive processes and reaction rules for each operator and organisation involved. Due to the potential cross-border safety and security implications of open market ADSP/VC services (which are new in comparison to nowadays operations), these processes must furthermore include and appropriately address any regulatory or procedural differences/discrepancies between different impacted countries.

Define comprehensive processes, including reaction rules in case of a cybersecurity issue, for each operator and organisation involved in the ADSP/VC concept. These processes must address any regulatory or procedural differences/discrepancies between the different countries impacted.

Safety investigation processes also need to be newly addressed, clarified and ratified by the relevant authority/regulator of each country before the implementation of new operational architectures. This is to avoid severe implications to human performance by enabling an environment of trust and security for operators. Questions arising from ADSP/VC concepts that should be considered include:

- Who will be in charge to carry out the safety investigation?
- What are the required levels of competency, impartiality and independence?

Establish clear overall responsibilities and accountabilities for cybersecurity. This should also address oversight, safety and security investigations aspects and be ratified by the relevant authority/regulator of each country involved, before the implementation of new ADSP/VC operational architectures.

2.3.2 Contractual arrangements

2.3.2.1 Service level agreements including backup, roll-back and last resort operations

Operational inefficiencies or constraints can result from using data services provided by external organisations. As an example, today, systems maintenance or other technical interventions are planned to minimize impacts to operations. Usually, these interventions take place during off peak periods and combined system degradations are avoided. The latter is a strong recommendation from the Überlingen tragedy evaluation report.

In the ADSP business model multiple ATSUs consume services from one or multiple ADSPs. Each ADSP can function as main, backup or last resort service for an ATSU. This increases the complexity of planning technical interventions at ADSPs that do not impact ATSUs operations and consequently operator's levels of stress and workload and it increases resilience of the system and reliability of the services.

To avoid any consequences to ATSU's operational services, technical interventions at an ADSP have to be coordinated with all served ATSUs and backup mechanisms must be in place, this might even require a backup using other ADSP(s). Ultimately, ATSU's operations must be safeguarded by robust contractual service level agreements, or even mandatory requirements, which minimise any risks of data service disruption due to inadequate maintenance programmes and/or backup systems put in place by ADSPs.

Robust contractual service level agreements, or even mandatory requirements, addressing service disruption, backup programmes, contingency plans and last resort operations are required.

ADSPs will also need to coordinate maintenance activities with each another to avoid ATSUs potentially being impacted by simultaneous degradations of main and backup data services from different ADSPs.

One relevant example might be that of an AIRAC cycle related change, needing to be implemented at a fixed date by all ADSPs in more or less the same timeframe. Without prior coordination between ADSPs and ATSUs, it seems highly likely that multiple data service degradations might occur simultaneously. Maintenance activity coordination between ADSPs will therefore have to be planned in a timely manner so the risk of overall service quality impacts can be assessed, de-conflicted, agreed and mitigated by all stakeholders involved. Today this coordination is done at the ANSP level, with mostly internal stakeholders, whereas expansion into an ADSP / VC architecture will add a level of complexity due to the number, interdependencies and interests of individual stakeholders.

Appropriate forms of planned degradation coordination between ADSPs and ATSUs (for example, Collaborative Decision Making or a single authority overlooking planned and unplanned service degradations) will need to be investigated.

2.3.3 Standardisation of Systems & Data

2.3.3.1 Systems Interoperability

The requirement of interoperability between Civil and Military ATSUs and new (non-ANSP) ADSPs will create new responsibilities and accountabilities, as well as mandatory standards and levels of service. These aspects have to be addressed.

For example: will a new ADSP have to comply with ANS regulations/standards? This is a relevant question since mandatory requirements for critical systems (e.g. flight data processing systems, FDPS) may impact the level of control/availability of outsourced servers. According to *Reg. (EU) 2017/373*[9] an ADSP can be considered to be part of the functional system as defined in Annex 1 point (56)[10] so it can be inferred that the same ANS regulations/standards apply.

As such, responsibilities, standards and levels of service should be established and clearly communicated to all operators, in particular ATCOs, this should avoid problems as registered in the past which resulted in failed delegation of services. Some of these aspects should already be considered in EASA's rulemaking task *RMT.0161*.

Add the standardisation of interoperable ATSU and ADSP systems to existing rulemaking activities, such as EASA's RMT.0161, in particular and as a priority for critical systems and taking into account any civil-military specific requirements.

2.3.3.2 IT standards

To optimize the interface between ATSUs and ADSPs in the context of the human-machine system, it is also important to define minimum common working methods. The evolution of the systems architecture, implying remote, virtualised or cloud based systems/servers, will have to be supported by solid service level agreements (SLA) from non-ANSP providers, which might be covered by different regulations and use different IT practices. In terms of human aspects the need here is as with cybersecurity, to provide front-line operators with a high level of confidence in the systems that they will depend on to provide a safe and effective ATM service.

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[9] *Laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight.*

[10] *"'functional system' 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;"*

Today, several IT practice sets (such as ITIL) are available, which may lead to the use of diverging practices, even among non-ANSP providers, this may increase the complexity of cooperation with all these organizations. Furthermore, the ITIL standard is widespread among IT related organisations, but ANSP do not necessarily use it. A lack of standardized working methods and harmonised regulations may negatively impact operators' performance, especially due to the difficulty to cooperate when incompatible working methods are in place.

A process of harmonisation of methods, ways of work and leverage of systems' standards should be assessed, building on transversal commonly used IT standards, and taken forward by the Commission and EASA in their rulemaking processes.

2.3.3.3 Data aspects

Besides technical interoperability, user interface and working methods harmonisation, aspects related to data processing and display need to be considered since they can differ from one country to another, or even between two ACCs in the same country, and these differences may strongly restrict the possibility to perform a delegation of services.

To avoid these restrictions in a new architecture based on ADSPs, data processing and presentation needs to be made consistent and homogeneous.

Establish consistent and homogeneous requirements and principles for data processing and presentation, on a European level.

2.3.4 Resourcing, Training & Licensing

2.3.4.1 Selection and recruitment of professionals and resource planning

To realise the expected flexibility and resilience benefits enabled by ADSPs and VCs, in particular during any delegation of services or during a contingency event it is crucial to ensure the availability of suitable staff, including trained and certified ATCOs and skilled ATSEPs familiar with the appropriate operational concepts. Failure to do so is likely to result in workload and stress level increases for existing operational staff, with associated negative potential implications on safety and performance. Resourcing and rostering plans will therefore also account for aspects specific to ADSPs and VCs, since there will be the need to have available staff to perform contingency services or delegation of services on-request. For example, joint rostering schemes across different ADSPs or ATSUs might be required, while ensuring social human dimension aspects are addressed.

To enable a more flexible resource planning and a more balanced workload of staff across the system resourcing and rostering plans for ADSP/VC operations need to be adapted, possibly including joint rostering between different ATSUs while addressing social human dimension aspects

2.3.4.2 Training and licensing

Operational interoperability between countries will be required whenever an operator (ATCO, ATSEP, FDA, AIS, FMP staff, etc.) needs to work at a foreign unit of another provider. Aspects like training, competence, maintenance of the levels of confidence, working methods, licensing, rating maintenance and authorization for an operator to work at a foreign unit of another provider need to be addressed, as soon as the concepts of operation, architectures and technologies become mature, furthermore it will be important to use a common European wide language (e.g. English). The individual learning process, led by the human, is another key factor, fundamental in reaping the benefits of training.

Adapt selection and training programs as soon as the concepts of operation, architectures and technologies become mature, including the use of a common European wide language (e.g. English). These changes should consider inputs from the operational stakeholders.

Furthermore, training and licensing requirements will need to be consistent to ensure the same level of knowledge and experience requirements for each human role operating beyond national borders. In particular licensing requirement aspects on a European level should be reflected in EASA regulations. These requirements already exist for ATCOs, but not for other human ATM roles.

EASA to continue addressing training, skills and performance requirements for operational interoperability between countries on a European level, for all human ATM roles beyond ATCOs.

Regarding non-ATSU technical staff working for an upstream ADSP, to guarantee a minimum level of shared knowledge and experience between this staff and ATSU technical staff, specific minimum ATM competences and training requirements should be established and made mandatory. This will mitigate any risks of insufficient understanding of the ATM operational context.

Specify mandatory minimum ATM competences and training requirements for non-ATSU ADSP technical staff.

ADSP and VCs may also contribute to the acceleration of the ATM digitalisation, what might impact differently different groups of operators[11], the ones more familiar with digital technologies and the ones more resistant to change. This rapid and unprecedented transformation makes it entirely possible that many HF/HP implications of ASDP/VC concepts might differ significantly between these two groups of front-line operators. No known public research exists[12] on this topic in relation to ATM, such that few conclusions can yet be drawn. It should therefore be carefully considered by domain experts as an input to the future architecture.

It is possible that HF/HP implications of ASDP/VC concepts might differ significantly between more digitally aware and more resistant to change front-line operators. This needs to be examined carefully by domain experts and addressed in change management plans.

2.3.5 Safety and Just Culture

The introduction of new players to the ATM industry should follow the same levels of safety and just culture already in place in the ATM industry[13]. This will contribute to the maintenance of trust and confidence among

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[11] *As an example, in the past, some ANSPs have witnessed a wave of retirements caused by the digital transition, which had important implications on ANSPs human resources.*

[12] *But Skyguide has seen the differences in controlled experimental simulations for the LSAS endorsement. This has been communicated to FABEC and SESAR.*

[13] *To support a Just Culture regulation, education, training and implementation across the aviation sector many initiatives are in place, namely:*

- *Regulation (EU) No 376/2014 which requires the civil aviation system to promote a Safety Culture facilitating the spontaneous reporting of occurrences, and thereby advancing the principle of a Just Culture.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R0376
- *European Corporate Just Culture declaration published by industry in 2015 in support of the Just Culture regulation (and particularly 376/2014) and its implementation.* https://ec.europa.eu/transport/sites/transport/files/modes/air/events/doc/2015-10-01-just-culture/declaration.pdf
- *The Just Culture Toolbox from 2018, targeted at staff and managers within organisations providing ATM/ANS. Co-authored by the ATM Partners for Just Culture: ATCEUC, CANSO, ETF, IFAIMA, IFATCA, and IFATSEA.* http://www.etf-atm.org/WP/wp-content/uploads/2018/10/Just-Culture-Toolbox-Final.pdf
- *IFATCA Just Culture Guidance material.*
- *EUROCONTROL Just Culture Task Force.*
- *Just Culture Model Policy regarding Criminal Investigation and Prosecution of Aviation and Railway Incidents and Accidents issued in 2018. https://skybrary.aero/sites/default/files/bookshelf/4772.pdf*
- *Just Culture judiciary course (prosecutor expert).* https://www.parlament.ch/en/ratsbetrieb/suche-curia-vista/geschaeft?AffairId=20190478

different operators, and will indirectly diminish reproduction of incidents and improve safety, through the sharing of lessons learned.

> Extend ATM safety and just culture from ATSU to ADSP staff, according to (EU) No 376/2014[14] of 3 April 2014, which requires the civil aviation system to promote a Safety Culture facilitating the spontaneous reporting of occurrences, and thereby advancing the principle of a Just Culture.

The number of undertakings involved in the service provision of one ATS unit is currently rather low and, in most instances, the air navigation service provision is a business which is largely done in house by one single entity. The introduction of virtual centres and even more the introduction of aeronautical data service provision will introduce a substantial change in the distribution of responsibilities and the setup of service provision will vastly differ from the current situation.

It is paramount to make every effort possible to mitigate the loss of knowledge and understanding of the overall safety chain. Increased training for all safety chain actors is required, including for those already on the job. All actors of the safety chain should understand the consequences their actions have on other components of the safety chain.

> EASA should develop and enforce requirements for recurrent training on the constituents of the ATM safety chain to all staff with a safety related duty.

2.4 Potential HF implications for ATCOs

With the introduction of ADSPs and VCs, the basic role of the controller (e.g. monitor aircraft separation and provide vector guidance to pilots) might suffer some initial adaptations, but will overall remain unchanged, as will the ATCO's duties in the nominal situation. Even in case of a technical issue, the change in the future ADSP & VC ecosystem ideally should not have any functional impact, the point of contact for technical issues will remain the same (i.e. the SMC (ATSEP WP) ATSEP).

However, the different location of personnel that will most likely lead to remote contact, should not be underestimated. A situation that could be aggravated in case of linguistic difficulties, in particular during a contingency context, what could cause further problems and certainly an increase in workload.

In the following subsections are discussed particular aspects that might enhance, facilitate or challenge ATCO's functions, as well as measures in to promote the benefits and mitigate the challenges.

Overall this section is focused on aspects related human role implications associated to the delegation of services. As for the previous section, these aspects are grouped according to the categories defined in Figure 4.

2.4.1 Concept of operations

2.4.1.1 Enabling processes for delegation of services

ADSP and VC concepts propose a strong enhancement of interoperability between different ANSPs, allowing ATCOs to control multiple airspaces in a more flexible manner. ADSP and VC technologies should enable Air Traffic Service Providers to optimise traffic management operations during peak hours and off-peak hours by delegating airspace and balancing the workload among ATS units. Assuming that required prerequisites as highlighted in this document (e.g. training, certification, systems and operational interoperability …) are in place, if one ATS is no longer able to provide its control services, another can replace it using the data provided by the ADSP.

Delegation could be particularly interesting to support a centre facing staff shortage, or other constraints that prevent normal provision of services, or to address a configuration where this specific airspace is required to handle the traffic in a different manner (e.g. a portion of airspace needed for approach in specific QFU). Thus,

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[14] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R0376.

if the service delivery model together with the system are well designed, it may bring a clear benefit in capacity which will contribute positively to balanced workloads. Nonetheless, this will most likely take time to research, test, adjust and advance.

Nonetheless, the allocation of non-familiar sectors to ATCOs raises challenges, since their level of proficiency, awareness and decision making ability may be much lower than that of their colleagues used to control those sectors, and therefore also more used to traffic behaviour, etc. ATCOs proficiency and awareness will be directly impacted by the frequency of delegation of services, corresponding to the level of familiarity controlling a sector, and also by the level of traffic of this new sector, if it is a low traffic sector the level of proficiency and awareness should also be less impacted.

Shift handovers between remotely-operating ATSUs also needs to be addressed. This is likely to introduce new operational risks, especially during busy periods. Existing flexibility to vary the time of a handover to be based on workload intensity may also be diminished when the transferring units are not collocated. R&D activities results such as Solution PJ.10-W2-93 — Delegation of services amongst ATSUs and PJ33-W3 FALCO - Flexible ATCO Endorsement and LDACS Complement can contribute.

In case of a contingency situation, these challenges will even be more prominent. The workload increase will overlap with the high stress induced by the non-standard situation.

A well designed system and service delivery model will enable balanced workloads. In relation to ADSP/VC concepts, this model must include appropriate processes for services delegation between ATSUs and/or ADSPs that take into account ATCOs endorsements, traffic levels and operational environment/context.

2.4.1.2 Change Management

Even though the ATCO role will overall remain the same, changes will occur in the operational concepts and to ensure a smooth transition and avoid decreased awareness and additional stress caused by fear of change it will be important to set the scene as clearly, completely and early as possible.

All the challenges highlighted also reinforce the need for careful phased introduction of new concepts of operation and for the creation of usages where there is sufficiently frequent exposure to "on-demand" sectors to be controlled.

Change management, ensuring phased introduction of new concepts (e.g. "on-demand" and non-adjacent sectors) and maintenance of situation awareness is crucial.

The principles included in the report 'Change Management in the ATM Industry – Principles and Process (Feb 2019)' developed in collaboration by ATCEUC, ETF and CANSO should be implemented.

2.4.2 Standardisation of Systems & Data

2.4.2.1 ATCO working position

Even though virtualisation will enable an ATCO to use their "own" control working position (CWP) independent of the volume of airspace being managed, a move towards harmonisation of the CWP may enable more uniform training, bringing potential benefits in terms of both comfort and mobility.

Harmonisation (e.g. of the controller working position) may contribute to the optimisation of HF/HP benefits introduced by ADSP and VC concepts and could be explored.

2.4.2.2 Data accuracy monitoring

Another key factor to enable an efficient human performance is trust in the ATM human-machine system. Requirements for data accuracy, reliability and availability will remain key. To ensure safety and to avoid a

decrease in efficiency and/or increased stress of ATCOS, such requirements need to be fulfilled in a future architecture, at least at the same level as today, and this has to be demonstrated to operators.

Mechanisms to inform ATCOs of potential degradation of service will need to be widely available. System failures are often not obvious (for example in cases when "credible corruption" of data might be the main symptom) so robust and transparent monitoring systems are essential for ensuring ATCO confidence. Each ATM system in an ADSP-ATSU operation should be able to self-assess and inform about its current status, while also checking and monitoring data accuracy, and this status information should be easily available to ATCOs in the ATSU.

Another aspect to be ensured is the efficient response of the system while combining, splitting and taking over sectors, since this is a moment of increased vulnerability for the whole system.

Monitoring, control and alerting processes to ensure quality, reliability and accuracy of data produced by the ADSP and delivered to operational ATCOs will be key in ensuring maintenance of situation awareness. These mechanisms will be particularly important during the process of combining, splitting and taking over sectors.

Trust might be seriously compromised if multiple incidents do occur, which impact may even be amplified by the physical separation of ATSEP and ATCOs since their relationship may be weakened in comparison with today. The impact of being more removed from the core business and functions could be further explored in R&D activities.

Clearly-defined mitigation and recovery responsibilities and the promotion of direct contact and regular interactions between remotely located ATSU and ADSP personnel are both important mitigations to this perceived risk.

Clearly-defined responsibilities and the promotion of regular interactions between ATSU and ADSP personnel are important to generate a positive working culture and cooperation.

2.4.3 Resourcing, Training & Licensing

2.4.3.1 Training and licensing requirements

To ensure expected ADSP and VC operational benefits are realised without compromising safety, training and certification requirements will need to be adjusted to accommodate the new paradigm shift. In the particular case of ATCOs, the following points should be considered:

- Any proposal that ATCOs must be trained and endorsed to work sporadically and/or on demand on a sector would represent a huge challenge. Maintaining proficiency for operational routines and procedures in a volume of "foreign" airspace would require more hours of training and operating of such sectors[15], which could be expensive and time-consuming.
- It should never be assumed that a controller can operate, in case of need, in a sector in which it is difficult to maintain skills/ratings, e.g. due to required minimum number of hours operating that sector. The preliminary results of ongoing research projects, such as PJ.10-W2-93-V2 Final VALR, confirm this premise.
- The endorsement to operate in busy ACCs will probably be impacted and may become a more complex/time-consuming process that may impact staff availability.
- New training and licensing requirements would therefore have to be created in consideration of the frequency of services delegation and specific traffic to be controlled, including whether such delegation of services would take place during normal operations, or only in contingency circumstances. Controllers would need to maintain skills in 'on demand' sectors with an adequate

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[15] Developing and maintaining the competence for safely controlling a sector requires an adequate training and a minimum time of operation. For instance, Hungarian ATCOs controlling Kosovo air space were trained for several weeks, and for DSNA ATCOs to keep their license a period of operation of 200hrs is required.

number of working hours on those sectors, so as not to decrease safety levels and impact the service provided. Equally important is the individual learning process, led by the human, which promotes the consolidation of concepts acquired.

- ATCOs today work in "continuum airspace" (a sequential model) whereas in a VC architecture sectors can be disconnected from each other, resulting in ACCs with multiple virtual sectors. This will need to be reflected in the ATCOs training and rating requirements.
- In case of technical failures or issues, reduced experience/familiarisation in a single specific environment can lead to slower reaction times and undesirable human responses such as surprise, freezing, denial etc. Training should therefore include how to react to or address potential specific ADSP/VC-related failures, covering immediate actions in terms of separation, display etc.

Adaptation of ATCO's training and licensing requirements to the new paradigm shift (e.g. "on-demand" and non-adjacent sectors) considering contingency operations.

2.4.3.2 Resource planning

Among other benefits, ADSP/VC concepts are intended to make resource planning easier and more flexible, thereby enabling a more balanced workload of staff across the system.

At the same time, the delegation of services will introduce new requirements on resource planning and rostering because services can only be delegated if there are suitable ATCOs available. It should not be assumed that 'reserve crews' will be able to take over without consequences in terms of workload and stress, in particular in the current context of staff shortage. Joint rostering between different backup ATSUs might be considered, as long as, related social human dimension aspects are considered.

ATCO resource planning will need adapting for ADSP/VC concepts, in particular to ensure the availability of appropriately qualified staff whenever services are delegated. Joint rostering between ATSUs may be necessary, as long as, related social human dimension aspects are considered.

2.4.4 Digital & AI-based Support Tools

Other aspects to be considered in support to the enhanced delegation of services is the implementation of new digital tools (e.g. incorporated using artificial intelligence algorithms) that assist the human and contribute to the maintenance of the individual and shared situational awareness of ATCOs, as well as increasing flexibility while potentially reducing ATCO workloads and overcoming potential human factors implications (such as linguistic differences between remote units). This will be particularly important for ATSUs operating remotely in a Virtual Centres environment.

Such digital tools and automation will not be standalone measures, however, and ADSP/VC concepts still assume that ATCOs will remain in the loop.

Digital support tools for human operators working under ADSP-ATSU concepts should be specifically designed to preserve and enhance the individual and shared situational awareness of ATCOs, while taking remote operations and service delegation issues into account.

2.5 Potential HF implications for FMP staff

2.5.1 Concept of operations

The Flow Management Position (FMP) is a key position in ATFCM. It actively contributes to the optimisation of traffic flows according to air traffic control capacity while enabling airlines to operate safe and efficient flights. The change in service delivery model, and more precisely the delegation of ATSU, will slightly impact the Flow Coordinator or Flow Controller ways of working.

The future architecture will come with a necessary stability of time delegation. Indeed, FMP staff will have fixed time delegation (night or day) and the FMP area of responsibility will be adapted to match airspace controlled by ATSU, which will make it easier to handle.

However, the Flow Management Position will have to adjust to the "capacity on demand" concept. To do so, FMP staff from two different ATSUs may have to coordinate delegation to maximize common capacity, which could increase coordination needs and consequently workload related to communication with other ATSUs. This coordination can be even more complex when involving civil-military coordination.

Furthermore, the FMP officers should have supporting tools to correctly address how to combine sectors etc. Harmonisation in the ways of working across the network might also be required.

Delegation of services has to be coordinated to maximise common capacity and balance workload of FMP staff. This coordination should consider, as required, civil-military coordination needs.

During contingency operations it may be necessary to reduce the declared capacity of specific sector(s) to mitigate potential increases in ATCO workload.

ATFM measures, such as reducing the declared capacity of ATM sectors, may be necessary to support service delegation including for contingency.

2.5.2 Resourcing, Training & Licensing

In practice, the concept of capacity on demand is complex to implement and might also increase the complexity of rostering planning, since different restrictions per ATSU may coexist, adaptations will be required. Other aspects to be accounted for are highlighted in *Eurocontrol's ATFCM Operations Manual* for the strategic, pre-tactical and tactical phases.

Adaptation of resource planning to ensure FMP staff availability, maybe resorting to joint rostering with different backup ATSUs, as long as, related social human dimension aspects are considered.

It is important for the FMP to be appropriately competent in relation to the specific sectors they are monitoring, whether in their own national or other airspace.

2.6 Potential HF implications for ATSEPs

The change in the service delivery model and the virtualisation introduced by ADSPs and VCs will have a significant effect on the role of the ATSEP that will become more important as the middle man in the data processing chain. Even if functions as System Monitoring and Control (SMC), System Management, installation and technical support and the ATSEP Working Position should remain the same as today, the ATSEP's role will noticeably be modified to include new duties and changed responsibilities according to the technological evolution. As stated in the AAS, data and service assurance from third parties will require new monitoring tools and an even greater emphasis on cyber security. The ATSEP role will need to evolve to acquire new skills and take on these new responsibilities.

As for the previous sections, HF/HP implications related to the ATSEP role are grouped in the following subsections according to the categories defined in Figure 4.

2.6.1 Concept of operations

2.6.1.1 New ways of working

The overall evolution of system architecture will deeply modify the way systems (server/hardware) are designed and used. For example, they may be remote, virtualised and/or cloud-based.

In many cases, to administrate and manage the systems an ATSEP may have to rely on external colleagues or providers, which may deeply modify his perception of his work and autonomy. Autonomy is a key factor in the personal development of individuals in their work, such that its loss may contribute to reduced motivation. In addition, in case of an incident caused (directly or otherwise) by an external party trust is likely to be compromised, which could impact future collaboration.

In the new context an ATSEP's day to day operations will probably demand increased communications with external providers, resulting in increased effort that may be aggravated by the need of using a foreign language.

As an example, the SMC ATSEP situated at a Virtual Centre will experience a major change in their role. Instead of working with local colleagues in their current language, they might need to contact a foreign external provider by telephone, web portal or email.

To cope with such challenges an ATSEP communication layer will need to be established, and the necessary coordination tools will have to be researched, developed, tested and validated. These and similar aspects should be included in the SRIA[16]. Language requirements will also have to be reinforced, to ensure proper communication among involved operators.

This communication layer should not only look at the current service state, but also at future degradations to ensure a coordinated and agreed overall overview of service quality and system state at any given moment in a foreseeable timeframe.

Where this coordination is now done at the ANSP with mostly internal stakeholders, in the ADSP and VC architecture this requires procedures and tools to align and communicate service degradations between ADSP's and ATSU's.

Conception of a communication and coordination layer for ATSEPs, using a common language and supported by coordination tools to be researched, developed, tested and validated.

Definition of clear responsibilities and accountabilities will contribute, guaranteeing that each party is mindful of their role. Other measures can include, promotion of contact and interaction between the local and the remote personnel promoting a working team.

Definition of clear responsibilities and accountabilities for all ATSEP roles, both at ATSU or at ADSP.

2.6.1.2 Incident monitoring, resolution and contingency processes

The increased complexity of diagnostic and troubleshooting may severely impact ATSEP performance, and may also have an impact on other human roles performance such as data end-users (ATCOs, FMP staff, Pilots…), in particular in case of long systems/data disruption.

Backup services and procedures for resilience and contingency must be put in place and be readily available, and activation and restoration, rollback procedures must be defined and included in the training.

Shared contingency plans, which might require adaptations and new tools at the different working positions, must be developed and put in place together with appropriate training to handle degradation of services.

Contingency plans, that will introduce new tools, stakeholders geographically apart and different cultural backgrounds, must be well-defined, tested and validated before being put in place.

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[16] *Strategic Research and Innovation Agenda,* https://www.sesarju.eu/sria.

2.6.2 Contractual arrangements

2.6.2.1 Last resort operations/services

For last resort systems (which have to work when all else fails) a consideration has to be made to what extend a dependency on external service providers is desirable.

Last resort services will still be the only remaining service under complete responsibility of the ATSU ATSEP. This is heavily depending on the ATSU policy and currently remains an unknown component of the future architecture. These systems will require specific technical knowledge and will probably have a low hands-on frequency of the ATSEP, an extra attention to proficiency on these systems is required.

This aspect should be further investigated before the implementation of the new architecture.

In the case of the CNS/ATM ATSEPs serving the CNS Sensor sites (including Space based CNS Ground stations) different scenarios are put forward by the AAS and ADSP Study. Some include the CNS sensors and related personnel as being integrated within the same ANSP and others consider the subcontract of CNS services. There may also be cases where the VC and CNS sensors share common human resources. These scenarios raise different challenges that might be aggravated during contingency contexts.

For example, in case the sensor is also an ATSU last resort facility the interaction may skip the ADSP layer and is directly between ATSU and sensor ATSEP. In this case the agreement between the ATSU and the local subcontractor at the sensor level may conflict with the subcontractor and ADSP agreement. When the ATSU is a virtual centre, it becomes even more complex, because the location of the VC may be distant from the sensors' location.

A solution may pass by a mandate enforcing that last resort operations may only take place at the physical location of the sector(s) under control. But, further research is needed to investigate ATSU (VC) last resort operations and related architectural, procedural and contracting requirements before the implementation of the future architecture.

> Investigate and define last resort services and its implications to the ATSEP responsibilities and required competences, as well as contractual implications and regulatory needs.

2.6.3 Standardisation of Systems & Data

Depending on their location, either located at the ATSU or at the ADSP, the ATSEPs may have different focus and face a different situation awareness,

For the SMC ATSEP located at the ADSP, the consequences of a technical problem might be perceived as a technical service interruption, for which they will have limited visibility on the associated operational consequences, given the physical separation from the ATSU. As a result, responses will probably be based on service level agreements which may not take all operational circumstances into consideration.

This example shows that the physical separation between ADSP and ATSU may reduce situational awareness at the ADSP level, which could ultimately result in non-optimal decision making by the ATSEPs.

Other aspect that can contribute to reduce the situation awareness is different data/information needs from different ATSUs served by the same ADSP.

This particular challenge can be addressed at the ATSU or ADSP level. Or the ADSP sends a standard notification to all ATSUs served and this information is processed at the ATSU according to their needs or the ADSP sends tailored notifications to each ATSU.

Overall, shared situation awareness of service quality and systems state ("health") must be harmonised between the different parties, enabling an effective Collaborative Decision Making (CDM) process. Noting that from the ATCO working position perspective these technical arrangements should be imperceptible, irrespective of the system reconfigurations.

> Standardise system's notifications between ATSEPs at the ATSU and ADSP in support of shared situation awareness and enabling an effective Collaborative Decision Making (CDM) process.

Research is required on how to ensure shared situation awareness. Such research could lead to specific requirements as input for the new ADSP/VC system architecture. This topic should be included in the SRIA[16].

For maintenance activities or other activities causing service degradation at ADSPs and ATSUs, a shared, coordinated and agreed overall plan has to be established and maintained.

A procedure has to be in place to integrate planned and unplanned service degradations into an overall overview of service quality and system state. Not only current, but also future service degradations have to be taken into account to ensure predictable and controllable quality and continuity of services at the ATSU level.

All stakeholders must have access to all relevant information in this overview, without having to filter the information themselves. Taking the potential amount of information available in this overview into account, situational awareness is severely reduced when this is made available to all stakeholders without any form of filtering.

> Research is needed into requirements to develop a new system architecture that enables the required shared situation awareness, including of planned system maintenance.

2.6.4 Resourcing, Training & Licensing/Certification

In the new architecture, ATSEP will have a role of technical supervision. The role of ATSU ATSEPs will tend to be more specialised and to evolve towards system manager. They will have to manage (sometimes swiftly) configuration changes or updates from different providers. Moreover, the ATSEP will interact with systems from different providers (Thales, Indra, Aerion, etc.). All of these may have a huge impact on required competences and training.

ATSEP will most likely have to manage more systems and adjust to technological developments. In addition to current systems required to produce data, additional systems may be required with the future architecture. For example, ATSEP teams will have to work with systems supporting delegation of ATC services, systems supporting interoperability, new back-up systems, configuration management system, or even systems supporting the geographical distribution of services. This situation will probably increase the complexity to day-to-day operations and consequently the overall workload. The employer therefore has to ensure adequate training, competency acquisition, etc. Equally important is the individual learning process, led by the human, which promotes the consolidation of concepts acquired.

Training and licensing/certification requirements, included in annex 13 of IR (EU) 2017/373, will have to evolve to take in all the new requirements introduced by the new ways of work and operational concepts and will most likely need to include virtualisation and cloud based technologies as well as principles for management of interfaces with external ADSP.

> Update of ATSEP's training and licensing/certification requirements and review the selection and recruiting criteria to address the new ways of work and operational concepts and to include virtualisation and cloud based technologies as well as principles for management of interfaces with external ADSP.

Furthermore, and even though adaptation to the evolution of technology already takes place today, the new service delivery model might introduce pressure for technological evolution and increased competition in the labour market, with new competition from IT units in other sectors such as banking and communications. The associated implications are both positive and negative. Different implications might also be observed on different ATSEP generations, the younger generation might be more flexible and agile to change than the older generation.

These changes have to be properly managed to ensure sufficient continuity (by avoiding flee of skilled and experienced staff), mitigating any consequences on ATSEP performance and experience.

> Change management to ensure ATSEP adaptation to the potentially more abrupt technological evolution, avoid under resourcing and guarantee sufficient continuity from senior to junior staff.

Client's service units facilities might be located remotely, having its own times of high traffic/high workloads in another time zone, than the "delivery" ADSP has. Planning of local ADSP's duty shifts and resourcing has to take those different time zones into consideration [17].

Planning of local ADSP's duty shifts and resourcing has to take different time zones into consideration.

The CNS/ATM ATSEP located at a remote ADSP may also be impacted by the physical and functional distance to a client ATSU, which may in turn cause diminished understanding of an ATCO's operational needs. In the existing situation at a traditional ASNP where most systems are located close together, an ATSEP might often be assigned to work on systems outside of their core expertise (for example, a NAV ATSEP might support the introduction of new technology such as remote TWR systems) with a corresponding positive benefit to their system-wide understanding. Such capability benefits may be unavailable to ATSEPs who are fully focused on the delivery of a specific service at an ADSP, remote from any ATSU(s) being served.

Training and maintenance of competences will remain the most important solution for managing these aspects and ensuring that ATSEPs will continue to work on safety-critical ATM systems with an appropriate level of competence and skills.

Adaptation of ATSEP's training to the new technical and operational requirements of an ADSP-ATSU operation. These adaptations can build on lessons learnt from other sectors where decouple between service delivery and data management/provision has been implemented.

ANS cybersecurity is a transversal domain involving both ground and space based CNS and ATM systems and according to the EU regulation the ATSEP is the sole technical specialists authorized to provide support and intervene on electronics and software enabling these systems. Even though on the tactical level ATSEP is the only professional authorised to address cyber threats, on a strategic level cybersecurity should involve combined teams of ATSEP, ATCO, AIS/AIM personnel, etc.

As ANS equipment becomes increasingly digital, interconnected and automated the risk of cyber-attacks augments as increases the difficulty of monitoring and preventing cyber-attacks, what directly impacts the work of the ATSEP. To mitigate the impact of this issue on ATSEP's human performance, ATSEP's human competence and training profile will have to evolve accordingly to include new forthcoming requirements.

Addition of an adapted cybersecurity layer to ATSEP's training covering new data management processes.

2.6.5 Digital & AI-based Support Tools

The availability of needed information to the interested parties at the right time is key in case of incidents. The separation between ADSP and ATSU can lead to delays and to the need of more coordination for obtaining all required details related to the service interruption or malfunction (i.e. what is the origin of the issue, how long will it take to recover, etc.). These delays strongly impact SMC ATSEP's performance on managing the incident and ability to inform the ATCO, responsible for the operational decision on how to handle the situation. This results in overall reduced situation awareness with a greater or lesser impact on operations depending on the level of uncertainty.

The risk of degraded transmission of incident or malfunction details could be mitigated with the introduction of new support software tools at the ATSEP working position, in particular for the SMC ATSEP, that contribute to the maintenance of the situation awareness to all parties.

Development of new support software tools at the ATSEP working position, in particular for the SMC ATSEP, that contribute to the maintenance of the situation awareness to all parties.

Cybersecurity procedures (including diagnose, communication and troubleshooting) are also required, but these should not make the ATSEP's workload non-sustainable, as these procedures tend to be high

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[17] As an example: the ECAC area itself covers 5 time zones, but also covers ICAO NAT region/oceanic operations, where US originating traffic enters the Area of responsibility during night times

workload/intensive. The development and use of support, AI based, digital tools may contribute to the mitigation of cyber risks while not overloading the ATSEP. These tools may support the ATSEP by continuously monitoring and proactively detecting evolving system abnormalities or combined attacks, which are difficult to detect promptly by human capabilities only, in particular as systems become more complex and interconnected.

Research and development of AI based digital tools to support continuous monitoring and proactive detection of evolving system abnormalities or combined attacks.

2.7 Potential HF implications for AIS/AIM personnel

2.7.1 Concept of operations

Implications to AIS/AIM personnel from the introduction of ADSP and VC are still unclear since they have remained mostly excluded from studies conducted and ongoing, as such predictions here discussed will need further investigation. Overall, the impact will depend on the model that prevails, but what can be expected is for implications to be more severe with higher level of centralisation.

Whatever the new scenario, clear working and contingency procedures as well as responsibilities have to be defined.

Define clear working and contingency procedures as well as responsibilities for AIS/AIM staff.

2.7.2 Resourcing, Training & Licensing

Deriving from currently known projections most of AIS/AIM functions will stay the same. However service and locations would be more than ever centralised, which is primarily positive when it is done within one country.

For instance, in Slovenia (as well as in several EU countries) ARO service was recently centralised, which means that instead of 3 units only one is operating 24/7 offering the service 24/7. The other units are no longer required.

With all operations concentrated from one place, staff must be aware and trained with a broader scope of local specificities. All the staff can be located in one centre, which is a benefit during the holiday season as well as during pandemic periods. This can contribute to decreased and/or more even workload, to a broader scope of knowledge acquired and possibly to a decrease in the risk of human error.

This benefit may be easily replicated in small countries, but in larger countries this becomes more complex, since negative implications will be accentuated, such as commuting or transfer of staff causing decreased quality of life, or even staff layoffs due to a smaller number of the personnel needed.

The competition–driven approach of the ADSP model also introduces other consequences, such as, ADSPs competing on an open market would force a "race towards the bottom" regarding staff costs. That would mean reduced numbers of staff and higher workload with lower salaries for the remaining employees. But can also mean that the new architecture may lead to a need for more skilled jobs.

Staff reductions would accentuate a current problem, aging of AIS staff. In several countries the average age of AIS employees is currently quite high. With staff reductions and no new employments the situation would deteriorate.

A balanced recruitment and staff development policy is needed to match the AIS work force to the evolution of the job.

The need for a broader scope of knowledge also creates issues, since there could be lack of local knowledge if no additional training is provided.

These challenges would only get aggravated if the centralisation would take place in a cross border service, due to the introduction of competition between different ANSPs.

Language is another important aspect to be considered. Despite that the official language in aviation is English, the local language plays also an important role, especially when working in ARO where main customers are VFR pilots and also when issuing the NOTAMs, since they are issued in English and in the language of each country.

The solution may pass by mandating the maintenance of use of both languages, since automatic translator solutions (e.g. google translator) might not be adequate due to high risk of misunderstandings, NOTAM errors would be a safety issue.

Mandate the requirement for a good level on both national and common language for AIS/AIM personnel.

2.8 Potential HF implications for FISO

Flight Information Service Officers operating in an Area Control Centre often use the same tools and systems as ATCOs, hence aspects discussed in section 2.4 also apply to FISOs. Nonetheless, it should be noted that in some Countries, FIS is conducted by dedicated personell not located at the ACC (e.g. separate room or location).

Centralisation of FIS sectors is already practised in several European states, for example in Germany, where FIS services are located in Langen ACC, but in a separate operations room. Lessons learned and best practise from all such states might be used to support the further introduction of ADSP-ATSU operations from a FISO perspective.

2.9 Potential HF implications for FDA staff

Flight data is an essential aspect of modern air traffic management for area control operations: in controlled airspace, no flight data means no flight. Flight data accuracy, timely availability, exchange and forwarding is key to an ATCO's productivity and efficiency. With the increasing introduction of ADSP-ATSU operations the importance of flight data will only increase, with flight data operations staff increasingly being at the core of operations.

Changes in the ATSU service and ADSP/ATSU systems will bring changes in working methods for FDP staff Training and licensing adaptations, as discussed in section 2.3.4, will therefore be essential to ensure both quality and capacity in the delivery of flight data services.

Some centralisation of flight data services might be possible, although it is likely to have several HF implications, including for example:

- Common operational situational awareness
- Understanding between ATCO's and other operational personel
- Reduced local knowledge and understanding of ATM systems

Delivering Flight Data Services from an external ADSP (remote from the ATSU(s) being served) will risk introducing a disconnecttion from local knowledge, local working methods, systems knowledge and systems proficiency. For example, ATSU's operating with different ATCAS systems and distinct local working methods may prefer to process flight data in different ways, which could lead to important and safety-related misunderstandings.

3 RECOMENDATIONS

In this position paper the EGHD puts forward pragmatic recommendations to the Commission to support the successful implementation of ADSPs and VCs, while maximising the potential benefits and mitigating the associated risks regarding human performance. Associated objectives include an improved shared awareness of the safety chain, improved operational performance and an increased safety and resilience of ATM.

By assessing potential human factors and human performance implications arising from the introduction of ADSP concepts and Virtual Centres, a series of constructive mitigating actions have been identified by the EGHD, as documented in section 2. To derive from these mitigating actions a concise set of tangible recommendations to be targeted at specific organisations, they have been grouped into six discrete categories, as identified in Figure 4.

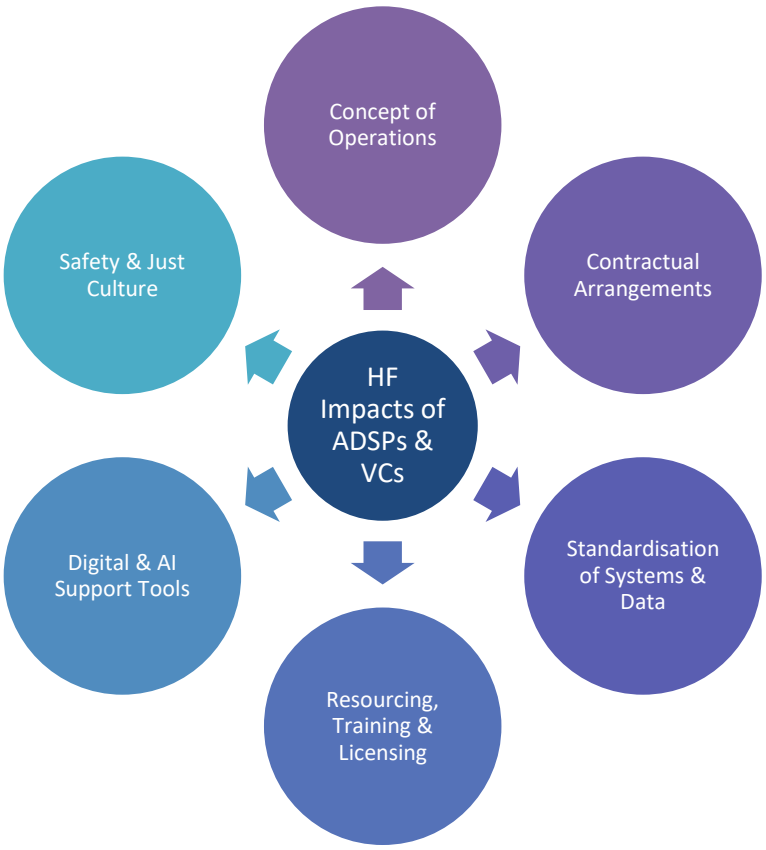

FIGURE 4: MITIGATION CATEGORIES USED FOR HF/HP IMPLICATIONS OF ADSP & VC

For each category of mitigation the EGHD is proposing a high-level recommendation, to be targeted in each case at a single organisation to hold *initial* responsibility for progressing the recommendation. Due to the developing nature of ADSP and VC concepts, in several categories the recommendations imply R&D activity for which the natural initial target organisation should be SESAR.

A summary of the high-level focus of recommendations and target organisations for each category can be seen in the following table:

Mitigation Category	Key focus of a recommendation relating to human aspects	Expected bodies for action	Human roles impacted
Safety & Just Culture	**Just Culture policy and principles implementation for all ATM stakeholders including ADSPs together with recurrent training for all actors of the ATM safety chain**	EC, EASA, EUROCONTROL and Member States	**All** (see section 2.3.5)
Resourcing, Training & Licensing/ Certification	**Develop a new ATSU-ADSP competency scheme with associated training and licensing/certification**	EASA with support from SESAR (S3JU and appropriate mandate by the EC	**All** (see section 2.3.4) *Specific aspects noted for:* **ATCOs** (section 2.4.3) **FMP staff** (section 2.5.2) **ATSEPs** (section 2.6.4) **AIS/AIM** (section 2.7.2)
Contractual Arrangements	**Establish mandatory minimum requirements for ADSP-ATSU service provision**	EASA	**All** (see section 2.3.2) *Specific aspects noted for:* **ATSEPs** (section 2.6.22.6.1)
Concept of Operations	**Test, validate and update the CONOPS for ATSU-ADSP ATM operations**	SESAR (S3JU)	**All** (see section 2.3.1) *Specific aspects noted for:* **ATCOs/FISOs** (section 2.4.1) **FMP staff** (section 2.5.1) **ATSEPs** (section 2.6.1) **AIS/AIM** (section 2.7.1)
Digital & AI Support Tools	**Specify ATSU-ADSP digital support tools to enhance human situational awareness and capability**	SESAR (S3JU)	**ATCOs** (section 2.4.4) **ATSEPs** (section 2.6.5) **AIS/AIM**
Standardisation of Systems & Data	**Develop and introduce new standards for interoperable ATSU and ADSP systems**	EUROCAE with support from SESAR (S3JU) and EASA	**All** (see section 2.3.3) *Specific aspects noted for:* **ATCOs** (section 2.4.2) **ATSEPs** (section 2.6.3)

TABLE 1 – SUMMARY OF MITIGATION CATEGORIES FOR HF/HP IMPLICATIONS OF ADSP & VC

3.1 Safety & Just Culture

3.1.1 Summary of EGHD position

The introduction of any new organisations to the ATM industry, including new ADSPs, should follow the same safety and just culture schemes and requirements that are already in place. This will make an essential

contribution to the maintenance of trust and confidence among front-line operators, and will indirectly improve safety by reducing incident repetition through the transparent sharing of lessons learned.

Furthermore, since the ATM safety chain will be distributed among more undertakings with a consequent decrease in the knowledge about the tasks led by others, it is essential that all actors of the safety chain are regularly trained. This training will ensure all actors are aware of the state of the safety chain and understand the interdependencies and the impact actions have on the overall safety system.

3.1.2 Expected bodies for action

Considering the current landscape for Just Culture and the Regulation (EU) No 376/2014, the EGHD advises the European Commission, EASA, EUROCONTROL and Member States to continue in its efforts to raise awareness and educate the relevant actors from the transport and judicial worlds on their responsibility in keeping European aviation safe and proposes the extension of this culture to ADSP staff.

Since EASA is the body in charge of aviation safety and of drafting the related requirements, EGHD advises to add a requirement for recurrent training of all actors of this chain, on the constituents of the ATM safety chain, especially those with a duty affecting safety.

3.1.3 EGHD recommendation

In relation to the Safety & Just Culture category of mitigation, the EGHD makes the following recommendation (see section 2.3.4.2):

- **EGHD_2022_1_1: The European Commission, EASA, EUROCONTROL and Member States should continue in its efforts to establish a Just Culture environment for all ATM-related stakeholders involved in supporting ADSP-ATSU ATM operations. EASA should develop and enforce requirements for recurrent training on the constituents of the ATM safety chain to all staff with a safety related duty.**

3.2 Resourcing, Training & Licensing/Certification

3.2.1 Summary of EGHD position

To realise the expected flexibility and resilience benefits enabled by ADSPs and VCs, while simultaneously avoiding increases in workload and stress for front-line operators, it is crucial to ensure the availability of suitably trained and certified staff who are familiar with the appropriate ATSU-ADSP operational concepts.

Aspects related to this include working methods development, training, competence, licensing, rating maintenance and international authorisations for an operator to work on the unit of a foreign provider. Another essential aspect of staff availability is rostering – which may be especially difficult to regulate across state and organisational boundaries.

3.2.2 Expected bodies for action

Ultimately the EGHD would expect EASA to be responsible for establishing a new or adapted competency scheme for ATSU-ADSP operations.

Before this can realistically happen, the EGHD anticipates that further research and development into the many associated roles, human capabilities, training needs and licensing requirements will be needed. As research-focused work relating closely to ATM development concepts proposed in the SESAR ATM Masterplan (2020), the EGHD would expect the SESAR 3 Joint Undertaking (S3JU) to lead such development work, with input from EASA as appropriate.

EASA on the other hand should take this work into consideration when developing a new ATSU-ADSP competency scheme together with associated training and licensing/certification. As it is unclear whether EASA holds a mandate to carry out this recommendation under the Basic Regulation (EU Reg. 2018/1139), the EC is recommended to make sure this mandate is made clear.

3.2.3 EGHD recommendation

In relation to the Resourcing, Training & Licensing category of mitigation, the EGHD makes the following recommendation:

- **EGHD_2022_1_2: EASA should initiate under EC supervision a preparatory work before drafting any new competency scheme exploring 3 main areas:**
    - **Classify or better propose a method to classify technical staff/tasks/functions according to their proximity/link with functional systems/critical systems.**
    - **Identify and list appropriate and diverse regulatory tools (from binding IR to soft AMC or GM).**
    - **Identify subjects/matters of interests for a competency scheme (e.g. technical skills, non-technical skills, safety awareness/training, ATM awareness/training, cyber-security skills.**

  The objective of this work should be to lead the development of adapted qualification, training, and licensing and rostering schemes for professionals working in ATSU-ADSP environments.

  This work should be informed by the SESAR 3 Joint Undertaking and should consider the analysis conducted by the EGHD in section 2, which is summarised below:
    - Relating to all human ATM roles (see section 2.3.4):
        - Resourcing and rostering plans possibly including joint rostering between different ATSUs, while addressing social human dimension aspects.
        - Training and licensing requirements for operational interoperability between countries on a European level, including a common language.
        - Minimum ATM competences and training requirements for non-ANSP ADSP technical staff.
        - Resource implications on more and less digitally aware front-line operators.
    - Relating especially to ATCO roles (section 2.4.3):
        - Adaptation of ATCO's training and licensing requirements.
        - Adaptation of ATCO's resource planning, maybe resorting to common rostering between different backup ATSUs, while addressing social human dimension aspects.
    - Relating especially to ATSEP roles (section 2.6.4):
        - Adapted selection and recruiting criteria, training and license/certificate requirements, including virtualisation and cloud based technologies, cybersecurity, as well as principles for management of interfaces with external ADSP.
        - Planning of local ADSP's duty shifts and resourcing has to take different time zones into consideration.
        - Change management to mitigate consequences of more abrupt technological evolution (e.g. on resourcing).
    - Relating especially to AIS/AIM roles (section 2.7.2):
        - Staff development policy to match the evolution of the job.
        - Requirements on both national and common European language.
    - Relating especially to FMP staff roles (section 2.5.2):
        - Resource planning, maybe resorting to joint rostering between different backup ATSUs.
        - FMP to be appropriately competent in relation to the specific sectors they are monitoring, whether in their own national or other airspace.
        - Role allocation and associated responsibilities must be made as clear as possible.

- Relating especially the MET roles:
  - Ensuring the timely availability of all weather related information to the ATCO/FISOs requires sufficient staffing and tools to help track what is most urgent.

3.3 Contractual Arrangements

3.3.1 Summary of EGHD position

ATSU-provided ATM operations must be safeguarded by robust contractual service level agreements, or even mandatory requirements, which minimise the risk of data service disruption due to inadequate ADSP maintenance programmes and/or backup systems. Contingency arrangements, in which one or more ATSUs or ADSPs agree to cover the services of another in the event of technical disruptions, will need to be similarly protected. In all cases, increased operator stress and workload is likely to be a significant impact of any failure to adequately mitigate the associated risks.

For example, in existing ATM systems, maintenance tasks and other technical interventions are carefully planned to minimize impacts to operations, usually taking place during off-peak periods and with combined system degradations being carefully avoided. In the ADSP business model such planning is more difficult: multiple ATSUs may consume services from one or multiple ADSPs, with each ADSP functioning as main, backup or last resort service for an ATSU. This arrangement adds inter-organisational complexity to technical intervention planning, including at any ADSP which serves multiple ATSUs. To avoid serious consequences to ATSU operational services, appropriate agreements for such outages must therefore be in place, including backup mechanisms which might include the use of alternative ADSPs.

Contractual arrangements, whilst very much needed, will not be sufficient as to ensure that the overall safety chain is still appropriately known and taken into account by all actors and this recommendation goes hand in hand with recommendation in section 3.1.

3.3.2 Expected bodies for action

This recommendation primarily addresses the need for mandatory requirements for ADSP-ATSU service provision. As the relevant safety regulator, such mandatory requirements are likely to be the responsibility of EASA. Other bodies including SESAR might also be involved in earlier research and development.

3.3.3 EGHD recommendation

In relation to the Contractual Arrangements category of mitigation, the EGHD makes the following recommendation:

- **EGHD_2022_1_3: EASA should establish comprehensive requirements for ATM service provision involving ATSU-ADSP concepts, especially regarding service resilience and contingency.** This work should consider the analysis conducted by the EGHD in section 3, which is summarised below: :
  - Relating to all human ATM roles (see section 2.3.2):
    - Mandatory requirements, addressing service disruption, backup programmes, contingency plans and last resort operations.
  - Relating especially to ATSEP roles (section 2.6.22.6.1):
    - Investigation and definition of last resort services and their implications for ATSEP responsibilities and required competences, as well as contractual implications and regulatory needs.

3.4 Concept of Operations

3.4.1 Summary of EGHD position

The benefits and challenges to human factors and performance introduced by ADSP and VC models, and associated new IT skills, new ways of working with different countries, languages, cultures and more interfaces, can be both promoted and mitigated by advanced awareness of personnel, adapted concepts of operation and procedures, adjusted selection, resourcing, training and licensing programmes, *as soon as the concepts, architectures and technologies become mature enough*.

In many cases, further progress in successfully developing ADSP concepts and technologies is dependent on a better understanding of the specific Concepts of Operations for which they are intended or expected to be implemented. A high number (13) of the specific measures identified by EGHD relate directly to this need.

3.4.2 Expected bodies for action

As a research-focused recommendation relating closely to ATM development concepts proposed in the SESAR ATM Masterplan (2020), this recommendation is targeted at the SESAR 3 Joint Undertaking (S3JU) for immediate implementation, and for consideration in the context of the next version of the ATM Masterplan. The Network Manager can act as a contributor on aspects related to the delegation of services and ATFM measures.

3.4.3 EGHD recommendation

In relation to the Concept of Operations category of mitigation, the EGHD makes the following recommendation:

- **EGHD_2022_1_4: The SESAR 3 Joint Undertaking should test, validate and update the operational concepts, responsibilities and ways of working defined for ATSU-ADSP ATM operations, including Virtual Centres, with the specific goal of improving the human-machine system.** This work should consider the analysis conducted by the EGHD in section 2, which is summarised below:
    - Relating to all human ATM roles (section 2.3.1)
        - Responsibilities and accountabilities to ensure the maintenance of situation awareness of all actors;
        - Organisational and operational boundaries;
        - Cross-border operations including civil-military coordination;
        - Comprehensive processes and reaction rules for contingency, cybersecurity, and safety and security investigations (to be ratified by the relevant authority/regulator of each country);
        - Eventual regulatory or procedural differences/discrepancies between different impacted countries or organisations.
        - Change management, ensuring involvement of all parties including operational actors and phased introduction of new concepts considering the principles included in the report 'Change Management in the ATM Industry – Principles and Process (Feb 2019)' developed in collaboration by ATCEUC, ETF and CANSO.
    - Relating especially to ATCO/FISO roles (section 2.4.1):
        - Processes for services delegation that take into account ATCOs ratings, traffic levels and operational environment/context.
        - Processes to ensure interface with lower airspace structure including flight information services.

- Operational feasibility over time to keep current competence on the areas being controlled.
- Change management, ensuring involvement of all parties including operational actors and phased introduction of new concepts considering the principles included in the report 'Change Management in the ATM Industry – Principles and Process (Feb 2019)' developed in collaboration by ATCEUC, ETF and CANSO.

- Relating especially to ATSEP roles (section 2.6.1):
  - Communication and coordination layer for ATSEPs, using a common language and supported by coordination tools to be researched, developed, tested and validated.
  - Backup services and procedures for resilience and contingency including activation, restoration and rollback procedures.
  - Shared ATSU-ADSP contingency plans, which might require test, validation, adaptations and new tools at the different working positions.
- Relating especially to FMP staff roles (section 2.5.1):
  - Coordinated delegation of services as an enabler of maximum common capacity and balanced workload of FMP staff, while considering civil-military coordination needs. Provided that qualification requirements are taken into account[18].
  - ATFM measures (e.g. reducing the declared capacity of sectors) in support of services delegation processes.
- Relating especially to AIS/AIM roles (section 2.7.1):
  - Clear working and contingency procedures, including associated responsibilities.
  - Appropriate tool development to keep track of AIS/AIM activities within the area of responsibility.

3.5 Digital & AI-based Support Tools

3.5.1 Summary of EGHD position

Delegation of services may be supported or even enhanced by the implementation of new digital tools, perhaps using machine-learning algorithms.

For the ATCO these tools should assist the human and contribute to enhanced situational awareness (individual and shared) as well as increasing flexibility, while potentially reducing workloads. Such new digital tools and automation will not be standalone measures however and ADSP/VC concepts still assume that ATCOs will remain in the loop. This might involve new Human Factors implications, for example potential linguistic difficulties associated with increasing remote collaboration.

For the ATSEP, data and service assurance from third parties will require new monitoring tools and an even greater emphasis on cyber security. The ATSEP role will need to evolve to acquire new skills and take on these and other new responsibilities.

For the AIS/AIM staff, the concept of area of responsibility is likely to be altered and clear indication of task allocation and priorities must be established.

3.5.2 Expected bodies for action

As a research-focussed recommendation relating closely to ATM development concepts proposed the SESAR ATM Masterplan (2020), the recommendation for this mitigation area is targeted at the SESAR 3 Joint

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[18] *In some countries FMP staff is qualified for specific sectors. To avoid capacity constraints or extensive training periods, it is important to ensure FMP is qualified to a limited number of sectors (a balance between the training required and the number of sectors FMP staff is qualified for).*

Undertaking (S3JU) for immediate implementation, and for consideration in the context of the next version of the ATM Masterplan.

3.5.3 EGHD recommendation

In relation to the Digital & AI-based Support Tools category of mitigation, the EGHD makes the following recommendation:

- **EGHD_2022_1_5: The SESAR 3 Joint Undertaking should research and develop digital and AI-based human operator support tools specifically to support ADSP-ATSU operations, with the goal of delivering shared situation awareness, enhanced human capabilities in face of complex scenarios and balanced human workloads.** This work should consider the analysis conducted by the EGHD in section 3, which is summarised below:
    - Relating especially to ATCO roles (section 2.4.4):
        - Digital based human operator support tools in contribution to situation awareness (individual and shared), HF and HP.
    - Relating especially to ATSEP roles (section 2.6.5):
        - Support software tools at the ATSEP working position, in particular for the SMC ATSEP, in contribution to the situation awareness of all parties.
        - AI-based digital tools to support continuous monitoring and proactive detection of evolving system abnormalities or combined attacks.
    - Relating especially to the AIS/AIM roles:
        - Clarify priority setting when in charge of multiple ATSUs

3.6 Standardisation of Systems & Data

3.6.1 Summary of EGHD position

Responsibilities, standards and levels of service must be established and clearly communicated to all operators and accounted for in the applicable regulations, to guarantee the interoperability between Civil (and Military) ATSUs with external ADSPs

For example, a shared situational awareness of service quality and systems health needs to be harmonised between the different parties to enable an effective Collaborative Decision Making (CDM) process. From the ATSU working position these technical arrangements should be imperceptible. At the same time, a move towards standardisation of the ATCO working position may enable more uniform training and rating requirements, bringing potential benefits in terms of both comfort and mobility.

3.6.2 Expected bodies for action

This recommendation concerns the development and introduction of new standards for interoperable ATSU and ADSP systems. EUROCAE are the European leader in the development of worldwide recognised industry standards for aviation and the EGHD therefore expects that this is the most appropriate organisation to lead a response to it. At least EASA and the S3JU may also need to be consulted and involved.

3.6.3 EGHD recommendation

In relation to the Standardisation of Systems & Data category of mitigation, the EGHD makes the following recommendation:

- **EGHD_2022_1_6: EUROCAE with support from EASA and SESAR 3 Joint Undertaking, should lead the research, development and standardisation of interoperable ANSP and ADSP systems on a European level, including associated principles for data processing and presentation.** This work should consider the analysis conducted by the EGHD in section 3, which is summarised below:

- Relating to all human ATM roles (see section 2.3.3):
  - Standardisation of interoperable civil-military ANSP and ADSP systems (considering rulemaking activities, such as EASA's RMT.0161), in particular and as a priority for critical systems.
  - Requirements and principles for data processing and presentation, on a European level.
  - Transversal IT standards.
- Relating especially to ATCO roles (section 2.4.2):
  - Standardisation or interoperability as an enabler of HF/HP, eventual harmonisation of CWPs.
  - Monitoring, control and alerting processes to ensure quality, reliability and accuracy of data.
- Relating especially to ATSEP roles (section 2.6.3):
  - Standardisation of system notifications.
  - System architecture as an enabler of shared situation awareness and of coordinated system maintenance

ANNEX A. ACRONYMS

Abbreviation	Full Term
ACC	Area Control Centre
ADSP	ATM Data Service Provider
AIM	Aeronautical Information Management
AIS	Aeronautical Information Service
ATCO	Air Traffic Control Officer
ATFCM	Air Traffic Flow and Capacity Management
ATOS	Air Traffic Services Operations Specialist
ATSEP	Air Traffic Safety Electronics Personnel
ATM	Air Traffic Management
ATSU	Air Traffic Service Unit
AU	Airspace Users
EASA	European Union Aviation Safety Agency
ECTL	EUROCONTROL
EGHD	Expert Group on Human Dimension
FDA	Flight Data Assistant
FDP	Flight Data Processing
(A)FISO	(Aerodrome) Flight Information Service Officer
FMP	Flow Management Position
HF	Human Factors
HP	Human Performance
KPI	Key Performance Indicator
MET	Meteorological (information)
SES	Single European Sky
SESAR	Single European Sky ATM Research
SMC ATSEP	System Monitoring and Control ATSEP (Regulation (EU) 2017/373)
SRIA	Strategic Research and Innovation Agenda
VC	Virtual Centre

ANNEX B. GLOSSARY

A

ADSP	An ATM Data Service Provider is an entity that will manage some or all of the data processing and associated support services needed by one or several Air Traffic Service Units (ATSUs) to deliver air traffic services to airspace users. In this way, the ATM Data Service Provider concept encompasses the decoupling of ATM data service provision from other air traffic services. An ADSP service can be provided to a given ATSU in several ways, for example: 1. The ATSU could have a single ADSP providing all real-time ATM data needed for it to deliver ATS services; 2. Different data services including flight data processing, surveillance or meteorological data could be provided by different ADSPs. This might also involve some exchange of data between those ADSPs. Because it can be geographically remote from the ATSU, the ADSP is enabler for the Virtual Centre. ADSP concepts enable separation of the various ATM functions, responsible for operational data and associated technical services, while ATSU remain focussed on the core business of air traffic management and control. An ADSP could exist in joint ownership or close partnership with an ATSU, as may be the case for many existing ANSPs, or it might exist as a certified external entity providing a service under market conditions. (*Source: SESAR JU, Airspace Architecture Study, March 2019; EGIS*)
AIS/AIM personnel	Personnel directly involved in the provision of Aeronautical Information Services (AIS) and management (AIM) a service established within the defined area of coverage responsible for the provision of aeronautical data and aeronautical information necessary for the safety, regularity and efficiency of air navigation. An AIS shall ensure that aeronautical data and aeronautical information necessary for the safety, regularity or efficiency of air navigation are made available in a form suitable for the operational requirements of the air traffic management (ATM) community (involved in flight operations and air traffic services, including pre-flight, see DOC 9854). ICAO Annex 15 specifies that each Contracting State must provide an aeronautical information service (AIS) or delegate this to an appropriate non-governmental agency. An AIS shall receive, collate or assemble, edit, format, publish/store and distribute aeronautical data and aeronautical information concerning the entire territory of the State as well as those areas over the high seas in which the State is responsible for the provision of air traffic services. Aeronautical data and aeronautical information shall be provided as Aeronautical Information Products.

	The service shall be available during the whole period an aircraft is in flight in the area of responsibility of AIS, plus a period of at least two hours before and after such a period. Service shall also be available at such other time as may be requested by an appropriate ground organization. An AIS shall, in addition, obtain aeronautical data and aeronautical information to enable it to provide pre-flight information service and to meet the need for in-flight information (from the AIS of other States or other compliant sources) (*Source: ICAO Annex 15*)
ANSP	An Air Navigation Service Provider (ANSP) is a public or a private legal entity providing Air Navigation Services, which supports the management of air traffic on behalf of a company, region or country. Depending on the specific mandate, an ANSP either directly or indirectly provides one or more of the following services to airspace users: • Air Traffic Management (ATM) • Communication navigation and surveillance systems (CNS) • Meteorological service for air navigation (MET) • Search and rescue (SAR) • Aeronautical information services/aeronautical information management (AIS/AIM). These services may be provided to air traffic during all phases of operations (approach, aerodrome and en-route). *(Source:* European Commission, December 2020)
ATM human operators	Includes ATCOs, FMP staff, ATSEP, AIS/AIM staff, FISO, FDA, pilots, MET officers, Network Manager staff.
Air Traffic Services Operations Specialist (ATOS)	ATOS is the overall definition for different roles in ATS, which are not ATCO, ATSEP, and MET. ATOS is part of ATS. Roles within ATOS can include one or multiples of the following roles: FDA, FDS, FDP, AIS, ARO, NOTAM-Office, FMP, Flow Coordinator, Data Assistant, FISO and AFISO, Clearance Delivery, Apron Control. ▪ **Flight data specialist (FDS), Flight Data Assistant (FDA), Flight Data Processing (FDP), Data Assistant:** FDS monitor the flight plans of all controlled flights within their area of responsibility. They relay, change and process information regarding flight plans ensuring that air traffic controllers have the most accurate and up-to-date information to work with. This includes information pertaining to flight plans, relevant information within the area of responsibility (SIGMET, AIRMET, MIL exercises, etc.) and coordination or forwarding of relevant information to adjacent units. ▪ **Flow Management Position, Flow Coordinator:** Flow Management Position (FMP) is responsible for ensuring the local promulgation, by the appropriate means (national NOTAM, AIP, ATM operational instruction, etc.) of procedures which affect ATC Units or operators within the FMP's area. FMPs shall monitor the effectiveness of such procedures. The FMP's role is, in partnership with the Network

	Manager, to provide the most effective ATFCM service to ATC and AOs. The FMP shall be the local ATFCM partner for the ACC(s), other ATS units (military and civil) within the FMP area of responsibility and local Aircraft Operators. (Source: EUROCONTROL ATFCM Operating Procedures For Flow Management Position (Edition N°: 18.1.1)). ▪ **FISO – Flight Information Service Officer:** Flight Information as 'a service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights' (ICAO Annex 11: Air Traffic Services, 15th edition, 2018). Flight information service officers shall provide service to all aircraft which are likely to be affected by the information. Flight information service (FIS) is intended to supplement and update flight information on weather, status of navigation aids and other pertinent matters (military exercises, airspace restrictions, etc.). Flight information service shall ensure the provision of flight information service and alerting service within a flight information region (FIR) – unless specified otherwise locally. (ICAO DOC 4444 PANS ATM (16th edition 2016), chapter 4.2). ▪ **AFISO – Aerodrome Flight Information Service Officer:** For aerodromes that are busy enough to justify Air Traffic Service, but do not require air traffic control, Aerodrome Flight Information Service (AFIS) can be provided to ensure the appropriate safety levels. Contrary to Enroute FIS, two-way radio contact is usually mandatory at AFIS- aerodromes and the surrounding airspace (ATZ). ICAO DOC 4444 (PANS ATM). ▪ **Clearance Delivery Position – FDA in Tower/APRON Control:** Clearance delivery is the position that issues route clearances to aircraft, typically before they commence taxiing. These clearances contain details of the route that the aircraft is expected to fly after departure. Clearance delivery or, at busy airports, Ground Movement Planner (GMP) or Traffic Management Coordinator (TMC) will, if necessary, coordinate with the relevant radar centre or flow control unit to obtain releases for aircraft. Flight data (which is routinely combined with clearance delivery) is the position that is responsible for ensuring that both controllers and pilots have the most current information: pertinent weather changes, outages, airport ground delays/ground stops, runway closures, etc. Flight data may inform the pilots using a recorded continuous loop on a specific frequency known as the automatic terminal information service (ATIS).
ATSEP	Air Traffic Safety Electronic Personnel (ATSEP) describe those technical specialists authorised to work to provide and support the electronics and software which enable ATS systems to function. ATSEP comprise engineers, technicians, and computer hardware and software specialists who are responsible for the specification, procurement, installation, calibration, maintenance, testing and certification of ground electronic systems used to help control aircraft movements. ATSEP have a basic level of initial training in the electronics and engineering domains followed by specific system/equipment ratings in four disciplines Communication, Navigation, Surveillance and Data Processing.

	At a time of increasing complexity of the air traffic system, ATSEPs have an increasingly important role in the safety chain. **APPLICABLE RULES** There is currently no provision in ICAO Annex 1, Personnel Licensing, for ATSEP to be issued with, or to hold, individual documents such as licences, but guidelines regarding skills of such personnel can be found in: - ICAO Annex 10 and guidance material in ICAO Doc 7192 - AN/857 Part E2 - Training Manual for Air Traffic Safety Electronics Personnel (ATSEP); - EUROCONTROL SAFETY REGULATORY REQUIREMENT (ESARR) related to ATM SERVICES' PERSONNEL, *ESARR 5*, Section3 - Requirements for Engineering and Technical Personnel Undertaking Operational Safety Related Tasks - Commission Implementing Regulation (EU) *2017/373* of 1 March 2017, laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight. Including annex XIII where are set "Requirements for service providers concerning personnel training and competence assessment. These requirements transpose the equivalent requirements of ESARR 5 into European Community law. *(Source: ECTRL, European Commission, SKYBRARY, January 2022)*
ATSU	Air Traffic Service Units (ATSUs) are specially designated to provide an air traffic service (ATS). The objectives of air traffic service as stated in ICAO Annex 11 are to: • prevent collisions between aircraft; • prevent collisions between aircraft on the manoeuvring area and obstructions on that area; note that this objective does not include the apron and ATS in general is not intended to prevent collision with terrain. • expedite and maintain an orderly flow of air traffic; • provide advice and information useful for the safe and efficient conduct of flights; • notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required. An ATSU may provide more than one of these types of services. For example, an air traffic control unit may provide a flight information and alerting service, in addition to air traffic control. *(Source: ICAO Annex 11)*

D

Data accuracy	A degree of conformance between the estimated or measured value and the true value. *(Source: ICAO Annex 15)*
Data completeness	The degree of confidence that all of the data needed to support the intended use is provided. *(Source: ICAO Annex 15)*
Data format	A structure of data elements, records and files arranged to meet standards, specifications or data quality requirements. *(Source: ICAO Annex 15)*

Data integrity (assurance level)	A degree of assurance that aeronautical data and its value has not been lost or altered since the origination or authorized amendment. (*Source: ICAO Annex 15*)
Data product	Data set or data set series that conforms to a data product specification (ISO 19131). *(Source: ICAO Annex 15)*
Data product specification	Detailed description of a data set or data set series together with additional information that will enable it to be created, supplied to and used by another party (ISO 19131). A data product specification provides a description of the universe of discourse and a specification for mapping the universe of discourse to a data set. It may be used for production, sales, end-use or other purpose. *(Source: ICAO Annex 15)*
Data quality	A degree or level of confidence that the data provided meet the requirements of the data user in terms of accuracy, resolution, integrity (or equivalent assurance level), traceability, timeliness, completeness and format. *(Source: ICAO Annex 15)*
Data resolution	A number of units or digits to which a measured or calculated value is expressed and used. *(Source: ICAO Annex 15)*
Data set	Identifiable collection of data (ISO 19101). *(Source: ICAO Annex 15)*
Data set series	Collection of data sets sharing the same product specification (ISO 19115). *(Source: ICAO Annex 15)*
Data timeliness	The degree of confidence that the data is applicable to the period of its intended use. *(Source: ICAO Annex 15)*
Data traceability	The degree that a system or a data product can provide a record of the changes made to that product and thereby enable an audit trail to be followed from the end-user to the originator. *(Source: ICAO Annex 15)*

H

Human Factors (HF)	Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people. (Source: International Ergonomics Association)
Human Performance (HP)	Human Performance (HP) represents the human contribution to system performance and refers to how people perform their work. Throughout the aviation system, people are both the source of some of the risks and an integral part of identifying and managing all risks. (Source: *Doc10151- Manual on Human Performance (HP) for Regulators*)

J

Joint Human Machine System	Human and machine complement each other to achieve system goals. A humanistic design that allows humans to recover from the rare high-risk Scenarios. (Source: *IFATCA*)

V

Virtual Centre	A Virtual Centre is composed of one or more air traffic service units (ATSUs), using data provided by ATM data service providers (ADSPs). It may provide Air Traffic Services to one or more ACCs or aerodrome towers, which may or may not be geographically adjacent. In some cases therefore, a Virtual Tower may be an example of a Virtual Centre. Each ATSU may use ATM data services from multiple providers, just as a data provider may serve multiple ATSUs. Enabled by the ADSP concept, the Virtual Centre concept refers to the decoupling of air traffic management (ATM) data services from the physical controller working position (CWP). This enables the geographical, and ultimately the organisational, decoupling of ATM data service providers from ATSUs. It requires standardised data formats to manage information, processes, resources and infrastructure. Data involved might include for example flight data, radar data and weather information. The services required by the Virtual Centre concept are listed below. These services can be provided independently from one another by different service providers. - **Air traffic services (ATS)**, consuming ATM data services, is the core service that maintains separation between aircraft, expedites and maintains an orderly flow of air traffic. - **ATM data services**, consuming integration services, provide the data required to provide ATS. - **Integration services**, integrating information from different regions of geo-fixed services and/or different data providers, overcoming geographic constraints. - **Geographically-fixed services**, in support of CNS, these are services that have a fixed relationship with a geographical location. They include the provision of navigation signals, weather and surveillance sensors and the provision of air-ground antennae. - **Transversal services**, security and communications. (*Source: SESAR JU, Airspace Architecture Study, March 2019*)

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