Digitalization, AI in Aviation and the Human Factor

Presented by IFATSEA

31/01/2020

To: Hermes - Air Transport Organization

Subject: Position paper by IFATSEA for Hermes - Air Transport Organization on Digitalization, AI in Aviation and the Human Factor.

Introduction

IFATSEA's response to the three questions posed by HERMES within the above subject is listed below.

Q1: What changes are needed to ensure that aviation proactively embraces digitalization and AI in a way that ensures continued safety, security and sustainability? Are current arrangements with ICAO (regulations, standards, etc) and industry associations (industry standards, bench-marking, sharing of best practices, etc) adequate or is there a need for more explicit leadership in aviation and, if so, by whom?

Q1:(keywords: changes, proactively embrace digitalization and AI , current regulations/standards and explicit leadership)

The forthcoming implementation of Digitalization in aviation and especially in the domain of ATM/ANS, has not been clearly defined yet as a concept, nor it has reached maturity in terms what it really is, so it is difficult to answer. A quick reply would be closer to speculation rather than sound judgement on solid technical and operational grounds. Moreover, the areas to be impacted within ATM/ANS have not been identified yet.

A clear and unambiguous definition of the term ''digitalization'' that is commonly adopted by all stakeholders in aviation as *a concept of the way of operating , is missing.*
Nowadays various things are met with the term digitalization, like, Surveillance data processing (includes ADS-B and MLAT), Medium-Term Conflict Detection (MTCD), 4D Profiles for separation and MTCD, Electronic flight strips, Auxiliary Aeronautical Information Display (including weather information) etc.

All the above are based on modernization of CNS/ATM infrastructure but what else could embrace the term ''digitalization'' in full breadth of the ATM industry, is not yet clear.

What about the digitalization of AIS service? To which extent that digitalization will be extended? What about the METEO data and in particular those that will be directly uploaded to aircraft? etc. However, some indications have risen through the work in the SESAR exploratory research and even through dedicated industrial applications.

On this basis and taking into consideration the ATS, CNS, AIS, MET constituting the services of ATM/ANS in

Europe, there are two domains which are both of Operational nature. The Technical systems and procedures on the operation of CNS/ATM systems (dealt by ATSEP) and the associated procedures and the operations of ATS (linked to ATCO).

While the discussion on the introduction and implementation of the Automation and AI notions into the safety critical area of Air Navigation Services is ongoing, some CNS services are already provided from space based infrastructure and in some cases combined with terrestrial elements.

While we are moving towards distributed and interoperable ANS systems , we rely on defined interoperability European standards aiming at achievement of interoperability. However, we are overlooking means and tools like System Monitoring and Control (SMC) to assist the ATSEP aiming at ensuring the highest Resilience of ATM/ANS system as a whole that will be able to pace and sustain the ground ATM/ANS community into the Automation and AI era. It is like designing procedures how to fly the space shuttle without ensuring its Technical systems interoperability, CNS systems health monitoring, and control.

In addition, discussions focus only on the Operations side taking for granted that they are based upon robust, stable and resilient electronic infrastructure, that never fails. Evenmore, until recently ,not fully realizing the operational role of Cybersecurity, which inevitably will be another parameter of potential instability within the digitalized environment. It must be noted that IFATSEA has alerted the CNS/ATM community on the cyber risks of the proposed distributed architecture but without managing to be heard as the focus was only on Operations and their cost reduction. Recent failures on current, state of the art, ATM flight data processing or CNS systems (e.g Irish FDP or NATS Voice Communication configuration) rendered large parts of controlled airspace to be highly affected with hundreds of millions of Euros cost.

Moreover, over focusing on reducing the cost of services while asking for more capacity and generally better performance, is the wrong way to go about it. Furthermore, Cybersecurity will probably entail additional cost, due to new systems and procedures involved aiming at protection of the operational CNS/ATM systems. This additional cost was probably not anticipated when designing a distributed system over SWIM. The ICAO Total System approach is not evident in the ongoing discussions while Performance/cost prevail. There have been presentations from ICAO where, CNS on which all services are based upon, is not mentioned at all.

ICAO is the implicit and appropriate leader to drive this out of the box endeavour of the introduction of extent Automation and AI that will bring us into the new Automation and AI era. Including in the loop all stakeholders from the States, the industry and Professional Staff Associations such as IFATSEA , while not overlooking the Academic and research community, will be beneficial for reaching a meaningful approach and road map forward.

*This cooperation and endeavour must come in **two** steps.*

Step 1: First ICAO collects input on the envisaged Automation and AI introductions in aviation, providing clear definitions and objectives and potentially a road-map of implementation.

Step 2: The second step is the definition and development of the Concept of Automation and AI in technical systems and operations , not only for operational issues, without disregarding the interoperable technical solutions.

A collective approach of all the above will be actually beneficial for the future ATM/ANS system. It must be noted that after moving aviation into the AI ecosystem there may be a 'no turning back' road after a few years .

A lot of newly appearing questions appearing, due to the new aviation ecosystem based on AI, besides Responsibilities and Liabilities, have also to be addressed. The impact to Procedures e.g incident or accident reconstruction and analysis with ever changing AI self learning algorithms is really a challenge.

IFATSEA believes that only after these two steps described above are taken , we will be able to talk about ICAO NGAP updated training content (delta from today) and development of regulations.
Similarly , current arrangements either in ICAO and world regions will be incomplete since the above building elements, described in Steps 1 & 2, will not be available since it will be difficult to implement them while there will soon be a need to revisit them. We need to know what kind of systems/equipment will eventually be needed, what kind of procedures and then extrapolate the needs on HR.

In summarizing :

1. We have to Think out of the Box as the forthcoming situation has never existed before. The shift of Human tasks to a machine has to be thought of very carefully and be able to safely recover from degraded or failure modes of AUTOMATION. This includes AI applications, at least during the first years of maturity until we come to trust the machine and the process, the process and the machine.
2. Currently the attention only on OPS separately for the ground element with a culmination of focus on the ATS provision disregarding the ultimate consumer/user of the ANS product (being Safety and Efficiency/Performance) with Over-focus on COST reduction, distorts the viewing and decision making angle.
3. New challenges, unique, must be proactively addressed e.g Incident reproduction on ANS/ATM applications based on AI ever-changing algorithms have to be considered from start
4. According to ICAO Chicago convention the responsibility for the provision of ATM/ANS services relies on Member States. In light of adoption of AI, to which extent the States have been involved? And what conclusions (if) has this consultation delivered?
5. New tools to aid ATCO & ATSEP into their areas of expertise are needed for the new environment. Their development must be gradual, with buy-in and learning from other safety critical domains (such as Space or Nuclear domains).
6. There is a clear lack of standards and/or Technical specification for the ground ATM Systems since they exist only for CNS systems (ICAO Annex 10 Vol I-IV)

Cybersecurity: some questions as food for thought

a) Producing Regulations is desirable but have we understood the problem? Especially in a real time, safety critical environment like the ANS/ATM services provision?
b) Are there any tools available for a CNS/ATM digitalized environment to help ATSEP identify (preferably proactively) whether a degradation is due to Cyber attack, technical failure or both? If not, how can we contain and mitigate a cyber-attack during live operations?
c) SESAR was and is successful because it incorporates input from airspace and ground users including Professional staff organizations (PSOs) so it has a pretty good idea of the applicability and acceptance of the researched concepts and systems before they become products for deployment. Let's harvest it!

Q2: What policies and regulations need to be instituted, altered or removed to ensure successful implementation of digitalization and AI in aviation? Is a performance-based approach to human involvement and to regulation sufficient or is there a need to be more prescriptive on when human involvement and management is essential?

Q2: (Keywords : policies and regulations needed, performance based approach to human involvement)

-New regulations must not be focused only towards Performance-wise on Cost reduction but also on Technical and Operational Resilience of the Total System.

While the complex structure integrating ground, air and space which is extremely demanding, is progressing, equal attention must be exhibited for all areas. For example while intense care is taken for the airborne systems software e.g FMS with extreme care placed in the coding in terms of Software safety assurance, the regulations referred to ground ATM systems globally, do not include Technical Specifications and Software safety assurance requirements for the Ground systems (in Europe regulation EU 482/2008 on software safety assurance has been repealed). Neither, do we have Technical specifications or Minimum Performance Requirements defined for the ground ATM systems yet.

The latter seems to be contradictory as the requirements for increasing performance figures in terms of capacity, safety etc., are sought from ATS without having ensured the optimum performance (in terms of availability, accuracy, response time, continuity of service etc.) of ATM/ANS systems and tools being used. However, having said that, we must not forget the notions like the new proposed End to End assurance approach that the TSG has done on behalf of the European Commission or the older Total System Approach by ICAO .

With regard to the Human factor, for the ground part, we have to focus on ATSEP and ATCOs which are the professionals that will mainly be in charge for ensuring availability and efficient operation of the ATM/ANS system and systems. What has to be understood right from the beginning is that these personnel will continue to do their current routine tasks while the paradigm change of Automation and AI introduction is taking pace. This means that the same people of today, (in many cases aged) will be needed to maintain-operate the existing systems as well as to monitor and through trials to evaluate/validate the new solutions.

Speaking specifically for ATSEP, they will be needed to be retrained to new technologies new notions like understanding AI algorithms behavior (in ATM applications) and their troubleshooting in trying to identify the root cause of a potential unexpected behavior of ATM/ANS applications. Although the new automated systems to be used by ATCO will be needed to continue to deliver ANS while in degraded modes of operation or failures, the identification of strange behavior of AI and their resolution will be a quite demanding and hard task which is obviously directly linked to **safety of services** and **resilience** of the system. These two parameters Safety of services and system's Resilience are also related to Performance which has to be ensured as well.

To achieve the aforementioned goals the appropriate training for ATSEP is a basic presupposition. That training must not only be focused on the academic approach of "principles of operation" but also on monitoring and addressing proactively an imminent malfunction, the restoration to nominal service, maintenance, predictive monitoring and health management , mitigation of Cyber attacks while maintaining the ANS service to users unaffected and non degraded.

In addition the smooth transition to fall back scenarios in cases of serious malfunctions or cyber-attacks has also to be part of training program. All the above will incur ANSPs with additional cost which seems to be inevitable in light of the new systems and new concepts of operation but they must not be disregarded.

Human resources must be prepared to intervene when automation fails, or when it encounters conditions it hasn't been programmed to deal with.

It must be noted that currently there is no reference on the need to Hire more ATM/ANS personnel (ATCO&ATSEP) at least to cover needs for the interim period before Automation expands in terms of implementation & deployment. Are there any indicators envisaged we have thought for the Human pillar?

Q3: Digitalization and AI will reduce the cognitive load on humans but will also have a significant impact on the need for human time and resources. How can aviation best anticipate and manage that impact? What changes are needed to recruitment, management, retention and retraining practices to ensure adequate and appropriate human resources that thrive in the aviation workplace?

Q3: (keywords: impact of Automation and AI on Human roles, changes are needed to recruitment, management, retention and retraining) .

We have to be extremely cautious when we are going to introduce AI in the domain of Aviation and it will be needed to follow a stepped approach. There is a lot of knowledge and experience to be learned and is much better to acquired them without causing fatal incidents.

Digitalization in ATM/ANS or aviation in total is understood in different ways by different actors. How can we reach a Common understanding when we have such diverse understanding of Digitalization ? When we are referring to the Cognitive load we mostly refer to operators like Pilots or ATCO.

In the case of ATSEP responsible for the safe and efficient operation of the CNS/ATM ground systems is a totally different question. There, the needs which will be a lot more demanding and in a way that has not been studied yet (!). How can the ATSEP of the future achieve a Total (distributed) System Awareness and address its malfunctions or cascade failures?

Especially for ATSEP, there will be a need for a Human machine formalized interface for the interoperable over SWIM systems as well as specialized instances for Automation related degradations which have not been studied in CNS/ATM yet! It is noted that the EGHD body advising the European Commission in Europe has started work on the ATSEP working Position (ATSEP WP) with innovative and useful output.

In Europe there are options like Remote Towers and Virtual ATC centers notions, potentially fed with data from ADSPs (ATM data service providers) that are on the pipeline. However, without having addressed how the full system wide awareness and resilience will be achieved by ATSEP for these Geographically separated system elements. Seen it in a Total system approach this is not recorded yet.

Some questions that naturally arising when defining the problem.

Digitalization in ATM/ANS from the Human side :

- d) *What exactly do we mean by Digitalization in ATM/ANS? We must have a common understanding*
- e) *Which are the domains? We have to identify the domains that we have an anticipation on the mapping of the impact?An accepted Digitalization Impact assessment?*
- f) *Where in the different areas of ATM/ANS do we expect an impact and what should be the global approach?*

The employee profile for the new Automated Aviation environment and especially for ATM/ANS, and especially for ATSEP, will evolve to a more demanding need for scientific background along side the usual technical background ones . Today's ATSEP are working on legacy and up to state of the art CNS/ATM

systems with a large portion of their work on software related work, such as operational systems management configuration and maintenance as well as monitoring and control.   During the last 15 years there has been a major shift in the inclusion of computer controlled systems , local and remote operations , while maintaining the older systems like SSR or ILS in operation to be retained at least in the mid term future (10years). So there is an existing software culture in the profession of ATSEP where in the past ATSEPs were doing a lot of replacing of modules in systems.

Nowadays the scope of the work is maintaining the continuity of service, therefore a lot of resilience is needed in the architecture of systems. The main aim is to offer the ATCO continuously the same interrupted image of the Functional system. This requires a lot more programming and a lot more understanding of the architecture of systems. So on the one hand more specialists will be needed and also on the other hand more general / overall knowledge for ATSEPs will be needed.

ATSEP will have an advanced role in the global scene, been among the critical enablers of succeeding the required growth in aviation. Moreover, they will play a vital role in advancing all needed technological steps towards a new era in aviation. An era in which the human pillar will still be in control of all the new beyond state-of-the-art technologies implemented.

ATSEP will have to be retrained in new principles and domains while this must be taken care for newcomers for which new a lot more elevated scientifically qualifications will be needed:

Impact on ATSEP:.

✓ **Disruption** on the ATSEP Entry Qualifications and ongoing training must be thought off very carefully, as they will be required to identify the root causes and restore applications and systems, that will be distributed over different geographical areas implementing Automation and AI. They will need to be retrained to accommodate the new technologies as "Digital transformation" demands a broader skill set...

✓ **Retention**: ATSEP Licensing introduction will lead to commitment and retention of ATSEP on the Job and justify the investment. We cannot afford to hire, train and then loose technical experts (ATSEP) especially with accumulated experience in CNS/ATM systems that cannot be found in the market.

✓ **Lack of ATSEP**: ATSEP in the near future are going to be scarce since the other industries are and will be antagonistic and offer better business opportunities at less Responsibility and Safety requirements

✓ ATSEP **English language proficiency** requirements will constitute an enabling factor for interoperability, mutual understanding and coordination between ATSEP and ATCOs for problem understanding and resolution as by 2030, it is expected that Sensors, Radar Data Processing, ADSPs and Virtual Centers will be geographically separated. This anticipated Fragmentation of services delivery will introduce a strong need for coordination between the providers that does not exist today!

✓ **Resilience** enabling decision making for ATSEP with special tools for addressing system wide awareness and cybersecurity (with Prediction capability). They can be   based on AI for ATM/ANS system failures or degradations due to Cyber or Technical incidents. This has not been addressed yet at ICAO (Again, only recently EGHD in Europe has produced some basic documents e.g on the ATSEP Working Position).

✓ **Crisis management** over large geographical areas for inter-ANS providers for cases of Cybersecurity or failure of common elements and Cascade failures, will introduce new needs for cross border cooperation on top of those for ATC related activities, involving ATSEP and ATCO. This context has not been addressed or studied yet and will impact their Training.

✓ **New actors**: UAV induced degradations or interference in Surveillance for example will require special training and tools for ATSEP. Signal in space interference in combination with space navigation interference at a busy airport will be a very realistic scenario for the near future and has also to be dealt with in the ATSEP tasks.

The ATSEP(-s) will need to have different training and cooperation with entities outside their remit e.g police, Space navigation providers, National Security teams e.t.c. What will be the new procedures?

All the above arguments make it clear that a paradigm shift like the introduction on Digitalization and AI in the aviation can drive towards the identification of a need for a lot more specialized scientific background for technical staff like the ATSEP but also for the other front line operators like Pilots and ATCO.
Regulations must follow after the problem has been understood and defined.Cost will be an issue but the product will be more capacity efficiency and comfort of the passenger with an increase of safety.

Links*:

✓   https://www.aviation24.be/air-traffic-control/breaking-air-traffic-stopped-in-ireland-due-to-radar-issue/
✓   https://www.irishtimes.com/news/ireland/irish-news/irish-air-traffic-system-failure-caused-by-irregular-software-fault-1.3651638
✓   https://www.theguardian.com/uk-news/2014/dec/13/london-airport-chaos-computer-failure-nats-heathrow-gatwick-airspace
✓
https://www.caa.co.uk/WorkArea/DownloadAsset.aspx?id=4294974241
✓   https://www.nats.aero/wp-content/uploads/2014/08/ATC%20Disruption%207%20Dec%2013%20-%20Report.pdf

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