Doc 9750

Global Air Navigation Plan

~~Seventh edition~~
Eighth edition

INTERNATIONAL CIVIL AVIATION ORGANIZATION

EXECUTIVE SUMMARY

The powerful socio-economic driver represented by the aviation ~~industry~~ sector is facing a variety of challenges. Air traffic, with its movement of passengers and goods around the world, is expected to double within the next 15 years. At the same time, new demands on the aviation system, emerging technologies, innovative ways of doing business and the shifting human role are bringing not only challenges but also opportunities that call for an urgent transformation of the global air navigation system so that aviation can continue to boost social well-being worldwide.

Acknowledging that aviation has entered a new era and that a good future is not an extrapolation of the past, but emerges to face the challenges of the future, the ~~seventh~~ eighth edition of the Global Air Navigation Plan (GANP) responds to these challenges.

In aviation's fast and ever-changing landscape, achieving sustainable growth of international air transport strongly relies on a high-performing and seamless global air navigation system. The GANP brings the aviation community together to achieve an agile, safe, secure, sustainable, high-performing and interoperable global air navigation system.

Developed in collaboration with and for the benefit of stakeholders, the GANP is a key contributor to the achievement of ICAO's Strategic Objectives and has an important role to play in supporting the United Nations 2030 Agenda for Sustainable Development. A key goal that relates to the GANP is Sustainable Development Goal (SDG) 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. In addition to developing the GANP, ICAO has developed global plans for the specific areas of safety and security: the *Global Aviation Safety Plan* (GASP, Doc 10004) and the *Global Aviation Security Plan* (GASeP, Doc 10118). These three global plans are complementary.

The content of the GANP is organized into a multilayer structure with each layer tailored to different audiences. This allows for better communication with both high-level and technical managers with the objective that no State or stakeholder is left behind. The four-layer structure is made up of global (strategic and technical), regional and national levels, and provides a framework for alignment of regional, sub-regional and national plans. The four-layer structure facilitates decision-making by providing stable strategic direction for the evolution of the air navigation system and, at the same time, timely relevance in the technical content.

In addition, to enable different stakeholders to access and use relevant information, all four levels of the GANP have been made available via a printer-friendly, interactive, web-based platform – the GANP Portal (https://www4.icao.int/ganpportal). The platform ensures a common entry point to, and consistency between, all four levels of the GANP.

Global strategic level

The global strategic level is presented as an electronic document, written in executive language and available in the six working languages of ICAO. It provides high-level strategic direction for decision-makers to drive the evolution of the global air navigation system.

The vision of this document is the creation of a globally interoperable air navigation system, as well as a proactive, integrated and common approach to emerging challenges and opportunities stemming from aviation and technological trends. The evolution, driven by this vision and reflected in the conceptual roadmap, will create a high-performing global air navigation system that will meet the ever-growing expectations of society and reduce global disparities. The conceptual roadmap is aimed at transforming the air navigation system based on strengths and opportunities, rather than to simply improve it, by providing a more holistic approach to its evolution.

The realization of this vision requires strong commitment and investment from all members of the aviation community. The global air navigation system is becoming more complex as it accommodates new demand. Transformation is, therefore, not an end goal in itself, but the way to achieve the vision. The strategy for transforming the air navigation system responds not only to performance ambitions but also to the ambitions of many States and regions wanting to make increased use of available and emerging technologies.

The aviation industry needs to ensure its position at the forefront of innovation by adopting an increasingly cross-domain and global perspective. There is much at stake for the global economy and for citizens if the modernization of the global air navigation system does not continue.

Global technical level

The realization of the global air navigation system transformation relies on technical managers who, with the support of the decision-makers they report to, continue to improve the air navigation system. While one size does not fit all and there is no set end date for the evolution of the air navigation system, continuous improvements will ensure that the system adapts to global, regional and local opportunities and challenges in a timely and orderly manner.

Derived from the global strategic level, the global technical level is designed to support technical managers in planning the implementation of basic services and new operational improvements in a scalable and cost-effective manner and according to specific operational and performance needs, while ensuring interoperability of systems and harmonization of procedures.

Regional and national levels

The regional and national levels of the GANP ensure consistency from the development of operational improvements to their implementation. Such levels provide the global aviation community with a common basis for short- and medium-term implementation planning.

The regional level addresses regional and subregional performance and operational needs, differences, constraints and opportunities through the ICAO Regional Air Navigation Plans and other regional initiatives aligned with the global strategic and technical levels.

The national level focuses on State planning. The development of national air navigation plans, in coordination with relevant stakeholders and in alignment with regional and global plans, is a strategic part of the State's national aviation planning framework and is crucial to achieve the common vision being developed in the GANP.

The leadership demonstrated by the creation of this Plan and ICAO's vision contained therein ensure that there will be a relevant air navigation evolution for all stakeholders and that no country will be left behind.

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GLOSSARY

DEFINITIONS

Air navigation system. A system that supports the safe and orderly development of international civil aviation through the collaborative integration of humans, information, technology, facilities and services. Within the technical scope, the system comprises aerodrome operations, air traffic management, meteorology, aeronautical information and search and rescue services supported by air, ground and space-based communications, navigation and surveillance (CNS) capabilities. Within the operational scope, the system encompasses en-route to en-route operations to integrate airport operations and flight turnaround. Within the community scope, the system comprises all stakeholders involved in the provision of, or requiring the use of, air navigation resources.

Air navigation service providers (ANSPs): Within the context of the GANP, ANSPs refer to all stakeholders involved in the provision of air navigation services in the areas of aerodrome operations, air traffic management, meteorology, aeronautical information and search and rescue.

Airspace users. Organizations or individuals operating flights using aircraft and/or vehicles in the airspace. Three classifications of airspace users are considered in the GANP:

a) ICAO-compliant manned flight operations (the largest segment);
b) ICAO non-compliant manned flight operations; and
c) flight operations of unmanned aircraft systems (UAS).

ICAO-compliant manned flight operations are those conducted in accordance with ICAO provisions (Standards and Recommended Practices (SARPs) and Procedures for Air Navigation Services (PANS)). ICAO-compliant airspace users include:

a) all civil aircraft operators (i.e. those engaged in commercial air transport (passenger, mail and cargo services), aerial work, air taxi operators, business aviation, private air transport, sporting and recreational aviation, etc.); and
b) the portion of States' users operating State aircraft using civil air traffic rules.

ICAO non-compliant manned flight operations are those conducted by State aircraft which cannot comply with ICAO provisions for operational or technical reasons.

Flight operations of unmanned aircraft systems (UAS), a growing segment of airspace users, include both civil and military applications of UAS technology. In certain situations, UAS technology is seen as a more cost-effective solution than the use of conventional aeroplanes or helicopters.

~~In some circumstances, using UAS proves to be safer and more effective, whereas in other cases it may be the only way to get a job done. However, the operation of civil UAS in the same airspace as that for manned operations is an emerging requirement, and the regulatory framework for such operations is under development.~~

Aviation System Block Upgrade (ASBU) framework. A group of operational improvements and associated performance benefits organized in key feature areas of the air navigation system and scheduled according to time of availability.

Aviation community. All stakeholders involved in the provision of, or requiring the use of, air navigation resources, including:

a) ICAO and other aviation standards-making organizations;

b) States in the role of regulators, airspace sovereigns and sometimes ANSPs;

c) the aerodrome community;

d) ANSPs, including, information service providers;

f) airspace users;

g) State aviation;

h) aircraft and equipment manufacturers;

i) research and development organizations; and

j) international organizations including professional staff organizations.

Aviation system. A system that comprises all activities, economic and non-economic, related to air transportation.

Basic building block (BBB) Framework. Framework outlining the foundation of a robust air navigation system. It identifies basic services to be provided for international civil aviation in accordance with ICAO Standards. These basic services are defined in the areas of aerodromes, air traffic management, search and rescue, meteorology and information management. The BBB framework also identifies the end users of these services as well as the assets (CNS infrastructure) that are necessary to provide them.

Conceptual roadmap. A series of transformational operational changes providing a holistic approach to the evolution of the air navigation system, based on its strengths and opportunities.

Key performance area (KPA). A way of categorizing performance subjects related to high-level ambitions and expectations. ICAO has defined 11 KPAs: safety, security, environmental impact, cost effectiveness, capacity, flight efficiency, flexibility, predictability, access and equity, participation by the ATM community and global interoperability.

Performance ambition. A qualitative statement providing global priorities regarding the evolution of the performance of the global air navigation system. The performance ambition should not be seen as a target against which performance is continuously monitored and reported, but rather a catalyst for change. It is performance-oriented, time-bound and challenging, and at the same time, realistically considers the public environment, timing and available resources.

Performance objective. A qualitative and focused statement that defines a desired trend from today's performance (e.g. improvement).

ABBREVIATIONS AND ACRONYMS

ANC	Air Navigation Commission
ANSP	Air navigation services provider
ASBU	Aviation System Block Upgrade
ASBU PPT	ASBU Panel Project Team
ATM	Air traffic management
BBB	Basic building block
CNS	Communications, navigation and surveillance
FIR	Flight information region
GA	General aviation
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan
GASeP	Global Aviation Security Plan
GATMOC	Global Air Traffic Management Operational Concept
GMVT	GANP Multidisciplinary Vision Team
ICAO	International Civil Aviation Organization
KPA	Key performance area
KPI	Key performance indicator
PANS	Procedures for Air Navigation Services
PIRG	Planning and Implementation Regional Group
RASG	Regional Aviation Safety Group
SARPs	Standard and Recommended Practices
SDG	Sustainable Development Goal
UAS	Unmanned aircraft system

CHAPTER 1: INTRODUCTION

1.1 GENERAL

1.1.1 Aviation is an integral part of society, connecting people and transporting goods worldwide, and an important driver of economic growth and sustainable development, improving the standard of living of people around the world through the safe and reliable operation of over ~~120,000~~ 96,577[1] flights every day. Forecasts ~~confirm~~ predict robust air traffic growth within the next 2~~0~~ 5 years owing to positive economic, political and societal changes.[2]

1.1.2 The achievement of sustainable growth within the international air transport system strongly relies on a high-performing and seamless global air navigation system. The global air navigation system supports the safe and orderly development of international civil aviation through the collaborative integration of humans, information, technology, facilities and services. Within the technical scope, the system comprises aerodrome operations, air traffic management, meteorology, aeronautical information and search and rescue services supported by air, ground and space-based communications, navigation and surveillance (CNS) capabilities. Within the operational scope, the system encompasses en-route to en-route operations to integrate airport operations and flight turnaround. Within the community scope, the system comprises all stakeholders involved in the provision of, or requiring the use of, air navigation resources.

1.1.3 A performance-driven, service-oriented and technologically advanced global air navigation system is therefore critical to achieve greater connectivity of passengers and goods, ensuring the sustainability of the growing aviation sector worldwide. In addition to the fundamental aviation performance principles of safety, security and environmental and economic sustainability, there are several other performance requirements that must be satisfied to meet the needs of society. As such, the need for performance should drive the evolution of the air navigation system.

1.1.4 ICAO's ~~objective~~ vision is to achieve ~~sustainable growth of the global civil aviation system~~a safe, secure and sustainable international civil aviation system that connects the world for the benefit of all nations and people. To this end, ICAO sets the necessary standards and policies to ensure the safe and orderly development of international civil aviation by serving as a global forum among its 193 Member States.[3] With the GANP, ICAO brings the aviation community together to achieve an agile, safe, secure, sustainable, high-performing and interoperable global air navigation system.

1.2 What is the GANP?

1.2.1 The GANP is an important planning tool for setting global priorities to drive the evolution of the global air navigation system and ensure that the vision of an integrated, harmonized, globally interoperable and seamless system becomes a reality.

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[1] https://aviationbenefits.org/media/nokgjtbg/abbb2024_summary.pdf
[2] https://www.icao.int/sustainability/WorldofAirTransport/Pages/the-world-of-air-transport-in-2023.aspx ~~https://www.icao.int/sustainability/Pages/eap-fp-forecast-scheduled-passenger-traffic.aspx~~
[3] ~~https://www.icao.int/about-icao/Council/Pages/vision-and-mission.aspx~~ ICAO-Strategic-Plan-2026-2050-V2.pdf

1.2.2 Developed in collaboration with and for the benefit of stakeholders,[4] the GANP is a key contributor to the achievement of ICAO's Strategic Objectives[5] and plays an important role in supporting the United Nations SDGs.[6]

1.2.3 The GANP's content is organized into four levels, as shown in Figure 1. This allows for better communication with both high-level and technical managers and enables the different stakeholders to access and use the information at the level of detail that is most relevant to their area of interest. In this regard, the global strategic level, the GANP's highest level, addresses policymakers and executives, while the target audience of the GANP's subsidiary levels are subject-matter experts.

1.2.4 This electronic document represents the strategic angle of the GANP at the global strategic level. Its main purpose is to provide decision-makers with a strategic direction to drive the evolution of the global air navigation system for 2040 50 and beyond by outlining a vision, the associated performance ambitions and a conceptual roadmap. The global strategic level also ensures the stability of the GANP within the defined timeframe and provides a clear view of the performance and technical frameworks described at the global technical level, for which it serves as the reference.

1.2.5 The global technical level includes two technical frameworks, the basic building blocks (BBBs) and Aviation system block upgrades (ASBUs). It also includes a, with its associated performance framework, which includes identifies performance objectives and key performance indicators (KPIs). The BBB framework outlines the foundation of a robust air navigation system. It can also be viewed as the commitment of the State, under the *Convention on International Civil Aviation* (Doc 7300), to provide essential air navigation services for the safe and orderly conduct of international civil aviation.

1.2.6. With the implementation of the BBBs, an air navigation system will be able to deliver the essential services to be provided for international civil aviation. The subsequent performance of these air navigation systems can then be improved through the application of the ASBU framework. The ASBU framework drives the evolution of the global air navigation system towards the achievement of the identified performance ambitions[7] by defining operational improvements and associated performance benefits, derived from specific concepts of operations defined in the different evolutionary steps of the conceptual roadmap.[8] Once validated and made available for deployment, these operational improvements support the adoption of a holistic, performance-based approach towards modernizing the air navigation system in a cost-effective manner. The adoption of a globally harmonized performance management process for the modernization of the air navigation system is necessary to align global, regional and national plans.

1.2.7 The two remaining regional and national levels of the GANP ensure consistency from the initial development of operational improvements to final implementation. These levels provide the global aviation community with a common basis for short- and medium-term implementation planning. The regional level of the GANP addresses regional and subregional performance and operational needs, differences, constraints and opportunities through the ICAO regional air navigation plans and other regional initiatives aligned with the global levels. The national level of the GANP, under the responsibility of the State, focuses on national planning. The development by States, in coordination with relevant stakeholders, of Air Navigation Plans as a strategic part of their national aviation planning frameworks and their alignment with relevant regional and global plans are crucial to achieving the common vision being developed in the GANP.

[4] See Chapter 2
[5] https://www.icao.int/about-icao/Council/Pages/Strategic-Objectives.aspx
[6] https://www.un.org/sustainabledevelopment/
[7] See Chapter 5
[8] See Chapter 6

1.2.8 All four levels of the GANP are available for interactive consultation via the GANP Portal.

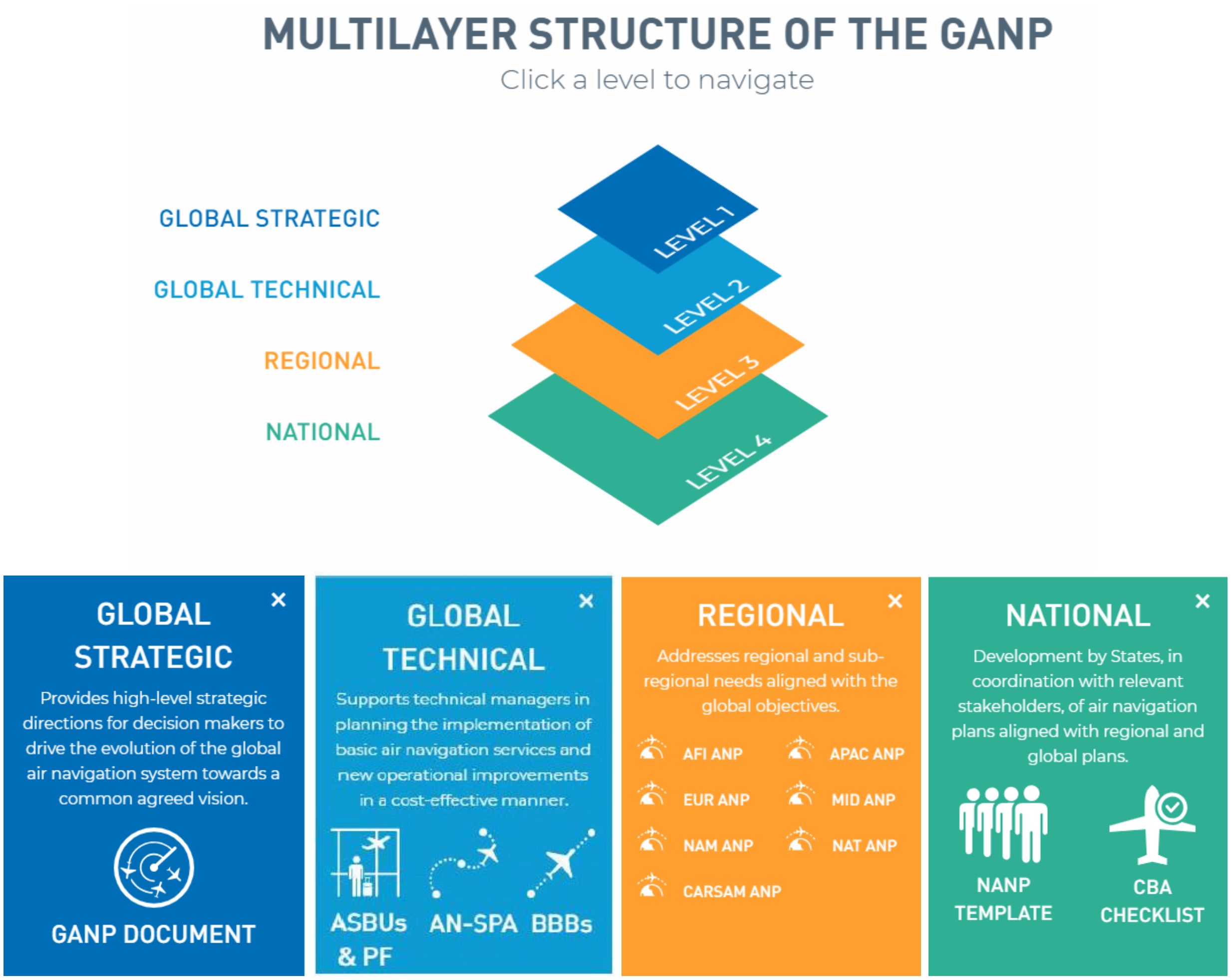


Figure 1: The multilayer structure of the GANP

1.3 GANP MAINTENANCE PROCESS

1.3.1 To provide stable strategic direction for the evolution of the air navigation system while ensuring timely relevance, each level within the multilayer structure of the GANP is subject to a different maintenance process. The strategic directions within the GANP are stable and not subject to change in the short term. This facilitates a smooth transition towards the improved implementation of interoperable and harmonized air navigation planning around the world. However, it is essential that the technical content of the GANP evolves over time in response to new technologies, different operational environments, new types and growing volumes of air traffic demand, and emerging priorities.

1.3.2 The global strategic level of the GANP is reviewed prior to each triennial session of the ICAO Assembly, and is updated as necessary.

1.3.3 Following the endorsement of the fifth edition[9] of the GANP by the 39th Session of the ICAO Assembly in 2016, a GANP Multidisciplinary Vision Team (GMVT) was established to support ICAO in

[9] https://www.icao.int/airnavigation/pages/ganp-resources.aspx

the development of the GANP's global strategic level. This team, made up of executives of key industry and research and development stakeholders, developed the vision, performance ambitions and conceptual roadmap presented to the Thirteenth Air Navigation Conference (AN-Conf/13), held from 9 to 19 October 2018 in Montréal, Canada. The Conference welcomed these initiatives whilst highlighting that commercial airspace vehicles should be considered as spacecraft rather than aircraft.

1.3.4 At the global technical level, the multidisciplinary ASBU Panel Project Team (ASBU PPT), composed of independent professionals from relevant ICAO expert groups, was established to support ICAO in updating the ASBU framework. The air navigation system is constantly evolving. In updating the ASBU framework, it was highlighted that, in order for the framework to remain meaningful, it was necessary to define a change management process to keep the framework's content up to date and ensure transparency by tracking the proposals, evaluation, approval and implementation of any amendment thereto.

1.3.5 The ASBU framework is therefore reviewed and updated as follows:

a) a change to the ASBU framework can be submitted to ganp@icao.int by any member of the aviation community by filling-in the template available on the GANP Portal with the proposed changes shown as a markup of the original text together with the rationale and impact assessment for the change. Supporting documentation should also be submitted, if applicable;

b) the ICAO Secretariat, with the support of the ASBU PPT, will conduct an initial evaluation of the proposal and prepare it for further consideration;

c) if the proposal relates to ICAO Standards and Recommended Practices (SARPs) or Procedures for Air Navigation Services (PANS), the Air Navigation Commission (ANC) will review and approve, modify or reject the proposal in accordance with the established process. If the proposal is unrelated to SARPs or PANS, the ASBU PPT and ICAO Secretariat will review and accept, modify or reject the proposal; and

d) if the proposal, as amended through the above steps, is approved or accepted, the ICAO Secretariat will include it in the ASBU framework within the following six months. If the proposal is rejected, the ICAO Secretariat will notify the originator and provide the rationale for refusal.

1.3.6 The BBB framework will take into account amendments to ICAO air navigation SARPs and PANS and will be updated by the Secretariat on a biannual basis.

1.3.7 The AN-Conf/13 requested ICAO to establish a group of performance experts to continue to expedite the work on performance related to the GANP (referred to in Recommendation 4.3/1 —Improving the performance of the air navigation system), due to its criticality for the establishment of a globally harmonized performance management process for the modernization of the air navigation system.

1.3.8 At the regional level of the GANP, it is the responsibility of ICAO regional offices to coordinate the review and update ICAO regional air navigation plans. Regional offices follow a well-established amendment process, which was approved by the ICAO Council on 18 June 2014 and is detailed in Volume I, Part 0, Appendix A of any regional air navigation plan.

1.3.9 The national level of the GANP is the responsibility of States. States are encouraged to develop and implement policies and procedures specifying the interval and methodologies for updating their national air navigation plans.

1.3.10 As recommended by the AN-Conf/13, ICAO has~~is~~ established~~ing~~ a GANP study group to steer and manage the teams that are reviewing and updating the GANP.

1.3.11 The ANC reviews the GANP as part of its regular work programme and consults, as necessary, with States and non-governmental organizations on proposed amendments. The consultation is conducted via the State letter process or, alternatively, through an Air Navigation Conference or High-level Safety Conference. The GANP is then presented to the Council for approval. After approval by the Council, the GANP is presented to the following ICAO Assembly for endorsement by Member States.

1.4 RELATIONSHIP WITH OTHER DOCUMENTS

1.4.1 The *Global Air Traffic Management Operational Concept* (GATMOC, Doc 9854) presents a vision for a common operational concept of an integrated, sustainable, harmonized and globally interoperable air traffic management (ATM) system. The operational concept is independent of technology and is a statement of the envisaged "what". The timely development of a sustainable aviation system based on the GATMOC requires a collaborative, synchronized and maintained planning tool such as the GANP. Hence, the vision, performance ambitions and conceptual roadmap embedded in the GANP refer directly to the GATMOC. The GATMOC's companion manuals, which include, inter alia, the *Manual on Air Traffic Management System Requirements* (Doc 9882) and the *Manual on Global Performance of the Air Navigation System* (Doc 9883), will continue to evolve and provide the sound conceptual basis and focus for an integrated, sustainable, harmonized and globally interoperable air navigation system.

1.5 RELATIONSHIP WITH OTHER GLOBAL PLANS

1.5.1 Key to the operational concept is a clear statement of the expectations of the aviation community. These expectations are defined in 11 key performance areas (KPAs)[10] and stem from efforts to document the end user's requirements. Although all these areas are equally important, as they are interrelated and cannot be considered in isolation, some areas are more visible to society than others. The 11 KPAs are listed in Figure 2. The GANP considers all these areas through the performance ambitions outlined in Chapter 5.

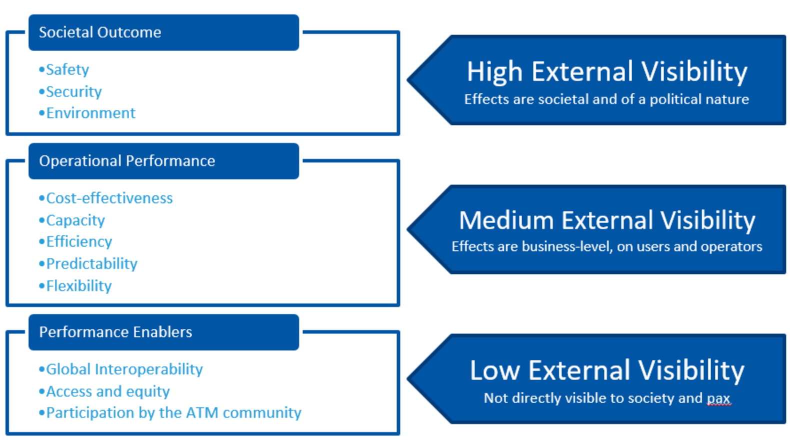


Figure 2: The 11 KPAs of the GANP

[10] *Manual on Global Performance of the Air Navigation System* (ICAO Doc 9883)

1.5.2 The public's perception of safe air travel is key to the prosperity of the aviation sector, which is why, in addition to developing the GANP, ICAO has developed global plans related to safety and security: the GASP (Doc 10004) and the GASeP (Doc 10118).

1.5.3 Safety is critical when planning the implementation of air navigation operational improvements. To determine if these improvements can be implemented in a safe manner, a safety risk assessment provides information to identify hazards that may arise from, for example:

a) any planned modifications in airspace usage;

b) the introduction of new technologies or procedures; or

c) the decommissioning of older navigational aids.

1.5.4 A safety risk assessment also enables the assessment of potential consequences. Based on the results of a safety risk assessment, mitigation strategies may be implemented to ensure that an acceptable level of safety performance is maintained. Any operational improvement should be implemented only on the basis of a documented safety risk assessment. The GASP therefore supports the GANP by providing States and service providers with the tools to implement a safety management approach through State safety programmes (SSPs) and safety management systems.

1.5.5 Fatalities resulting from acts of unlawful interference also affect the public's perception of aviation safety. The GASeP provides a foundation for States, industry, stakeholders and ICAO to work together with the common goal of enhancing aviation security worldwide. Its aim is to promote a security culture and improve oversight. The cumulative improvements to aviation security globally enhance the safety, facilitation and operational aspects of the international civil aviation system.

1.5.6 The GANP, through its conceptual roadmap and operational improvements detailed in the technical frameworks, supports the GASP and GASeP by enhancing the safety and security aspects of the air navigation system, as reflected in the performance ambitions.

CHAPTER 2: ROLES AND RESPONSIBILITIES

2.1 GENERAL

2.1.1 All stakeholders, whether traditional or emerging, aim to move passengers and goods from place to place without delay, at minimum cost and in a safe, secure and environmentally sustainable way. For this to be successful, it is imperative that such stakeholders take accountability of their roles and responsibilities within the respective GANP levels.

2.2 GANP STAKEHOLDERS ─ ROLES AND RESPONSIBILITIES

2.2.1 GANP stakeholders include all members of the aviation community.

2.2.2 States

2.2.2.1 States contribute to the development of the GANP by providing expertise on local and regional matters and insight into the operational considerations required to meet ICAO provisions.

2.2.2.3 States contribute to the implementation of the GANP by developing national air navigation plans to ensure the provision of essential air navigation services for international civil aviation and the modernization of their air navigation system based on local performance and operational needs, taking into consideration regional requirements. In addition, States contribute to the implementation of the GANP by sharing best practices and lessons learned from implementation challenges, performing cost-benefit analyses and assessing environmental impact, human performance and safety.

2.2.2.4 Moreover, States provide a clear and stable regulatory framework compliant with ICAO provisions to ensure that the aviation community can operate safely and efficiently. At the same time, this regulatory framework is flexible, agile and scalable enough to allow for the innovation required to meet the needs and responsibilities of aviation.

2.2.3 ICAO and other aviation standards-making organizations

2.2.3.1 The evolution of the air navigation system requires orchestrated implementation by all participating stakeholders. ICAO serves as a global forum that brings together the aviation community so that it can define a common strategy for the evolution of the global air navigation system at the global strategic level of the GANP.

2.2.3.2 To support air navigation modernization, ICAO provides tools and identifies, at the global technical level of the GANP, which stakeholders need to be involved in the implementation of operational improvements in order to realize the full potential of such improvements.

2.2.3.3 The GANP outlines a performance-based evolution of the air navigation system as ICAO recognizes that regions and stakeholders have varying needs and may therefore have different expectations. To accommodate these varying expectations, the ASBU framework allows for flexible and scalable modernization. However, a globally coordinated approach towards the rationalization, integration and harmonization of air navigation facilities is fundamental to reaping the full benefits of the GANP's implementation.

2.2.3.4 ICAO and other aviation standards-making organizations develop global provisions to ensure the interoperability of systems and harmonization of procedures within the operational improvements described in the GANP. ICAO ensures the timely availability of its provisions through its technical air navigation work programme.

2.2.3.5 At the regional level, ICAO coordinates the review and updating of regional air navigation plans. ICAO also coordinates the activities of Planning and Implementation Regional Groups (PIRGs) to ensure their alignment with the GANP and ensures close coordination between PIRGs and Regional Aviation Safety Groups (RASGs). To verify the effectiveness and rate of operational improvements implementation, ICAO should provides data and tools to support performance and implementation monitoring and facilitates the sharing of relevant information and best practices across regions.

2.2.3.6 At the national level, ICAO encourages States to actively support other States in need of air navigation assistance, facilitates access to resources and technical assistance and promotes capacity-building in different areas of expertise.

2.2.4 PIRGs

2.2.4.1 PIRGS are key to the success of the GANP since they provide the medium-term planning and implementation horizon to States and other stakeholders.

2.2.4.2 PIRGs are responsible for the regional level of the GANP. Based on regional performance and operational needs, differences, constraints and opportunities, PIRGs are responsible for defining regional planning and implementation priorities, aligned with the GANP, through Volumes I, II and III of air navigation plans. They are also responsible for the identification of air navigation deficiencies taking into account the air navigation plans.

2.2.4.3 In Volumes I and II of the air navigation plans, PIRGS define stable (Volume I) and dynamic (Volume II) planning elements related to the assignment of responsibilities to States for the provision of aerodrome and air navigation facilities and services, and the current to medium-term mandatory regional requirements related to aerodrome and air navigation facilities and services to be implemented by States in accordance with regional air navigation agreements, including requirements related to the basic building blocks (BBBs). ~~The two volumes list the essential air navigation services offered to international civil aviation from a regional perspective.~~

2.2.4.4 In Volume III of the air navigation plans, PIRGs identify dynamic/flexible planning elements for modernizing the regional air navigation system, following a performance-based approach. As part of this approach, PIRGs define regional priorities and performance objectives, ~~using~~ linked to the key performance areas (KPAs) and indicators (KPIs) of the GANP, to achieve the global performance ambitions ~~and identify~~ as well as to the operational improvements within the ASBU framework ~~to~~that could be implemented by States, based on ~~regional requirements~~ identified needs at local and national level.

2.2.4.5 Following the change management process highlighted in section 1.3, PIRGs can contribute to the development of the GANP by proposing amendments to the ASBU framework based on lessons learned from their implementation challenges and experience.

2.2.5 The aerodrome community[11]

2.2.5.1 Airport operators support the development of the GANP with the aim of increasing the efficiency of their operations for the benefit of all the stakeholders that they serve, including regulators, airlines, air navigation service providers (ANSPs), passengers and local residents.

2.2.5.2 Airport operators are working closely with international and national regulators so that airports become fully integrated into the air navigation system. Airport operators collaborate by providing information on airport capabilities and operations. Such information supports measures for optimizing and increasing the efficiency of the infrastructure's use. Airport collaborative decision-making has helped airline and airport operators to work together to make the best use of limited infrastructure; the development of fully integrated airport operations centres represents a natural progression towards this goal.

2.2.5.3 Airport operators also contribute to the implementation of the GANP by providing data, forecasts and resources so that the infrastructure and services of the global air navigation system can be optimally designed, developed and operated and can provide sustainable benefits to the communities being served.

2.2.6 ANSPs and information service providers

2.2.6.1 ANSPs are responsible for planning, organizing and efficiently managing the air navigation system so that it achieves its optimum performance. In the context of the GANP, ANSPs refer to all stakeholders involved in the provision of air navigation services in the areas of aerodrome operations, ATM, meteorology, aeronautical information and search and rescue. Although these services are mostly provided by specific, dedicated entities in their areas of responsibility, sometimes, and under the proper regulatory framework, service provision can be delegated to other members of the aviation community.

2.2.6.2 Information and data service providers play a particularly important role in the evolution of the air navigation system. The generation and timely distribution of relevant information and data for the effective provision of air navigation services requires reliable telecommunication networks and databases with accurate and dynamic information. As a result, ANSPs are facing new requirements for managing the use of new digital enablers comprising state-of-the-art technologies.

2.2.6.3 ANSPs work closely with their civil aviation authorities to implement the GANP and fill the gap between the executive and technical levels. This facilitates appropriate, transparent and timely funding for upgrading the infrastructure, system capabilities and provisions necessary for a safe, secure and environmentally friendly air navigation system.

2.2.7 Airspace users

2.2.7.1 Airspace users refer to organizations or individuals operating flights using aircraft or other vehicles in the airspace. This includes ICAO-compliant manned flight operations, ICAO non-compliant manned flight operations, as well as the flight operations of unmanned aircraft systems (UAS).

2.2.7.2 The majority of ICAO-compliant flight operations are commercial. Scheduled airline services provide a worldwide transportation network that supports and sustains itself as an essential enabler for global businesses, tourism and economic growth. In order to sustain such a service, these airlines require air navigation infrastructure that can ensure safe, efficient and sustainable operations, especially in the face

[11] Both airside and landside activities are included in the scope of the GANP.

of increased air traffic growth. As such, airline operators contribute to the GANP by identifying future trends, resulting operational requirements and infrastructure elements needed for sustainable growth.

2.2.7.3 ICAO-compliant flight operations also include general aviation (GA), comprising different areas of air transport from aerial work activities to personal transportation, each with distinct roles and responsibilities under the GANP. GA, including its dedicated airports, has always been the entry point, training ground and source of personnel for both GA and commercial operations supporting the next generation of aviation professionals. The GA community participates in the planning and implementation of operational improvements described in the GANP by providing perspectives on the impact on GA operations so that States and ANSPs can take into account any potential constraints of the operational improvements. More details on GA can be found here: https://www4.icao.int/ganpportal/document/inputGA.

2.2.7.4 ICAO non-compliant manned flight operations include operations conducted by State aircraft that cannot comply for operational or technical reasons. State aviation is discussed separately due to the different roles involved.

2.2.7.5 The GANP is a coalescing framework for new entrants. New entrants differ from legacy aviation in terms of their vehicles, preferred CNS capabilities and requirements, manner of operating and pace at which they innovate. The application of existing aviation protocols constrains the innovation sought by new entrants; national regulators are coping with the latter by developing their own regulations. In this connection, the GANP provides a common point for sharing best practices, standardization efforts and regulatory approaches that are being developed in different States.

2.2.7.6 ANSPs, regulators and new entrants should provide insight into the GANP with respect to ongoing research, development and what is being planned to establish standards and performance requirements for their regular inclusion into non-segregated airspace. New technologies and procedures are expected to provide a starting point for further innovation of the air navigation system.

2.2.8 State aviation[12]

2.2.8.1 One of tThe ~~main~~ stakeholders within the State aircraft operator group is the military. In many cases, the military acts not only as an aircraft operator but also as a regulator, ANSP and airport operator for its operations.

2.2.8.2 Civil-military collaboration is key to a seamless air navigation system, which is why military aviation authorities actively participate in the development of the GANP. By providing their operational requirements from the outset as new concepts and technical solutions are being developed, military airspace users ensure that their needs in terms of access to airspace, aircraft mobility, civil-military interoperability and confidentiality are taken into account. This helps to avoid potential adverse financial, security, efficiency and safety impacts and supports global interoperability.

2.2.8.3 Military aviation authorities actively participate in civil-military cooperation and coordination functions within their own State, which ensures ~~that~~ that the full benefits expected from the implementation of the GANP can be achieved. Beyond civil-military coordination and cooperation, proper civil-military collaboration forms the basis for fulfilling civil and military operational objectives safely and efficiently. More details on opportunities stemming from civil-military collaboration can be found here: ~~[~~inputMil~~]~~.

[12] Mention of State aircraft, State aviation, military and/or State aviation authorities in the GANP and any suggested participation (e.g. in civil-military collaboration) is without prejudice to Article 3 of the *Convention on International Civil Aviation* (Doc 7300).

2.2.9 Manufacturing industry

2.2.9.1 The manufacturing industry contributes to the evolution of the technical content of the GANP by providing up-to-date industrial standards, technical insight and expertise across the technological domains relevant to air transportation. Having access to this expertise is key to developing effective and cost-efficient provisions.

2.2.9.2 The performance-based nature of the GANP allows for flexibility in the development of the technologies needed to implement ICAO provisions. The manufacturing industry can develop and standardize system solutions at the industry level while taking into account ICAO guidance and adapting the solutions to regional needs. This performance-based approach can also reduce life-cycle costs by allowing for future upgrades with new technologies without having to rewrite prescriptive requirements.

2.2.9.3 During the implementation phase, the manufacturing industry plays a consulting role with other stakeholders to identify and provide the most cost-effective solutions, services and equipment aligned with the global technical frameworks of the GANP.

2.2.10 Research and development organizations

2.2.10.1 The GANP provides a common strategy for joint efforts to drive research and development activities in the same direction. Research and development organizations manage innovation activities by delivering in-depth insights and solutions connected to the performance needs for the evolution of the GANP and ASBUs and efficiency of the air navigation system.

2.2.10.2 Generally, research and development organizations contribute to modernization activities under programmes at the State or regional levels involving all stakeholders. The pooling of air navigation expertise combined with the early participation of research and development organizations ensures a better baseline for successful industrialization and subsequent implementation of products, services and processes to fulfil market, operational and performance needs.

2.2.10.3 Research and development organizations are now active in all areas of aviation and at all levels, including academia. This level of engagement not only ensures effective knowledge transfer, but also fosters a new generation of competent aviation professionals.

2.2.11 International organizations including professional staff organizations

2.2.11.1 International organizations, including those of airspace users, airports and ANSPs, support ICAO in the development and implementation of the GANP by sharing information with organization members and raising awareness on compliance requirements through the delivery of training and audit activities.

2.2.11.2 International organizations also convey operational requirements to their members and help them to plan effective solutions, which in turn are taken into account when developing operational improvements within the technical frameworks of the GANP.

2.2.11.3 The primary role of aeronautical personnel, such as flight crews, cabin crews and air traffic controllers, is to adhere to standard operating procedures in order to ensure the highest level of safety and most efficient implementation of the GANP.

2.2.11.4 At the same time, professional staff organizations contribute to the development of the GANP by sharing their operational expertise. Such collaboration ensures that the technology, equipment and procedures proposed for inclusion take into account human factors and the role of the human in the system, and that the proposed developments therefore yield the expected results in terms of safety and efficiency.

2.2.11.5 Professional staff organizations also make use of all channels, including reporting mechanisms in safety management systems, to report deficiencies and provide input for the continuous improvement of the overall system.

CHAPTER 3: CHALLENGES AND OPPORTUNITIES

3.1 GENERAL

3.1.1 The powerful socio-economic driver represented by the aviation industry is facing a variety of challenges. Air traffic, with its movement of passengers and goods around the world, is expected to double within the next 15 years. At the same time, new demands on the aviation system, emerging technologies, innovative ways of doing business and the shifting human role are bringing not only challenges but also opportunities that call for an urgent transformation of the global air navigation system so that aviation can continue to boost social well-being worldwide.

3.2 CHALLENGES: A NEW ERA IN AVIATION

3.2.1 Continued support of social well-being worldwide

3.2.1.1 Aviation supports the growth of the global economy. Over half of the world's tourists who travel across international borders each year are transported by air. ~~Air transport carries some 35 per cent of world trade by value. More than 90 per cent of cross-border business-to-consumer (B2C) e-commerce is carried by air transport.~~[13] This results in more than ~~65.5~~ 86.5 million jobs and USD ~~2.7~~ 4.1 trillion in annual economic activity.~~[14]~~[13]

3.2.1.2 Moreover, the aviation industry provides personal and social benefits. It is the safest and fastest means of transportation available, overcoming oceans and borders to bring people together – families, friends and business colleagues. It gives people the freedom to be almost anywhere in just 24 hours and has turned a big planet into a small world filled with enormous potential and endless opportunity.

FACTS AND FIGURES
(20~~17~~23 in USD)[13]

$~~2.7~~4.1 trillion	Global economic activity supported by aviation
~~65.5~~86.5 million	Jobs worldwide supported by aviation
~~1,303~~1,138	Commercial airlines
~~3,759~~4,072	Airports with scheduled commercial flights
~~31,717~~29,039	Commercial aircraft in service
~~170~~162	ANSPs
~~45,091~~67,300	ATS routes
~~20,032~~21,000	Unique city-pair ATS routes
~~4.1~~4.4 billion	Passengers
~~41.9~~35.3 million	Scheduled commercial flights worldwide
~~7.75~~8.17 trillion	Passenger kilometres
~~62~~61.4 million	Tonnes of cargo
$~~6~~8 trillion	Value of transported cargo
~~35~~33%	Of all international trade by value

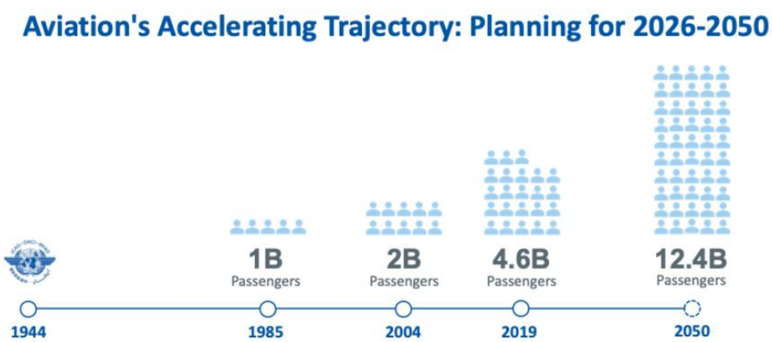
~~[13] https://www.icao.int/Newsroom/Pages/traffic-growth-and-airline-profitability-were-highlights-of-air-transport-in-2016.aspx~~

~~[14]~~[13] More information on the benefits of aviation to global economic and social development is available in the following documents:

- Aviation Benefits Beyond Borders, a biennial publication by the Air Transport Action Group (ATAG)~~; and~~
- ~~Aviation Benefits 2017, by ICAO and the Industry High Level Group (IHLG).~~

3.2.1.3 The Covid-19 pandemic caused the worst crisis in international civil aviation since World War II. However, the sector recovered to 2019 levels by 2024 and returned with great vitality and vigour. To understand where we are today and what we expect aviation to be in 2050, it is essential to consider key figures:

3.2.1.4 To put this growth in perspective, consider that the threshold of 1.0 billion passengers annually was reached in 1985 roughly 40 years after ICAO was created; then 2 billion passengers in 2004 – just 19-years later. In the following, 15 years traffic increased to 4.6 billion passengers. These impressive growth figures will present enormous challenges for international civil aviation and still aviation is expected to move passengers and goods around the globe quicker than ever before.



3.2.2 Accommodation of increasing demand and new types of demand

3.2.2.1 Greater prosperity around the world means that air travel is becoming accessible to more people. Likewise, the ongoing trend towards economic globalization will further increase the need to move high-value goods quickly around the world, creating a growing market for air cargo. Within the next 15 years, the necessary infrastructure should therefore be in place to accommodate twice[14] as much air traffic, as passengers and goods travel globally. In addition, the global ~~GA~~ general aviation market was valued at USD ~~21.1~~ 35.15 billion in 20~~17~~25 and is estimated to register an annual growth rate of ~~0.72~~ 4.17 per cent during the forecast period of 20~~16~~25–20~~24~~30.~~15~~14

~~3.2.2.2 Air traffic growth will be boosted by new types of aircraft and vehicles, ranging from small unmanned aircraft to autonomous urban air taxis, high-altitude balloons, commercial space vehicles or upper-atmosphere supersonic and hypersonic flights. Some of these users, although labeled as new entrants, have in fact been in the system for several years. The availability of technology has increased both the ease and cost of manufacture, as well as the ease of operations of new entrants. This in turn has expanded the nature of their missions, including surveying, delivering products and proving telecommunications. Perhaps the greatest change has been the shift of some operations from State to commercial and non-commercial operators. These new entrants, with significantly different operational characteristics and needs, will be increasingly used to provide new services to society, serving new locations and/or providing existing~~

~~15~~14 https://www.mordorintelligence.com/industry-reports/general-aviation-market

~~services in a new or more cost-effective way. Employment is expected to grow rapidly to support these new airspace users and aircraft types.~~

~~3.2.2.3 New entrants, including UAS, operating at the lowest and highest altitudes, are not expected to be provided with the same services as manned commercial aircraft or even manned GA, but are expected to have easy access to the airspace. Neither the infrastructure in place for manned operations nor ANSPs currently meet the needs of operations at the lowest altitudes or endurance operations at the highest altitudes. In order to accommodate the growing demand for access to the airspace by UAS and their operations, an airspace management system based on the paradigm of shared information for managing cooperative separation needs to be developed.~~

~~3.2.2.4 Commercial space and larger UAS operators operating spacecraft in traditional airspace expect to access airspace through reservations, and their separation is managed in the same way as conventional manned aircraft. In order to accommodate the increasing numbers of these operators transiting the airspace, the definition of space flight capabilities as well as the initiation and cessation of airspace reservations will need to be improved. In addition, to be managed, the risk volume will need to be more precisely defined in collaboration with the commercial spacecraft operator community.~~

3.2.2.2 The term "New entrants" encompasses a variety of aircraft and mission types such as, but not limited to, electric or solar powered, vertical lift, unmanned, airships, balloons and a variety of flying operations below, above and within the range of altitudes generally used by aviation today. Many of these aircraft are in the developmental phase, and it is anticipated that their operations will experience exponential growth in the coming years. They are expected to be piloted and managed in novel ways, and are entering into the airspace with new modes of operations.

3.2.2.3 Achieving seamless integration, involves mitigating these limitations and paving the way for more resilient and scalable operations. Beyond a certain degree of automation and their new modes of operations, what these new entrants have in common is the need to rely on robust information networks built upon a high degree of connectivity. This connectivity opens the door, and is critical, to the development of new operational methods enabled by more automation and autonomy based on the continuous information exchange between the aircraft and the rest of the infrastructure.

3.2.2.4 To support operators to meet their mission goals, authorized service providers will provide new traffic management methods for the provision of conflict management, demand capacity balancing, time-based management, and potential use of new flight rules, initially in designated airspace. The new flight rules and methods are expected to be gradually applied to the entire airspace.

3.2.2.5 In higher airspace, advanced performance-based infrastructure, continuous information exchange and novel practices will overcome operational limitations, particularly those stemming from limitations with current CNS/ATM technologies.

3.2.2.6 In the lowest airspace information exchange, novel traffic management, together with automation and autonomy, will allow operations beyond the limits of human sight, and replacing visual observation with alternative procedures, to provide the scalability needed for those emerging operations, and the safe and efficient operation of all aircraft.

3.2.2.7 In the increasingly dense middle levels, information exchange, associated procedures and automation may allow for a volume and complexity of operations exceeding the limits of current operational methods to provide for a safe and efficient integration.

3.2.2.8 Over time, this connectedness, automation and new operational methods will provide opportunities for all aircraft to digitally collaborate and expand participatory management in ways that improve flight efficiency and achieve holistic integration.

3.2.3 Use of advanced technologies

3.2.3.1 Advanced technologies enable a wide array of capabilities in aviation. These capabilities range from automated support systems, such as autopiloted and remotely-piloted aircraft, to other highly sophisticated systems using machine learning, which can enable aircraft and air navigation systems to perform complex tasks in support of the human operator.

3.2.3.2 Aviation is moving towards the notion of full connectivity, meaning that anything that *can* be connected, *will* be connected. This provides many alternatives to the way we currently design our air navigation system infrastructure. For instance, rather than ANSPs providing sensors and dedicated CNS infrastructure, they can leverage advancements in computing, data and information exchange and storage to make their services and infrastructure more integrated, agile and scalable. This creates a shift from large, monolithic programmes for decision support to a wide array of service applications. At the same time, it places a premium on the performance of data and information in a globally shared infrastructure, but also, due to the threats associated with full connectivity,[16] on aviation's approach to safety, cybersecurity and cyber resilience.

3.2.4 Automation and artificial intelligence

3.2.4.1 The future of the air navigation system will increasingly rely on higher levels of automation to safely and efficiently manage the growing diversity and complexity of aircraft operations and airspace management. It is also expected that future automation will leverage_artificial intelligence to enhance the capability of automation to effectively support nominal, off-nominal and contingency operations, improving resilience and adaptability. The primary driver is to optimize total system performance whilst keeping the human in the loop. Alignment with social expectations and business needs are also important considerations.

3.2.4.2 Given the international nature of aviation, it is imperative that processes and frameworks for the safe incorporation of automation and artificial intelligence be harmonized to support the efforts of both developers, users and implementers. The safe, secure and responsible use of artificial intelligence in the air navigation system requires adherence to an agreed set of principles. The United Nations (UN) has defined the following principles[5] for using artificial intelligence in the UN system:

- do no harm;
- defined purpose, necessity and proportionality;
- safety and security;
- fairness and non-discrimination;
- sustainability;

[16] https://www.agcs.allianz.com/content/dam/onemarketing/agcs/agcs/reports/Allianz-Risk-Barometer-2019.pdf

- right to privacy, data protection and data governance;
- human autonomy and oversight;
- transparency and explainability;
- responsibility and accountability; and
- inclusion and participation.

3.2.4.3 These principles aim to ensure that the use of artificial intelligence within the United Nations is beneficial, ethical and aligned with the core values of human rights, peace and sustainable development. These principles can be adapted to guide the use of artificial intelligence in the air navigation system.

3.2.4.4 In addition, the increasing use of automation and incorporation of AI in the air navigation system requires a common understanding of the levels of automation. The nature of the decision to be supported will determine the level of automation required.

1. **Manual or human-controlled automation**

   — Foundational level with human control.

   - Humans retain full control; automation assists.
   - Tasks simplified; workload reduced.

2. **Assisted or supervised automation**

   — Intermediate level where automation operates with greater autonomy under human supervision.

   - Humans set parameters; intervene when needed.
   - Collaborative approach for human-automation teaming.

3. **Autonomous automation**

   — Advanced level where automation can make independent decisions based on data and rules.

   - High autonomy; capable of adapting to various scenarios.
   - Humans set goals, but system manages tasks independently.

3.2.4.5 It is also crucial to recognize the importance of comprehensive and accurate localized data necessary for the development of artificial intelligence suitable for one's specific needs. This should be considered when planning for the incorporation of artificial intelligence in support of automation.

3.2.~~4~~5 Human capability and capacity

3.2.~~4~~5.1 Human capital is a critical and integral element in the air navigation system. Even in an increasingly automated or autonomous environment, humans remain a critical part of the system's design and management. Since the operational environment is complex and dynamic, system designers cannot anticipate all possible situations. Humans are necessary for real-time innovations that meet unique situational demands, which the air navigation system, as designed and anticipated, cannot address. The adoption of automation continues to extend and expand the human capability of the aviation community. Even now the community continues to learn how humans and machines can collaborate most effectively in complex environments where trust and compatibility are crucial.

3.2.~~4~~5.2 Fostered by technology, increased automation in the air navigation system will:

a) relieve operators from some repetitive operational tasks, which will enable them to concentrate on more complex decision-making;

b) interact more collaboratively with operators, enabling the human and machine to function as a team to achieve operational work goals;

c) analyse large amounts of information presented in new ways, to support human decision-making and understanding; and

d) enable all of the above to be undertaken when the technology and operator are geographically separated from each other.

3.2.~~4~~5.3 Digital transformation and increased automation will require a parallel and structured approach that gives due consideration to the role of the human and the human-machine interface. The aim should be to make optimal use of human strengths and the capacity of humans to control tools while using the support of machines to manage situations, including those which are unexpected, quickly and safely.

3.2.~~5~~ 6 Emerging, new and adapted business models

3.2.~~5~~ 6.1 The transformational change in the aviation sector must be business-oriented as well as responsible in terms of global harmonization and interoperability. The air navigation system, although recognized as a system of systems, is also a business of businesses, which, vertically, are highly dependent on one another (e.g. airspace users, aerodrome operators and ANSPs) and, horizontally, are in competition for market share. Business-to-business (B2B) and/or business-to-customer (B2C) approaches should be used since they will focus on the need to support investments in several businesses in a coordinated manner, leading to the synchronization of ground and on-board capabilities.

3.2.~~5~~ 6.2 Regulators continue to play an important role, but this role needs to evolve. With regulations still in place, there will be a need to deliver scalable and flexible innovation, especially when considering the new business models upon which the privatization of aerodromes, ANSPs and new entrants is based. Regulations should set the performance standards that society expects rather than specify in great detail individual technical components. This regulatory framework should be improved in such a way that it facilitates and encourages innovation, meets performance requirements and supports the evolution of the air navigation system while providing for monitoring and oversight.

3.2.~~5~~ 6.3 States remain responsible for the regulations and services in the airspace under their responsibility. They will ensure that their regulatory processes support B2B and/or B2C approaches, specifically by allowing more options for service provision and enhancing the quality of services in their areas of responsibility. Essentially, States will be cognizant of the fact that aviation is a global business and should deliver a consistent quality of service at a global level.

3.2.~~5~~ 6.4 The transition of the air navigation system towards a B2B and/or B2C paradigm represents in many ways a transition from a centralized system (central regulator and ANSP) to a system that is distributed and coordinated and that offers services tailored to the needs of the network and to those determined by users.

3.2.7 Supporting climate goals through innovation and efficiency

3.2.7.1 The 41st Session of the ICAO Assembly adopted a global long-term aspirational goal (LTAG) for international aviation of net-zero carbon emissions by 2050 in support of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement's temperature goal[17], recognizing that each State's special circumstances and respective capabilities (e.g. the level of development, maturity of aviation markets, sustainable growth of its international aviation, just transition and national priorities of air transport development) will inform the ability of each State to contribute to the LTAG within its own national timeframe. Meeting this goal will require the collective efforts of the aviation community to adopt innovative solutions to improve operations and reduce CO2 emissions.

3.2.7.2 Operations of new types of aircraft are forecast to grow significantly in the coming years. These new types of aircraft are wide-ranging and include unmanned aircraft, aircraft for higher airspace operations and future aircraft with new engine, propulsion and fuel technology such as electric and hydrogen. It is essential that the environmental impacts of these new aircraft are understood.

3.2.8 Maintaining operational performance through improved resilience

3.2.8.1 Aviation serves as the connector of the world, an important supporter of jobs and economies, and is essential for connectivity during crises, enabling the swift transport of aid and personnel to where they are needed. Due to the importance of aviation to society, disruptions to operational performance can have broad impacts. These impacts could be mitigated by improved resilience. Resilience can be in relation to the day-to-day operations or the impact of more significant or longer-term events.

3.2.8.2 Disruptions that affect aviation will continue to happen. Such disruptions have highlighted the vulnerability of the aviation system and the challenges it can face during the disruptions, during the recovery and post-recovery, and when operations and supply chains are disrupted, and knowledge and experience are lost.

3.2.8.3 How we learn from past experiences and invest in resilience to future threats will determine the success of the recovery efforts, no matter the nature of the disruptions themselves. Addressing resilience includes designing systems and system architectures that embed resilience considerations, and having robust contingency and business continuity plans that consider a wide range of factors.

3.2.~~6~~ 9 Such challenges are rapidly turning into opportunities driven by the expectation that they will return significant benefits related to safety, security and environmental and economic sustainability. This will shape the transformation of the air navigation system.

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[17] A41-20, Consolidated statement of continuing ICAO policies and practices related to environmental protection — General provisions, noise and local air quality, A41-21, Consolidated statement of continuing ICAO policies and practices related to environmental protection — Climate change and A41-22, Consolidated statement of continuing ICAO policies and practices related to environmental protection – Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

3.3 TRANSFORMATION: TURNING CHALLENGES INTO OPPORTUNITIES

3.3.1 The social and economic benefits of aviation will continue to be recognized by governments and policymakers. ICAO has demonstrated its commitment to supporting the United Nation 2030 Agenda for Sustainable Development and its 17 SDGs, aimed at improving the living conditions and economic prosperity of people all over the globe. A key goal that relates to the GANP is SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

3.3.2 Modernizing and building necessary infrastructure within the air navigation system to generate new services and optimize current services is essential to accommodating growing demand and meeting the requirements of a new era in aviation. This requires both significant political will and investment.

3.3.3 Unlike other modes of transportation, air transport has historically been self-sustaining in terms of infrastructure costs and has not been financed through taxation, public investment or subsidies. Infrastructure costs are generally covered by user charges~~, most of which are added to airfares. In 2016, it was estimated that airlines and passengers paid USD 125.9 billion[14] to airports and ANSPs~~.

3.3.4 Aviation has chosen a proactive approach to address climate change. The aviation system can contribute to meeting climate goals by:

Improving operational efficiency

3.3.4.1 Improvements in the efficiency of operations in all phases of flight (including ground operations), e.g., reducing airborne delays and improving flight profiles, have the benefit of reducing fuel burn, CO_2 emissions and the associated impacts on the climate.

Efficiently accommodating increasing diversity in the skies

3.3.4.2 As new types of aircraft are introduced, air navigation services will need to manage increasingly diverse air traffic operations; they will need to be flexible and adaptive to accommodate and integrate these operations both on the ground and in the air, while preserving flight efficiency of all operations.

Leveraging new and emerging technologies enabled by regulatory frameworks that facilitate and encourage innovation

3.3.4.3 As innovations are introduced into operations, procedures and aircraft, environmental benefits in terms of reduction in fuel burn and CO_2 emissions can be realized sooner with the evolution of a performance-based regulatory framework that ensures safety, interoperability and efficiency.

3.3.4 5 Due to the critical factor of aviation safety, the pace and uptake of innovation can be slow. However, the aviation industry is beginning to look at other industries where emerging technologies may be applied to aviation. These tried and tested technologies have the potential to reduce innovation life cycles and accelerate change in aviation, while ensuring that the net cost per passenger remains steady or is reduced.

3.3.~~5~~ 6 It is also possible to speed up change by including early stage research, industrial research and development, and implementation experiences within the innovation life cycle. This minimizes deployment risks at an early stage by making good use of and sharing validated results from research and development activities taking place worldwide. This requires the performance validation and close collaboration of the aviation industry so that potential risks and threats can be understood and managed at an early stage.

~~3.3.6~~3.3.7 An aviation system that is at the forefront of innovation, and that actively addresses cybersecurity and ensures adequate integration of military requirements needs to be capable of providing suitable and timely responses to threats and attacks. The aviation system can enhance resilience by:

Ensuring human capability and enhancing human performance to support resilience.

3.3.7.1 Human assets continue to be critical to aviation infrastructure, which is why it is important to continue promoting the next generation of aviation professionals. Addressing staff well-being, competency retention and providing training to enable new services or modes of delivering services is critical. The ability to better diagnose and handle disruptions will continue to rise in significance as operations and systems become more sophisticated and interdependent.

Reducing the impacts caused by threats and failures with agile and diverse capabilities.

3.3.7.2 Implementing system architectures and digital solutions that can offer redundancy, "soft failure modes", or alternative solutions can help reduce the impact of disruptions.

Providing cost-effective and scalable services in line with demand through a service-oriented architecture.

3.3.7.3 Demand is not constant. A system that scales with increases and decreases in demand is more resilient in the long term and provides for cost-effectiveness. As improved digital capabilities are introduced or enhanced, investments in the underlying architecture will boost resilience. However, the increase of digitalization and usage of new technologies could also introduce new risks and be a new source of disruption. In particular, regarding capabilities in cyber-resilient technologies, system redundancies, a highly trained workforce, good communications and proper planning will increase the value in the investment in a globally harmonized aviation industry.

Ensuring effective lessons learned are captured from how disruptions, recovery and post-recovery complications have been addressed by industry and authorities.

3.3.7.4 These lessons learnt can lead to recommended practices for contingency planning, resilience planning, as well as communications planning. Thus, when another disruption to aviation is encountered, these plans can be put into place with effective communication, training and continued post-recovery review (i.e., what went well and what needs improvement).

~~3.3.6~~3.3.7.5 The system must be capable of maximizing human capacity and strongly supported by technology. Since aviation consists of a system where the servicing of mobile assets, including large aircraft, small manned aircraft and unmanned vehicles, is the primary objective, ensuring the integrity of all information is of utmost importance. Embracing mainstream information and network technology can lead to a more cost-effective and rapid modernization of the aviation system.

3.3.~~7~~ 8 In this rapidly changing landscape, it is agreed that the air navigation system must be transformed to address imminent challenges. Transformation is not an end goal in itself; rather, it is the way to achieve the GANP vision, the ultimate goal of which is to deliver a high-performing air navigation system. The strategy for transforming the air navigation system, which is described in the conceptual roadmap, responds not only to the performance needs discussed above, but also, to many States and regions, to the ambitions and policies of many States and regions aimed at increasing the use of digitization. The aviation industry needs to ensure its position at the forefront of innovation by adopting an increasingly cross-domain and global perspective. There is much at stake for the global economy and for citizens if the modernization of the global air navigation system does not continue.

CHAPTER 4: THE VISION

4.1 GENERAL

4.1.1 The GANP vision reflects the ultimate objectives of the air navigation system as well as the emerging challenges and opportunities stemming from aviation and technological trends. The evolution driven by this vision will yield a high-performing global air navigation system that meets the ever-growing expectations of society.

4.2 THE TARGETED AIR NAVIGATION SYSTEM

4.2.1 The VISION

4.2.1.1 The global air navigation system has witnessed significant improvements in recent decades. For the air transport system to continue to contribute to social development and economic progress worldwide, a safe, secure, efficient and sustainable global air navigation system, which limits the impact of aviation on climate change, must transform from conceptual approaches designed in the twentieth century.

4.2.1.2 Air and ground systems, including airports, will act as a single integrated infrastructure to accommodate the growth of air traffic and support a better performing aviation system in an intermodal environment. Remotely-piloted and unmanned platforms will expand traditional business models and accelerate the transition towards an environment that is rich in digital information.

4.2.1.3 This information-rich environment will fuel collaborative decision-making in a network-centric context to enable management by trajectory, which will improve mission- and business-oriented operations. Information will also play an integral role in the highly interconnected systems that will increasingly enable autonomous operations and human-machine collaboration.

4.2.1.4 At the core of this transformation is a strong need for a fully harmonized global air navigation system built on agreed performance-based standards with interoperable and scalable systems. Within this harmonized system, airspace users will have access to the air navigation resources consistent with their adherence to performance requirements.

4.2.2 The global vision and leadership embodied in the GANP outline an evolution in air navigation for all stakeholders, which will ensure that no country or stakeholder will be left behind.

CHAPTER 5: PERFORMANCE AMBITIONS

5.1 GENERAL

5.1.1 In addition to the fundamental aviation principles of safety, security and economic and environmental sustainability, there are several consequential performance requirements that the air navigation system must meet to fulfil the ever-growing expectations of society in general and, in particular, the aviation community. The air navigation system's required level of performance involves difficult decisions and strong commitments. Based on what we know about the future and its opportunities and challenges, the air navigation system should provide for certain performance ambitions.

5.2 MEETING EXPECTATIONS

5.2.1 Safety, security and environment are high on the public agenda. Society – both from a passive and active customer perspective – not only expects to reap the benefits of aviation, but also expects that all airspace users' flight operations will remain safe, environmentally sustainable and will not jeopardize the security or privacy of individual citizens, businesses and States. These social expectations originate from the need to prevent aviation safety from becoming negative "headline news", and from higher-level aviation and transport policy goals.

5.2.2 **Safety** is and will continue to be paramount. Flying is extremely safe, and all stakeholders have continuously cooperated to improve the air navigation system with a view to making flying even safer. In this regard, the aviation community is committed not only to completely eliminating air navigation service-related accidents, but also, as part of its robust commitment to safety, to reducing the number of air navigation service-related serious incidents by half.

5.2.3 As part of this commitment, the safety strategy set forth by ICAO in the GASP supports the prioritization and continuous improvement of aviation safety. The purpose of the GASP is to continually reduce fatalities with the aspirational safety goal of zero fatalities in commercial operations by 2030 and beyond, and reduce the risk of fatalities associated with accidents.

5.2.4 **Access and equity** will become more important over the coming years. In response to economic and social needs, the airspace user community is expected to grow, become more diverse and generate more traffic. This, together with customer expectations, will increase competition and drive the airspace user community to become more demanding in terms of access to physical operating environments (airspace and landing sites) and equitable treatment in relation to other airspace users. For airspace users, access is an essential business enabler. No member of the aviation community should be excluded or treated unfairly, and harmonious interaction within the community should be a key goal.

5.2.5 To ensure that future flight operations will meet the above social expectations and that shared use will be made of the finite air navigation resources, all stakeholders should collaboratively contribute to the aviation value chain. In essence, the task of managing this value chain at the level of flight operations falls within the scope of the air navigation system. In the future, it will be even more important for each member of the aviation community to **participate** (at a pre-agreed level) in the operations of the air navigation system.

5.2.6 The global air navigation system is distributed geographically and across organizations. It consists of interacting ground, air and space-based segments owned and operated by various members. As with all systems, the expectation is that each element in the value chain, whether it be a system or member, deliver the maximum benefit at the minimum **cost**, regardless of the locally selected funding and charging methods. In any case, the value of the benefits for all members should exceed the cost of modernizing and operating the system.

5.2.7 Modernization requires investment in the right infrastructure at the right time, as well as the flexible deployment of resources to match fluctuating demand, when and where they are needed. There is widespread consensus that making the right technological and organizational choices in the modernization of the air navigation system can help to avoid further increases in the total cost. It is also agreed that, irrespective of the evolution of demand, the **productivity** of the system can be significantly improved over time without sacrificing other performance aspects such as safety or quality of service.

5.2.8 The notion of **capacity** is a well-accepted planning tool for protecting the air navigation system from a service delivery overload and is also used to reduce or prevent access to airspace and landing sites at times when operating in such areas would be inherently unsafe (e.g. due to severe weather). In general, the nominal capacity of the air navigation system has to be scaled up incrementally in anticipation of traffic and has to be sufficiently flexible to handle peaks in demand associated with the accommodation of traffic pattern variability.

5.2.9 ~~The air navigation system should also be resilient to planned and unplanned disruptive events. This is essential to enable airspace users to execute their planned flight operations in a predictable manner, in support of their business model.~~ The air navigation system should be capable of absorbing, adapting and recovering from disruptive events. Disruptive events can be internal or external, in expected or unexpected conditions, and of short or long duration. Such events can impact service provision by the air navigation system or service consumption on the airspace user side.

5.2.10 **Predictability** is critical for cost-effectiveness, operational efficiency and business credibility, regardless of the type of business and business model. A lack of predictability in the system can result in costly buffers for all stakeholders. To improve predictability, the aviation community is committed to enhancing stability in the provision of air navigation services and availability of assets.

5.2.11 Key to improving the predictability of the system is the sharing of more accurate and timely information as well as improved forecast models. That is why the air navigation system is becoming increasingly automated, digitized and interconnected and why large volumes of information are being circulated between all members for planning and real-time decision-making. This is reaching a level of complexity which makes automated data-processing support inevitable. In such an environment, a high level of **interoperability** will be a prerequisite for successful participation in the air navigation system.

5.2.12 As automation, digitization and connectivity increase and access to the system is provided to more members via digital interfaces, new risks caused by cyber vulnerabilities will emerge. Potential impacts range from unauthorized access to and disclosure of sensitive information, to large-scale disruptions in aviation operations or compromised safety. Managing such risks and making the future system cyber-resilient are therefore top priorities. That is why all aviation stakeholders are making a great collaborative effort to protect and **secure** the air navigation system against acts of unlawful interference. As part of this proactive approach, the development of a trust network in collaboration with States, industry and other stakeholders will allow for the secure exchange of information worldwide.

5.2.13 Ideally, the air navigation system should never impose any restriction on individual flight operations. In practice, this is rarely feasible because of external constraints (beyond the control of air navigation services) or the conflicting needs of airspace users, among other reasons. In such cases, the overall ambition is to seek an optimum combination of trade-offs that maximizes the collective performance of all members (i.e. network optimization), while respecting predefined requirements for safety, security, the environment, access and equity. This will be achieved through collaborative decision-making involving all members on multiple planning horizons.

5.2.14 The overall goal is to continuously seek optimum network performance under a variety of operational conditions. The aim is to progressively reduce the impact of trade-offs and, essentially, enable airspace users to fly their preferred trajectories. In this respect, the air navigation system should be **flexible** enough to integrate changes in business and operational trajectories at the frequency required by airspace users.

5.2.15 As a side effect of this evolution, operational cancellations and diversions will be reduced, and flight **efficiency**, in all flight phases and trajectory dimensions (delay/longitudinal/speed, plus lateral and vertical), will improve as it approaches the airspace user's desired optimum trajectory, while still being subject to safety, security and noise constraints.

5.2.16 Improved flight efficiency will automatically lead to savings in fuel burn, which in turn will bring **environmental** benefits on a per flight basis. ~~Faced with an unprecedented global environmental challenge requiring commitment from a wide range of industries, the aviation industry has itself committed to very ambitious goals: carbon neutral growth from 2020 and a 50 per cent cut in CO_2 emissions by 2050 compared to 2005. ICAO Member States have adopted two global aspirational goals: a 2 per cent fuel efficiency improvement per annum and carbon neutral growth from 2020, and a basket of measures, which include operational improvements, to progress towards these goals.~~ At the 41st Session of the ICAO Assembly, States agreed to work together to strive for a Long-term Aspirational Goal (LTAG) that the aviation industry achieve net zero carbon emissions by 2050, a goal in line with the objectives of the Paris agreement to limit global warming to 1.5°C.

5.2.17 This will require maximum effort by all aviation stakeholders to deploy the ICAO basket of measures, including operational improvements aimed at reducing fuel burn. Deployment of ASBU elements and other operational improvements and GANP initiatives can also lead to savings in fuel burn and associated emissions.

5.2.18 ICAO Resolutions[18] call upon States to implement operational improvements outlined in the GANP as part of their national strategy to reduce environmental impacts, including CO_2 emissions, from international aviation.

5.2.19 Aviation operations can have adverse[3] environmental effects upon noise and air quality, particularly for people living and working in the vicinity of airports. To address these environmental effects, ICAO develops Standards, Recommended Practices and Procedures and/or guidance material on aircraft noise and emissions.

5.2.20 Aviation is taking action to reduce noise and local air quality impacts through the deployment of operational improvements. Operational measures to reduce local environmental impacts should follow the balanced approach for noise management established by ICAO and consider the means to reduce air quality impacts.

[18] A41-20, Consolidated statement of continuing ICAO policies and practices related to environmental protection — General provisions, noise and local air quality, A41-21, Consolidated7 statement of continuing ICAO policies and practices related to environmental protection — Climate change and A41-22, Consolidated statement of continuing ICAO policies and practices related to environmental protection – Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

SUMMARY OF THE GANP PERFORMANCE AMBITIONS A high-performing system by 20~~40~~50 and beyond	
KPA	**Ambition**
ACCESS AND EQUITY	No member of the aviation community excluded or treated unfairly
CAPACITY	Nominal capacity easily scalable with demand
	~~Disruptive events do not interrupt service provision and do not significantly affect the performance of the system~~ The maintenance of service provision and system performance in the face of disruptive events.
COST-EFFECTIVENESS	No increase in the total direct cost of air navigation services while maintaining the safety and quality of service
	Significant increase in air navigation service productivity, irrespective of demand
EFFICIENCY	Reduced gap between the flight efficiency achieved and desired optimum trajectory of airspace users
ENVIRONMENT	~~Air navigation services-induced inefficiencies progressively removed in support of the global ICAO aspirational goals for CO_2 emissions~~ To minimize, through operational improvements that in particular reduce fuel burn, the adverse environmental impacts of aviation activity on the climate
	~~Benefits from achieved flight efficiency gains~~ To minimize, through operational improvements, the adverse local environmental impacts of aviation regarding noise and local air quality
FLEXIBILITY	Absorption of required changes to individual business and operational trajectories
INTEROPERABILITY	Compatibility of systems at an operational and technical level
PARTICIPATION BY THE ATM COMMUNITY	Pre-agreed level of participation for maximum shared use of air navigation resources
PREDICTABILITY	No increase in the variability of air navigation services delivery, including asset availability
SAFETY	Achieve continual safety performance improvement in aviation in each ICAO region
SECURITY	Zero significant disruptions due to cyber incidents

5.2.17 Achieving the above ambitions and realizing the GANP vision will require a series of transformational changes.

CHAPTER 6: THE CONCEPTUAL ROADMAP

6.1 GENERAL

6.1.1 The global air navigation system is becoming more complex as it supports new demand. To manage this complexity, meet the global performance ambitions and realize the GANP vision, the air navigation system must transform and build upon the use of emerging technologies, information and concepts of operations, many of which are not specifically designed for aviation purposes.

6.1.2 The evolution of the air navigation system is built on the notion of management by trajectory, empowered by access to timely and accurate shared information, which should improve ~~mission and business trajectory executions~~ overall safety and efficiency of the airspace.

6.1.3 ~~Information exchanges between airspace users, ATM systems and aerodrome operations~~ The aviation community will increasingly depend on the provision of accurate, secure and timely data that is quality-assured and situationally relevant to ensure that timely and consistent decisions are made on a network-focused and flight-centric basis. ~~New entrants such as spaceport operators, c~~ Commercial space operators and new users of higher~~-altitude~~ airspace as well as advanced air mobility operators and other users in the middle levels and the lowest airspace will all contribute to the dynamic decision-making process ~~in this business of businesses~~.

6.1.4 This evolution will be enabled by a progressive increase in automation, powered in some cases by artificial intelligence, advancements in technology and the use of ~~standardized~~ harmonized, interoperable ground and air systems in an integrated infrastructure. This aviation infrastructure, based on the ubiquitous sharing of information, will interface with non-aviation transportation systems to achieve an efficient, multimodal transport system.

6.1.5 The conceptual roadmap presented hereafter is aimed at transforming the air navigation system based on its strengths and opportunities, rather than simply improving it, by providing a more holistic approach to its evolution. This evolution is described through four steps, which address the transformation of the air navigation system through digitalization (Step 1), enhancing time-based operations (Step 2), moving to trajectory-based operations (Step 3) and a total performance management system (Step 4).

6.2 ON THE CUSP OF TRANSFORMATIONAL CHANGE

6.2.1 The next 20 years will be a period of transformational change for the aviation sector, especially for the business of ATM and flight operations. While this will be an evolutionary change, even evolution has its disruptors that mark new eras. New types of aircraft, vehicles and airspace users are introducing a next-generation of operating models to aviation through the application of advanced technologies and sophisticated operational decision-making processes in an integrated manner. This will expand traditional business models and accelerate the transition towards a total performance management system in which airspace users and other aviation stakeholders will be able to make orchestrated and/or choreographed collaborative decisions based on their business and mission objectives. In order for the last ~~stage~~ step to be reached, the conceptual roadmap brings together the opportunities that rising digital technologies of the information age and full connectivity are bringing to the aviation community.

6.2.2 Aviation is and will continue to be a safety-focused business. ATM has always been about safely and efficiently managing air traffic flow, flight operations and access to air navigation resources in a way that agreed levels of safety are always met. Given the forecasted increased volumes of traffic with ~~multiple~~

increasingly diverse business and mission objectives, the tactical management of flight operations based on static, individual and unique management of air navigation resources will no longer be sufficient.

6.2.3 A new paradigm based on the ability to manage, describe and communicate constraints at increasingly finer levels of resolution, as well as the capability to accept and react to inputs and data not only internal (e.g. flight plans with service provider needs and desired capabilities) but also external (e.g. weather) to the system is key to ATM. Such paradigm is also essential to leverage the availability of air navigation resources and maximize the system's inherent performance.

6.2.4 Evolution in technology, digitalization and data goes hand-in-hand. A data-driven network is only possible if technological and digital advancements happen in parallel. With data comes opportunity, but also responsibility. Therefore, cyber security and cyber resilience will become system-wide priorities, with global quality standards to which the aviation community will comply.

6.2.4 EVOLUTIONARY STEP 1: FLIGHT OPERATIONS IN A DIGITALLY RICH ENVIRONMENT

6.2.4.1 Air navigation resources are limited. In a safety-critical environment, the capacity of the system relies on the ability to exploit air navigation resources. To unlock the inherent capacity of the system ~~by~~ and allow~~ing~~ ~~more scheduled flights~~ increasing volumes and density of traffic, a move towards a more ~~tactical~~ data-driven environment is required. In an information-poor system, the acceptable number of flights (i.e. declared capacity) is restricted to eliminate the possibility of excessive holding, sector overloads or diversions, which results from the lack of sufficient information to provide even tactical levels of planning.

6.2.4.2 Limited airspace and runway capacity results in delays, passengers not being served, goods not being delivered and loss of potential opportunities to accommodate demand. Therefore, industry and government leaders must embrace the opportunities that digital technologies are creating in order to unlock substantial benefits for the aviation community.

6.2.4.3 Opportunities

6.2.4.3.1 The first step of the conceptual roadmap focuses on improving the system's capacity. Constraints have an allocated volume with an associated time and position. The volume, time and position are based on the quality of the underlying information that defines the constraint. The introduction of digital technologies in aviation improves the quality of the information and removes or minimizes constraints to access to and use of air navigation resources, thereby increasing the capacity of the system while maintaining and enhancing safety.

6.2.4.3.2 The emergence of digital technologies not only improves the quality of data and information, but also increases data storage and enhances processing capabilities while allowing a wider distribution of information, which, as a result, is no longer limited to the front-line actor. Thus, digital technologies make it possible for more stakeholders to participate in the decision-making process and enable the design of specific decision-support~~ing~~ tools and automation for more focused decision-making processes in ATM.

6.2.4.4 Challenges

6.2.4.4.1 Improving the quality of data and information based on dedicated aviation applications, sensors and automation implies large investment by aviation stakeholders. Moreover, this information, when available, is often limited to front-line actors either by dedicated ground connections or by air-ground data communications. This reflects the poor state of data and information exchange and the cost of point-to-point communications, in comparison with other technologies used in society at large. Although capacity improves locally due to richer information on constraints, the lack of data and information sharing beyond the local setting means that the system operates in an isolated manner. This fragmentation results in multiple views and disjointed operations caused by isolated automation and fit-for-purpose systems supporting only a loose network approach.

6.2.4.4.2 Although operations are generally improved by automation, the benefits that arise at airspace boundaries – both geographic and time boundaries – may result in conflicting approaches, leaving many potential benefits unachieved. For instance, the airport schedule of a time-based arrival tool may be disrupted by a more strategic initiative which balances demand and capacity and involves aircraft that have multiple destinations but are all in the same flow. Although automation is necessary as a first step in the system's evolution, the return on investment in digital technologies is subject to the comprehensive and full utilization of the generated digital information.

6.2.5 EVOLUTIONARY STEP 2: TIME-BASED OPERATIONS ENABLED BY AN INFORMATION REVOLUTION

6.2.5.1 Aviation is a global business of businesses where customer satisfaction depends on the aviation system's predictability. Customer satisfaction varies from the passengers arriving at their destination on time, to the airlines maintaining daily schedules. Although the digital transformation has increased the capacity of the air navigation system, ~~the~~ isolated ~~(~~local~~)~~ ~~nature of~~ decisions can result in unforeseen delays to schedules and customer dissatisfaction, along with additional costs and inefficiencies. As a first step, a regional approach to flight operations based on the timely integration of information and seamless cross-border services is required.

6.2.5.2 Opportunities

6.2.5.2.1 The second evolutionary step focuses on improving efficiency, predictability and cost-effectiveness by moving from isolated data pockets and automation to a single, shared view/coordinated system involving the use of non-aviation specific and dedicated resources.

6.2.5.2.2 What has been uniquely developed in aviation in the past has become an opportunity for other industry segments, given the inherent capabilities of automation, navigation and communications used in social and commercial interactions. However, in the last decade, other industries have taken the lead in providing high-level performance thanks to cutting-edge technology that is superior to existing aviation technologies. Other industries and society at large benefit from the robust distribution of information and have moved from a point-to-point to network approach where information is available to all interested parties. To ensure that aviation stays up to date with global best practices and reduce costs, air navigation services will be increasingly provided by facilities and services outside of current air navigation systems and beyond the traditional aviation industry.

6.2.5.2.3 Data that are digitally available and referenced to common systems (time and position data) are shared through globally accepted exchange models. Increased access to commonly available data sources, enabled by data cloud storage capabilities, together with big data analysis and machine learning applications, make it easier to process vast amounts of information that could not be processed by humans. This is leading to a more accurate and precise definition of constraints, including common projections of aircraft position and intent, enabling time-based operations. With greater precision comes earlier and more accurate predictability, which in turn is reducing system uncertainties and their associated operational buffers. As a result, the overall network efficiency is improved. This, together with the sharing of information in a system-wide environment, will further improve the predictability of the air navigation system, leaving room for improved, independent and collaborative decision-making, and seamless cross-border services. The increased availability and greater accuracy of data and information will also make it possible to apply big data analysis methodologies and take an improved, proactive approach to safety and efficiency of operations.

6.2.5.2.4 The expanded information pool will enable the introduction of, or enhancements to, network management functions supporting a resilient and robust regional network approach. This increased ~~regional network~~ capability, coupled with greater availability of accurate data and information, will support synchronization across local tactical decision~~-making~~ support~~ing~~ tools.

6.2.5.3 Challenges

6.2.5.3.1 In this information revolution, ~~the synchronization of different decision-making supporting tools will be made possible~~ capabilities are enhanced by the sharing of actionable information across the network enhancing decision-support tools. However, there are limitations as to the quality of the information provided, as some data and information inputs are estimated, derived and possibly not obtained directly from the source, since not all systems are connected to the network. There are still aircraft that can only provide limited data sets based on legacy protocols and data communication systems, airline tools that may provide estimated versus actual flight status information, and weather tools that are yet to benefit from the increased pool of observations from aircraft. Decision support tools ~~Automation support for decision-making tools~~ continues to suffer from ~~have uncertainty margins on recommended actions so that the accuracy of mixed~~ inaccuracy in the information on which they rely ~~can be taken into account, although margins are smaller~~. In addition, the level of automation is only beginning to evolve from manual or human-controlled and has not reached the levels required to support trajectory-based operations.

6.2.6 EVOLUTIONARY STEP 3: TRAJECTORY-BASED OPERATIONS ENABLED BY FULL CONNECTIVITY THROUGH THE INTERNET OF AVIATION

6.2.6.1 One of the barriers to improving ~~the~~ regional air navigation system is the lack of full participation due to the high cost of aviation-specific technologies. The need to accommodate all stakeholders can therefore result in ~~S~~suboptimal decisions ~~are therefore made to accommodate all stakeholders. The lack of information on current wind, turbulence and weather conditions, resulting in a less accurate definition of constraints, is also part of the issue~~. ~~Finally, t~~The inability to connect cross-regional information sources and synchronize trajectory information is affecting global flights and the ability of ~~ANSPs and airspace users~~ the aviation community to ~~further plan~~ optimize the planning of their operations. A move toward the global internet of aviation will reduce such costs and inefficiencies.

6.2.6.2 Opportunities

6.2.6.2.1 As access to broadband Internet becomes more widely ~~available with faster and better value for money~~, and as more devices with built-in connection capabilities and sensors enter the market, a perfect environment for the Internet of things will be created in the aviation industry. The third evolutionary step envisages a scenario in which everything in aviation that can be connected, is connected. This evolution in aviation is already occurring in some areas including remotely-piloted aircraft systems, where the Internet and wealth of possible communications networks are providing direct links between aircraft/vehicles and their stations, and aircraft/vehicles and ANSPs.

6.2.6.2.2 In this step, each actor will be seen as a system node, source of and user of information. Constraints, very accurate in time and position, will be minimized due to the increased near instantaneous processing capability of richer information and opportunities to continuously recalculate and review the scenario based on the ongoing supply of accurate data and information.

6.2.6.2.3 The aircraft's intent will be readily available to ANSPs, and atmospheric conditions surrounding each aircraft will be available owing to enhanced grid data sets and forecasts. The automation tools of airspace users employ the state of the network and arrival management, surface management and departure management schedules in real time. As a result, network management will become a globally shared endeavour, free of the boundary inefficiencies caused by limitations in cross-regional boundary information.

6.2.6.2.4 Trajectory-based operations are the natural step forward in this environment of rich information sharing and advanced automation levels. Pre-flight trajectory deconfliction, augmented by advanced onboard technologies, will enable self-separation in normal operations in certain environments. In implementing trajectory-based operations, it will be necessary to take advantage of the increased precision in the position, intent and time of constraints will enable all stakeholders to more increased precision in the position, intent and time of constraints to fully benefit from the larger number increased availability of air navigation resources available.

6.2.6.3 Challenges

6.2.6.3.1 The emergence of aircraft, airspace users and ANSPs as nodes in the global network will support flow management and time-based management that extend across flight information region (FIR) boundaries to efficiently support the increasing demand and complexity of ground and air operations. As a result, it will be essential to move towards a global approach to information security. More common approaches to information exchange must also be considered since operational improvements now need to be either regional, as a minimum, or in many cases, global.

6.2.6.3.2 To fully accommodate airspace users with different operational capabilities and needs and take advantage of innovation and rising digital technologies, a shift from aviation-specific to performance-based system solutions and architecture will be necessary. A performance-based system will enable the safe use of infrastructure and capabilities not specifically designed for aviation, resulting in cost-effective operations enabled by high-quality services.

6.2.6.3.3 Even within this enhanced environment of information, the principles of decision-making will still be held at the ANSP level, despite the improved collaborative decision-making process as a result of better data and information received from users and the upgraded tools for the collaborative modelling of constraints.

6.2.7 EVOLUTIONARY STEP 4: TOTAL PERFORMANCE MANAGEMENT SYSTEM FOCUSED ON BUSINESS/MISSION NEEDS

6.2.7.1 Moving passengers and cargo worldwide is not the sole purpose of aviation. The emergence of multiple airspace users and different vehicles and business models has added significant complexity to decision-making among ANSPs. Without flexibility in the decision-making process, ultimate customer satisfaction will not be met. ANSPs will only meet these various new demands by managing the process that enables their direct customers and other stakeholders to make their own decisions based on predefined system performance requirements. The aviation industry is experiencing significant changes in airspace usage, aircraft and business models leading to increased complexity in the air navigation system. This has created a need for greater flexibility in managing air traffic and shifts in the roles and responsibilities of the various stakeholders involved. The redistribution of responsibilities will focus on managing a process that enables airspace users to make their own decisions based on predefined system performance requirements. By embracing a more flexible and collaborative approach to air traffic management, the aviation industry can better accommodate the growing diversity of airspace users and vehicles, while improving safety, efficiency and sustainability in the air navigation system.

6.2.7.2 Opportunities

6.2.7.2.1 The last step of the conceptual roadmap is to take full advantage of ~~this~~ the information-rich environment to fully optimize decision-making and satisfy the needs of airspace users. In the past, ATM decisions became centralized due to the limitations of information availability among airspace users on both the ground and flight deck. In each of the previous steps, improvements to information-gathering ~~are focused on~~ and sharing served to provid~~ing~~e the A~~S~~NSPs with a larger amount of and more accurate information so that they ~~can~~ could make better decisions ~~on behalf of~~ in collaboration with airspace users.

6.2.7.2.2 With this improved total system performance in mind, the entire focus will shift to who is best positioned and able to make decisions. Even with shared information, there are aspects of each flight that may be unique to the operator. ~~Therefore, despite this pool of rich information, a situation in which only ANSPs make decisions based on inputs will be suboptimal.~~ Processes and procedures will be developed to ~~shift and~~ enable the operator to manage the flight trajectory, while ANSPs focus on managing constraints and air navigation resources. With the move towards the Internet of things, information will no longer be the limitation.~~, and the focus will shift to who can make the best decisions resulting in improvements to the total system performance. This will be possible because c~~Constraints will be minimized owing to the increased accuracy and availability of data, considering all inputs to the system and the absence of coordination limitations with everyone connected to the network. Now, the organization and management of airspace is harmonized and increasingly automated.

6.2.7.3 Challenges

6.2.7.3.1 Achieving the optimum decision-making scenario requires new approaches for ensuring "access and equity" to air navigation resources. Care must be taken so that users with the fastest information technology capabilities do not dominate the process, but still bring the advantages of being fast movers to all players in the system. The simple rules of capacity-rationing, air traffic flow management and time-based scheduling, implemented in the past, need to be replaced through a gradual introduction of "market rules". ~~with r~~Regulations must be adapted to the needs and possibilities of the market to self-regulate, as long as the performance of the overall network is not negatively impacted~~ and access and equity are preserved so as to accommodate all demand~~.

CHAPTER 7: FROM CONCEPT TO OPERATIONS

7.1 GENERAL

7.1.1 In the past, the modernization of air navigation systems was guided by technological innovations implemented at individual State levels. As States implemented these innovations, global provisions were developed in response to the individual State initiatives in order to harmonize procedures and support the interoperability of technologies for the safety of flight operations. This approach created a gap between mature and maturing aviation ecosystems leading to global disparities.

7.1.2 The vision outlined in the GANP is a proactive move towards a globally interoperable air navigation system and constitutes an integrated and common approach to emerging challenges and opportunities stemming from aviation and technological trends. The evolution of the global air navigation system, driven by this vision and reflected in the conceptual roadmap, will result in a high-performing system that meets the ever-growing expectations of society and reduces global disparities. The realization of the GANP vision requires commitment and investment by the aviation community.

7.1.3 The GANP and its vision are aimed at supporting the evolution of the air navigation system and ensuring that no country or stakeholder is left behind.

7.2 A STRUCTURED APPROACH DRIVEN BY PERFORMANCE

7.2.1 There is no end point or end date to the evolution of the air navigation system. Continuous improvements will ensure that the system adapts to global, regional and local opportunities and challenges in a timely and orderly manner.

7.2.2 The GANP provides a path to the safe, orderly and efficient evolution through the BBB and ASBU frameworks. Obligations in terms of the provision of essential air navigation services have been reflected in the BBB framework to ensure a robust baseline for the evolution. The evolutionary transformation reflected in the different steps of the conceptual roadmap is also reflected in the ASBU framework to ensure the interoperability of systems, harmonization of procedures and a harmonized approach to the modernization of the global air navigation system. New users, operations and roles, and all stakeholders are part of this structured transformation.

7.2.3 The way the evolutionary steps are reflected in the ASBU framework is through the description of conceptual steps for the ASBU threads aligned with the four evolutionary steps of the conceptual roadmap. These conceptual steps for the ASBU threads are available in https://www4.icao.int/ganpportal/document/MappingToThreads[19]. Within the ASBU threads, the ASBU elements represent the availability of operational improvements in time. To better show how these elements support the progression within the conceptual roadmap, each element is mapped to an appropriate conceptual step within their thread. This mapping, which is available at https://www4.icao.int/ganpportal/document/MappingToElements[20], serves to link the technical level (ASBU framework) to the conceptual roadmap (strategic level).

[19] The tables provided in this hyperlink are under the review of the GANP-SG and will be updated for the 42nd session of the ICAO Assembly.
[20] The tables provided in this hyperlink are under the review of the GANP-SG and will be updated for the 42nd session of the ICAO Assembly.

7.2.~~3~~ 4 The ASBU framework is not a miscellany of all possible solutions, but a list of operational improvements structured in a way that highlights what is available and what is under development. Based on its demand, an implementer can therefore select with confidence an existing capability or decide to defer implementation until a new solution is available if the demand does not pose a constraint.

7.2.~~4~~ 5 It is a pivotal time for development and modernization in aviation. While a common, incremental approach in terms of an operations concept makes sense, the same approach is not suitable with respect to technological upgrades. Some developments and modernization initiatives serve to enhance existing infrastructure and are logical for members of the aviation community who have already invested in modernization. Other members of the aviation community have opportunities to invest in more advanced operations supported by new, evolving technology rather than in interim solutions that require an investment in existing infrastructure or in legacy technologies, which can result in leapfrogging. The concept of leapfrogging encourages innovation and urges the aviation community to modernize the provision of air navigation services by selecting the most mature alternative and avoiding the costs of legacy solutions.

7.2.~~5~~ 6 Traffic demands and available infrastructure may differ depending on the airport, airspace, State and region, resulting in different levels of motivation to modernize. Similarly, resources in the global aviation community are limited and unevenly distributed. One size does not fit all, which is why the air navigation system evolves according to performance needs and requirements. The GANP contains solutions that should be implemented as needed, in line with specific operational requirements and performance needs.

7.2.7 Once a solution has been identified, operational and economic incentives may be considered to expedite its implementation to enable tangible benefits to be realized as soon as possible. For example, access or operational benefits could be prioritized for the most capable users—based on their available capabilities—within designated airspace volumes or at dedicated aerodromes. Any incentive should be implemented in close coordination with all stakeholders and ensure alignment with regional planning.

7.2.~~6~~ 8 Most improvements to the air navigation system rely on the coordination and transfer of data and information across multiple stakeholder networks, systems and facilities. As a result, there is a need for multi-State and regional coordination processes to achieve the full potential and benefits expected from operational improvements. Such processes may be in the form of bilateral, multilateral agreements or even regional air navigation agreements.

7.2.~~7~~9 The expectation of the GANP, which follows the underlying philosophy of "think global, act local", is not for everyone to implement everything, everywhere. Rather, the expectation is that a seamless quality of air navigation services should be delivered worldwide through regional and national performance objectives for meeting the performance ambitions. To achieve seamlessness while ensuring optimum use and allocation of resources, efforts should be made in each State and region to analyse the operating environment and to make consistent choices for increased modernization.

7.2.~~8~~10 Although there are several ways to apply a performance-based approach, a globally harmonized process for performance management is recommended. The goal of this process is to identify optimum solutions based on operational requirements and performance needs so that the expectations of the aviation community are met by enhancing the performance of the air navigation system and optimizing the allocation and use of all available resources.

7.2.~~9~~ 11 The performance management process is based on three principles: a strong focus on desired or required results; reliance on facts and data; and collaborative, justified decision-making. The successful implementation of this process requires:

a) commitment from all members of the aviation community;
b) agreement on goals and consensus on the desired outcome of performance management in terms of performance results to be achieved;
c) accountability and organization among members of the aviation community in terms of roles and responsibilities;
d) human resources and knowledge/expertise;
e) data collection, processing, storage and reporting;
f) collaboration and coordination; and
g) investment.

7.2.~~10~~ 12 This process can be applied to varying extents at the global, regional and local levels. States and regions should, in collaboration with all members of the aviation community, use this performance management process as the basis for developing national and regional air navigation plans adapted to their specific operational requirements and performance needs.

7.2.~~11~~ 13 For more information regarding the ASBU framework, performance management process and supporting performance framework, refer to the Global Technical Level of the GANP.

7.3 GLOBAL, REGIONAL AND NATIONAL IMPLEMENTATION PLANNING

7.3.1 The planning process at the global, regional and national levels should enable a well-understood, manageable and cost-effective sequence of improvements that meet user needs and culminate in an integrated, high-performance system.

7.3.2 The GANP provides a global basis on which regional and national air navigation implementation plans are developed. All three levels of planning – global, regional and national – must be adequately addressed and integrated to promote a seamless global air navigation system.

7.3.3 Regional air navigation planning is very well established. Article 28 of the *Convention on International Civil Aviation* (Doc 7300) establishes the responsibility of contracting States to provide the necessary air navigation services to facilitate international air navigation. In order for air navigation implementation to be bettered managed, the world is divided into air navigation regions.[21] The ICAO regional air navigation plans are used as repository documents for the assignment of these responsibilities.

7.3.4 PIRGs are responsible for the development and maintenance of air navigation plans. They provide for the planning and implementation of air navigation systems within specified areas, in accordance with agreed global and regional planning frameworks.

7.3.5 Air navigation plans are published in three volumes~~: Volumes I and II define requirements aligned with the BBB framework, and Volume III follows the performance management process for selecting relevant ASBUs. For more information regarding the purpose, content or amendment process of air navigation plans, please visit the GANP Portal~~. In Volumes I and II of the air navigation plans, PIRGS

[21] ICAO currently recognizes nine regions: the African-Indian Ocean (AFI) Region, Asia (ASIA) Region, Caribbean (CAR) Region, European (EUR) Region, Middle East (MID) Region, North American (NAM) Region, North Atlantic (NAT) Region; Pacific (PAC) Region and South American (SAM) Region.

define stable (Volume I) and dynamic (Volume II) planning elements related to the assignment of responsibilities to States for the provision of aerodrome and air navigation facilities and services, and the current to medium-term mandatory regional requirements related to aerodrome and air navigation facilities and services to be implemented by States in accordance with regional air navigation agreements, including requirements related to the basic building blocks (BBBs).

7.3.6 In Volume III of the air navigation plans, PIRGs identify dynamic/flexible planning elements for modernizing the regional air navigation system, following a performance-based approach. As part of this approach, PIRGs define regional priorities and performance objectives, linked to the key performance areas (KPAs) and indicators (KPIs) of the GANP, to achieve the global performance ambitions as well as to the operational improvements within the ASBU framework that could be implemented by States, based on identified needs at local and national level.

7.3.~~6~~ 7 Whereas ICAO addresses the planning strategy at the global and regional levels, planning at the national level is the responsibility of States. A national planning framework should be developed by each State based on its needs and in collaboration with regional and global partners. This will ensure to the greatest extent possible that solutions are internationally harmonized and integrated.

7.3.~~7~~ 8 Planning for the modernization of the air navigation system must begin with a thorough understanding of user system requirements and take into account traffic density and complexity, and the level of sophistication required for the provision of necessary services, among other elements.

7.3.~~8~~ 9 Accurate forecasts of civil aviation activity must therefore be developed to support activities in air navigation system planning. This forecasting involves the assessment of future trends in aircraft movements as well as volumes of passenger and freight traffic, both within States and throughout regions. In addition to understanding user requirements, an investment in new systems requires empirical data to sustain the validity of any proposals associated with that investment.

7.3.~~9~~ 10The demonstrated capabilities of new systems must be clear to the investing aviation community so that it recognizes the value of equipping fleets or installing the necessary infrastructure at the earliest opportunity.

7.3.~~10~~ 11 Determining who pays and who benefits should not be a contentious issue among the members of the aviation community; it should be addressed through a collaborative approach based on an understanding of the benefits and interconnectivity of the global aviation system. While States are ultimately responsible for defining, planning and funding modernization efforts, they should not be isolated, as all efforts are interconnected with regional partners and industry. Through open and transparent implementation planning in conjunction with other States and industry, shared benefits can be identified and agreed upon.

7.3.~~11~~ 12 The GANP can be used to identify the potential capabilities available and, through links to existing implementation plans, gauge the associated costs and benefits. Once gaps are identified and costs and benefits analysed, States can work with regional and global partners to consolidate resources and take advantage of similar economies of scale to develop implementation plans. Follow-up is needed at each step of the process to ensure that levels of safety are maintained and/or improved upon where necessary. Concurrently, the role of the human and environmental impact of proposed operational improvements should be considered.

7.3.~~12~~ 13 National air navigation plans, as well as other national plans dealing with other aspects of aviation such as safety, security and facilitation, should all be linked together in a broader national aviation plan to ensure an integrated strategic approach at the State level. This broader plan can be considered as a civil aviation "master plan" addressing all aspects of air transport at the State level. The objective is to provide a clear and comprehensive planning and implementation strategy for the future development of the entire civil aviation sector in terms of policies, legislation, objectives, facilities, equipment, organization and capacity-building.

7.3.~~13~~ 14 The master plan should also emphasize the importance of air transport for the economic development of the State. As such, the master plan should be linked to the State's overarching national development plan, where applicable, in order to mobilize public and private resources and partnerships for the implementation of the plan and to strengthen the civil aviation sector.

7.3.~~14~~ 15 A clearly defined relationship between national air navigation plans aligned with the GANP, civil aviation master plans and States' national development plans will enable the prioritization and optimum allocation of resources for all planned projects within States and across all sectors of activity.

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