IFATCA
INTERNATIONAL FEDERATION OF AIR TRAFFIC CONTROLLERS' ASSOCIATIONS
64th ANNUAL CONFERENCE
28 April – 02 May 2025, Abu Dhabi, United Arab Emirates

Agenda Item: C.6.11 **WORKING PAPER** **WP No: 157 IFATCA'25**

ATCO skills with the use of Artificial Intelligence and legal liability

Presented by PLC

SUMMARY

Air traffic management is not exempt from the rapid evolution of automation such as artificial intelligence (AI) and machine learning (ML), as well as increased automation not limited to AI and ML. However, concerns are being raised about how the future of Air Traffic Control will be shaped and under which conditions will the human professionals and the machine interact. PLC is tasked to research this topic.

1. INTRODUCTION

1.1. Artificial intelligence (AI) and machine learning (ML) are leading the way in innovation in the rapidly evolving field of technology. Due to the rapid advancements in AI and ML, this period has completely changed the way people use technology, make decisions, and even influence future trends in a variety of global businesses.

1.2. Artificial intelligence is playing an increasingly significant role in the rapid advancement of the ATC system. The questions surrounding the application of machine learning in the context of air traffic control (ATC) have evolved into the following: Will some skills that were previously critical to ATC become less important as a result of the incorporation of new automated systems? In the future, when an air traffic controller is recommended, or even compelled to obey the machine's orders, what liability and skills will they have?

1.3. PLC is assigned the responsibility of investigating this wide subject and summarising any pertinent information, with a particular emphasis on the essential skills of air traffic controllers in the AI and ML era as well as the critical issues of liability and Just Culture under the influence of AI/ML.

2. DISCUSSION

2.1. Every day, the world advances as a result of the development of new technology and better living standards. Times will not be too far off when machines will complement human talents, assist the human in making better decisions, and integrate themselves into our daily life.

2.2. Although machine learning is a subset of artificial intelligence (AI), the terms are frequently used interchangeably. In this context, machine learning refers to the technologies and algorithms that allow systems to recognise patterns, make decisions, and improve themselves through experience and data, whereas artificial intelligence refers to the general ability of computers to mimic human thought and perform tasks in real-world environments. [1]

2.3. As human-human teams transition to human-AI-based system teams (HAT), complexity is increasing to a degree that humans are now unable to completely understand. Nonetheless, it is important to define cooperation and collaboration in relation to the HAT notion. The AI-based solution cooperates with the end user to assist them achieve their own goals and objectives. Cooperation does not entail that the AI-based system and the end user have the same vision. Cooperation does not require effective communication as a prerequisite. Conversely, collaboration is the process by which a person and an AI-based system cooperate to accomplish a shared objective (or work independently on a specified objective) and resolve a conflict using a constructive method. Working together requires the ability to communicate situation awareness, modify plans of action, and tasks in real time. In order to provide the important information required to accomplish the goal, communication is essential. [2] Effective collaboration is vital for ensuring that controllers can leverage AI tools while maintaining situational awareness. Training programs must evolve to prepare controllers for working alongside AI systems, promoting a symbiotic relationship rather than a competitive one.

2.4. EASA has highlighted some design considerations[3], which centre on the various functionalities that an AI-powered system ought to possess in order to facilitate effective collaboration, including the following:

- The ability to share situation awareness aspects;
- Recognise abnormal/unusual situations and carry out diagnostics;
- Assess the applicability of the end user's suggested solution;
- Engage in negotiation or debate; and be adaptive.

2.5. Organisations need to be able to introduce technology in a way that not only withstands change but really embraces it to create new strategic opportunities in order to remain viable. This also applies to Air Navigation Service Providers (ANSPs), which are the building blocks of the Air Traffic Management (ATM)

[1] Artificial Intelligence (AI) vs. Machine Learning. CU-CAI. (2023, October 3). Available from: https://ai.engineering.columbia.edu/ai-vs-machine-learning/ [Last accessed: 08 July 2024]

[2] EASA (2024) "EASA Concept Paper: Guidance for level 1&2 machine learning applications. A deliverable of the EASA AI Roadmap"

[3] EASA (2024) "EASA Concept Paper: Guidance for level 1&2 machine learning applications. A deliverable of the EASA AI Roadmap"

system. The ability to continuously adapt to shifting contexts, stakeholders, demands, restrictions, and settings within the larger aviation system (sustained adaptability) is a constant call to action for ANSPs. [4]

2.6. One of the best examples of an AI/ML application in a cognitively complicated safety-critical system is the ATM system. ATM systems are made up of many airspace sectors and aerodromes with variable air traffic flows that interact and evolve in complex ways over time. The anticipated advantages of digitising ATM systems primarily pertain to operational concerns, including more efficient flight operations, better strategic planning, more accurate trajectory prediction, and fuel efficiency. However, there are also financial benefits, with a focus on cost savings. [5]

2.7. The International Air Transport Association (IATA) projected in their 20-Year Passenger Forecast published in 2018 that the number of passengers will double by 2037, indicating the aviation industry's extraordinary expansion.[6] More sophisticated systems are required to safely handle the rising number of flights as a result of this surge. Large-scale datasets can be analysed and patterns can be predicted by AI and ML, but integrating these technologies into current ATC frameworks is quite difficult technically. Priority issues include making sure that the system is compatible with existing systems, creating trustworthy data sources, and preserving system integrity.

2.8. Ensuring the safety of passengers and aircraft is the primary goal of the Air Traffic Controller. Uncertainties are introduced by the use of AI and ML since these systems can act in an unpredictable way. An artificial intelligence system's mistake or malfunction could have disastrous results. Ensuring the reliability of AI algorithms is still a major challenge, particularly in situations when decisions must be made quickly. To mitigate these risks, strict adherence to regulatory standards, testing, and validation procedures are required. In particular, concerns about accountability and transparency are brought up by the use of AI in ATC. Controllers need to be able to comprehend the recommendations made by AI systems, which is why the algorithms guiding these processes need to be comprehensible by them. However, there is a limit to what controllers are willing to comprehend. ATCOs do not wish to receive training on the programming of the machine itself. In this regard, a stringent distinction ought to be made. It will be necessary for ATCOs to be involved in the process of creating a tool that they will need to utilise. A reason is that, one of the main problems in the field of AI/ML is explainability, which will be discussed more thoroughly in a later part of this paper. For human operators to comprehend and validate AI and ML systems' decision-making process, they must be transparent and explicable. On the other hand, training on the machine's programming is undesirable. Moreover, regulatory agencies need to

[4] Stathis Malakis and Marc Baumgartner, The Aviation & Space Journal, Year XXII n. 1 (2023), “Just Culture in the Era of Digitalization: How Artificial Intelligence is Expected to Influence Just Culture in the Air Traffic Management System?”

[5] IFATCA, (2023), Artificial Intelligence Development in ATM and Legal Issues. Montego Bay, Jamaica. WP No.161

[6] Reuters, Airline passenger numbers could double to 8.2 billion in ... (2018). Available from: https://www.reuters.com/article/business/airline-passenger-numbers-could-double-to-82-billion-in-2037-iata-idUSKCN1MY20O [Last accessed 06 August 2024]

create policies that control AI applications in aviation, handling liability concerns and guaranteeing adherence to safety requirements.

2.9. IFATCA has thoroughly researched the topic of the Artificial Intelligence and Machine Learning development in ATM and especially in ATC, through the work of the Joint Cognitive Human Machine System Group (JCHMS) and by numerous TOC and PLC papers. [7] [8]

2.10. The degree to which automation alters people's ways of working is one of the most divisive and controversial topics concerning automation at this moment in technology. In this new scenario, the primary effects are:

- inadequate staff training and system knowledge,
- heavy traffic loads that are difficult for human operators to handle safely and easily in the event of a disruption, and
- insufficient or non-existent legislation regarding operator responsibilities when using AI systems.
- possible loss of jobs due to partial automation

2.11. While the present legal framework in the ATM area addresses the applicability of several liability models (fault-liability, organisational liability, and design liability), it does not address the particular concerns related to the interaction between automated devices and humans. This will become increasingly important in the future of ATM. These issues include those pertaining to highly automated systems that perform actions without explicit human intervention, delegation procedures that dynamically transfer responsibility from controllers to pilots or other technical systems, and functional airspace blocks that involve new task allocation. [9]

2.12. This evolution raised a few possible questions. The first query considers whether liability for accidents could shift from operators to technology providers – such as organisations, manufacturers and system developers- due to the adoption of new automated technologies. Such a shift suggests that, in addition to moving the first line of accountability attribution from human operators to technology manufacturers or users, different criteria will also be considered: human negligence in performing duties as assigned will give way to a technology's defect in performing its function. It is clear that the introduction of AI and ML has resulted in different conditions being met, as well as distinct defences and standards for the burden of proof and evidence evaluation.[10]

2.13. The use of AI technology may potentially entail additional people or organisations that could be held liable in the event that something goes wrong. For example, the programmers who created the AI system's code and/or the

[7] IFATCA, (2023), Artificial Intelligence Development in ATM and Legal Issues. Montego Bay, Jamaica. WP No.161

[8] IFATCA, (2020), Artificial Intelligence and Machine Learning in ATC. Singapore. WP No.92

[9] G. Contissa Et Al. (2012), Automation and Liability in ATM As Fundamental Issues in Socio-Technical Systems

[10] Stathis Malakis and Marc Baumgartner, The Aviation & Space Journal, Year XXII n. 1 (2023), "Just Culture in the Era of Digitalization: How Artificial Intelligence is Expected to Influence Just Culture in the Air Traffic Management System?"

ANSP who presented the system and guaranteed that it complies with safety regulations. Accountability gaps between the various ATC system participants may arise from the application of ML techniques. It could be difficult to determine who is ultimately in charge of an algorithm's correctness and dependability, for instance, if it was created by a third-party vendor, however it is clear that someone has to be held accountable and even if the programmers will be held as the source of the accident or incident it will not change the outcome or the ATCOs feelings or sense of liability .

2.14. Another topic of discussion is concerning the best way to handle this change to ensure that liabilities are distributed as efficiently as possible. This will require reevaluating liability's function as a tool for risk redistribution, raise ATM performance and safety standards, and encourage the growth of a safety culture within the ATM business. As a result, it will be crucial to:

1) identify the responsibilities of operators (managers, ATCOs, pilots, etc.) and automated tools;

2) determine the expected performance level for each task;

3) take into account various types of errors (intentional violations, careless behaviours, and unintentional rule violations); and

4) specify the proper legal and disciplinary sanctions and/or safety incentives in relation to different errors, risks and accidents.[11]

2.15. Defining precise channels of accountability for all parties engaged in the ATC system, such as third-party vendors, AI algorithms, and human operators, is crucial. It is ultimately important to make sure that everyone is aware of their roles and duties and that decision-making accountability is clearly delineated. At each step of using an AI/ML technology, certain guidelines that explicitly outline the degree of accountability for each involved party should be implemented. The ATCO should be at liberty not to use an AI/ML tool, as long as the liability issue and level is not cleared up and determined. Overall, a clear and thorough understanding of the operational duties that can be assigned to the machine must serve as the foundation for the task delegation approach.

2.16. When it comes to new technology, air traffic controllers ought to be at the forefront. ATCOs should be included at every stage of the development of any AI/ML technology that will aid air traffic control in the future in order to close the communication gap between designers and users, as IFATCA recommends.[12] Their role shall include:

- Establishing user requirements.
- Defining operational training requirements prior to implementation.
- Participating in the risk assessment process.
- Validating the system.

[11] G. Contissa Et Al. (2012), Automation and Liability in ATM As Fundamental Issues in Socio-Technical Systems

[12] IFATCA TPM - AAS 1.13 Determining Operations Readiness of New ATM Systems

- Providing feedback in the further development of the system.

2.17. To complete the design, so as to adapt to the situations that designers never anticipated, humans must remain a part of the system. Control is progressively and irreversibly lost as a result of digitalisation, which depends on extremely efficient but poorly understood algorithms to replace human activities with technology. IFATCA suggests that rather than using technology to substitute the human operator we use technology to amplify human abilities and support the human operator in solving problems.[13]

2.18. Designs that aim to maximise management values may, whether on purpose or not, prioritise the managerial goals and so limit the scope of humanistic design. This reduces the end user's degrees of freedom and has an impact on buffers and margins, which limits the system's ability to maintain and retain adaptability in the face of uncertainty and unexpected events. As a result, the system is less effective. Furthermore, a greater distance between the system and the air traffic controllers limits the ATCO's capacity to step in in the event of an emergency.[14]

2.19. It is critical to comprehend multiple perspectives—that of the user and the AI system—in order to solve these design issues. Designers must understand users' information and interaction demands, routines, and skills from their point of view. Understanding the data inputs, capabilities, and constraints of the AI system is crucial. We can develop AI architectures that are more user-centred and able to provide meaningful value by combining these viewpoints. After all, according to the EASA AI Roadmap, the development of a human-centric AI trustworthiness framework is the top objective.[15] According to this, the goal of the European Union's (EU) comprehensive global AI strategy is to guarantee that AI is created and applied in a trustworthy, secure, and human-centred manner. The European Union is firmly committed to a human-centred approach to artificial intelligence that upholds fundamental rights and values, encourages inclusivity and diversity, and fosters sustainable and conscientious innovation.

2.20. Regrettably, ATCOs feel that their feedback is not being included sufficiently or adequately into system design. Users of new and advanced tools—in our case, ATCOs—have been observed to become involved very late, for example, during the simulator phase or operation validation. Without having participated at every stage of the design, even in the very early theoretical stages of it and without having participated at the discussion of what precisely the tool that is about to be designed is going to be used for, whether we need it operationally, and if so, to what extent.

2.21. Before creating any technical tool, the IFATCA Joint Cognitive Human Machine Systems Group has established a few guidelines in their previously released

[13] IFATCA (2024) Report of the Joint Cognitive Human Machine System Group (JCHMS), Singapore, WP No. 105

[14] IFATCA (2023) Report of the Joint Cognitive Human Machine System Group (JCHMS), Montego Bay, Jamaica. WP No. 165

[15] EASA (2023) ARTIFICIAL INTELLIGENCE ROADMAP 2.0, Human-centric approach to AI in aviation

Guidance Material for the design and use of JCHMS[16]. The initial phase involves consulting a set of strategic inquiries regarding the justification for the launch of the technological project. Put otherwise, these procedures deal with the project's managerial reality.

It is very crucial that the set of follow-up inquiries be addressed:

- Has the rationale for the decision to introduce the technology been properly documented?
- Are we solving the right problem with the right tool?
- Does the technology display appropriate information to allow operators to meet their performance obligations and their responsibilities?
- Does the technology provide the operators with the appropriate level of control?
- Are the human performance expectations and responsibilities clearly identified?
- How are technology-induced surprises mitigated?
- What knowledge and skills does the operator need in order to manage the technology in normal and abnormal situations?
- Are there any unintended adverse effects of the introduction of the technology?

2.22. It is also imperative that end users be consulted in order to provide answers to these questions. If not, there's a risk that a system would be developed that confuses air traffic controllers with unnecessary, useless or even misleading information, overloading their cognitive capacity rather than helping them solve problems. [17] [18]

2.23. When the air traffic controller's perspective is ignored when answering these questions, the technology that is about to be built will ultimately become inadequate. Not involving the end user in every step of the design process raises a lot of problems, one of which is whether a specific tool that was developed, was actually required. Other questions that could arise are as follows:

- Were there any issues being resolved by the use of the tool?
- Should the ATCOs be forced to utilise a tool for which their input was not solicited during the early stages of the development?
- Is the use of such a tool mandatory or just recommended?
- Should an ATCO decline to use the tool, what liability does that leave them with?
- Was the aim of the tool increasing safety or capacity or both?

It ought to be evident what kind of risk they face if they employ a tool and its creation is done without their knowledge, input or approval. The IFATCA

[16] IFATCA (2023), Joint Cognitive Human Machine System Group (JCHMS), Guidance Material for the design and use of Joint Cognitive Human Machine Systems

[17] IFATCA TPM - AAS 1.13 Determining Operations Readiness of New ATM Systems

[18] IFATCA, (2023), Information Overload in ATC. Montego Bay, Jamaica. WP No.158

JCHMS Group makes a number of additional recommendations that are highly advised to be taken in order to move forward with an AI-specific project.

2.24. EASA introduced the Concept Paper "Guidance for level 1&2 machine learning applications" and at the section of Human-AI teaming, some important objectives are being set, amongst them that if a decision is taken by the AI-based system that requires validation based on procedures, the applicant should design the AI-based system with the ability to request a cross-check validation from the end user, the applicant should design the AI-based system with the ability to process and act upon a proposal rejection from the end user, the applicant should design the AI-based system with the ability to detect poor decision-making by the end user in a time-critical situation, alert and assist the end user and others.[19] It is very evident that those goals cannot be achieved without the participation of air traffic controllers, who act as end users.

2.25. IFATCA has policy for the AI and ML in ATC which can be seen below.[20]

> Artificial Intelligence and/or Machine Learning based systems should only be implemented as decision support systems and shall not replace the decision of the ATCO.
> Where an ATCO is responsible for decision making, and in the event that system tools fail or are not available, the ATCO should always have the capacity to safely manage their area of responsibility.
> The introduction of AI systems shall be tested and validated with the assurance of appropriate standard levels of operations in terms of safety, security, robustness, and reliability.
> In case of disruption and in addition to backup and continuity systems, appropriate procedures and training shall be put in place to assist ATCOs in emergency situations.
> With special attention to airspace capacity, traffic complexity and available backup systems, a safety risk assessment shall be carried out to determine the possibility for ATCOs to intervene in case of disruption.
> IFATCA and MAs shall undertake actions to raise awareness at an international and national level about the impact of automation in ATM and hasten for appropriate legal changes in ATCO's responsibility.
> ATCO's responsibility shall be proportionally decreased in accordance with the level of automation and their ability to intervene and control automated systems.

IFATCA TPM – AAS 1.20 ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN ATC

2.26. Another relevant policy can be found in WC 10.2.5 AUTOMATION / HUMAN FACTORS:

> Automation shall improve and enhance the data exchange for controllers. Automated systems shall be fail-safe and provide accurate and incorruptible

[19] EASA (2024) "EASA Concept Paper: Guidance for level 1&2 machine learning applications. A deliverable of the EASA AI Roadmap" ch.4.2.
[20] IFATCA. (2024). IFATCA Technical and Professional Manual (TPM). 2024 Ed. Montréal, Canada: International Federation of Air Traffic Controllers' Associations

data. These systems shall be built with an integrity factor to review and crosscheck the information being received.

The human factors aspects of Automation shall be fully considered when developing automated systems.

Automation shall assist and support ATCOs in the execution of their duties.

The controller shall remain the key element of the ATC system.

Total workload should not be increased without proof that the combined automated/human systems can operate safely at the levels of workload predicted, and to be able to satisfactorily manage normal and abnormal occurrences. Automated tools or systems that support the control function shall enable the controller to retain complete control of the control task in such a way so as to enable the controller to support timely interventions when situations occur that are outside the normal compass of the system design, or when abnormal situations occur which require non-compliance or variation

IFATCA TPM – WC 10.2.5 AUTOMATION / HUMAN FACTORS

2.27. Furthermore, during the 63rd Annual Conference in Singapore, PLC & TOC at the paper concerning the review of automation policies recommended following policy at TRNG 9.2.5., which has been accepted:

AI systems or applications in ATM shall be human-centred throughout the whole development process. ATCOs shall be thoroughly trained and introduced to the new concepts, including AI systems and ML algorithms, to be able to handle all traffic situations, and also during unforeseen situations such as emergencies or system failure.[21]

2.28. IFATCA is not content to just be a mere follower; on the contrary, it always strives to stay ahead of the curve. IFATCA has already established policies with an eye toward the future, specifically a sustainable future, and with the intention of always being ready for the possibility that digitalisation may become a major component of the ATM system. As a result, a number of pertinent policies have been set down pertaining to the involvement of Air Traffic Controllers in the creation of artificial intelligence and technical tools, and IFATCA strongly advises ANSPs to adhere to those.

2.29. While creating a system that leverages AI to support ATCO's responsibilities, there needs to be a re-evaluation of the roles that individuals play and an openness in comprehending the work that the machine is performing. A high degree of transparency on the internal workings of the AI-based system is desired by both development and end users. Transparency and traceability are also two of the EU AI Act's main objectives. According to the regulation, AI systems must be created with transparency and traceability in mind so that users can comprehend the decisions that are made and the data that is used.[22]

[21] IFATCA (2024) Review of Automation Policies, Singapore, WP No. 98

[22] Regulation (EU) 2024/1689 of the European Parliament and of the Council. (2024) Artificial Intelligence Act

2.30. Regarding the training that air traffic controllers currently receive, none of it is formal regarding AI/ML. This is especially true when it comes to the latest algorithms, such as neural networks, and their limits. What amount of AI/ML training is required of the controllers, and is it mandatory? Before giving controllers digital assistants in the OPS room, we should decide if we need to teach them all the technical provisions such as bias-variance trade-offs, explainability problems, data validation, feature engineering, hyper-parameter selection, overfitting, limitations of data-driven models and any other relevant AI/ML information.[23]

2.31. As a result, IFATCA has already established the policies mentioned above regarding liability, which state that a controller's responsibility will be inversely proportional to the level of automation and their capacity to intervene and control automated systems[24], and that they will not be held accountable for incidents that may arise from the use of inaccurate data if they are unable to verify the accuracy of the information they have received. It is important at this point to remember that the State and its legal system will ultimately determine who bears responsibility for any occurrences.

2.32. Additionally, according to IFATCA policy, a Controller is not responsible for situations where an automated system's resolution advisory results in a loss of separation.[25] However, what happens if an air traffic controller chooses to disregard the system's recommendation, even if it's not required? If the Controller is adamant that the advice is inaccurate? Should the controller be held accountable in that scenario for disregarding the advice even though there was still a loss of separation? Regretfully, the assumption is that the ATCO will most certainly bear the liability in reality. Consequently, it's important to make sure that the legal and regulatory framework governing the application of AI/ML technologies in aviation and air traffic control is current and functional.

Skills required for ATCOs in an automated environment

2.33. Artificial intelligence (AI) also generates new needs for different applications of human talents like creativity, critical thinking, communication, and teamwork, which augment and expand AI's capabilities. Some of an ATCO's current abilities are being lost in order to collaborate with AI, while others must be developed to adjust to the new environment and the demands of this partnership.

2.34. Up until now, quick decision-making ability, pressure-resilience, spatial awareness, the ability to visualise complicated situations, effective prioritisation skills, adept multitasking, flexibility, attention to detail, excellent communication abilities, remarkable memory, and cooperative teamwork were some of the

[23] Stathis Malakis and Marc Baumgartner, The Aviation & Space Journal, Year XXII n. 1 (2023), "Just Culture in the Era of Digitalization: How Artificial Intelligence is Expected to Influence Just Culture in the Air Traffic Management System?"
[24] IFATCA TPM - AAS 1.20 Artificial Intellingence and machine learning in ATC
[25] IFATCA TPM – WC 10.2.5. Automation/Human Factors

most important abilities for any ATCO. [26] [27] To those could be added the ability to focus, the capacity for rational, logical thought, and in-depth comprehension of computer systems and applications.[28] Some of those competencies will probably become obsolete in the future but for the time they are being seen as vital.

2.35. There are several competencies that are considered to be necessary for comprehending, adjusting, and creating in the AI-driven environment. Some of them include:[29]

- The capacity to gather, handle, and analyse vast and varied data sets using a variety of instruments and methods, as well as to visually represent the results in a clear and understandable manner, is known as data analysis and visualisation. Controllers need to be adept at utilising cutting-edge technology, such as AI-based instruments. Comprehending machine learning concepts and data analytics will be essential for analysing AI results and arriving at wise choices.
- Systems thinking and design thinking are the processes of comprehending and evaluating intricate systems and issues from various angles, as well as coming up with innovative and workable solutions that satisfy user requirements and expectations.
- Using facts and information to back up and explain choices, courses of action, or policies is known as data-driven decision making. It is still essential to have the capacity to think critically and resolve challenging issues. AI-generated proposals will require controllers to be assessed, their consequences considered, and decisions made under duress, particularly in the event of emergencies or system breakdowns
- Continuous learning and agility refer to the capacity to pick up new skills, behaviours, or knowledge quickly and efficiently and to adapt such skills to shifting circumstances.
- Communication Skills: In ATC, effective communication is essential, especially when controllers engage with AI systems and other staff members. To maintain cooperation and safety between aircraft crews and ground operations, clear communication of ideas and directives will be required.

2.36. While honing the aforementioned skill set is advised, human-centric competencies are beneficial for boosting AI systems' productivity and ingenuity as well as for helping people deal with the complexity and uncertainty of the future. Human-centric abilities are crucial for addressing the ethical, social, and environmental challenges that AI raises in addition to engaging with and

[26] International Learning Institute (2023, September 12). Mastering the skies: 10 essential skills for air traffic controllers. Available from: https://internationaltraininginstitute.edu.vn/mastering-the-skies-10-essential-skills-for-air-traffic-controllers/ [Last accessed 12 August 2024]

[27] Government of Canada , Job Bank, Competencies Air Traffic Controller (ATC) in Canada. Available from: https://www.jobbank.gc.ca/marketreport/skills/22705/ca;jsessionid=5418006F90BFCD4AEA059F825610781C.jobsearch74 [Last accessed 08 January 2025]

[28] Air-Traffic-Controller | Explore careers | National Careers Service. (n.d.). Available from: https://nationalcareers.service.gov.uk/job-profiles/air-traffic-controller [Last accessed 12 August 2024]

[29] Scholedge International Journal of Multidisciplinary & Allied Studies (2023) Developing Human Skills in the Era of Artificial Intelligence: Challenges and Opportunities for Education

influencing AI systems. It is feasible to learn and acquire human-centric abilities not just through education and training but also by testing and investigating different AI systems and applications.[30]

2.37. The foundation for creating an adapted competency model appropriate for ANSPs is provided by the ICAO competency framework for air traffic controllers.[31] This will be utilised in the development of their training programs. Amongst the competencies, the management of non-routine situations can be found. This means, according to the definition, to "Detect and respond to emergency and unusual situations related to aircraft operations and manage degraded modes of ATS operation". Observable behaviours include:

- OB 6.1 Recognises, from the information available, the possibility of an emergency or unusual situation developing
- OB 6.2 Verifies the nature of the emergency
- OB 6.3 Prioritises actions based on the urgency of the situation
- OB 6.4 Selects the most appropriate type(s) of assistance that can be given
- OB 6.5 Follows prescribed procedures for communication and coordination of urgent situations
- OB 6.6 Provides assistance and takes action, when necessary, to ensure safety of aircraft in area of responsibility
- OB 6.7 Detects that ATS systems and/or equipment have degraded
- OB 6.8 Assesses the impact of a degraded mode of operation.
- OB 6.9 Follows prescribed procedures for managing, coordinating and communicating a degraded mode of operation
- OB 6.10 Creates solutions when no procedure

2.38. As a result of the introduction of a tool, it will be brought to ANSP's attention that a controller may require additional training to retain the necessary and vital competencies. The traffic volume and complexity should be lowered to the new skill level in the event of a system failure if the ANSP does not offer this necessary training and skills deteriorate as a result of relying on a new system.

2.39. It is critical to avoid letting ATCO's abilities wane (Skill fade). They need frequent training to keep their skills current and stay informed about new safety protocols and technological advancements in order to accomplish this. But this also involves instruction on how to recognise and validate the judgments rendered by AI/ML systems, as well as how to identify and fix mistakes when they arise. With the heavy use of AI, the controller's role may be relegated to that of a supervisor as a result of such circumstances, which may not be welcomed. Moreover, interactions between two controllers on a team, for example while working at an ACC position, are essential to sustaining motivation and stimulation. These dynamic exchanges might decrease if an AI assistant takes the place of one of the controllers.

[30] Scholedge International Journal of Multidisciplinary & Allied Studies (2023) Developing Human Skills in the Era of Artificial Intelligence: Challenges and Opportunities for Education

[31] ICAO Doc 9868 – Procedures for air navigation services, Training, Third Edition, 2020. Part IV, Chapter 2, Appendix 2.

2.40. Furthermore, it could be required to upgrade current training curricula to include fresh AI/ML-related information and abilities and to eliminate some of the current training requirements if it can be demonstrated that they are no longer necessary. Since the radar era might be compared to it, skill deterioration may eventually be seen as a temporary situation for some skills that are no longer of high importance. However, it is very hard to define those abilities.

2.41. The degree of job satisfaction, which is part of wellbeing, following the integration of AI/ML capabilities into the air traffic control system is also a crucial factor to take into account. After implementing AI, strategies should be developed to improve job satisfaction, which will minimise personnel loss in the ATC industry. A system being designed, should be aiming to improve the quality of working life and job satisfaction of those operating in and with the system. Employee effectiveness depends critically on job satisfaction. Research has demonstrated that higher job satisfaction is positively correlated with dedication, efficacy, efficiency, productivity, ownership, and loyalty among employees.[32]

2.42. In research on the topic of workers' growing reliance on AI at work, participants were asked if using AI tools extensively could limit their ability to be creative or productive. 78% of the respondents strongly (50%) or partly (28%) agreed with this, indicating that a dependence on AI-based tools too much may lead to employees becoming bored, demotivated, or lazy.

2.43. A pertinent policy has already been implemented by IFATCA, which states that "Automation should be designed to enhance controller job satisfaction."[33] The ATCO should maintain sufficient control over the tools to enable the controller to remain attentive when required. If the ATCO is forced to take over without being attentive, this might have consequences. This is something that designers of such tools should have in mind.

2.44. At this point, it should be highlighted that IFATCA hold a policy concerning skill fade at section TRNG 9.5.1. – Refresher Courses. According to this:[34]

> ATCOs shall participate in a refresher course at least every year. This course should not have a bearing on the validation of the controller. The training and simulation provided during the refresher course should be designed to ensure the maintenance of knowledge and abilities with respect to all standards, procedures, equipment and techniques currently in use.

[32] Razig & era, A. the modern. (2015, July 12). *Impact of working environment on job satisfaction*. Procedia Economics & Finance. Available from: https://www.sciencedirect.com/science/article/pii/S2212567115005249?ref=pdf_download&fr=RR-2&rr=7d1a6b5c88e01103 [Last accessed 24 September 2024]

[33] IFATCA. (2024). IFATCA Technical and Professional Manual (TPM). 2024 Ed. Montréal, Canada: International Federation of Air Traffic Controllers' Associations

[34] IFATCA TPM – TRNG 9.5.1.- Refresher Courses

In addition to a yearly refresher course, adequate training shall be provided before the introduction of new or modified equipment and changes to standards or procedures.

Member Associations are encouraged to submit proposals to their ANSP regarding the implementation of refresher training courses.

2.45. This policy specifically addresses the issue of skill fade, by stating that the training and simulation offered during the refresher course should be designed to ensure the maintenance of knowledge and abilities with regard to all standards, procedures, equipment, and techniques currently in use. It should be made certain that ATCOs maintain their proficiency and remain up to date on new safety procedures and technology developments during the refresher sessions.

3. CONCLUSION

3.1. Air Traffic Control is set to undergo a significant evolution in the near future with the integration of AI and ML. Although the expectations for improving efficiency and safety by integrating these technologies are very high and the future of air traffic management seems to be promising, obstacles and concerns remain. In order to successfully embrace this change, ATCOs will need to possess a growing skill set that combines critical thinking, adaptability and technical acumen, or even if already possessed, to employ them in a different manner.

3.2. The "best of both worlds" should be combined in human-machine interaction: humans with their ingenuity and flexibility in handling unexpected circumstances, and machines with their learning capabilities, massive data handling capacities, and ability to identify patterns in data. Establishing a human-machine coexistence setting where the machine acts as a "sidekick" supporting people rather than as a potential "rival" is essential to attaining well-guided AI.35 At every level of developing an AI/ML tool connected to ATM, feedback from air traffic controllers is essential to achieving this goal. It should be noted at this stage that, although not ideal and in violation of IFATCA policies, there will probably be a major push to deploy this kind of technology in order to make the ATCO far more efficient.

3.3. Precise frameworks for liability and accountability need to be established in order to guarantee the ongoing safety and reliability of air traffic management. The crucial point should remain that AI and ML are here to assist the professionals and not to replace them. In order to achieve this, the controller shall receive sufficient training to keep their skills current and avoid skill fade. The future of air traffic control must be human centric and not machine centric.

3.4. The advent of AI/ML has the potential to be as transformative as the ATC's RADAR in the 1950s. It has since evolved into the main tool used by air traffic controllers. The principles of radar systems theory and data processing

[35] IFATCA, (2020), Artificial Intelligence and Machine Learning in ATC. Singapore. WP No.92

systems are currently taught to controllers through a comprehensive formal and on-the-job training program. Although the extent of this change is still unknown, we must steer it in the proper path. As a result, in terms of Just Culture, concepts as "honest error", "gross negligence", "wilful violations", "destructive acts" and others, should be redefined in the near future.[36]

4. RECOMMENDATIONS

4.1. It is recommended that the following be accepted as policy and added to AAS 1.20 ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN ATC:

IFATCA TPM (2024), AAS 1.20. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN ATC

Proposal:

Artificial Intelligence and/or Machine Learning based systems should only be implemented as decision support systems and shall not replace the decision of the ATCO.

Where an ATCO is responsible for decision making, and in the event that system tools fail or are not available, the ATCO should always have the capacity to safely manage their area of responsibility.

The introduction of AI systems shall be tested and validated with the assurance of appropriate standard levels of operations in terms of safety, security, robustness, and reliability.

In case of disruption and in addition to backup and continuity systems, appropriate procedures and training shall be put in place to assist ATCOs in emergency situations.

With special attention to airspace capacity, traffic complexity and available backup systems, a safety risk assessment shall be carried out to determine the possibility for ATCOs to intervene in case of disruption.

IFATCA and MAs shall undertake actions to raise awareness at an international and national level about the impact of automation in ATM and hasten for appropriate legal changes in ATCO's responsibility.

ATCO's responsibility shall be proportionally decreased in accordance with the level of automation and their ability to intervene and control automated systems. When using Artificial Intelligence and/or Machine Learning based systems, it shall be ensured that the Controller is aware of their roles and duties and that decision-making accountability is clearly delineated.

5. REFERENCES

[36] Stathis Malakis and Marc Baumgartner, The Aviation & Space Journal, Year XXII n. 1 (2023), "Just Culture in the Era of Digitalization: How Artificial Intelligence is Expected to Influence Just Culture in the Air Traffic Management System?"

5.1. Artificial Intelligence (AI) vs. Machine Learning. CU-CAI. (2023, October 3).

5.2. EASA (2024) “EASA Concept Paper: Guidance for level 1&2 machine learning applications. A deliverable of the EASA AI Roadmap”

5.3. Stathis Malakis and Marc Baumgartner, The Aviation & Space Journal, Year XXII n. 1 (2023), “Just Culture in the Era of Digitalization: How Artificial Intelligence is Expected to Influence Just Culture in the Air Traffic Management System?”

5.4. IFATCA, (2023), Artificial Intelligence Development in ATM and Legal Issues. Montego Bay, Jamaica. WP No.161

5.5. Reuters, Airline passenger numbers could double to 8.2 billion in ... (2018).

5.6. IFATCA, (2020), Artificial Intelligence and Machine Learning in ATC. Singapore. WP No.92

5.7. G. Contissa Et Al. (2012), Automation and Liability in ATM As Fundamental Issues in Socio-Technical Systems

5.8. IFATCA (2024) Report of the Joint Cognitive Human Machine System Group (JCHMS), Singapore, WP No. 105

5.9. IFATCA (2023) Report of the Joint Cognitive Human Machine System Group (JCHMS), Montego Bay, Jamaica. WP No. 165

5.10. IFATCA (2023), Joint Cognitive Human Machine System Group (JCHMS), Guidance Material for the design and use of Joint Cognitive Human Machine Systems

5.11. IFATCA, (2023), Information Overload in ATC. Montego Bay, Jamaica. WP No.158

5.12. IFATCA. (2024). IFATCA Technical and Professional Manual (TPM). 2024 Ed. Montréal, Canada: International Federation of Air Traffic Controllers’ Associations

5.13. IFATCA (2024) Review of Automation Policies, Singapore, WP No. 98

5.14. Regulation (EU) 2024/1689 of the European Parliament and of the Council. (2024) Artificial Intelligence Act

5.15. International Learning Institute (2023, September 12). Mastering the skies: 10 essential skills for air traffic controllers.

5.16. Government of Canada, Job Bank, Competencies Air Traffic Controller (ATC) in Canada

5.17. Air-Traffic-Controller | Explore careers | National Careers Service. (n.d.).

5.18. Scholedge International Journal of Multidisciplinary & Allied Studies (2023) Developing Human Skills in the Era of Artificial Intelligence: Challenges and Opportunities for Education

5.19. ICAO Doc 9868 – Procedures for air navigation services, Training, Third Edition, 2020. Part IV, Chapter 2, Appendix 2.

5.20. Razig & era, A. the modern. (2015, July 12). Impact of working environment on job satisfaction. Procedia Economics & Finance.

-=END=-