HARMONY MOVE IN AIR TRAFFIC: COORDINATION OF SESAR AND NEXTGEN

Hava Trafiğinde Uyum Hareketi: Sesar ve Nextgen'in Koordinasyonu

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Anahtar Kelimeler:

Havacılık,

Hava Trafik,

NextGen

JEL Codes:

L10, L90, L91, L93.

Öz

Avrupa ve Amerika Birleşik Devletleri arasındaki Açık Semalar Anlaşması, dünya çapında iki büyük havacılık pazarını bir araya getirerek Atlantik'in her iki yakasındaki milyonlarca insanı hava yolu ile birbirine bağlamakta ve son yıllarda havayolu endüstrisinin seyrini değiştirmektedir. Bu anlaşma, canlı ve büyüyen bir transatlantik havacılık pazarı yaratmıştır. Bu büyümeyi destekleyen temel unsurlardan biri olan Avrupa-Amerika Birleşik Devletleri İş Birliği Mutabakatı, ABD'nin "NextGen" ve Avrupa'nın "SESAR" olarak bilinen iki büyük hava trafik modernizasyon girişimini uyumlaştırmayı hedeflemektedir. Bu çerçevede yürütülen ortak çalışmalar, günümüzde hava trafik sistemlerinin küresel ölçekte birlikte çalışabilirliğini teşvik etme açısından önemli sonuçlar doğurmuştur. Böylece, hava trafik modernizasyonunun tüm yaşam döngüsünü kapsayan bir düzenleme ortaya çıkmıştır. Bu düzenleme, Avrupa ve ABD İş Birliği Mutabakatı'nın kapsamını geniş bir şekilde yansıtmakta ve dağıtım faaliyetlerine ilişkin iş birliği aşamalarını ortaya koymaktadır. Çalışmada ayrıca, veri iletişimi ve "SWIM" gibi güncel odak alanlarındaki önemli gelişmelere de yer verilmektedir. Bu bağlamda, havacılık alanında önde gelen iki bölgenin güçlerini birleştirmesi durumunda nelerin başarılabileceği genel anlamda ortaya konulacaktır. Çalışma aynı zamanda "NextGen" ile "SESAR" arasında gerekli uyum düzeyinin ve küresel iş birliğinin sağlanmasına yönelik ilerlemeyi de gözler önüne serecektir. Nitekim, hava sahası kullanıcılarının bu modernizasyon girişimlerinden tam anlamıyla faydalanabilmesi için Avrupa ve ABD'de kurulan bu tür yeni sistemlerin uyumlu ve birlikte çalışabilir olması gerekmektedir. Bu çalışmayı önceki çalışmalardan ayıran en önemli fark, literatüre ilk kez girecek olan "CACAVU Modeli"nin bu çalışma kapsamında ortaya konulacak olmasıdır. Söz konusu modelin küresel uyuma katkı sağlaması beklenmektedir. Gerçekten de, küresel uyum ve birlikte çalışabilirlik hedeflerinin karşılanamaması, hava sahası kullanıcıları için maliyetleri artıracak ve genel hava trafik sistemi açısından verimsizliklere yol açacaktır.

Abstract

The Open Skies Agreement between Europe and the United States, which brings together two major aviation markets worldwide and connects millions of people on both sides of the Atlantic via air travel, has changed

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Keywords:

Aviation,

Air Traffic, NextGen

JEL Codes:

L10, L90, L91, L93.

the course of the airline industry in recent years. This agreement has created a thriving transatlantic aviation market. The European-American Memorandum of Cooperation is a key element supporting this growth and aims to align the two major air traffic modernization initiatives, the US's ''NextGen'' and the European ''SESAR''. The joint efforts within this framework have yielded significant results in terms of promoting global interoperability of air traffic systems today. Thus, a regulation has emerged that will address the entire life cycle of air traffic modernization. Broadly reflects the scope of the European and US Cooperation Memorandum and reveals the stages of cooperation regarding distribution activities. The study also includes important developments in current focus areas such as data communication and ''SWIM''. The study aims to reveal what can be achieved when two leading regions in the aviation field combine their strengths in the most general sense. In this context, the study will also reveal the progress towards achieving the necessary level of harmony and global cooperation between ''NextGen '' and ''SESAR''. Indeed, in order for airspace users to fully benefit from these modernization initiatives, these types of new systems established in Europe and the US must be compatible and interoperable. The most important difference that distinguishes the study from previous studies is that the ''CACAVU Model'', which will enter the literature for the first time, will be revealed in the study. It is expected that the model will contribute to global harmony. Indeed, Failure to meet global compliance and interoperability goals will increase costs for airspace users and lead to inefficiency in the overall air traffic system.

1. INTRODUCTION

In order to increase the effectiveness, safety and efficiency of the air navigation system and to reduce flight costs and environmental impact in the face of the increasing density of air traffic globally, important projects such as SESAR, NextGEN, CARATS etc. are being developed within the framework of actors such as ICAO, Eurocontrol, FAA, Japan for the purpose of restructuring Air Traffic Management (ATM). Within the scope of these projects, the transition process from the paper-based, product-oriented Aeronautical Information Service (AIS) approach to the digital data-oriented, system-based Aeronautical Information Management (AIM) has been initiated in order to create Digital Aeronautical Information Management and SWIM (Extended Information Management System) Systems (Kokpit, 2024).

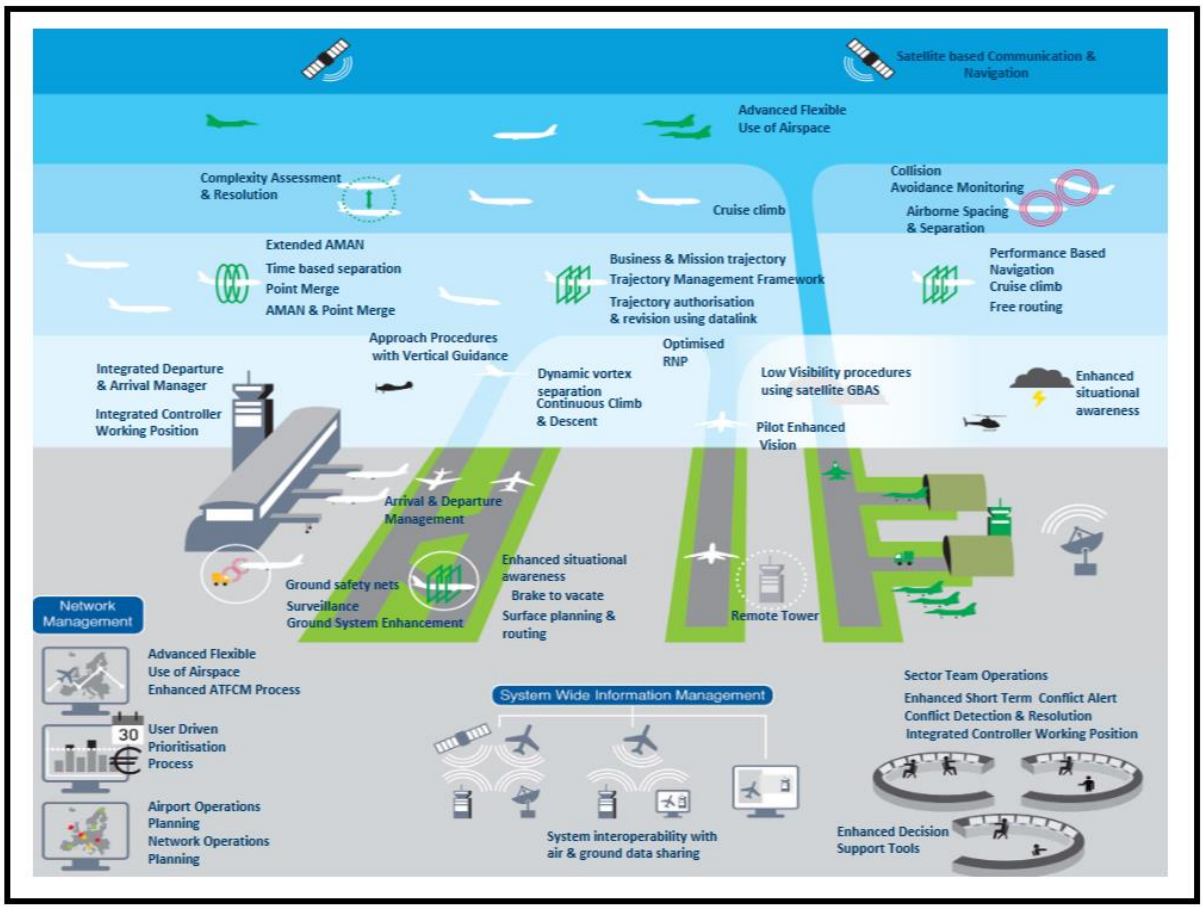

Figure 1. NextGen, SESAR and SWIM Concept

Source: (SESAR Joint Undertaking, 2024)

The primary objective of this study is to demonstrate the nature of the collaboration between the US's "NextGen" and Europe's "SESAR" air traffic modernization projects and to assess their contributions to the interoperability of global air traffic management systems. The integration level of these two major players in global air traffic modernization will be assessed, particularly by analyzing how these partnerships have guided technological transformation processes and the advances they have made in critical areas such as data communications and SWIM. The CACAVU Model, developed within the scope of this study and introduced to the literature for the first time, offers an innovative framework for ensuring harmonization between air traffic systems and is expected to make a significant contribution to the literature. Considering the potential systemic cost increases and efficiency losses that may arise from a lack of harmonization, the significance of this study in both academic and practical areas becomes even greater.

The study consists of six main sections. The first section, the introduction, outlines the general framework of the study and introduces the research topic, problem statement, and conceptual framework. This section also highlights the study's uniqueness and potential contribution.

The second section examines the NextGen system, the US air traffic modernization program, in detail, explaining the system's objectives, technological infrastructure, impact on users, and implementation stages. The innovations NextGen has introduced in air traffic management and its level of interaction with the global system are evaluated in this section.

The third section examines the SESAR system, Europe's parallel modernization project. SESAR's structure, objectives, technological solution proposals, and applications in European airspace are detailed, and comparative analyses are conducted with NextGen.

The fourth section describes the SWIM (System Wide Information Management) system in the context of data sharing, communication systems, and network-based management approaches, and outlines its role in the transatlantic cooperation process.

The fifth section covers the study's problem statement, purpose, significance, assumptions, limitations, literature review, methodological approach, data collection process, and analysis techniques. This section explains the scientific justification for the research methodology used and details the study design.

The sixth and final section interprets the findings, provides general assessments based on the analysis results, and offers concrete recommendations for practitioners. Furthermore, the innovative contributions offered by the CACAVU Model, its applicability, and its potential for future research are discussed.

2. Next Generation Air Transportation System (NextGen)

In the United States, the Next Generation Air Transportation System (NextGen) is a complete modernization of the national airspace system. It offers a comprehensive suite of upgrades, technologies and procedures that improve every phase of flight and enable aircraft to operate more efficiently from departure to arrival.

NextGen uses satellite technology for navigation and surveillance, deploys digital systems for communication, and improves information management. By renewing automation systems, NextGen will also add extensive operational capacity to the national airspace system.

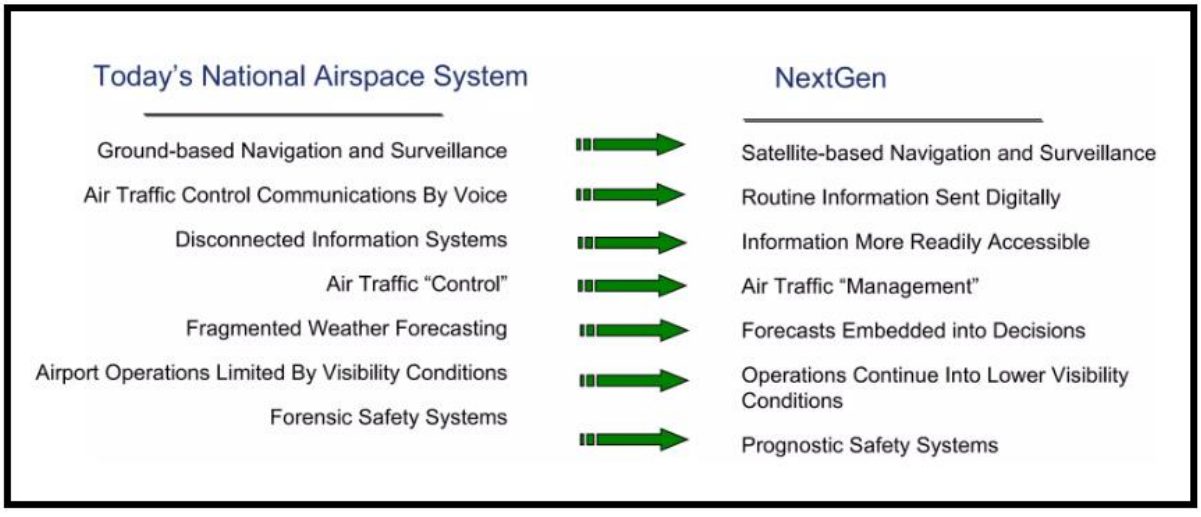

Figure 2. NextGen Concept

Source: (FAA, 2008)

3. Single European Sky Air Traffic Management Research (SESAR)

SESAR is the technological reflection of the broader ''Single European Sky'' initiative, which aims to modernise and harmonise Europe's air traffic management system. SESAR's aim is to identify, develop and implement operational solutions and technology enablers needed to improve the performance of Europe's air traffic system.

The SESAR Joint Undertaking (SESAR JU), established in 2007, is responsible for coordinating and bringing together all air traffic-related research and development efforts in Europe. SESAR JU also represents a public-private partnership between Eurocontrol, Europe's main public stakeholder [‡], and the European aviation service and manufacturing industry. SESAR JU is also responsible for setting SESAR's objectives and priorities.

The ''SESAR Application Manager'' (SESAR DM), established in 2014, is responsible for the implementation of SESAR solutions. SESAR DM plans, coordinates, synchronizes and reports the implementation of such joint projects. In this sense, SESAR DM acts as a project manager (Skybrary, 2024).

4. Extended Aeronautical Information Management (SWIM)

Extended Aeronautical Information Management [§]represents an understanding that will complement human-human communication with machine-machine communication and increase the data distribution and accessibility regarding the quality of the exchanged data. SWIM is implemented to promote information-based air traffic integration. This understanding consists of standards, infrastructure and management that enable the management of information related to air traffic management and the exchange of information between the parties.

SWIM provides seamless access and exchange of information between all air traffic information and service providers and their users. It takes the use of web technologies as an example in general and applies these examples to air traffic systems. In this sense, it reduces compliance costs and makes the aviation data market more competitive. Thus, it also allows users to choose a new provider without a major impact on their systems.

Figure 3. SWIM Concept

Source: (AAI Aero, 2024)

[‡] An international organization that aims to increase the safety of flights and manage airspace congestion by providing coordination between air traffic control centers.

[§] From now on, this expression will be referred to as "SWIM" in this study.

Eurocontrol supports the development and implementation of SWIM in the areas of information services, technical infrastructure, development of standards and supporting materials, management and civil-military cooperation (Eurocontrol, 2024).

5. Expanding Air Traffic to the Modern Life Cycle

5.1. Problem, Purpose, Importance, Assumption and Limitations

The main purpose of this study is to comprehensively understand the benefits of the implementation of the said cooperation and to prioritize appropriate actions regarding this benefit. The purpose of the study is to enable the interpretation of the benefits in this area by addressing the air traffic area.

The study is important in terms of shedding light on the future of air traffic. A new model will be highlighted in the field in question. In this respect, the study, which is examined for the first time in Turkey, is expected to fill an important gap in the relevant field in terms of its contributions to the scientific literature.

Within the scope of the study, the research is based on the assumption that the sampled projects will be able to sustain their activities for at least the next 50 years. The study will be limited by accepting 2025 as a milestone. In this sense, the study will be able to easily provide a perspective to the beneficiary for the coming years.

5.2. Literature

All academic studies to be examined in this section are limited to the aspects of ‘‘directly addressing both technical and operational aspects of SESAR and NextGen; examining the similarities and differences of the two systems by focusing on issues such as decision processes, digitalization and technological integration’’. The studies below reflect the studies that have passed through this filter and are directly related to the research.

Table 1. Literature

Year	Name of the Study	Author(s)	Subject/Examination	Source(s)
1997	Flight to the Future: Human Factors in Air Traffic Control	National Research Council (Wickens, Mavor, McGee - Eds.)	Examines human factors in air traffic control, focusing on the impact of automation and future system design.	National Academies Press
2008	SESAR R&D and Project Portfolios for Airline Business Needs	Peter Brooker	SESAR's R&D projects designed to meet airline needs.	Journal of Navigation, Vol. 62(2), Cambridge University Press
2009	Human Factors Measurement for Future Air Traffic Control Systems	Janice Langan Fox, Michael J. Sankey, James M. Canty	SESAR and NextGen. Aimed at improving human–machine interaction in future systems.	Human Factors (Human Factors Society)
2009	Human–Automation Teams and Adaptable Control for Future ATM	Janice Langan-Fox, James M. Canty, Michael J. Sankey	Proposes adaptable control models for effective teamwork between humans and automated systems in ATM.	International Journal of Industrial Ergonomics, Vol. 39(5)
2010	SESAR Safety Decision-Making: Lessons from Environmental, Nuclear, and Defense Modeling	Peter Brooker	Lessons from environmental, nuclear, and defense modeling applied to SESAR security decision-making processes.	Safety Science
2012	Situation Awareness in the NextGen Air Traffic Management System	Dan Vu Chiappe, Kim-Phuong L. Vu, Tom Strybel	NextGen systems: operations, information management, pilot–ATC interactions.	International Journal of Human–Computer Interaction, Vol. 28(1–3), pp. 140–151
2013	Tracking of Non-Cooperative Airborne Targets Using ADS-B Signal and Radar Sensing	Ming-Shih Huang, Ram M. Narayanan, Yan Zhang, Arthur Feinberg	Aircraft tracking tech with ADS-B and radar in NextGen infrastructure.	International Journal of Aerospace Engineering, Wiley / OALib
2025	SESAR Innovation Pipeline: Air Traffic Management Research and Innovation: 2024 Highlights	SESAR 3 Joint Undertaking	Highlights from SESAR R&D activities in 2023 and strategic innovation priorities for 2024–25 under SESAR Innovation Pipeline	SESAR Innovation Pipeline report (2025 publication)

Source: (Created by the researcher)

5.3. Method, Data Collection and Analysis

The document analysis method was used in the study. This method is a method of examination conducted especially on texts and written documents. In this context, the method was used to understand the content of the documents examined, collect data, obtain in-depth information on a specific subject and seek answers to the research question of this study. The form of the method was chosen as context analysis. This analysis helped to place the documents examined within a broader framework of meaning. In this sense, the documents were read carefully, thematic categories were created and how these categories were processed in the text of the study was examined. In the study, since the phenomena examined throughout the study consisted of interrelated information, the data was collected by examining the documents. The interpretation of this data was presented with a systematic approach. Within the scope of the method and qualitative data in question, the research has reached findings in line with two separate premises. The findings in the first part are the findings obtained from SESARJU documents. In the second of these findings, the ''CACAVU Model''that will reveal the uniqueness of the research will be put forward for the first time in the literature. In the first part, operational activities will be explained and the harmonization of these activities will be justified. In the second part, a new generation model that will facilitate this harmonization will be proposed.

5.4. Findings and Interpretation

5.4.1. Operational Activities and Reasons for Harmonization

GANP is a global aviation management plan developed by ICAO (SESAR Joint Undertaking, 2024). The aim is to improve air traffic management and enhance aviation safety worldwide. GANP provides a roadmap to make air transportation more efficient, safe, and environmentally friendly. Establishing and maintaining GANP is a tool that allows the United States and Europe to promote and support modernization by aligning their plans and global approaches with those of other parts of the world. The primary goal of the United States and Europe is to ensure that the language of GANP is broad enough to encompass the needs of NextGen and SESAR, while also allowing for regional and national implementation (Federal Aviation Administration, 2024).

''Aviation System Blocking/Limiting Updates'' (ASBU) are a series of innovative measures developed as part of GANP , which progressively provide modernization in air traffic management (SESAR Joint Undertaking, 2024). ASBUs provide targets organized in blocks aimed at improving specific areas in air traffic management. These blocks can be implemented according to the needs, resources and capabilities of each state and region. ASBUs provide measurable operational performance improvements organized as flexible and scalable building blocks, modules and elements. These elements can be introduced as needed and implemented by each state and/or region based on their own needs, capabilities and resources.

In addition, standards development organizations in the USA and Europe are jointly carrying out standard development work for the aviation telecommunication network using the internet protocol suite (SESAR Joint Undertaking, 2024).

Discussions are ongoing between the two parties to develop a joint strategy that will provide a holistic view of surveillance infrastructure needs and capabilities. Strategies to meet surveillance infrastructure needs could coordinate potential new surveillance technological capabilities and related applications between NextGen and SESAR.

Again, for both parties, the application of ''Automatic Dependent Surveillance-Broadcast'' (ADS-B) [**]may be the focal point of a new cooperation (SESAR Joint Undertaking, 2024).

One of these strategies is ICAO's ''Information Management Panel'' (IMP). This strategy will provide a US-EU harmonization and interoperability perspective on issues such as roles, required standards, and service management requirements within the global SWIM community.

Today, aviation infrastructures around the world connect major airports, secondary airports, vertiports and heliports to a multimodal transportation network. Passenger and cargo infrastructure, services, operators, aircraft, airports, ground handling and military units are integrated into relatively coherent multimodal networks. Shared information platforms and new information technology concepts have facilitated planning and decision-making processes. Passenger access to airports and uninterrupted door-to-door services have increased. Airport design, processes and services are based on new and efficient concepts and are carried out with operations that are resistant to possible disruptions. Similarly, automation levels are enabling unmanned flights to become widespread and paving the way for new aviation applications. Air traffic management has also benefited from these developments.

Another notable breakthrough is trajectory management. Trajectory management aims to improve air traffic operations and, in particular, increase capacity predictability for airline users and all users of the air traffic management system.

Four-dimensional (4D) trajectory management is a precise definition of the aircraft's route, including the current flight path obtained from the flight plan (latitude, longitude, altitude) as well as the time element. 4D trajectory management allows the planning of a selected route to be flown in a specific

[**] An advanced surveillance technology that combines an aircraft's positioning source, aircraft avionics, and ground infrastructure to create an accurate surveillance interface between the aircraft and the air traffic tower.

time period, while ensuring a certain level of safety for airspace users and taking into account weather conditions (SESAR Joint Undertaking, 2024).

An important element of the 4D orbit management concept is FF- ICE . This element ensures the exchange and distribution of information. This is where NextGen and SESAR coordinate work in this area by collaborating with global partners in the field of 4D orbit management and FF- ICE.

The common navigation systems roadmap is also being updated to align with the current capabilities and future strategies of NextGen and SESAR. This roadmap describes planned developments regarding the sustainability and evolution of ground-based and satellite-based navigation infrastructure to support ''performance-based navigation'' (PBN) and precision approaches in both regions (SESAR Joint Undertaking, 2024).

Finally, after the operational activities and the reasons for harmonization are explained, the issues that will ensure harmonization will be emphasized. Before explaining this new model, it is essential to introduce the ''concept of interoperability'' (Chiappe vd., 2012). The concept of interoperability†† is the ability of different systems, organizations or technologies to work effectively with each other. This means that data and information can be shared seamlessly and function in a harmonious way to achieve common goals. In aviation, this understanding (interoperability) is vital to ensure that air traffic management systems, aircraft, ground services and technologies in different regions or countries can communicate and work in a unified manner. This helps to increase efficiency, safety and performance in air transportation operations (SESAR Joint Undertaking, 2024). The main elements of interoperability in aviation are:

I. Communications: The ability of systems to exchange data, for example air-ground communication or data sharing between aircraft through air traffic control.

II. Navigation: Compatibility of different navigation systems, for example global navigation satellite systems (GNSS) and performance-based navigation (PBN).

III. Surveillance: Integration of systems such as ADS-B (Automatic Dependent Surveillance Broadcast) and radar allows for common situational awareness.

IV. Procedures: Harmonization of operational procedures across regions ensures smooth operation of air traffic flow and standardized responses in various situations.

5.4.2. ''Is Rational Interoperability Possible?'': CACAVU Model

According to the research; a series of innovation portfolios are required for the USA and Europe to offer the world a digital and compatible sky in air traffic. A new model created from the initials of the elements in this portfolio in English will be examined in this part of the research. The model presented is '' Connected Air Traffic Management'', '' Autonomy in Air-Ground Integration'', '' Capacity -on-Demand '', ''AI in Aviation '', '' Virtualisation and It consists of the elements of ''Cyber-Secure Data Sharing '' and ''Urban Mobility ''.

†† The concept is frequently used in the literature as " interoperability ".

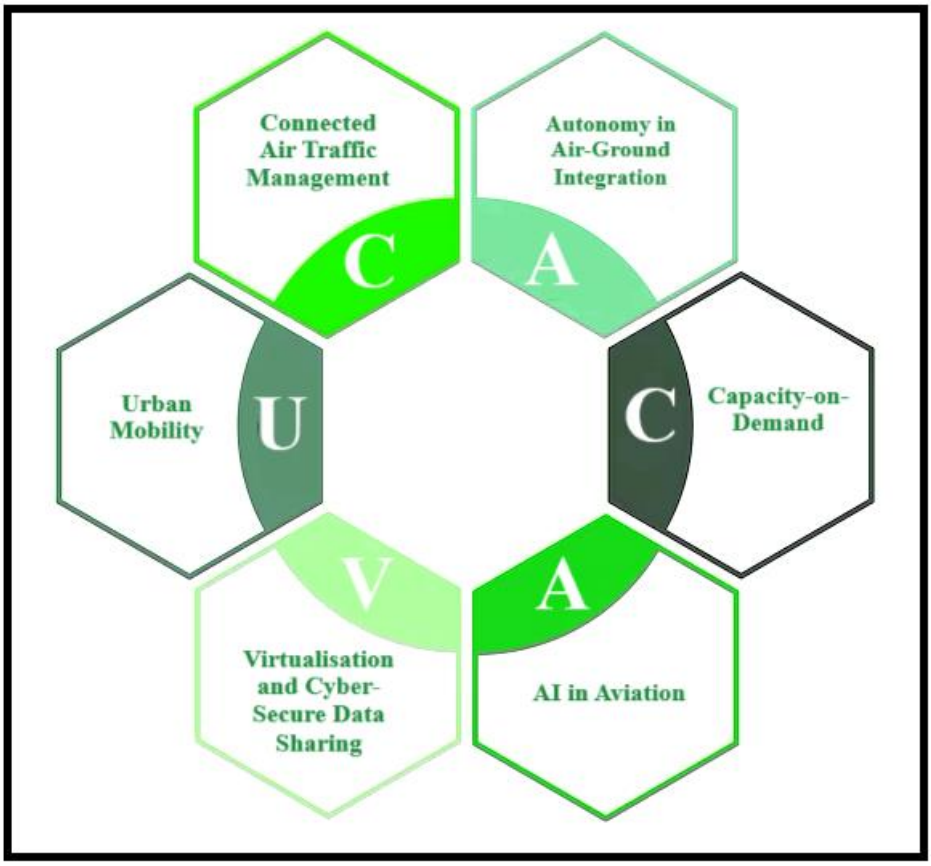

Figure 4. ''CACAVU'' Model

Source: (Created by the researcher)

The elements of the model can be expressed in our language as; ''Connected Air Traffic Management, Independence in Air-Ground Integration, Capacity on Demand, Virtualization and Cyber Secure Data Sharing, Artificial Intelligence in Aviation, Urban Mobility''. In this section, it is useful to explain the details of these elements. The air traffic management system of the future will undoubtedly provide hyper-connectivity between all stakeholders via fixed and/or mobile networks with high bandwidth and low latency. Highly automated systems with multiple actors will interact seamlessly with each other, making the system both scalable and more secure than today. The second element is ''Autonomy in Air-Ground Integration''. A progressive transition to autonomous flight supported by autopilot technologies requires more advanced integration of the infrastructures. This integration will enable the infrastructure to function as a digital twin of the aircraft.

Another element is ''Capacity on Demand''. Here, technology will enable dynamic configuration of capacity services on demand to ensure that air traffic services continue smoothly at pick times. The element ' Virtualization and Cyber Secure Data Sharing' concerns the flawlessness of the service provided in air traffic. Service provision will be made independent of the physical infrastructure, and thus air traffic and data service providers will be able to integrate their operations securely to the places needed beyond national borders. While explaining the ''Artificial Intelligence in Aviation'' element, it is necessary to explain the concept that expresses many computer technologies. In fact, this element has already entered our lives with its applications that are in the infancy stage. In this context, the aviation infrastructure of the future will be more data-oriented. Thanks to the application of machine learning, deep learning and big data analytics in air traffic, it will be possible to design a smarter and safer system that constantly analyzes the air traffic management environment and even learns from this environment. The last element is the ''Urban Mobility'' element. In the digital sense,

the domestic traffic management systems of countries will provide safe and secure integration of aircraft in the airspace (especially in urban areas). This system understanding should consider existing aircraft, new aircraft and autonomous operations. One of the most challenging usage scenarios of this element is the concept of ‘‘urban air mobility’’, which is expected to provide development of autonomous technologies in many areas. The development of this mobility depends on the development of vehicles with vertical take-off and landing (VTOL) capabilities.

6. Conclusion and Recommendations

NextGen and SESAR are working together on a new effort to introduce new or updated technologies and procedures to global audiences and demonstrate the performance gains that can be achieved. The scope of these demonstrations covers all phases of flight (planning, takeoff, cruise and arrival), but today’s trials are focused specifically on flights between North America and Europe. These activities include accelerating projects with shared goals, accelerating the development of certain technologies and operational procedures, and supporting the implementation of ICAO’s GANP and ASBUs by contributing to global harmonization.

It is important to see the benefits that new technologies and capabilities can provide in terms of compatibility, operational and financial efficiency, and performance gains such as environmental and safety. These globally focused introductions facilitate the implementation of technologies, operational capabilities and procedures. This type of cooperation provides a consistent life cycle approach. The ‘‘CACAVU Model’’, which was first put forward in this study for the healthy execution of this life cycle, can benefit stakeholders and researchers. Thanks to the clear determination of the coordination requirements expected to be provided in the partnership , risks for stakeholders in the implementation process will be reduced. One of the meetings that will reduce these risks; ‘‘SESAR JU Annual Conference 2025’’ will be held in Brussels. Here, the launch of the ‘‘European Air Traffic Master Plan’’, which sets out the vision of making Europe the most efficient and environmentally friendly flight area in the world and indicates an important vision for European aviation, will also be held. It may be beneficial for stakeholders from both the European and US aviation ecosystems to participate in such meetings. On such days, discussions of digitalization and new technologies can be expected.

Unlike the individual studies on NextGen and SESAR in the literature, this study focuses on the integration of these two major aviation modernization initiatives, specifically addressing the operational harmonization and global cooperation perspectives in transatlantic air traffic in a holistic manner. The study's most significant innovation is its introduction of the "CACAVU Model," a previously unseen framework, providing a comprehensive framework for ensuring technological and operational harmonization in air traffic management across the lifecycle. This model aims to mitigate potential risks during implementation by clearly defining coordination needs among the parties, thus facilitating the effective use of systems by stakeholders on a global scale. Furthermore, the study comprehensively examines NextGen and SESAR's joint projects contributing to ICAO's GANP and ASBU programs, as well as practical trials specifically for transatlantic flights, thus establishing a significant bridge for translating theoretical knowledge into practice.

The significance of the study is that it provides a concrete roadmap for the harmonization and global integration of air traffic systems in light of the increasing digitalization and sustainability goals in the aviation sector. In this context, it is recommended that stakeholders be encouraged to follow and contribute to developments in innovative technologies and digitalization by emphasizing the importance of international platforms such as the "SESAR JU Annual Conference" to be held in 2025. Future studies recommend monitoring field implementations of the "CACAVU Model" and conducting performance evaluations, as well as exploring integration opportunities with other regional modernization programs. Limitations of this study include the lack of broad practical applicability of the "CACAVU Model" and the possibility that simulations based on existing data may not fully reflect actual operational conditions. Therefore, the model requires further field testing and evaluation with broader stakeholder participation.

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