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Transmogrifying the Frontiers of Aviation with AI; The Imperative for Efficient Regulation in the Age of Machine Learning

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ABSTRACT

"Artificial intelligence is a tool to help humanity. We need to be responsible about how we use it." says Satya Nadella, CEO of Microsoft". The perpetually evolving aviation industry has increasingly employed Artificial Intelligence (AI) with an objective of enhancing efficiency, safety, and passenger experience, the complexity and autonomy of AI systems have raised concerns regarding their regulation and safety. To explore the future of AI in aviation and the need for effective regulation, this essay seeks to analyze the likely increase in the use of AI in aviation sector, including predictive maintenance and air traffic control, and the significant potential of autonomous drones to revolutionize the industry. However, as AI systems become more complex and autonomous, the associated risks become more pronounced, such as the potential for significant public safety threats if autonomous drones malfunction. Consequently, given the outdated nature of current regulations and their failure to consider the unique risks linked with AI systems, the establishment of tailored regulations for AI in aviation is essential to ensure public and passenger safety. To achieve this, effective regulation of AI in aviation will necessitate a collaborative effort among industry stakeholders, government regulators, and the research community. Industry stakeholders must ensure transparency with regulators in the development and use of AI systems to develop safety standards and testing protocols, and regulators must liaise closely with the research community to remain updated on developments in the sector and maintain updated regulations that reflect new risks and challenges. As AI's potential for transforming the aviation industry is immense, it must be accompanied by effective regulation to safeguard safety and public trust, and achieving this will require collaboration among industry stakeholders, regulators, and the research community to develop effective regulation that balances innovation and safety.

***Keywords**: Artificial Intelligence, Safety, Autonomous Aircrafts, ATC, Maintenance, Regulations.*

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I. INTRODUCTION

It is said that "AI will the last invention that humanity will ever have to make". Artificial Intelligence are computer that will mimic the product of intelligent human problem solving, perception, and thought. It also comprises of those system that are capable of "learning" as well as those that have static rules and databases. The part of AI which is often stressed, and most agreed with is the mimicking, or emulating, of human techniques[3]. As a result of extensive study and researches, the concept of Artificial Intelligence has evolved over the years and does not confine itself to mimicking or computing that a human being can do rather it is now able to perform certain functions that was once considered to be impossible by the very human species.

Although early stage AI applications only included image and speech recognition systems, natural language systems, and handwriting analysis, it has now become much more advanced by its inclusion in a number of other applications ranging from sophisticated industries to day to day essentials. In a world that values data above all else, one can discover its hidden relationship to AI once you begin to harness the power of artificial intelligence and such data acts as it's feeder and are called as "Big Data". Artificial Intelligence is the consequence of Big Data Analysis. AI technologies that are mainly deployed in major industries around the world includes automation, machine learning, natural language processing, robotics and the ever developing autonomous vehicles. While the AI systems are proliferating in multiple industries and it is invariably argued that the deployment of Artificial Intelligence in a large scale could possibly replace human resources at work, AI has also made its crucial entry into the aviation sector after substantial investments were made by airports and airlines around the world.

II. AI IN AVIATION

The global artificial intelligence in aviation market size was estimated at US$ 653.74 million in 2021 and it is expected to surpass around US$ 9,985.86 million by 2030 with a registered CAGR of 35.38% from 2022 to 2030[4]. The implementation of AI at airports and by airlines is a direct effect of digitalization by focussing on a long term objective of bringing in innovation into the sector thereby enhancing the passenger/customer experience and to reduce the cost incurred for operations. Even though artificial intelligence can drastically reduce costs that are associated with various operations, it always lacks a human-touch that would be crucial in determining certain aspects in an exigency. The prime focus must not be limited to replacing

[3] L. HARRISON, P. SAUNDERS, J. JANOWITZ, *Artificial Intelligence With Applications For Aircraft,* U.S. DEPARTMENT OF TRANSPORTATION 1994), DOT/FAA/CT-94/41 (Last Visited Jan 10, 2023)

[4] Precedence Research, *Artificial Intelligence in Aviation Market (2022)*, https://www.precedenceresearch.com/artificial-intelligence-in-aviation-market (Last Visited Jan 10 2023)

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humans with machines rather the goal must be to apply machine learning models that let computer programs take on some of the repetitive, time-consuming tasks in order to free up time for people to contribute more meaningfully in other areas.

(A) How is AI currently Deployed in the Aviation Industry?

Aviation was one of the worst hit industries due to the Covid-19 pandemic when the world came to a standstill with counties announcing lockdowns that restricted air travel. Although, the industry had focussed in advancing the sector with AI, the COVID-19 crisis has put greater focus on the need for a flexible approach and resilience. In turn, the urgency to put available technology to use, to provide this flexibility and unlock the full benefits which are achieved with global coordination rather than isolated approaches. The introduction and adoption of AI by airlines and airports for it's operations worldwide was visualised as an effective tool in increasing the efficiency of the sector's service.

In recent years, AI has been leveraged to improve various aspects of airport operations, leading to the emergence of "smart airports". The cutting-edge technologies that are introduced in airports are committed to enhance the passenger experience, optimize operations and improve safety. In India, the civil aviation authority has introduced a laudable project known as "DigiYatra"[5] which is an AI based computer vision technology that ensures hassle free air travel for passengers. The project is initially launched in four major airports in India by implementing facial recognition technology. A passenger who intends to use this facility will need to generate a one time id that would be linked to their pnr number. The AI application will recognise the details such as the airport, airline and basic passenger details prior to six hours of the journey. By using DigiYatra, the security checks are expedited as the processes of ID authentication and authorisation are done through Aadhar credentials which is also integrated with computer vision technology. The project also supplemented the efforts to contain the spread of covid-19 as the operations are carried out in a contactless manner with the help of facial recognition which examines the factors such as distance between once eyes, distance from forehead to chin and facial landmarks. The computer vision technology are now being used in airports worldwide for intelligent baggage handling, runway inspection and for other surveillances that vital in ensuring the security of the airport.

Machine learning is recognised as an effective tool in ensuring predictive maintenance of

[5] Anjali Raja K, DIGI YATRA, CHANGING THE AIRPORT EXPERIENCE WITH AI AND COMPUTER VISION, Indiaai (2022), https://indiaai.gov.in/article/digi-yatra-changing-the-airport-experience-with-ai-and-computer-vision (Last Visited Feb 03, 2023)

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aircrafts[6]. Enhancing the system of predictive maintenance is vital when safety is taken into consideration as it involves utilizing a combination of tools, sensors, or connected devices, such as a flight data recorder, to continuously monitor the performance and condition of an asset during operation. This includes engine health monitoring which gathers aircraft data that is then analysed through machine learning to identify patterns and trends. This information forms the foundation for aviation maintenance activities, including planned check-ups, repairs, and spare part ordering. Unplanned maintenance tends to be a factor that causes flight cancellation and delays but with the implementation of machine learning algorithms, it will provide a mechanism to track technical condition of aircrafts and will alert the Aircraft Maintenance Technicians (AMTs) prior to the schedule.

Artificial Intelligence also influences the flight operations and safety as AI is helping airlines make more informed flight operation decisions, ranging from enhancing flight paths to lowering fuel consumption. Through analysing current weather conditions and real-time flight data, AI can suggest the most efficient flight routes, reducing carbon dioxide emissions and increasing fuel efficiency[7]. Furthermore, AI plays a key role in enhancing flight safety by monitoring flight information and recognizing potential issues before they escalate. For instance, AI can study data from flight recorders and other sources to uncover patterns that may signify a possible problem, enabling airlines to take precautionary measures to minimize the risk of accidents. The utilization of AI in the aviation sector is expected to keep expanding, offering airlines with greater insights and decision-making abilities to enhance operations and safety.

III. SOARING TO NEW HEIGHTS WITH AI ON BOARD- A FUTURISTIC PERSPECTIVE

With a number of leaps being made in developing of unmanned aerial vehicles, including the recent prototype of Indo-US UAV[8] which is set to be tested this year, the future of AI in aviation seems to be propitious. The inclusion and advancement of AI is not merely restricted to the UAVs but to increase the overall efficiency, reliability and sustainability of the sector ranging from operations to safety. AI and ML also has a potential of being exploited in air traffic management by providing a support to Air Traffic Controllers (ATCOs) and pilots to focus on tasks that are critical in nature.

[6] Josh Melin, MOVING BEYOND THE HYPE OF PREDICTIVE MAINTENANCE, Honeywell Aerospace (2020), https://aerospace.honeywell.com/us/en/about-us/blogs/moving-beyond-the-hype-of-predictive-maintenance (Last Visited Feb 03 2023)

[7] Xiangsheng Dou, BIG DATA AND SMART AVIATION INFORMATION MANAGEMENT SYSTEM, 19 May 2020 at 3,4

[8] Hindu Bureau, INDO-US AIR-LAUNCHED UNMANNED UAV LIKELY TO BE FLIGHT TESTED LATER THIS YEAR, The Hindu (2023), https://www.thehindu.com/news/national/aero-india-2023-indo-us-air-launched-unmanned-uav-likely-to-be-flight-tested-later-this-year/article66500470.ece (Last Visited Feb 13 2023)

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Armed with mountains of data, AI can significantly improve the commercial aspects of an airline as they now rely upon software that can predict the demand of air tickets and the number of passenger who might travel on a particular route. Such elements will help the airlines to dynamically price the airfares which could increase their revenue. AI can also be a game-changer in improving passenger experience and satisfaction, One of the latest industrial example is Cathay Pacific whose 50 percent of customers are handled by intelligent chatbots. Artificial Intelligence is now pushing the boundaries of aviation sector by bringing in revolutionary concepts like pilotless-aircraft and robotic technology in airport management. Major airport like Singapore's Changi has now set their course to AI by testing a prototype of baggage handling robots[9] to mitigate the likelihood of workplace injuries during baggage handling apart from it's cleaning robots Liang Liang, Jing Jing, Minnal, Palich Palich, Putih and Bersih[10].

IV. THE CHALLENGES OF AERONAUTICS MACHINE LEARNING- WHAT LIES AHEAD?

"The over-reliance on automation and AI in aviation has the potential to lead to complacency and decrease pilot proficiency, resulting in safety risks"

The aviation industry has experienced an alarming surge in the integration of AI systems in recent years. This trend spans from self-governing drones to pilotless aircraft and shows no signs of slowing down. The value of AI in air transportation lies in the fact that issues encountered in air travel unavoidably result in both quantitative and qualitative data. According to a report by Markets and Markets, the investment of the aviation sector in AI is forecast to grow from $152 million this year to $2.22 billion by 2025, representing a compound annual growth rate of over 46%. Calin Rovinescu, Air Canada's former CEO, notes that continuous access to this kind of data will lead to significant improvements in fleet efficiency, which serves as a major motivator and advantage of investing in new-generation technology.

In such a scenario, the inherent risks in the prodigious integration of artificial intelligence into the field of aviation have to be anticipated. From a technical perspective, one of the main challenges is ensuring the safety and reliability of machine learning systems in an aeronautical context. These systems must be able to make accurate and reliable decisions, even in the face of unexpected or abnormal situations. In addition, they must be able to operate effectively in a

[9] Brianna Wessling, SARCOS TESTS ROBOTIC BAGGAGE HANDLING SYSTEM, The Robot Report (2022), https://www.therobotreport.com/sarcos-tests-robotic-baggage-handling-system/ (Last Visited Feb 15 2023)

[10] Harvey Low, MEET THE ROBOTS OF CHANGI AIRPORT AND JEWEL, Now Boarding (2021), https://nowboarding.changiairport.com/discover-changi/robots-at-changi-airport-and-jewel.html (Last Visited Feb 18 2023)

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highly dynamic and unpredictable environment, such as the airspace. When providing air traffic control for the safe navigation of aircraft, many factors must be factored into the equation, such as the presence of other aircraft nearby; Severe weather conditions; simultaneous communication between multiple controllers in different airspace segments, all of which may be beyond the AI's cognitive capabilities.

Coping with the massive volume of data generated by modern aircraft poses another challenge, necessitating real-time data collection, processing, and analysis to ensure accurate and prompt decisions. This demands significant computational resources and sophisticated algorithms, while also leading to the accumulation, compilation, and analysis of substantial personal data, raising concerns about potential misuse or unauthorized access and resulting in severe privacy breaches. To tackle this issue, the International Civil Aviation Organization (ICAO) has established standards and best practices for the use of AI in the aviation sector, along with addressing data privacy and security concerns.

As aeronautical machine learning systems are developed and deployed, legal considerations become a vital aspect that must be carefully considered. One of the most important legal issues that arises is the liability in the event of an accident that involves an AI-controlled aircraft. The Federal Aviation Administration (FAA) in the United States has addressed this issue and has released guidelines on the use of AI in the aviation sector, as well as the matter of liability in the case of an accident involving an AI-controlled aircraft. In recent years, the Boeing 737 MAX airplane was involved in two fatal crashes which were ultimately attributed to a software malfunction in the flight control system of the aircraft. This incident resulted in significant scrutiny and criticism of the manufacturer and triggered the need for considerable modifications to the aircraft's design and operation to ensure that such an incident does not recur.

Another legal consideration is the issue of regulation and compliance. With the increased use of AI in the aviation industry, clear and consistent regulations and guidelines are required to ensure the safe and responsible use of this technology. The International Air Transport Association (IATA) has addressed this issue by developing a "Guidance on the Use of Artificial Intelligence in the Air Transport Industry" to provide guidance on the regulation and compliance of AI in the aviation sector.

In addition to the aforementioned legal considerations, ethical implications must also be taken into account when utilizing artificial intelligence (AI) in the aviation field. For instance, the implementation of AI in the aviation industry raises concerns about the technology's potential impact on the job market and economy, as well as the possibility of perpetuating bias and

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discrimination. Moreover, the adoption of AI in aviation could result in the loss of jobs, as it has the capability to automate tasks that were previously executed by human beings. This could result in adverse economic consequences, especially for individuals with lower skill sets.

In summary, the challenges surrounding the implementation of machine learning in aeronautics are manifold and intricate, encompassing technical, legal, and ethical considerations. To address these challenges, the aviation industry must work in close collaboration with researchers and regulators to ensure that machine learning systems are dependable, secure, and impartial for all stakeholders.'

V. THE REGULATORY ENVIRONMENT- REGULATORS, REGULATIONS AND ITS NEED

"Artificial intelligence may make decisions that are efficient and logical, but without a sense of ethics and morality, those decisions may not be in the best interest of humanity" says Stuart. J. Russell, a renowned British computer scientist.

Without a shadow of a doubt, the incorporation of artificial intelligence (AI) in the aviation sector possesses a momentous capacity to transform both the norms of travel and commercial practices. Nonetheless, its use should be optimized for the maximum advantage of humankind, with measurable economic and scientific gains. This optimization is significantly reliant on a meticulous governance strategy and how AI is leveraged to advance customer benefits without infringing on their fundamental rights of privacy, life, and liberty. Moreover, a well-defined legal and regulatory structure must be established to determine the responsibility and accountability of those utilizing AI in the aviation field.

One of the foremost concerns is the possibility of artificial intelligence (AI) malfunctioning or generating decisions that could potentially result in accidents or other unfavourable incidents. To mitigate this concern, it is vital to establish effective regulatory measures that oversee the use of AI in aviation. These regulatory measures should be formulated by experts in the field, giving careful consideration to the exclusive attributes of the aviation sector. They should be subject to periodic evaluation and updates, especially as technology evolves. In this regard, the FAA has disseminated a series of publications and guidance documents, such as the "FAA Policy and Procedures for the Approval of Unmanned Aircraft Systems in the National Airspace System" and the "FAA Unmanned Aircraft Systems Operations in the National Airspace System," aimed at providing guidance on the responsible and safe use of unmanned aircraft systems (UAS), which rely heavily on AI technology and are increasingly being employed in the aviation industry. Moreover, the European Union Aviation Safety Agency (EASA) has also instituted specific regulations for the use of drones in Europe, encompassing standards on the

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design, production, and operation of drones, as well as on the qualifications and training of drone pilots.

The ICAO has established various standards and recommended practices that govern the utilization of AI in the aviation industry, among which are the "PANS-AIM (Procedures for Air Navigation Services - Air Traffic Management)" and the "Manual on Remotely Piloted Aircraft Systems." These publications offer guidance on the cautious and responsible employment of AI-driven aircraft, including the use of unmanned aircraft systems (UAS) for commercial or other purposes.

Aside from the aforementioned regulatory institutions, several industry organizations and groups are actively endeavouring to advance the secure and judicious deployment of AI in the aviation field. One of such organizations is the International Air Transport Association (IATA), which has formulated the "Guidance on the Use of Artificial Intelligence in the Air Transport Industry," aimed at providing direction on the responsible and secure use of AI in the aviation industry. Additionally, the Association for Unmanned Vehicle Systems International (AUVSI) is another industry group focused on promoting the responsible and safe use of unmanned aircraft systems (UAS) and other AI-operated aircraft in the aviation sector.

VI. Conclusion

The application of artificial intelligence in the aviation industry is a transformative development that promises to enhance safety, efficiency, and profitability. However, the use of AI in aviation also poses significant regulatory challenges that must be addressed for the technology to be adopted widely. Extensive studies have shown that efficient regulation is imperative in the age of machine learning to ensure that AI is used safely and effectively in aviation. This essay has highlighted the various ways in which AI can transform aviation, including improved aircraft design, enhanced maintenance procedures, and more efficient air traffic management. It has also identified the potential risks associated with AI in aviation, such as cybersecurity threats and the need for robust ethical standards. Efficient regulation is critical in addressing these challenges and ensuring that AI is deployed safely and effectively. The study has shown that regulation must be forward-looking, adaptable, and data-driven to keep up with the rapid pace of technological change. Additionally, it must prioritize collaboration and transparency between stakeholders, including regulators, industry players, and the public. In conclusion, the development of AI in aviation is an exciting prospect that has the potential to revolutionize the industry. However, it is crucial to recognize that effective regulation is essential in ensuring that the technology is deployed safely and ethically. Therefore, policymakers must develop a

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regulatory framework that supports the integration of AI while ensuring the safety and security of the aviation industry.

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