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The role of Organizational theory for the formulation of a Sustainable Model applicable to Air Traffic Management and Control Operations.

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Abstract
This paper provides a comprehensive introduction to Air Traffic Management (ATM), which encompasses Air Traffic Control (ATC) procedures, Reduced Separation Vertical Minima (RVSM) and Performance-Based Navigation (PBN) schemes. It also discusses the role of these and other elements in promoting environmental sustainability and the key factors essential for creating effective aviation operations. The main objective of this paper is to identify and select the most relevant components for establishing a theoretical framework for sustainable ATM and ATC practices. Notably, the organizational theory is used in this paper, aiming to create a firm theoretical model that can support sustainability in the aviation sector. In the paper, a theoretical model based on the organizational theory is created, considering the basic operational principles of ATM. Additionally, the paper highlights principles and professional activities essential to ATM and examines how sustainability can be integrated into these operations. The proposed organizational theory framework is a theoretical approach that considers operational tasks in ATM and basic sustainability principles. This model aims to promote the creation and application of a model that will support a sustainability culture among ATM professionals and leaders. Finally, by developing the proposed theoretical model, this paper aims to increase awareness and encourage adopting sustainable practices in ATM and ATC professionals.

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1 Introduction

Air traffic has been increasing significantly in the last 20 years. After COVID-19, the air transportation sector continued to grow as people began flying again. Air Traffic Management (ATM) operates under an integrated, harmonized, and globally interoperable air transportation system. The sector requires a change at an operational level with a planning horizon beyond 2025, according to ICAO [1]. The system must maintain reliable and safe air transportation, increase air capacity, and use updated air traffic control systems. The aviation industry shows demand without precedence so far. The most current projections indicate 2024 as the year with the most travellers exceeding pre-Covid levels, with 4.7 billion passengers and an anticipated 3 billion more by 2040[2]. With airports losing their flights due to the ongoing pilot shortage, which is expected to persist past 2030 [2] the industry requires investment in sustainable operational methods, technologies and effective processes.

The ATM system should pursue with aviation's economic development globally, keeping as a priority passengers' safety, flight efficiency and an affordable transportation with less delayed flights and improved airport management. At the same time, environmental awareness is essential to mitigate risks that could potentially compromise aviation safety and local conditions. All these are necessary elements for a sustainable air transportation system. All users in an interoperable global air traffic management system must follow specific safety standards during flights and air transportation, provide and pursue optimum economic operations, meet national security requirements, and aim for sustainable practices. Developing a sustainable aviation model requires all domains that comprise what we call 'the aviation industry.' This model will require the development of practices and operations that will support the creation of individual sustainable approaches applicable to different aviation operations. This leads to the necessity of not only identifying these new factors but also identifying the contribution of operations and activities that were not initially intended as part of sustainability initiatives. However, they brought significant additions to sustainability. Performance-Based Navigation (PBN) and Reduced Vertical Separation Minimum (RVSM) are the two elements in air operations that were not initially developed to contribute to environmental sustainability. However, later in their application, PBN and RVSM brought significant recorded environmental and economic benefits. ATC manages systemically the air traffic flow and ensures aircraft and passenger safety during all stages of flight. The highest reliance for efficient ATCs is on human controllers, the available technology, and the existing processes and procedures to guide aircraft from taking off to landing. ATC requires a high degree of expertise, skills, and training as it is a very complex system. In addition, ATM operational improvements could lead to considerable CO_2 emissions mitigations, through advancements in airspace design, the deployment of interoperable technologies under ATM's operational framework. The implementation of sustainable operational improvements must be accelerated to reduce the fragmentation of ATM systems, airports and flights. Symptoms of fragmentation include but are not limited to, long waiting times for take-off, 'go-around' or missed approaches due to airport congestion in taxiways, excessive holding times over airport entry points, and delays in airline schedules, leading often to passenger dissatisfaction. Moreover, these are all factors that contribute to increased CO_2 emissions per region since these factors can affect aviation's sustainability [13]. Nevertheless, how do we combine all these necessary elements under the sustainability perspective? The current paper presents some elements that must be considered in creating a sustainable framework for ATC professionals, their culture and operations. The main research question of this paper is -How to create a theoretical model that could encompass all the vital components of sustainable ATM operations, and how this model can be laid out? The paper includes three main sections that describe the creation of this model. The first shows existing flying schemes that contribute to environmental and operational sustainability, like PBN and RVSM and apply to flight operations. The second explains the basic principles of ATM and ATC operations, and the third part presents the organizational theory, which is the tool that will encompass the elements of the first two components. The suggested theoretical model is developed considering the existing schemes and the current operations of the sector under the concept of organizational theory. The main objective of this model is to build the foundation for developing a sustainable operational framework, potentially applying it to ATM and ATC operations.

2 Aviation Sustainability and Air Traffic Management Operations

Sustainability applies to any system, business, or even acting and thinking. The term "holistic" originates from "holos," a Greek word which explains "a total" or "a whole "[3]. Holism is a notion that considers all systems complete and equal entities rather than just different parts of the same system. Sustainability has recently become an essential part of society, as it pertains to almost all human activities, the environment, and people, both internally and externally, in a system. The aviation industry is a vast and intricate system that involves numerous interactions within and beyond its boundaries. Implementing sustainability practices in all aviation subsystems can bring change and yield benefits. To pave the way for aviation sustainability, it is vital to understand the basics of sustainability and affiliate them with aviation and its multi-operational disciplines. Sustainability in aviation means addressing economic growth, protecting the environment, and supporting the people involved within the industry, represented as the social element. Employees constitute the internal social element, while any other externality, like passengers or suppliers, is the external social element [3]. Sustainable development meets present needs without compromising future generations' ability to meet their own needs [4]. The report' Our Common Future' introduced the concept of sustainable development, prioritizing future generations. Sustainability is the practical aspect of actions to bring sustainable development to a system or entity [5]. At an applicable level for the aviation industry, strategies and policies essential to support sustainable development aim to shield the natural environment and the people and sustain economic growth [4]. The priority should always be economic growth but with a balanced approach to society and the environment.

Additionally, sustainability requires significant changes that will benefit everyone, including actions that benefit societies in need. Since the ATC and ATM operations are, by nature, supporting elements of growth, ensuring passengers and goods flow between cities, countries, and continents, any adjustments to the ATC operations and ATM must align with the definition of sustainability. Air traffic management is a complex system based on principles to ensure safe, efficient, and effective communication between aircraft and ground control. Moreover, as in all aviation sectors, in this one, operations are driven by strict safety standards that guide aviation with demanding commercial and industrial expectations. The sector's sustainability should contribute to meeting the ever-growing global demand and industry's expectations, with countries having systems that evolve continuously with frameworks that can sustain their requirements. The ATM system relies on several resources, including airspace, aircraft, humans, and airports. These operations are based on the involvement of the human element and its capabilities, technological and systemic infrastructure, collaboration, and interrelation. Furthermore, it must be considered that the ATM system needs support to support sustainability efforts while meeting global harmonization and interoperability expectations. For any sector to become sustainable, it is first essential to explore and analyze its basic operational principles. The sustainability principles will be elaborated on and developed under the current operations framework. Hence, it is essential to begin with the air traffic management system's basic principles: humans, technology, safety, information, collaboration, and continuity. These principles can form a sustainable ATM system's backbone, always having aviation safety as a crucial component in its operations. It is worth mentioning that aviation safety is an essential element of both economic and social sustainability. As sustainability becomes increasingly present in aviation operations, it is essential to remember that the human element and its value in the air traffic management system form a big part of social sustainability. Along with the availability and proper allocation of resources, current training and new technologies, these are all factors that support the human element and, consequently, the creation of a socially sustainable working environment. Under that perspective, the organizational culture of the sector and the industry can influence systemic sustainability by enhancing and even creating a robust, sustainable culture. Another vital principle of ATM is technology. Technology is a crucial factor for air traffic management operations. Systems in aircraft navigation and communication, either in flight or on the ground, including infrastructures, surveillance, data management, and information technology, are essential for safe and efficient aircraft communication. A sustainable model for ATM requires an equal consideration of all these components. The holistic approach to sustainability highly considers appropriate technology, regulatory safety standards, human contribution, and managerial support. Timely and quality-assured information is also essential for making well-informed decisions to drive air transportation under high safety standards [3]. The use of the Continuous Decent Final Approach (CDFA) technique is a good example showing how technology, safety standards and decision-making can merge to enhance operations in a human-centric sustainable system. CDFA, was initially introduced to mitigate non-stabilized approaches and Controlled Flight Into Terrain (CFIT) hazards, yet it can be a technique promoting sustainability. Using CDFA, the aircraft can fly final approaches to a point approximately 50 feet above the landing runway threshold, without step-down descents, unnecessary high throttle settings, and with less workload for the pilots. The end result is reduced fuel burn and less noise along the final approach path. Less fuel consumption and noise reduction have a clear positive impact on environmental sustainability, but simultaneously, CDFA results in safer operations. The employment of the Global Navigational Satellite System (GNSS) further refines and expands this technique because the aircraft can fly and maintain the desired flight path angles with consistency and accuracy. It is evident that a well-designed ATM system uses routes, approaches, and published ATC procedures that combine all those different elements. into a homogeneous, interoperable environment.

Additionally, communication is critical in systemic sustainability, considering aviation is a multicultural and international environment with individuals from different regions, countries, and native languages. Hence, effective communication and procedural standardization are vital for maintaining the operational sustainability of the system. Finally, another vital element for operational efficiency and systemic sustainability is contingency measures for risk mitigation in air traffic safety in uncontrolled occasions, such as power outages, environmental catastrophes, civil unrest and social anomalies, security threats, and more. The continuity of operations constitutes a viable and sustainable system, suggesting a system that operates harmoniously, without non-conformities or major violations under specific systemic and regulatory pathways to mitigate or prevent various risks [3].

3 Performance-Based Navigation (PBN) and Reduced Separation Vertical Minima (RVSM) and Environmental Sustainability

In 2009, ICAO stressed the need to create new specifications for navigation due to the need to improve performance, equipment functionality, and infrastructure, and created the scheme Performance-Based Navigation (PBN). Performance-Based Navigation (PBN) represents a significant shift from traditional, ground-based navigation aids to a system where aircraft utilize onboard performance capabilities and navigation systems for more precise and flexible routes. This modern air navigation scheme allows aircraft to fly under more efficient routes using the maximum of their performance capabilities. In addition, PBN uses advanced satellite technologies such as GPS and inertial navigation systems and does not rely on traditional ground-based navigation aids. ICAO Member States have many reasons and benefits for implementing PBN [6]. An onboard navigation computer called an RNAV system, enables the Area Navigation, maximising the airspace capacity. Starting with Area Navigation -RNAV, an aircraft flies on desired paths following the available coverage of on ground station-referenced navigation points. The RNAV method is used within the limits of the capability of self-contained aids or a combination of these. Flight crew and ATC must comprehend the features of the RNAV system and match them with the airspace capacity and conditions.

With PBN, pilots can fly more direct routes, choose optimized flight paths, and lessen fuel consumption. Consequently, the use of PBN allows reduced fuel emissions and less fuel costs. PBN also reduces the risk of mid-air collisions and allows aircraft to pass over previously considered challenging areas due to ground morphology and weather conditions. Even though the purpose of Performance-Based Navigation (PBN) is to improve aircraft navigation performance, interestingly, it can also have a positive impact on environmental sustainability. It was later discovered that PBN offers direct and indirect environmental benefits, with one of the most significant benefits in fuel savings. As mentioned, PBN suggests more efficient flight tracks with reduced fuel consumption and profiles such as Optimum Profile Descent (OPD), Continuous Climb Operations (CCO), and Continuous Descent Operations (CDO). Additionally, PBN proposes more predictable operations reducing flight variance. It decreases landing minima, reducing weather cancellations and diversions. The probability of missed approaches, diversions, and airport holdings due to airspace and airport capacity are also minimised with PBN. The system's predictability and reliability also reduce the contingency fuel requirements. Furthermore, with PBN there is the opportunity for fuel savings leading to CO2 emissions and other pollutants reduction, such as carbon monoxide and nitrogen oxides. Moreover, reduced noise levels are achieved with PBN since it offers shorter flight paths and lower thrust levels, reducing the impact on domestic zones and airport entourage [6]. Inevitably, it could be supported that PBN has not only positive environmental effects but adds also to social sustainability. Additionally, the economic benefits of PBN include fuel cost savings for airlines, increased airspace capacity for greater traffic volume, and reduced delays. The concept of economic sustainability does not only rely on economic growth and savings but also on the support of other vital factors within a system. For example savings from fuel costs, might lead to investment in sources that will benefit the employees or the technical infrastructure of the ATM system. However, despite the fuel benefits of PBN, there is a lack of empirical data about its benefits to airspace; hence, it is not easy to quantify them and support evidence-based decisions when designing PBN routes and approaches. Aircraft operators and airlines are reluctant to publish fuel consumption data linked with their routes for various commercial reasons. The ICAO CORSIA scheme could bridge this gap, allowing ICAO member states' verified annual emission reports to create a baseline for ATM design or redesign based on PBN methodology. Moreover, one of the benefits of PBN apart from the reduction of emissions, contributes also to reduction in noise levels through flight paths' optimization. The reduction in flight noise levels and particularly in stages of flight like take-off and landing, contribute to societal considerations regarding noise impact around airports, supporting efforts towards social sustainability. One considerable example of noise reduction from CDO procedures and PBN is the case of Toronto Pearson International, where approximately 125,000 residents where exposed to a lower level of noise at scale 55dB. Simialr cases include Stansted Airport in the UK, Schiphol Airport in Amsterdam and many more.

Moving forward with another scheme that has contributed to aviation sustainability, it is worth mentioning the Reduced Vertical Separation Minimum (RVSM). Initially, the minimum vertical separation of aircraft must be held at 2000 feet, at heights higher than 29,000 feet [7]. However, ICAO's research expanded on the impacts of a further reduction of separation minimum to only 1000ft. The concept was to double airspace capacity and offer the possibility for more optimised operations with lower consumption in fuel. As a result, this research was correct, leading to the establishment of RVSM across the airspace globally. The reduction separation optimises aircraft routes, requiring an update to aircraft equipment and onboard avionics to feature two independent altitude measurement systems, an altitude alerting system, an automatic altitude control system, and a Secondary Surveillance Radar (SSR) transponder [8]. It is a requirement to have specialised pilots and controllers to ensure safe operations at higher altitudes. Overall, the RVSM approach served as a scheme that led to more environmentally sustainable flight operations. It has also been set that for every 1000 ft below its optimal cruise altitude the air operator would get a one per cent fuel burn penalty [8]. Consequently, fuel consumption is reduced, affecting emissions as well. This also led to the conclusion that RVSM inherently has more significant effects on reduced fuel burn than any policy in horizontal plane separation.

It should be noted that RVSM is simple to apply and can be executed without modifications to aircraft or air traffic control systems. Thus, it allowed the ICAO to push heavily for the implementation of RVSM since the 1980s [8]. Consequently, RVSM has positively impacted the environment and economy of airlines, and it was first applied in the European airspace in 2002. After that period, many studies found that emissions such as nitrogen oxide and sulphur oxide were downsized by almost 1%, resulting in about 3500 tons reduction yearly [9]. The total amount of fuel saved was also considerable, reaching about 310,000 tons per year, contributing to aviation's environmental and economic sustainability, even without this being the scheme's primary target. Although schemes such as PBN and RVSM have initially different purposes for aviation and flight operations, they can still bring significant outcomes supporting sustainability in Air Traffic Management (ATM). These two schemes were not developed under the mentality to contribute to sustainability. However, processes and schemes should be more thoroughly assessed when the holistic sustainability approach is examined. Their primary purpose might differ from the initial one, but benefits can expand a lot further than fundamental operations. A sustainable system should have an inclusive approach where all elements contributing to sustainability must be acknowledged and followed by the systems or company's personnel or the social element. The aviation industry requires a structured approach where all contributing factors to sustainability per different sectors must be listed and encompassed in a theoretical framework. Then, after the theoretical foundation is created, applicable processes must be set. These processes must be tailor-made for the system they apply.

4 Aircraft and Air Traffic Control Cybersecurity

While PBN and RVSM have significant positive impacts on optimizing and utilising better airspace and routes, they rely on newer communication and surveillance technologies. Their use is based on the digitalisation of aviation and the real-time connectivity capabilities of onboard or ground-based equipment. Of course, the question that might be posed is what is the connection between cybersecurity and ATC sustainability? Again, under the holistic approach of sustainability, a system must be inclusive of all the threats and risks that might affect its performance and viability. One example of this case is the NextGen updates and the airspace breaches. Specifically, FAA's NextGen updates to the National Airspace (NAS) along with the advanced aircraft connectivity and communication with air traffic control systems led to the exposure to various detrimental cyber risks. One vulnerable case could be the Automatic Dependent Surveillance-Broadcast (ADS-B). ADS-B observes almost all civil aircraft while in flight, aiming to facilitate the operations of air traffic control and manage aircraft separation. Pilots can spot the exact locations of aircraft in proximity. Sequentially, air traffic controllers utilise the information taken from the aircraft, to track them and avoid any conflicts or air and ground collisions. It is essential to note that that ADS-B operates on unencrypted IP networks and global positioning systems (GPS). This means that ADS-B can be weak to external cyber-attacks [10]. Cyberattacks obviously pertain high risks that affect operational activities and performance in any company. For aviation, the risk is even higher since compromised communications between the ground services and an aircraft in air, could lead to disastrous results. ADS-B and GPS systems can be exposed to three different types of cyber-attacks. A cyber-attack on GPS signals and disruption are among the main risks. Loss of GPS signals can severely affect navigation and flight for pilots and controllers' tracking. Potential obstructions of communication systems and networks can be another cyber risk [3]. This condition can affect air-to-air communication between pilots and air-to-ground communications. In addition, it can affect communication between pilots and controllers. The cyberattack on ADS-B communications is another type of risk which can induce denial-of-service or deletion of messages, compelling cluttered communication between operators, and severely compromising aviation safety.

The safety implications of inaccurate navigation and location data can significantly impact aviation operations and sustainability. Pilots' and air traffic controllers' situational awareness can be compromised by any factors that disrupt navigation and communication systems [11]. Aviation cyber risks and their implications are not limited to airports and airborne aircraft. Airlines and cargo carriers, regulatory authorities, and even maintenance facilities operate IP systems for their records, forms and general business processes. With the lack of robust cybersecurity standards, companies can easily expose themselves, their operations, and customers to raids on financial data, safety and maintenance records, and customers' personal information, among others. These conditions can shut down entire networks until companies agree to pay cyber-ransoms [3]. Since all these elements are interlinked and interrelated, the systemic disruption in air navigation is an issue that will impact the operations of all involved parties, airlines, ATCs, and airports, having, without a doubt, economic implications for all their parties. The implications could be both financial, like revenue losses or business shrinking, and social, like the lack of public trust, loss of jobs due to industry turmoil, or even by compromising flight safety in major accidents. The latter could be attributed to significant environmental events since aviation materials, like composites, oils, hydraulics, etc., pollute aircraft crash sites. Thus, a systemic approach to cybersecurity is essential for the aviation sector since any system with compromised safety and security operations automatically ceases to be sustainable. Recovery of operations and regain of trust are all factors that affect both economic and social sustainability. But how a system could be protected from potential cyberattacks? What are some measures and mitigation actions to be taken? The first approach in order to protect a system from risks is to train and educate the users for the potential risks they might face. The users can be air traffic controllers, pilots and communication and surveillance technicians. A sustainable system will not only focus on the technical infrastructure and technology mitigation actions but also make users part of the protection process. The aforementioned group professionals must be able to acknowledge the risks and to pursue specified actions as part of the risk mitigation process. This approach requires a set of actions that are published and accessible to personnel, with clear guidance of moving forward. Apparently, this approach is not simple, and it requires a systemic framework that is developed appropriately to cover a specific system. This study proposes to apply organizational theory and use it as a tool that will formulate a model applicable to ATC systems, with consideration of ATC operational principles, technology, infrastructure, cybersecurity measures, and flying schemes like PBN and RVSM, among others. The model will synthesize all these different elements using a shared methodology to achieve one common goal, a sustainable air traffic management system.

5 Materials and Methods: Organizational theory

Looking at the elements that must be adopted in a system like ATM, for ATC sustainable operations, it is always essential to look at a theoritical framework and how it can formulate the a model based on the current structure of an aviation system like ATC. This research section aims to propose an approach and explore how organizational theory, can be utilized as the tool that will unite the basic operational characteristics of an ATC system, with the sustainability practices that are applicable to that particular sector. The outcome of this research approach will support the creation of a theoretical model that will be the starting point for applying sustainability in different aviation sectors. Starting with the definition of organizational theory, it is the sociological study of the structures and operations of social organizations, including companies and other types of institutions. The role of organizational theory is to analyze the productivity and performance of organizations and in our case ATC providers, and assess the actions of the employees and groups within them. The study of organizational theory aims to comprehend and analyze the dynamics of a successful business and understand how companies operate, develop new processes, and adapt to changes in the external environment [12]. It is a research pathway management and leadership in a business environment can use to optimise corporate processes and strategies. Moreover, the concept of organisational theory contains various approaches and frameworks that examine organisations' behaviour, structure, and function. One of its main goals is to illustrate elements within the organisation, teams, individuals, departments, and the overall structure - their interaction and influence on outcomes. When understanding these dynamics, organisational theory offers beneficial facts for improving effectiveness, efficiency, and performance, which are essential for a sustainable system. The required features of an ATC should be examined and be part of this system to ensure efficiency and improved performance, leading to a viable and sustainable system.

Organizational theory could be considered as a crucial aspect of businesses that can help make informed decisions and implement necessary changes. In an Air Traffic Control (ATC) environment, sustainability must rely on the fundamental principles of organizational theory. Sustainability is a systemic change that needs to be appropriately addressed, especially in aviation. Organizational theory can support companies to apply models with systematic frameworks for decision-making, assisting leadership to identify formations, and convoluted conditions, and select data and theories that will lead to informed decisions. It is essential to select variables and factors that will create the new model adapting to the corporation's business objectives., with primary values efficiency and productivity. [3] Additionally, it should be addressed that organizational theory enables companies to rationalise their processes, minimize risk, and improve the available resource allocation. Companies must be adaptable in a fast changing business environment [12]. That is the main goal of the organizational theory, providing insights into how businesses can be innovative, and adaptable to changes and challenges. ATM and ATC operations are no exception to this concept as the air traffic volumes seems to increase to post-covid levels, hence optimisation using innovating technologies are key elements of the core business. Leaders must identify inefficiencies and adopt changes that would strengthen productivity utilizing interdependencies and the interconnectedness of various organization's parts. This can involve redefining roles and responsibilities, improving communication, or restructuring individual teams [12]. The results and processes of organizational theory and models that apply this theort, must be supported from top management that will motivate employees, develop a healthy and sustainable professional environment, and always striving to achieve organizational goals. [12] Additionally, organizational theory and models require significant information for efficient communication, employee motivation, and leadership styles encourages employee engagement [12].

Based on the initial approach of organizational theory, it is essential to understand how the company, an ATC system in this case, functions and how its operations might be affected by the environment in which it operates. As mentioned in the previous sections of the paper, some essential elements formulate the ATC and ATM operations. The impact of applying sustainability practices to the company's operations is an element that must be included in the organizational theory concept and the theoretical model proposed and presented below. A successful organizational theory model also requires a clear presentation of the organizational structure. For an ATC system, it is essential to have a transparent formal system of task authorization and control of relationships. In addition, an ATC system must have a clear structure on how people cooperate, how they use the available resources and their overall achievements and contributions to organizational goals. As in aviation operations and sectors, culture is also vital to ATC's organizational structure and operations. The ATC system employees' must share common values and norms first to accept and then embrace sustainability principles complementary to the safety commitments. It should be noted that ATC entities or Air Navigation Service Providers (ANSPs) , as they are widely known, can be either private organizations or state-owned companies. Incorporating all these elements under one common approach is a complex effort, so a theoretical model is proposed in the next paragraph.

6 Results: Proposed Model

An organizational model for ATC systemic sustainability requires to define the necessary specified elements that are essential to build that model. It is interesting to mention that organizations are collectives oriented to the pursuit of relatively specific goals and exhibiting high formalized social structures [12]. This indicates that organizational theory should be applied but also formulated under the system it concerns. For an air traffic management, a theoretical model must be based on the operational factors that constitute an efficient ATM system, incorporating the sustainability principles. Organizational theory models are often depicted as star diagram representations or clustered diagrams. In this theoretical framework, the model will be presented as a star diagram.

Figure 1. A sustainable Model for ATM, following the organizational theory.

7 Discussion

Sustainability is a topic that requires to go deep into a system, identify its processes and operations, and then select the necessary components that will make this system a sustainable one. A detailed and thorough review of ATM and ATC operations, shows that human factors, policies and regulations and technology, are some of the main elements that formulate and drive ATM and ATC operations. A suggested sustainable model for ATM based on the organizational theory can be formulated as of Figure 1. This model is based on the traditional organizational theory where the key elements feed the system in a systematic way. However, it is essential to examine their impact on the overall system performance and the interdependencies between those elements. For example, newly introduced communication technologies need highly qualified personnel, properly trained, with the resources provided by leadership, making everyone fully aware of their operational impact on energy resources and the environment while considering safety, compliance, and human factors principles. Notably, human factors expand not only to safety-related processes but to social and economic sustainability as well. Despite the automation, ATM and ATC are still human-driven systems. The ATC services provided by ANSP, in particular, include a substantial percentage of real or almost real-time processes of exchanging information about flight trajectories. The use of optimum and cybersecurity-resilient communication and surveillance protocols that can produce meaningful information to the ATC personal and the flight crews remains paramount. For example, the preparation of routes the anticipated workload and the specific operational parameters affecting the human's ability to reach reasonable conclusions should remain the cornerstone of flight operations. Understanding the concept of sustainability while operating safely requires a balance of decisions made by the ATC actors. Those decisions must also be supported by the compliance regulatory requirements that set the minimum standards for safe operations. Thus, the human element and the role of human factors in developing resilient organizational systems remain critical. The human element drives the social sustainability concept in any system. Human factors require support of operations through focused training and increased awareness. Moving forward, with the sustainable ATM model, technology infrastructure and relevant schemes necessary for flight operations should be appropriately managed and handled for optimum results in flight operations. PBN, RVSM, standardized communication and surveillance systems and cybersecurity protection as mentioned earlier in this paper, should be part of a sustainable model. A combined approach, which will require training personnel appropriately to manage these schemes and technology, is vital, as well as hiring qualified staff to handle these systems. Finally, leadership engagement is one of the most crucial factors for maintaining and improving any type of system, and a sustainable one. Leadership should allocate resources properly and engage in a sustainable culture, enhancing personnel culture to sustainable operations. Sustainable culture could become aviation's meta-safe culture that embraces not only the safe operations of today but nurtures the aviation operations of tomorrow, taking into account the holistic approach to the three pillars. With this mindset in the core value, economic sustainability is an element that should promoted by the leadership and support the other two pillars, social and environmental. A sustainable model requires all the three pillars of sustainability to be in balance through its processes and operations. A proposed theoretical model should encompass the elements presented in the model at figure. The purpose of this model is to be adaptable in the organization's systemic culture, through communication and training to the social elements- employees. It is of paramount importance to have leadership commitment and support. For each one of the model's elements there must be specified approaches, so respective processes are developed to cover all three pillars of sustainability. It is important to mention that the proposed model is only a theoretical model which should expand to particular companies' operations in the ATC sector. There is no 'one fit for all' model, hence adjustments must be considered per application. This approach will give the baseline of creating a sustainable framework that will be adjustable to more detailed sustainability approaches.

8 Conclusion

To conclude, this research paper offers a theoretical approach that is developed on two main elements; the basic principles of sustainability and the unique characteristics of the ATC sector. The holistic approach to sustainability requires all aviation systems and professionals to be informed and engaged in the industry's overall effort to sustainability. Changing an air traffic management system requires a good comprehension of its basic principles, safety, humans, technology, information, continuity, and functions. These elements are vital to be preserved and maintained in ATC operations. As mentioned in the paper, proper use of technology and involvement of the social element are vital drivers for sustainability. Using and measuring outcomes from tools such as PBN and RVSM can show how aviation sustainability is currently supported within the sector. Notably, both PBN and RVSM contribute to improved airspace capacity and reduced fuel consumption and carbon emissions. Both schemes have significantly inhibited environmental effects over the past two decades, with benefits in in-flight performance, fuel optimization, and emissions. Finally, the role of cybersecurity in ATM, navigation services, and airport operations is the elimination of cyber risks that will lead to a safe, secure and sustainable aviation system. The industry makes a significant effort to become sustainable and contribute to the industry's sustainability goals. Hence, ATM and ATC must be positioned as systems to identify operations or schemes under their systemic processes and measure their impact on aviation sustainability. Finally, considering all aviation sector and its companies that have set goals to meet the carbon goals by 2050, it is interesting to see the technology, new infrastructures and advances that will be developed through the next years considering a structured approach for a sustainable aviation future. To conclude, aviation sustainability in the ATC sector, requires a theoretical approach that is adjustable to changes and it is open to adopt new initiatives. Having a theoretical model in place, there is the opportunity for ATC entities, to start developing their own unique and tailor-made sustainability framework. Even though the concepts presented in this research paper are based only on theoretical elements and existing literature, the next steps of this research might be the potential applicability of this model, exploring the factors that can be the foundation of the creation of such model in an ATC entity, testing its efficacy in creating a sustainable framework in the sector.

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