INTERNATIONAL CIVIL AVIATION ORGANIZATION

AFI SEAMLESS ATM MASTER PLAN

Version 1.0 November 2023

This Plan was originally developed by the AFI ATM Master Plan Project Management Team and amended when appropriate by APIRG.

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EXECUTIVE SUMMARY

APIRG 22 Conclusion 22/35 resolved for the establishment of the AFI seamless Air Navigation System (ANS). To improve the flow of air traffic in the AFI region there is a need for the development of an AFI ATM regional ATM vision, future concept of operations and ATM master plan with enabling technology and infrastructure strategies for Africa.

The AFI Region aims at the establishment of a seamless upper airspace within the existing FIRs, in accordance with the GANP (Global Air Navigation Plan) provisions. It is envisioned that this will result in the incremental harmonisation through implementation of improvement of services within the distinct ATM performance areas by focusing on systemic arrangements and priorities that will enable interoperability and deliver benefits in the short-, medium-, and long-term implementation horizons.

The AFI region member States have recommended the development of the AFI seamless Air Traffic Management (ATM) Master Plan for which the performance and benefits of changes will carefully be monitored and evaluated. To ensure traceability with the GANP and ASBU, it is envisioned that implementation planning of the AFI ATM Master Plan will be aligned with the GANP including the improvement elements within the ASBU strategic outlook.

While pre-COVID 19 forecasts projected regional traffic growth to be approximately 5% per year over the next 20 years, the impact of COVID 19 significantly slowed travel demand resulting in traffic levels lower than previously anticipated projections. The recovery of global airlines' performances fueled by increasing air travel demand has been accelerating significantly especially in Asia Pacific, North America, and the European markets. Demand in the AFI region remains robust and infrastructure constraints will need to improve significantly in the short term and constraints addressed. Therefore, proper planning is required to avoid capacity constraints and congestion, especially for the busiest city pairs.

The AFI ATM Master Plan defines the AFI regional airspace distinctly according to CNS capabilities established to support operations within the respective airspaces as, oceanic/remote en-route and en-route continental and terminal airspace operations. Based on the AFI FRA Gap analysis outcome and traffic flows analysis, States have identified the prevailing conditions for FRA implementation and should develop a regional action plan to fill the gaps for the operationalisation of FRA concept. Similarly, airspace management should be based on the principle that airspace should not be designated as purely civil or military, but rather as a continuum in which all user requirements are accommodated to the greatest possible extent. States should manage their limited airspace in a way that accommodates both Civil and Military requirements on use of airspace. It is recommended that the AFI regional civil and military ATM coordination and flexible use of airspace implementation efforts are adequately supported.

The plan calls for States to commence the gradual migration of aeronautical communication from voice communications toward data-driven communication that allows automated systems to communicate with each other without or with limited human intervention to improve Collaborative Decision Making (CDM) within the civil aviation community and move the industry closer to performance-based operations.

Regarding Navigation, the plan encourages States to prioritise the migration to Performance Based Navigation (PBN) as opposed to conventional ground-based navigation and work with service providers to further the implementation of PBN as enabled by GNSS. Maintenance of conventional ground-based navigation aids like VOR and ILS including DME shall continue to be retained in the short to medium term within the AFI Region to mitigate GNSS outages. States and service providers in the Region are expected to engage in R&D with active support from AFCAC and ICAO Regional Offices to bring all the advantages of the available augmentation, not only for safety of lives, but also for industry sustainability through non-aviation application.

Modernisation of airspace, which means both route design, automation including new tools and technologies, will make air traffic management more efficient, enabling the reduction in aviation industry impact on and the environment, while ensuring sustainability and supporting future growth. The need for more integrated aviation planning requires solutions by introducing the consensus-driven Aviation System Block Upgrades (ASBU) systems. The technology roadmaps complement the ASBU elements implementation by providing timelines for the technology that will support the Communications, Navigation, and Surveillance (CNS), Information Management (IM) and Avionics requirements to enable attainment of the AFI seamless Air Navigation System.

The ASBU elements improvements within the performance areas; Information, Operational and Technology are captured within the technical plan and the implementation roadmap of the AFI ATM Master Plan. The outcome of the Gap Analysis informed the development of a technical plan and roadmap that will be implemented during the strategic outlook period in three distinct phases (short, medium, and long term) from the year 2024 to 2036 and beyond. The technological and the operational concepts as detailed within the technical plan are aligned with global air navigation plan and will enable achievement of the AFI Vision 2045.

The plan defines performance improvement areas and criteria in terms of assigned categories and priorities in line with the AFI Air Navigation Plan. The ASBU improvement elements are categorised as follows, Essential (E), ASBU elements that provide substantial contribution towards global interoperability, safety, or regularity; Desirable (D), ASBU elements that because of their strong business and/or safety case, are recommended for implementation almost everywhere; Specific (S), ASBU elements that are recommended for implementation to address a particular operational environment or mitigate identified risks; and Optional (O), ASBU elements that address operational requirements and provide additional benefits that may not be common everywhere.

Additionally, the elements are assigned priority 1 or 2; PRIORITY 1 is assigned to the elements with the highest contribution to the improvement of air navigation safety and/or efficiency in the AFI region and should be implemented where applicable and will be used for the purposes of regional air navigation monitoring and reporting. Whereas PRIORITY 2, is recommended for the implementation based on identified operational needs and benefits.

Of significance, prior to any significant system change, a cost/benefit analysis (CBA) should be conducted to demonstrate the value, negative or positive, of the projected change. A CBA of the transition to an AFI Seamless ANS environment will be developed when the Plan is derived from the AFI Air Navigation Plan on behalf of all AFI States. Although each State retains responsibility within sovereign airspace, acceptance of the Seamless ANS Plan by APIRG, on behalf of all States, creates an obligation to all AFI State, as far as practicable, to follow the agreed upgrade path.

Human performance considerations and capacity building objectives remain key enablers to support harmonious implementation of global and regional concepts including the successful execution of the AFI ATM master plan. Throughout the aviation system, people are both the source of some of the risks and an integral part of identifying and managing all risks. The Aviation system must enable the development of appropriate processes to address negative safety consequences through evaluation of human performance considerations and ensure that these are embedded in the State Safety Programmes.

Aviation professionals have an essential role in the transition to, and successful implementation of the AFI ATM Master Plan. The system changes will affect the work of many skilled personnel in the air and on the ground, potentially changing their roles and interactions and even requiring new proficiencies to be developed. Therefore, it is crucial to ensure that recruiting and training programmes are developed using a competency-based framework, fatigue-related risk is managed appropriately, and safety data, including the reporting of hazards, is collected, analysed, and acted upon within ATM Seamless systems. Furthermore, with the expected growth of aviation, it is critical that enough qualified and competent personnel are available to ensure a safe and efficient aviation seamless system. States and aviation stakeholders should conduct individual training needs assessment to identify areas of priority dependant on availability of resources.

Safety is a top priority in aviation. The purpose of the Global Aviation Safety Plan (GASP) (ICAO Doc. 10004) is continual improvement of safety and an associated reduction in the number of accidents and related fatalities within the international civil aviation system, by guiding the development of a harmonized aviation safety strategy and developing and implementing regional and national aviation safety plans. A safe aviation system contributes to the economic development of AFI member States and their industries. The GASP promotes the implementation of States' national safety oversight system, a risk-based approach to managing safety as well as a coordinated approach to collaboration between States, regions, and industry.

In line with the Safety Management concept laid out in the AFI Region CONOPS, safety and its rigorous implementation shall be central to aviation in the Region. The aim is to achieve continuous improvement of safety in the region. The RASG-AFI shall be the engine room and the main driver behind the planning and implementation of appropriate safety enhancement initiatives (SEIs) at regional level.

The AFI ATM Master plan provides the opportunity for the States to plan their ATM improvements and deployment of technology that meets future demands of achieving a seamless ATM environment. To attain the goals set for the region, it is important to ensure that all States work within the framework outlined by adopting the benefits from research and development available.

An integrated, harmonized and globally interoperable ATM system cannot be achieved if States do not collaboratively conduct their implementation planning activities. A strategic outlook of the AFI Vision 2045 has therefore been set for States and this document will provide guidance towards achieving the targets outlined in the ATM Masterplan implementation roadmap.

Through implementation of the ASBU modules outlined in the regional master plan, AFI States to take environmental management system requirements into consideration in preparation for the ever-growing global support of environmental protection strategies and the goals to curb carbon emissions. It is recommended that a mechanism be adopted to develop a digital platform to ensure the monitoring of implementation and the evaluation of the effectiveness of the improvements. States' active participation will enable the monitoring and evaluation objective and attainment of the AFI seamless ANS.

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ACRONYMS/ABBREVIATIONS

A-SMGCS	Advanced Surface Movement Guidance & Control System
ACARS	Aircraft Communication Addressing and Reporting System
ACC	Area Control Centre
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance – Contract
AFCAC	African Civil Aviation Commission
AFI	African Indian Ocean Region
AFIS	Aerodrome Flight Information Services
AFTN	Aeronautical Fixed Telecommunication Network
AIDC	Interfacility Data Communication
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Services
AIXM	Aeronautical Information Exchange Model
AMHS	ATS Message Handling System
ANGA	Augmented Navigation for Africa
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
AODB	Airport Operations Database
APCH	RNP Approach
APIRG	AFI Planning and Implementation Regional Group
APP	Approach
APV	Approach Procedure with Vertical guidance
ASBU	Aviation System Block Upgrade
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSU	Air Traffic Service Unit
ATS/DS	ATS Direct Speech
ARO	Aerodrome Reporting Office
AU	African Union
AWOS	Automated Weather Observing System
BBB	Basic Building Blocks
CANSO	Civil Air Navigation Services Organisation
CCO	Continuous Climb Operations

CDO	Continuous Descent Operations
CDR	Conditional Route
CLAM	Cleared Level Adherence Monitoring
CNS	Communication, Navigation and Surveillance
COM	Communication
COVID	Corona Virus Disease
CPDLC	Controller Pilot Data Link Communication
CTR	Control Zone
DFMC	Dual Frequency Multi-Constellation
DME	Distance Measuring Equipment
ENR	En-route
eTOD	electronic Terrain and Obstacle Data
FIR	Flight Information Region
FIS	Flight Information Service
FL	Flight Level
FMP	Flow Management Position
FUA	Flexible Use of Airspace
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
HF	High Frequency
HMI	Human Machine Interface
HQ	Headquarters
HR	Human Resources
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFP	Instrument Flight Procedure
IFR	Instrument Flight Rules
ILS	Instrument Landing System
ITU	International Telecommunication Union.
LNAV	Lateral Navigation
LOC	Local (runway) controller
LPV	Localizer Performance with Vertical guidance
LVP	Low Visibility Procedure
MET	Meteorology
MLAT	Multilateration
MOU	Memorandum of Understanding
MSAW	Minimum Safe Altitude Warning

MSSR	Monopulse Secondary Surveillance Radar
NASP	National Aviation Safety Plan
NAVAID	Navigation Aid
NDB	Non-Directional (radio) Beacon
NM	Nautical Mile
NOF	NOTAM Office
NOTAM	Notice To Air Men
OJT	On-the-job Training
OJTI	On-the-job Training Instructor
OLDI	On-Line Data Interchange
PIA	Performance Improvement Area
PIRG	Planning and Implementation Regional Group
PBN	Performance Based Navigation
PIB	Pre-flight Information Bulletin
PSR	Primary Surveillance Radar
RAM	Route Adherence Monitoring
RASP	Regional Aviation Safety Plan
RCC	Rescue Coordination Centre
REC	Reginal Economic Commissions
RNAV	Area Navigation
RNP	Required Navigation Performance
RPL	Repetitive Flight Plan
RWY	Runway
RX	Receiver
SAR	Search And Rescue
SARPs	Standards and Recommended Practices
SAATM	Single African Air Transport Market
SBAS	Satellite-Based Augmentation System
SEI	Safety Enhancement Initiatives
SID	Standard Instrument Departure
SMR	Surface Movement Radar
SMS	Safety Management System
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
STCA	Short Term Conflict Alert
TFG	Traffic Forecasting Group
TMA	Terminal Manoeuvring Area
TRA	Temporary Reserved Area
TSA	Temporary Segregated Area
TWR	Tower

TWY	Taxiway
TX	Transmitter
UNL	Unlimited
UTA	Upper Terminal Area
VCS	Voice Communication System
VDF	VHF Direction Finder
VFR	Visual Flight Rules
VHF	Very High Frequency
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VRS	Voice Recording & Replay System
VSAT	Very Small Aperture Terminal
WAM	Wide Area Multilateration
YD	Yamoussoukro Decision

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PART I

INTRODUCTION

1.1 Scope of the Plan

APIRG 22 Conclusion 22/35 resolved that to improve the flow of air traffic in the AFI region there is a need for the development of an AFI regional ATM Vision, future concept of operations and an AFI ATM Master Plan with enabling infrastructure strategy, which in turn will enable the achievement of the AFI Seamless air navigation system.

The AFI Region aims at the establishment of a seamless upper airspace with the existing FIRs, in accordance with the Global Air Navigation Plan provisions. This will result in increased harmonisation and improvement of the existing services by focusing on implementable arrangements that will increase interoperability and deliver benefits in the short, medium, and long term.

The AFI Region Member States have recommended the development of the AFI Seamless Air Traffic Management (ATM) Master Plan for which the Performance and benefits of changes will carefully be monitored and evaluated. To ensure traceability with the Global Air Navigation Plan, the AFI Seamless ATM Master Plan is developed in alignment with the GANP 6th Edition ASBU elements Block upgrades.

The AFI Seamless ATM Master Plan (hereinafter referred to as the 'Plan') references different levels. At the upper level is a global perspective, which is guided mainly by references to the *Global Air Navigation Plan* (GANP, Doc 9750), the *Global ATM Operational Concept* (Doc 9854) and the *Global Aviation Safety Plan* (GASP, Doc 10004). Beneath this level is regional planning primarily provided by this Plan and other guidance material, to define goals and means of meeting State planning objectives, such as:

AFI Regional Air Navigation Plan objectives;

(1) The Seamless ANS performance framework, with a focus on technology and human performance within Aviation System Block Upgrade (ASBU) Block 0 and Block 1 elements, non-ASBU concepts, industry, and civil-military cooperation elements;
(2) A deployment plan with specific operational improvements, transition arrangements, expected timelines and implementation examples; and
(3) An overview of financial outcomes and objectives, cross-industry business models, and performance versus risk management planning.

The Plan incorporated the ICAO/CANSO Mombasa Air Traffic Flow Management (ATFM) roadmap concept of operations and the AFI air navigation concept of operations (both hereinafter referred to as 'CONOPS'), and the AFI PBN implementation roadmap, superseding these documents.

The Regional Air Navigation Plan (RANP) is expected to incorporate key components of this plan and information on the mechanisms that enable these objectives to be met. High-level support may be necessary from regional bodies that can effectively support the plan's implementation, such as but not limited to:

(1) Africa Union (AU);
(2) Regional Economic Commissions (RECs); and
(3) African Civil Aviation Commission (AFCAC)

To achieve full liberalisation of air transport market in Africa, the Single Africa Air Transport Market (SAATM), flagship project of the AU, was introduced to expedite the full implementation of the Yamoussoukro Decision (YD) to move the continent forward towards the concrete implementation of the AU Agenda 2063. AFCAC as the executing agency of the YD in collaboration with States, Organs of the African Union, Regional Economic Commissions, airlines, industry associations and other air transport service providers are continually advocating on effective implementation of AFI seamless ANS.

The AFI seamless ANS strategy is expected to be implemented in several phases. No phase, nor any element, is binding on any State, but should be considered as a planning framework. The AFI seamless ANS strategy itself is therefore significant guidance material.

The main assumptions of this plan are:

(1) The operational concepts and ATM/cns architecture defined in this plan are implemented in a timely manner.
(2) The operational concepts and infrastructure defined in the ICAO GANP and ASBU Block upgrades remain relevant.
(3) The plans produced for the AFI region are executed by States.
(4) External projects (such as the implementation of EGNOS in the Africa region) continue to be undertaken in a timely and coordinated manner.
(5) Traffic Forecasts for the AFI regions are largely accurate, meaning that traffic will grow rapidly during the timeframe of this Plan.
(6) The existing FIRs will remain largely as they are today, excluding adjustments to better reflect operational requirements.

1.2 Plan Objectives and Development

The objective of the Plan is to facilitate AFI seamless ATM operations, by developing and deploying ATM solutions capable of ensuring safety and efficiency of air transport throughout the AFI region. The Plan provides a framework for a transition to a Seamless ATM environment enabled by technological advancement, to meet future performance requirements.

The Plan provides the opportunity for the AFI region to adopt the benefits from research and development conducted by various States in other ICAO regions including the NextGen programme (United States of America), the European Single European Sky ATM Research (SESAR), and Japanese Collaborative Actions for Renovation of Air Traffic Systems (CARATS).

ICAO Doc 9854 contains a vision of an integrated, harmonised, and globally interoperable ATM System, with a planning horizon up to and beyond 2025. In this context, the Plan is expected to encourage more partnering relationships among States within the sub-regions.

PART II

ANALYSIS OF TRAFFIC FLOWS AND ROUTE NETWORK

2.1 Introduction

This part analyses the current situation in the provision of air navigation services (ANS) in the AFI Region. Particularly, it captures the strengths and weaknesses of the current situation, and the aviation stakeholders' expectations. It is based on the contributions and meetings from Member States. It is a first step towards the development of the "AFI Air Traffic Management Master Plan".

2.2 Airspace Organization

The upper airspace of the 54 AFI Member States comprises 44 Flight Information Regions (FIRs) which together represent an area of more than 40 million square kilometres (land coverage is 30.39million km^2 i.e. more than 2.5 times the European airspace).

AFI FIRs

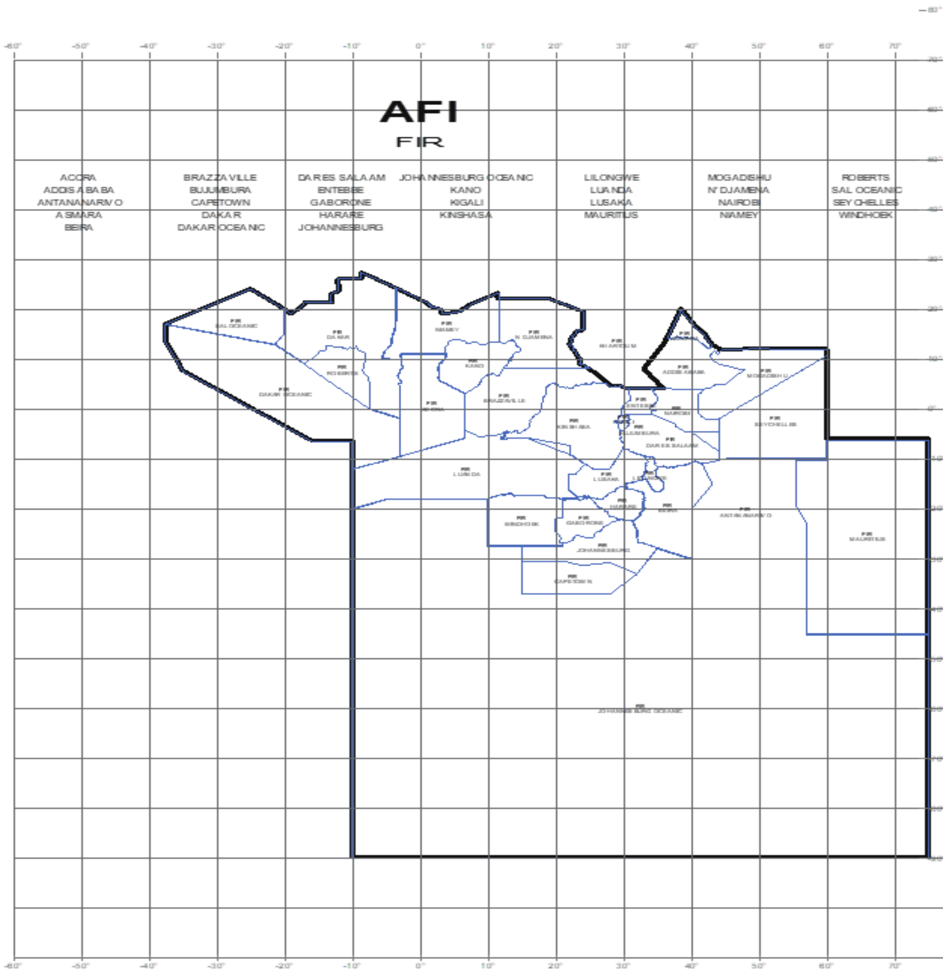

Figure 2-1. Map of AFI Flight Information Region

The current AFI airspace organisation is principally based on geographical boundaries and the division of airspace has been dictated for years by national considerations. This particularly impacts long haul and mid haul flights which must cross several control units along their route and adapt successively to various quality of service levels, which leads to inefficiencies and potentially operational safety problems.

One of the main opportunities offered by the implementation of a regional seamless ATM Master Plan is to contribute to the simplification of the organisation of the airspace, the harmonisation of ATM technologies and procedures in accordance with the recommendations of the GANP, and to provide airspace users with seamless services regardless of political boundaries, thus enabling sustainable development of the air transport system within the region.

The first step towards the improvement of the regional airspace organisation is to examine thoroughly the traffic patterns, airspace complexity and the evolution of the demand in the time frame of the implementation of the AFI Seamless ATM Master Plan.

2.3 Overview of the Current and Foreseen Aviation Market.

The purpose of this section is to present an overview of the current and foreseen market situation in African airspace in the AFI region. This should enable an understanding of the main goals of the airspace users and help to highlight benefits of implementation of this plan will bring.

The air transport sector in Africa has suffered not only from high prices and unprofitable and/or inefficient route network structures, including poor safety and reliability performances, which are significant issues for operators. Although a route network structure analysis of the current main traffic flows pointed out only a few routes where the demand meets the current ATM capacity, it is necessary to consider the future traffic forecasts.

While the pre-COVID 19 forecasts projected regional traffic growth to be approximately 5% per year over the next 20 years, the impact of COVID 19 significantly slowed travel demand resulting in traffic levels lower than previously anticipated projections. The recovery of global airlines’ performances fueled by increasing air travel demand has been accelerating significantly especially in the northern hemisphere and European markets. Demand in the AFI region remains robust and infrastructure constraints will need to improve significantly in the short term and constraints addressed soonest. Therefore, proper planning is required to avoid capacity constraints and congestion, especially for the busiest city pairs.

The current route network does not entirely adequately accommodate users’ preferences and often prevents users from using the most economical routes. It is for this reason that the implementation of concepts such as the ASBU FRTO elements cannot be overemphasized in line with global and regional requirements and expectations.

2.4 Airline Performance in the African and Indian Ocean Region

Airline industry analysis has showed the number of passengers carried in the African continent reached a value of 180 million; more than 2 million Tonnes of cargo were carried and 2.9 million movements. The performance of African airlines has been increasing on both domestic and international routes – the total number of passengers carried by African airlines reached almost 80 million and the transported cargo represented more than 800 thousand Tonnes in 2019. However, studies have revealed the average load factor remains significantly below the global average, although African airlines have a generally stronger load factor on domestic routes.

Air Traffic Movements and passenger performances in Africa.

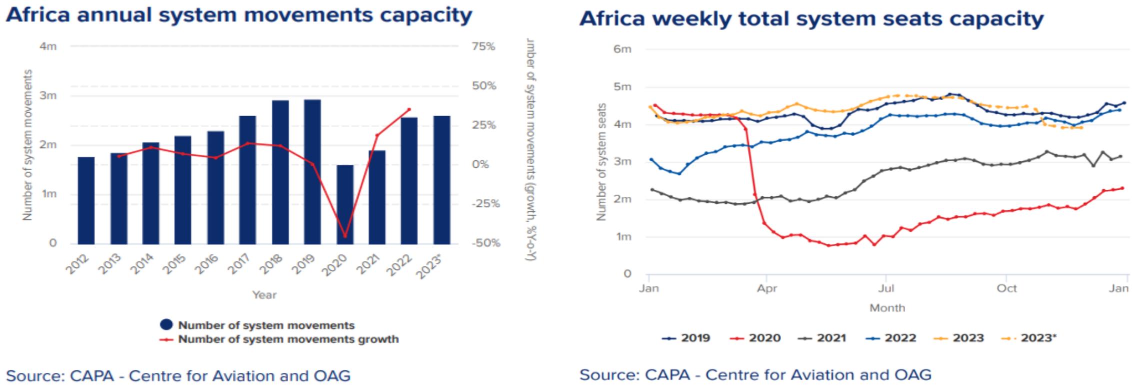

Figure 2-2. AFI traffic movements and passenger capacity

African carriers face stiff competition, especially for Africa – Europe and Africa – Middle East routes where the largest international market is located. In the Africa – Europe market they face stiff competition either from strong traditional carriers from Europe and the Middle East or by popular low-cost carriers. In the Middle East market, most of the capacity is taken by Middle East airlines such as Emirates, Qatar, and Etihad. Recently, the fastest growing market is Africa – Asia, where African carriers dominate in total capacity share and are trying to expand further. For Africa – North America, capacity share is also dominated by African airlines.

The African airlines overview represents the diversity of the different airlines' models in terms of destinations and fleets. Traditional carriers service domestic, regional, and international destinations. For this service they operate more diverse types of aircraft to achieve the best operational results. Low-cost carriers and regional carriers act differently.

The fleet is either unified to cut costs for training and maintenance or consists of small turboprops aircraft. Most of the low-cost carriers are domestically oriented with some exceptions for close regional destinations. As the price of tickets for low-cost carriers is lower than for traditional carriers, the load factor is higher. Cargo airlines do not provide relevant information for comparison, but a lot of cargo is transported in the belly of passenger aircraft. Destinations vary from regional to international routes, depending on demand.

2.5 Forecasts

As shown in Figure 2.3, global forecasts have projected that the aviation industry in the AFI region will grow significantly above global average rates. The fleet of new passenger and cargo aircraft is supposed to double by 2035, and the passenger fleet demand is expected to be focused on single aisle aircraft. Therefore, there is a need in the future to eliminate high levels of congestion both at airports, terminal environment, and en-route airspace.

This process is long lasting but thanks to effective collaboration and cooperation can bring successful results.

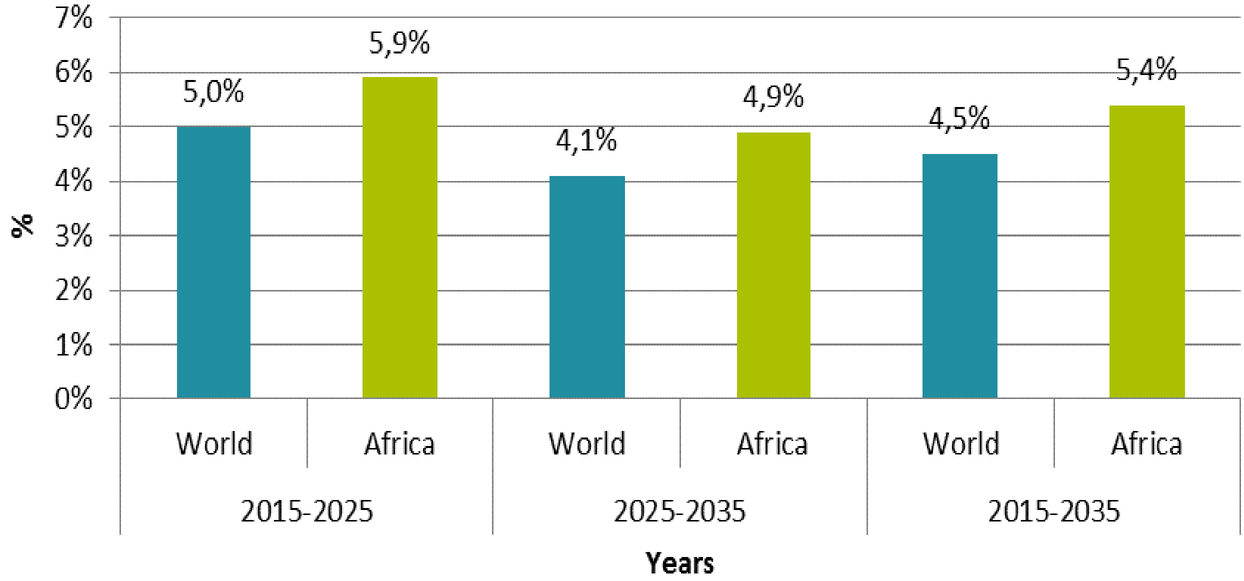

Figure 2-3 Total Revenue Passenger Kilometre (RPK) Traffic Growth Forecast

PART III

OPERATIONAL PLAN AND CONCEPT OF OPERATIONS.

3.1 CNS Enablers

3.1.1 Communication

The place of Aeronautical communication cannot be overemphasized in ensuring safety and continuity of civil aviation as an important backbone of all CNS applications. It is, therefore recommended in the regional ATM masterplan that States should commence the gradual migration of aeronautical communication from voice communications toward data-driven communication that allows automated systems to communicate with each other without or with limited human intervention to improve Collaborative Decision Making (CDM) within the civil aviation community and move the industry closer to performance-based operations.

AFI States are to put in place communication backbone to enhance voice communication together with the SWIM infrastructure converging to ATN/IPS and run over an aviation dedicated VPN to improve security. The Regional stakeholders to collaborate to put in place a dedicated satellite communication infrastructure to enable aviation applications to achieve the long-term aspiration of the regional ATM community. This achievement is likely to galvanise the regional community to continue to pursue these frequency bands in support of safety of life.

Further to that, States and stakeholders in the region must collaborate to ensure that the current and future CNS technologies, Spectrum requirements are protected through the International Telecommunication Union (ITU). A synergy between regulatory, operational and aircraft requirements must be achieved by aviation community to facilitate a holistic voice/datalink air-ground and ground-ground communication.

Consequently, AFI stakeholders will collaborate to put key drivers of this vision into place. This includes the provision of appropriate communication infrastructure to support future operating environments and the provision of consistent, globally aligned, solutions to enable achievement of the seamless ANS goal.
Considering the fundamental role of communication in aviation as an enabler, the common objective is to ensure the provision of the desired services meeting appropriate performance and interoperability requirements in a cost-effective manner.

The communication enablers as espoused in the ICAO Global Air Navigation Plan include;
Air - ground voice communication, Air – ground data link communication, Ground – ground voice and datalink communication.

3.1.1.1 Air–Ground Communication

The AFI region will deploy the following air-ground voice communication technologies in accordance with the ICAO GANP. VHF (25KHz): Air-Ground voice communications in continental airspace will remain on 25KHz VHF channel spacing. It is highly improbable that the AFI region will deploy 8.33KHz VHF voice channels, however future assessments will validate requirement and the transition to this capability.

HF and SATCOM: Air-ground voice communications in oceanic and remote airspace will continue to rely on HF and SATCOM with an imminent migration from HF to SAT Voice.

3.1.1.2 Air–ground data link Communication

The AFI region will deploy air-ground data link communication technologies in accordance with the ICAO GANP. The provision of services based on Automatic Dependent Surveillance – Contract (ADS-C) and Controller-Pilot Data Link Communication (CPDLC); and the implementation of a dedicated communication infrastructure to support the provision of services such as the VHF Data Link (VDL) Mode0/2 and the Aeronautical Telecommunication Network (ATN).

3.1.1.3 Ground–Ground Communication

The AFI region will deploy the following ground-ground communication technologies in accordance with the ICAO GANP. IPv6: a transition from IPV4 to IPv6 is expected to support national and international communications. Voice over IP (VoIP): a transition to VoIP with IPv6 is expected to support ATS/DS for voice coordination between ATSUs (at the national and international levels).

ATS Message Handling System (AMHS): a migration from AFTN to AMHS is expected for the exchange of ATS messages. The migration will enable a more modern technology as compared to AFTN that will provide increased functionality capable of binary data message exchange with increased message length limit. The migration will further provide extended services such as the exchange of OPMET, digital NOTAM and flight objects using XML.

3.1.1.4 Systems Supported Coordination (SYSCO)

Interfacility Data Communication (AIDC) / On-Line Data Interchange (OLDI)
The implementation of AIDC/OLDI is expected for flight coordination and transfer between adjacent ATS centres (between adjacent ACCs, or between an ACC and an adjacent Approach Centre). Adoption of a single platform by the region is the long-term goal for operational traffic coordination between adjacent FIRs.

System-Wide Information Management (SWIM): the implementation of an initial SWIM capability is expected to support data sharing among aviation stakeholders. The ATM communication environment is expected to continue to be based on ground Human Machine Interfaces (HMIs), voice switches, Flight Data Processing Systems (FDPS)

ATM systems, ground communications systems, routers, networks, radio ground stations, airborne radios, and communication end systems (e.g. airborne Communications Management Units (CMUs) and ground communications application processors). These components combine to form an end-to-end chain that must meet the performance and safety requirements for voice and data applications.

3.1.2 Navigation

The Region remains perhaps one of the few with ample traffic growth projection exceeding the global average. Consequently, implementation of technologies and initiatives that would improve safety, capacity, efficiency, and sustainability and ultimately serve as enabler for optimal utilization of the AFI airspace shall be given priority.
To that end in the short and medium term, attention shall be paid to Performance Based Navigation (PBN) as opposed to conventional ground-based navigation. Specifically, States shall work with service providers to further the implementation of PBN supported by GNSS.

The aim is to implement RNP in increasing specification not only for global harmonization, but for safety, access and equity, capacity, and predictability. The Region will go beyond RNAV 10 to RNAV 5, to progressively implementing RNP 4 RNP 2 and RNP 1 both for the enroute and at terminal phase of flight. RNP 0.3 implementation for the approach phase of flight will continue in the region. It is expected to be completed by 2025. To that end, implementation of APTA B0/1, APTA-B0/3, APTA-B0/4 and APTA-B0/5 has been prioritized in the AFI ASBU implementation template.

Maintenance of conventional ground-based navigation aids like VOR and ILS including DME shall continue to be retained in the medium term within the AFI region and evolve to serve as a Minimum Operating Network (MON) to mitigate GNSS outages. ILS will continue to be retained for reason of its capability to enhance precision approaches and DME for its capability to optimize existing network for a robust PBN operation up to 2028. ILS installation shall continue to be limited to CAT I and CAT II for reasons of capacity and appropriateness. Installation and commissioning of CAT III ILS shall be in response to specific operational needs in a particular environment.

In the meantime, such enablers of RNAV and RNP as timely renewal and upgrade of WGS-84 survey as well as calibration of conventional navigation aids shall be prioritized. This is aimed at maintaining the reliability of the current system in the medium term, while establishing the backbone for a sustainable implementation of GNSS-backed PBN in the Region in the long-term.

To that end, FRTO-B0/1, FRTO-B0/2, FRTO-B0/3 and FRTO B0-4 implementation shall be pursued for its safety, efficiency, improved capacity as well as optimization capacity derivable therefrom. States shall continue the regional implementation of Free Route Airspace (FRA) in accordance with the APRIG 23 adopted AFI FRA Concept of Operation. The aim is to achieve uniformity and seamlessness for a harmonised implementation across the region as exemplified in the AFI FRA CONOPS Document. In each instance, it shall be preceded by implementation of Direct Route Operation (DRO), conduct of a gap analysis, training of ATS staff as well as issuance of relevant enabling Aeronautical Information Publication (AIP) in line with DAIM-B1/1.
These ASBU modules shall be implemented with attention paid to threads of dependencies and relations for completeness and efficiency.

States and Service providers will implement GNSS Augmentation. ABAS, GBAS as well as SBAS implementation has gained some milage in the Region. The recorded gains shall be improved upon for it obvious operational advantages and flexibility. In the long term, conventional navigational/landing aids rationalisation will be implemented to take advantage of its smartness and cost-effectiveness. In the short term, APTA-B0/3 implementation shall continue in the region to improve access to aerodromes with restricted ILS installation. GNSS Augmentation- systems are recommended for application within the region. SBAS' efficiency and its economic profitability demonstrated at the continental level provide a cost-effective solution for precision approaches operations on both Runway ends. In accordance with APIRG conclusion 25/24, the outcome of the AUC/AFCAC study on the governance and institutional issues related to SBAS in Africa and facilitation in mobilisation of required resources will support the effective implementation of SBAS in the region.

Several States in the region have implemented LNAV/Baro-VNAV. Wider capability with ABAS augmentation will ensure the intended lateral as well as vertical guidance to runways during RNP APCH is achieved. For improved access, the implementation of the APTA-B1/1 in the medium term and APTA-B2/1 in the long-term for improved safety, efficiency, capacity, and sustainability is prioritized for regional implementation.

The Regional implementation of the use of SBAS to augment single-frequency GPS are well matured and currently effective. It shall be given wider implementation not only for improved navigation, but also for enhanced surveillance capability. The outcomes of the AUC continental CBA on Satellite-Based Augmentation System (SBAS) implementation in Africa were released in 2022 and depicted a positive outlay. The recommendations were that the feasibility of SBAS services provision in Africa in compliance with ICAO SARPS has been demonstrated and recognised under the ICAO Annex 10, Vol 1, Appendix b, table b-27 and attachment d paragraph 6.2.2; AUC and AFCAC in collaboration with the partners should develop the governance and institutional framework for SBAS including the financing models; The Airlines operating in Africa have demonstrated the value of SBAS in enhancing safety and improving efficiency at African international airports specifically domestic smaller aerodromes not equipped with ILS. The workshop noted that airspace users support implementation of SBAS in Africa provided that;

a) No mandatory requirements by regulatory authorities to fit SBAS equipment to aircraft;
b) No unjustified restrictions to operations due to a lack of SBAS equipment; and
c) No costs or charges related to SBAS being imposed directly or indirectly to airspace users who do not use such technology.

Any envisaged rationalisation and decommissioning of conventional navigation aids should take place with proper consultation with users and interested stakeholders through collaborative decision-making process under ICAO, and specifically the AFI GNSS Strategy.

The dual-frequency, multi-constellation (DFMC) GNSS capability upgrade for SBAS is now standardised by ICAO and will be available on-board in the next decade. SBAS is an enabler for vertically guided and precision approach operations, namely Localizer Performance with Vertical guidance (LPV) and Localizer Performance

(LP) minima. LPV operations enabled by SBAS uses geometric vertical guidance using altitude information derived from augmented GNSS and do not rely on QNH-setting by pilot.

As called by the African Union space policy and strategy, an indigenous SBAS infrastructure for Africa, named ANGA (Augmented Navigation for Africa), recognised by ICAO under Annex 10, is already being rolled out to enable the aviation industry to reap the benefits associated with SBAS services from 2026. The ANGA single-frequency and DFMC demonstration services are already available for test and field demonstrations purposes.

3.1.3 Surveillance

The AFI Surveillance strategy must be linked to the Global Air Navigation Plan for ATM/CNS systems and the AFI Plan including industry strategies for the regional civil aviation surveillance applications. The strategy must also describe the future evolution of the surveillance system in line with the ASBU framework and timelines. This shall constitute a component of the regional Air Traffic Management system.

Surveillance system implementation should be done under a firm foundation of the global harmonization and interoperability taking into consideration the user's expectations, operational requirements, and business cases inclusive of cost-benefit analysis.

To meet the current and future ATM requirements and expectations, the AFI States' implementation planning will consider the following surveillance systems;

a) Non – Cooperative surveillance systems
b) Cooperative surveillance Systems

The ATM community including other interested stakeholders i.e. aircraft operators, service providers, aircraft and avionics and infrastructure manufacturers etc. must collaboratively plan the implementation of these surveillance systems. The ATM system must keep evolving to maturity to continuously improve safety, efficiency, and sustainability. Emerging technologies and development should meet the requirements of the developing and dynamic ATM requirements considering systems technological advancement and functionality.

As the ATM requirements increase, new systems and concepts continue to emerge in response, as technology advances, offer potential improvements in safety, efficiency, and sustainability. Emerging technologies can support a variety of systems design and implementation options, some of which are still maturing. The regional surveillance strategies should be able to identify the goals, objectives and provide the initiatives for surveillance within the region, considering the aspects above.

This should be based on ATM operational requirements taking a gate-to-gate approach, while recognizing the large variety of aircraft with different performances and operational capabilities seeking to operate and perform at optimum levels by fully exploiting the benefits of new and rationalized systems. The needs for regional harmonisation and compliance to ICAO standards and provisions to achieve the desired safety, efficiency and sustainable improvements remain a key driver of the regional implementation.

3.2 Technology Roadmap

The AFI Technology Roadmap provides an overview of identified technological opportunities based on studies and assessments conducted to modernise the way airspace is structured and transform the technology used to enable the ATM system performance enhancement objective.

Modernising airspace, which means both route design, automation including new tools and technologies, will make air traffic management more efficient, enabling the reduction in aviation industry impact on and the environment, ensuring sustainability and supporting future growth. The need for more integrated aviation planning requires solutions by introducing the consensus-driven Aviation System Block Upgrades (ASBU) systems. The Technology Roadmaps complement the ASBU Modules by providing timelines for the technology that will support the Communications, Navigation, and Surveillance (CNS), Information Management (IM) and Avionics requirements of the AFI seamless air navigation system.

The AFI ATM Vision 2045 technology roadmaps provides guidance for infrastructure planning considerations by indicating on a per-technology basis the requirements for readiness in line with user expectations and operational requirements. The status of existing infrastructure, ICAO standards and guidance materials, performance demonstrations and validations, Initial Operational Capability (IOC) of emerging technologies including global implementation strategies informs definition of the technical implementation plan and technology roadmap.

While the technology and related ASBU elements define the expected operational improvements and drive the development of all that is required for implementation, the technology roadmaps define the lifespan of the specific technologies needed to achieve those improvements. Most importantly, they also drive global interoperability.

Investment decisions are needed well in advance of the procurement and deployment of technology infrastructure. The Technology Roadmaps provide certainty for these investment decisions as they identify the prerequisite technologies that will provide the operational improvements and related benefits. This is critically important as investments in aviation infrastructure are hardly reversible and any gap in technological interoperability generates consequences in the medium and long-term. They are also useful in determining equipment life-cycle planning, i.e. maintenance, replacement, and eventual decommissioning. The CNS investments represent the necessary baseline upon which the operational improvements and the associated benefits can be achieved.

To meet the future ATM requirements and user expectations, and in complimenting the ASBU Modules implementation, the AFI ATM Master plan also includes implementation considerations of 10 roadmaps covering five areas of the technology roadmaps in alignment with the AFI ATM Vision 2045, future concept of operations and the GANP.

3.2.1 Communication

Roadmap 1: Air-Ground Data Link Communication Safety related ATS where performance requirements, procedures, service and supporting technologies are strictly standardised and regulated. Information related services where performance requirements procedures and supporting technologies are less critical.

Roadmap 2: Ground-Ground Communication and Air-Ground Voice Communicating to provide for ground - ground voice communication migration to Voice-over Internet Protocols (VoIP) while Air-Ground Communication to enable migration from HF to SATCOM and SATVOICE in Oceanic and remote areas.

3.2.2 Navigation

Roadmap 3: Navigation strategy in support of the evolution of navigation infrastructure and avionics require dedicated technology with conventional and satellite-based enablers. Implementation of navigation concept such as RNAV, RNP and PBN provide a range of options for the use of navigation technology. Considerations for the use of navigation technology includes future terrestrial infrastructure requirements, the AFI Master Plan in alignment with the GANP has the objective of a future harmonised global navigation capability based on performance-based navigation (PBN) which includes area navigation (RNAV) and required navigation performance (RNP) supported by the global navigation satellite system (GNSS). The AFI region will harmonise the implementation of the strategic infrastructure rationalisation plan, as collaborated with industry and informed by a positive business case while also ensuring due consideration of user requirements and expectations.

Roadmap 4: Performance-Based Navigation (PBN) defines the migration paths for the implementation of PBN levels and precision approaches for the following operations:

a) En-route oceanic and remote continental,
b) En-route continental,
c) TMA arrival/departure, and
d) Approach.

Collaborative implementation planning is essential and AFI States must coordinate and align performance requirements in support of interoperability and harmonisation. Accelerated implementation where identified will be strategically fast tracked, ensuring implementation of demanding PBN specification while also ensuring the objective to satisfy airspace users' requirements with a basic specification. PBN Implementation and specifications should consider airspace users' capabilities following a CDM approach.

3.2.3 Surveillance

Roadmap 5: Ground-based and surface surveillance which entails deployment of cooperative and non-cooperative surveillance systems and techniques that will enhance surface operations. Different techniques must be mixed to obtain the best cost-effectiveness depending on local requirements and constraints. Cooperative surveillance must use available technologies currently using 1030/1090MHz RF bands (SSR, Mode-S, WAM and ADS-B).

Roadmap 6: AIR-AIR surveillance which provides for advanced situational awareness applications using ADS-B In/Out must be used for basic airborne (delegated) separation and limited self-separation in remote and oceanic airspace.

The airborne part of the surveillance system is therefore considered very important and should be "future proof" and globally interoperable to support the various surveillance techniques which will be used. The twin demands of increased traffic levels and reduced separation as required by and informed by the improved performance capability of ADS-B.

3.2.4 Information Management

Roadmap 7: SWIM, Flight & Flow, AIS/AIM, Meteorology and Time – Information Management which enables SWIM deployment allowing all participants, including the aircraft, to be able to access a wide range of information and operational services including full 4D-trajectory sharing. The sharing of information of the required quality and timeliness in a secure environment is an essential enabler for the ATM Target Concept. The scope extends to all information that is of potential interest to ATM including trajectories, surveillance data, aeronautical information, meteorological data, etc.

3.2.5 Avionics

Roadmap 8: Communications & Surveillance which will provide for avionics evolution with significant increase in capability that is possible through the integration of various on-board systems/functions. Aircraft access to SWIM applications will be provided using the various means described in the roadmap for air-ground data link communications.

Roadmap 9: Navigation which will provide for airport navigation integration (via ATN B2) to provide integration between the FMS and the airport navigation system function to among other things support the easy loading within the traffic computer of ATC taxi clearances transmitted by data link. GNSS-based services today rely on a single constellation, the global positioning system (GPS), providing service on a single frequency. Other constellations, i.e. the Global Navigation Satellite System (GLONASS), Galileo and BeiDou will be deployed. All constellations will eventually operate in multiple frequency bands.

PART IV

GAP ANALYSIS

4. Introduction

To support the operational plan and future CONOPs, it is necessary to perform a gap analysis and to define a Technical Plan that will outline the technology needed to enable the target operations to be performed within the AFI Region.

This part therefore presents the Gap Analysis and Technical Plan for the AFI Region in the short, medium, and long term, explaining the benefits of the technologies and the operational concepts that they will enable. Recommended actions are then developed for the timeframe of the AFI ATM Master Plan.

4.1 Methodology

The analysis performed to define the Technical Plan for the AFI Region is summarised in the following diagram and described in more detail in the following sections.

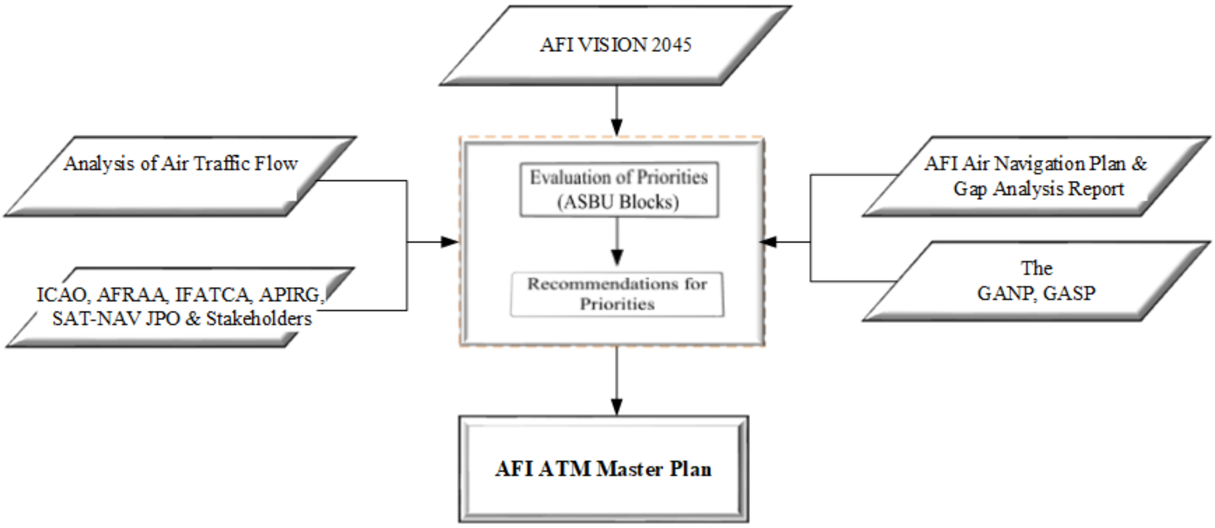

Figure 4-1 ATM Masterplan development roadmap

4.2 Presentation

The document consists of the following sections into which the technical concepts discussed in the context of this Master Plan are organised:

(1) Communication**,** covering air-ground communications and ground-ground communications (voice and data);

(2) Navigation, covering navigation based on PBN implementation plans and emphasis on migration to GNSS including augmentation systems and on conventional means and terrestrial infrastructure rationalisation strategies;

(3) Surveillance, covering ground-based (surface movements) surveillance and airport surveillance capabilities;
(4) Automation, covering ATC systems and ATFM systems, airport and airline operations systems including avionics; and
(5) Information Management, covering digital Aeronautical Information management, the System Wide Information Management (SWIM), and Meteorological Information.

Additionally, a GBAS and SBAS feasibility study performed as part of the Master Plan and used as an input to the development of the Technical Plan will be considered.

4.3 Current situation & Seamless Operations

For each technical concept, the current situation in the AFI region is presented, a brief explanation is provided and the requirements for seamless operations are given based on guidelines issued by international organisations and available information on best practice from other regions.

To best guide the implementation of the technology defined in the AFI ATM Master plan, the description of identified improvements and related evolutions have been considered in three distinct phases:

(1) **Short term (2024-2027)** – initiatives that can be implemented in a relatively short period, and that will immediately unlock airspace capacity in the AFI region and improve the safety of operations. This will include the implementation of the Basic Building Blocks (BBBs) where required, technology supporting the ASBU Block 0 and Block 1 elements, where appropriate.
(2) **Medium term (2028-2035)** – initiatives that will offer significant improvements in capacity, efficiency, and safety within the AFI region, but whose implementation is less urgent or requires more preparation. This timeframe is aligned with ASBU Block 2.
(3) **Long term (2036 and beyond)** – concepts which are more advanced and are more complicated to implement, and therefore require more time for planning and trials, or that will become relevant as traffic levels increases within Africa. This timeframe is aligned with ASBU Block 3 and Block 4.

4.4 Qualitative analysis

To define the target technical scenarios, the qualitative analysis has been based on the following:

(1) The current situation, as-is analysis of the provision of air navigation services (ANS) in the AFI region as defined in the gap analysis presented in section 4.6.
(2) The CONOPs for the AFI region in the timeframe of the ATM Master Plan as defined in part III of the AFI ATM Vision2045, future Concept of operations).
(3) The outcome of the continental study CBA on SBAS and GBAS feasibility studies and the existing ANGA initiatives will be considered in the AFI technology roadmap and technical plan.
(4) Airspace users' and other stakeholders' requirements and expectations, considering national and international carriers operating in the AFI region. It covers stakeholder expectations in terms of KPAs (safety, efficiency, and sustainability), as well as specific requests such as user preferred trajectories.

(5) Global and regional consistency including best practices. In terms of global and regional consistency including the definition of best practices, the ICAO Global Air Navigation Plan (GANP) and the Aviation System Block Upgrades (ASBUs) are considered of critical importance.

(6) Current situation in the provision of ANS in the AFI region. The current situation of the provision of ANS in AFI region (en-route, approach, and aerodrome) has been defined in part II of this ATM Master Plan. The current situation is used as a baseline upon which to base implementation recommendations in the short to medium term.

(7)

4.5 Stakeholders' expectations

Stakeholders' expectations and requirements are largely related to operational procedures, which are of course enabled by technological developments. Industry consultation and implementation planning collaboration will enable optimal implementation of suitable technologies and ensure sustainable implementation of technologies considering the airspace users' expectations and requirements.

The airspace users and other industry stakeholders' business models and strategies are critical components of the development and definition of the technology roadmaps and technical plan.

4.6 Implementation consistency and considerations.

The most important documents in ensuring regional implementation consistency in line with best practices are the Global Air Navigation Plan (GANP) and the associated Aviation System Block Upgrades (ASBUs), AFI ATM Vision 2045, future concept of operations and the AFI Air Navigation Plan.

AFI ATM Master Plan, Global Air Navigation Plan (GANP) and Aviation System Block Upgrades (ASBUs)

(1) The ICAO Global Air Navigation Plan (GANP) (Doc 9750) is described by ICAO as "an overarching framework that includes key civil aviation policy principles to assist ICAO regions, sub-regions and States with the preparation of their regional and State air navigation plans". It is designed to "guide complementary and sector-wide air transport progress for now and beyond 2036.

(2) The AFI ATM Master Plan in alignment with the AFI Vision 2045, future Concept of Operations, and the GANP represents a strategic outlook period of 25 years, and a strategic methodology which leverages existing technologies and anticipates future developments based on regional and State/industry implementation collaboration of operational objectives at national level. The AFI ATM master plan also aligns with the AFI ATM Vision where several technology roadmaps, which depict new and legacy technologies needed to support the implementation of identified ASBU elements and provide implementation roadmaps including associated timelines. The technology roadmaps must be considered when developing the technical plan for the AFI region.

(3) The ICAO Aviation System Block Upgrades (ASBUs) refer to the target availability timelines for a group of operational safety and efficiency enhancements that will eventually realise a fully harmonised and seamless AFI Air Navigation System.

The following upgrades have been defined:

(1) BBB = Basic Building Block (baseline)

(2) Block 0 = from 2013

(3) Block 1 = from 2019

(4) Block 2 = from 2025

(5) Block 3 = from 2031

(6) Block 4 = from 2037

The AFI ATM Master Plan relate mainly to the BBB (baseline), ASBU blocks 0, block 1 and block 2 including considerations of block 3 and 4 elements in line with AFI ATM Master Plan technology plan and implementation strategies.

The ASBU elements related to technology are used as an input for the development of the technical plan. The elements related to procedures have been used when developing the AFI ATM future concept of operations, but as the technical plan supports and enables the operational concept, they remain relevant for the AFI ATM Master Plan.

GANP ASBU Structure:

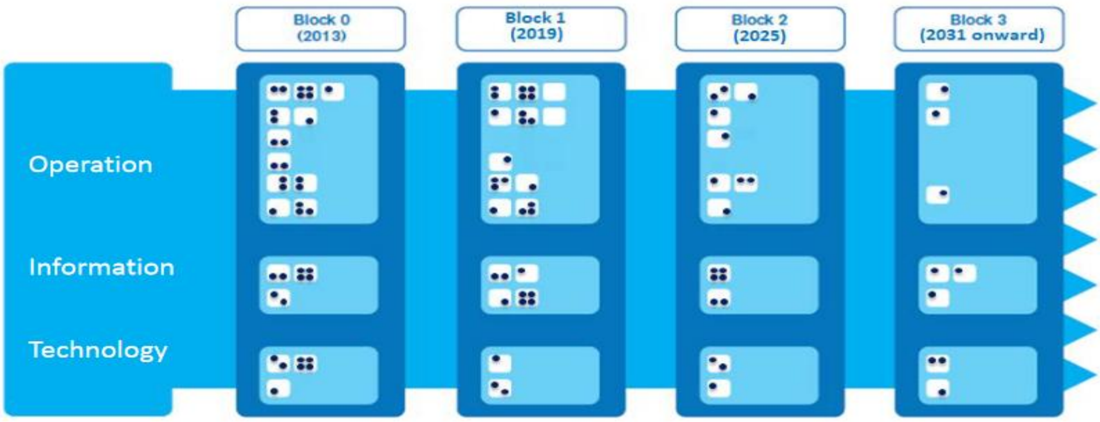

Figure 4-2 ASBU Blocks, Threads, Modules, and Elements.

4.7 Gap Analysis

4.7.1 Overview

The gap analysis presented below has been conducted based largely on the information provided by the AFI States and ANSPs through their responses to the questionnaire submitted to the APIRG AAO-SG and IIM-SG Projects. The information from these questionnaires was complemented by desk-based research of publicly available information both on a regional and national level.

It should be noted that some ANSPs did not respond to these questionnaires, and so the analysis approach estimated the existing gaps based on the respective technical and operational situations.

The gap analysis has been undertaken for the following technological and operational areas: Communication, Navigation, and Surveillance infrastructure, Air Traffic Control Systems, Performance Based Navigation, SWIM including Aeronautical Information Management, Meteorological Services, and Search and Rescue.

The current situation of the AFI States is analysed and compared to the target scenario as presented in the tables below:

4.7.2 Communication Infrastructure

Summary of Current Situation and Seamless Operations requirements.

Area	Current Situation	Seamless Operations
Telecommunication Network	Analogue VSAT networks, leased lines from national telecommunication companies (and sometimes Fiber optic links) are used as the media for exchange of messages and/or digital data between aeronautical fixed stations	Use of an AFI Aeronautical Telecommunications Network (ATN) to provide the inter-networking infrastructure for the CNS/ATM environment.
Ground-Ground Communications	Much of the coordination between ATC Centres is performed through HF, direct voice using the VSAT network, and the public telephone network. Many States have implemented IP networks, but they are not IPV6. ATFN is often used for the exchange of messages and/or digital data, although some States have implemented a basic version of AMHS (and very few have implemented extended AMHS).	Voice communications will be over Voice over IP (VoIP). IPV6 used for the transfer of data. AMHS (Aeronautical Message Handling Service) used as the system to transmit messages, digital NOTAMS, flight plans etc. AIDC (ATS Interfacility Data Communication) used to exchange flight data and ATC related information between Air Traffic Service Units (ATSUs).
Air-ground communications	Air-ground communications largely conducted over voice, using VHF with 25kHz channel spacing in Continental areas and HF in remote and oceanic areas	Voice communications will continue to be conducted over VHF with 25kHz channel spacing in Continental areas but migrate to SATCOM (Satellite Communications) in remote and oceanic areas. Air-ground communications will be increasingly conducted over data link, using CPDLC over ATN Baseline 1 (B1) in continental airspace and CPDLC/ ADS-C over FANS-1/A (ACARS) in remote and oceanic airspace. This will require the use of VHF Data Link Mode 2 as a link media in continental airspace, and SATCOM ACARS (or HF Data Link) in remote and oceanic airspace.

Gaps

(1) Telecommunications Network

The AFI Regional Aeronautical Telecommunications Communication Network (the ATN) is a regional concept yet to be implemented, and so presents an effective gap for all States.

(2) Ground-Ground Communications

Although many States currently operate IP networks, they must be upgraded to the latest version (IPV6). From the information available, very few States have implemented Voice over IP for voice communications between ATC Centres and other States have reported to be planning its implementation.

The extended version of AMHS is already operated by most of the States while others operate a basic version (which must be upgraded to the extended version) and so present partial gaps.

AIDC has already been installed by some States, although it must be ensured that it relates to all neighbouring ATCs in the future. Other States have also implemented AIDC/OLDI, but difficulties have been reported with connecting to some neighbouring ACCs due to compatibility issues, which should be addressed.

(3) Air-Ground Communications

Only a few States (from the information gathered) have planned implementation of VHF Data Link (VDL) Mode 2 (therefore, for those States that did not provide information, we have assumed that a gap exists for VDL). All other States must plan and implement VDL Mode 2 in their airspace. Many States already have enhanced communication capability and adequate transmitters/receivers and thus the region does not have significant gaps.

HF Data Link is not currently used by most States in the AFI region, and so presents a gap for each State. HF voice will only be used as back up to HF Data Link and SATCOM ACARS in remote and oceanic regions.

CPDLC will initially be implemented, and some Sates must make CPDLC fully available in their ACCs (using CPDLC over ATN Baseline 1 in continental airspace and CPDLC/ADS-C over FANS-1/A (ACARS) in remote and oceanic airspace). SATCOM ACARS will be used to carry voice data in the region – all States currently use HF for voice data in these areas, and so present a gap.

4.7.3 Navigation Infrastructure

Summary of Current Situation and Seamless Operations requirements

Area	Current Situation	Seamless Operations
NAVAIDs	Widespread use of conventional NAVAID such as NDBs and VORs, which will not support PBN. DMEs present in most States (either standalone or with VOR), but their number is often insufficient to support PBN operations	Sufficient number/density of DMEs to support RNAV operations. Other conventional NAVAIDs, such as NDB and VOR, to be gradually decommissioned as they finish their life cycle (being used as back-up/contingency in the meantime).
Use of core GNSS constellations to support PBN operations	GNSS used sparingly in AFI States	GNSS utilised as the primary means of navigation by the end of the Phase, to support PBN

Augmentation Systems for GNSS	No satellite-based augmentation (SBAS) available in the AFI region. No Ground Based Augmentation Systems (GBAS) used.	Use of SBAS and GBAS to enable the use of GNSS as a primary means of navigation for En-Route and approach.
GPMS	No GNSS Performance Monitoring System (GPMS) used in the AFI region	Use of GPMS to enable the use of GNSS as a primary means of navigation

4.7.3.1 Gaps

(1) NAVAIDs

Most States do not have adequate VOR/DMEs to support PBN operations (i.e. RNAV). It is therefore important that States implement enough VOR/DMEs to support PBN operations.

(2) GNSS

GNSS must be deployed/extended in every State to enable it to be used as the primary means of navigation, supported by a Satellite Based Augmentation System (SBAS), Ground Based Augmentation Systems (GBAS) (firstly at international airports), and a GNSS Performance Monitoring System (GPMS). An Aircraft Based Augmentation System (ABAS) will also be used to augment GNSS on-board aircraft but is not presented in the gap analysis as it is to be deployed by airlines.

4.7.4 Surveillance Infrastructure.

Summary of Current Situation and Seamless Operations requirements.

Area	Current Situation	Seamless Operations
Radar	Radar is an important method of surveillance in the region, although coverage is not consistent in many regions.	Radar will not be the primary method of surveillance and will not be extended systematically. MSSR will be expanded only in areas where enhanced surveillance is deemed to be required. Primary Surveillance Radar (PSR) will only be used in areas where there may be conflict between commercial aircraft and military aircraft and will be increasingly upgraded to multi-static PSR.
Automatic Dependent Surveillance Broadcast (ADS-B)	Ground based ADS-B In/Out is used by a few States, but many do not use it at all. While some States are implementing ADS-B in remote and oceanic airspace use of ADS-C continues to support operations and enhancing safety and efficiency.	Ground based ADS-B In/Out will be the principal means of surveillance in continental areas. ADS-C will initially be used consistently in remote regions and oceanic areas to unlock airspace capacity. By the end of the Phase, satellite-based ADS-B Out will replace ADS-C in remote and oceanic areas.
Multilateration (MLAT) Wide Area (WAM)	Multilateration implementation in WAM configuration is gaining momentum and it is envisaged that this will continue to mature in the short to medium term.	The use of WAM will be restricted to areas in which it can be shown to provide operational benefits, e.g. mountainous areas.

4.7.4.1 Gaps

(1) Radar

As PSR and MSSR will be implemented based on State's evolving situations, no gaps are identified for these surveillance technologies. MSSR technologies will be maintained where they already exist while also supporting the migration to SSR Mode S enhanced surveillance.

(2) ADS-B

Most States have been identified as steadily having improved their ground-based ADS-B capability. It is recommended that all implementation planning in the short to medium include considerations for additional ground stations to further enhance coverage capabilities in line with user requirements and expectations.

All States that require ADS-C (as they have areas that cannot be covered by other means) have already employed the technology. It is envisaged that States with large areas of oceanic/remote will require to implement satellite-based ADS-B in line with ASBU and the anticipated evolutions in the coming years, all these States present a gap.

(3) Multilateration (MLAT).

As the implementation of MLAT and in WAM configuration will be informed by coverage requirements in especially in areas where it can be shown to provide operational benefits, e.g. mountainous areas, so no gaps are identified for this surveillance technology.

4.7.5 ATM Automation

Summary of Current Situation and Seamless Operations requirements.

Area	Current Situation	Seamless Operations
Processing Systems	Flight Data Processing Systems (FDPS) and Surveillance Data Processing Systems (SDPS) have been implemented by a minority of States.	All States will utilise FDPS and SDPS within their ATC systems, to better integrate flight data and surveillance data (generating system tracks) in the ATC system.
Conflict Management Tools	Several States have installed conflict management tools, including Short Term Conflict Alert (STCA), Area Proximity Warning (APW), and Medium-Term Conflict Detection (MTCD) in their ATC systems, although many have not.	STCA and APW will be utilised by all ATC systems to increase safety by warning controllers of potential conflicts and incursions into dangerous areas, and MTCD will be used to balance more evenly the workload between tactical and planning tasks.
Recording & Replay System	Most States have implemented a Recording & Replay System (VRS), although most of these do not cover all of surveillance, flight, voice and MET data.	All ATC systems will include a VRRS function for surveillance, flight, voice and MET data. This data will be used for improving the efficiency of ATC operations.
Controller Display	Most States have an Automatic ATM controller situation display.	All ATC systems will have an automatic ATM controller situation display, which will display all relevant ATC data, increasing situational awareness.

4.7.5.1 Gaps

(4) Processing Systems

Most States already operate both a Flight Data Processing Systems (FDPS) and Surveillance Data Processing Systems (SDPS).

(5) Conflict Management Tools

Most States all operate Short Term Conflict Alert (STCA), Area Proximity Warning (APW), and Medium-Term Conflict Detection (MTCD) in their ATC systems.

(6) Controller Display and Recording & Replay System

An automated ATM controller situation display is used in some States. Other States operate Recording & Replay System (VRRS) that supports surveillance, flight, voice and MET data.

4.7.6 Performance Based Navigation (PBN) and Free Route Airspace (FRA)

Summary of Current Situation and Seamless Operations requirements.

Area	Current Situation	Seamless Operations
Route network	Much of the route network is based on conventional routes, where aircraft must fly between NAVAIDS, although many countries have implemented a significant number of RNAV routes	The implementation of RNAV routes in continental, remote and oceanic, and terminal airspace is a priority and should be completed by 2022. Later, advanced RNP routes, allowing greater route density, will be implemented. The route network, based on RNAV, will enable direct routes to be flown between major city pairs.
Approach and Departure	Although some approaches/ departures in the region are RNAV, most are conventional. There is very little evidence of the use of Continuous Descent and Climb Operations (CDOs and CCOs).	Advanced RNP approach procedures will be implemented using GNSS, replacing current instrument procedures. International airports should be prioritised. CDOs and CCOs will be implemented at all major international airports, using VNAV.
Free Route Airspace (FRA	There are no examples of FRA in the AFI region, although its implementation is planned in most States	Ideally, Free Route Airspace will be implemented in all regions, although it is understood that direct routing using RNAV will be a priority.
Airspace Design and Planning Coordination	Limited examples of cooperation in the planning and design of airspace exist.	Local level cooperation in airspace design and planning will take place, largely at a bilateral level between States.

4.7.6.1 Gaps

(1) En-route

Most States have implemented PBN and sufficient level of en-route RNAV routes. Most States however have conventional routes and therefore present a gap.

(2) Approach and Departure

Most States are known to have implemented RNAV approach/departures. Additionally, other States have implemented some RNAV approach procedures. Few States have implemented CDO and CCO at respective international airport and other States are incrementally implementing CDO and CCO at their main domestic airports.

(3) Free Route Airspace

All countries should implement FRA – AFI FRA airspace project is gaining implementation momentum and implementation planning underway, preliminary implementation focused on DCT operations in line with ASBU FRTO.

(4) Airspace planning coordination

All States must improve cooperation with neighbouring States for airspace planning and design.

4.7.7 Aeronautical Information Management

Summary of Current Situation and Seamless Operations requirements.

Area	Current Situation	Seamless Operations
Consolidation and compliance with ICAO Annex 15	AFI States are largely compliant with ICAO Annex 15 (compliant with AIRAC, use WGS-84, and have Quality Management Systems). However, a few gaps remain in these areas.	All States are fully compliant with ICAO Annex 15, including the use of Quality Management Systems and compliance with AIRAC. WGS-84 is used as a standard geodetic reference for all States.
AIM	The transition to AIM has begun recently. The AIXM 5.1 standard required is implemented or planned by many States. Most States do not yet publish electronic AIPs, and the provision of eTOD is variable. Although information is lacking, it is expected that most States do not publish Digital NOTAM.	The AIXM 5.1 standard will be used by all States to transfer Aeronautical Information, and all States will publish eAIPs. eTOD will be provided for all States and international airports. Digital NOTAMs will be issued over IP. States will implement Data quality and integrity monitoring.

4.7.7.1 Gaps

(1) Consolidation and compliance with Annex 15

Some States are known to present gaps for WGS-84, AIRAC and/or QMS, which are the building blocks of AIM (based on the most recent versions of their AIPs at the date of preparation of this report and other feedback received) but are currently under survey, and QMS is implemented for MET services but not for AIS.

(2) AIM

Some States have already implemented the AIXM 5.1 standard, while others have planned its implementation. Others operating different systems present a gap for AIXM 5.1, while other States implementation status are unknown. Some States have already published electronic AIPs, while most States are yet implemented.

Data on eTOD was difficult to source – from the information gathered only some Sates publish eTOD for international airports. Some States are also fully compliant with Area 1 and Area 4 Terrain and Obstacle requirements and plans to be compliant with Area 2 and 3 requirements by 2023. Information on the publication of Digital NOTAMs is scarce. As a relatively new concept, it can be expected that most States have not yet published.

In addition, all States will need to implement data quality and integrity monitoring. Due to a lack of information, and responses on implementation status and planning, it can be however deduced that AFI implementation gap exists.

4.7.8 Search and Rescue

Summary of Current Situation and Seamless Operations requirements

Area	Current Situation	Seamless Operations
State level SAR	Most States in the AFI region are compliant with ICAO Annex 12. Software tools, if used at all, are not harmonised.	All States fully compliant with ICAO Annex 12. States will use harmonised SAR software tools to improve the efficiency of operations. Civil/military cooperation for SAR operations clearly defined at national level using MOU (Memorandum of Understanding)
Cooperation	Some coordination initiatives exist within States in the AFI region. Regional SAR Plans have not been developed though some States are in the process of doing so.	Bilateral agreements will be agreed between neighbouring States for Assistance and Cooperation in SAR operations. Regional SAR Plans will have been developed at an appropriate level.

4.7.8.1 Gaps

(1) National SAR Implementation

From studying the AIPs that are available, almost all States are compliant with ICAO Annex 12. Other States are showing some small discrepancies and are therefore not fully compliant and should become so. It is recommended that a SAR software tool be introduced in each State. This SAR software would integrate and process data from various external sources to facilitate the search of the probable area of the accident and then to coordinate the rescue effectively.

Civil-military cooperation should be defined supported by Memorandums of Understanding – no information on this subject has been received and therefore gaps were yet to be verified.

(2) SAR cooperation

Some States have cooperation agreements in place with neighbouring AFI States and States that have not so will need to define formal SAR cooperation agreements. Even those States which are not deemed to have a gap could benefit from extending their SAR agreements to other neighbouring States.

A Regional SAR Plan will be developed at an appropriate level and so a country-by-country gap analysis has not been presented.

4.7.9 Meteorological Systems

Summary of Current Situation and Seamless Operations requirements.

Area	Current Situation	Seamless Operations
Availability of MET information	Most States publish SIGMETs and make regional forecasts from, world area forecast centres (WAFCs), volcanic ash advisory centres (VAACs) and tropical cyclone advisory centres (TCAC) available, as required by ICAO Annex 3, although a couple of gaps remain.	Forecasts provided by WAFCs, VAACs and TCAC will be made available to all ACCs in the AFI region. SIGMETs and other operational meteorological (OPMET) information will be issued to provide information on occurrence or expected occurrence of specific En-Route weather phenomena which may affect the safety of aircraft operations.

Area	Current Situation	Seamless Operations
Exchange of meteorological information	Inconsistent formats are used for coding meteorological data, and OPMET data is provided and exchanged in text, making the handling of global data difficult to use correctly and expensive to maintain.	The IWXXM standard will be used for operational exchanges of meteorological information, enabling the use of standard application and techniques for handling and processing of data.
Common procedures for MET reports to pilots	Each State defines their own procedures for reporting meteorological information to pilots	The procedures for reporting meteorological information to pilots will be consistent throughout the region.
Integrated meteorological information	Meteorological constraints are manually assessed, and the mitigation of those constraints calculated by humans, using forecasts. MET data is not integrated into the ATM decision making process.	Meteorological information will be integrated into the ATM system, and will support automated decision processes, in line with ICAO ASBU B1-AMET, allowing near-term planning considering MET conditions.

4.7.9.1 Gaps

(1) Availability of MET information.

Most States in the AFI region comply with the requirements of ICAO Annex 3 for the availability of Meteorological information (i.e. regional forecasts and SIGMETs) although all States should ensure that the information they provide is as comprehensive as possible.

(2) Exchange of meteorological information.

No States use the IWXXM standard, as it is a new concept contained in ABSU B1-DATM – therefore, all States present a gap.

(3) Common procedures for MET reports to pilots

Since each State currently defines their own procedures for reporting meteorological information to pilots, there is an effective gap for all States to introduce common procedures.

(4) Integrated meteorological information.

This is a new concept (ASBU B1-AMET) and so presents a gap for all States.

PART V

Technical Plan (Performance Improvement Plan)

5 AFI Air Navigation Plan

An initial version of the "AFI Regional Air Navigation System Implementation Action Plan" was approved in 2013 at the ICAO APIRG 19, based on the Fourth Edition of the Global Air Navigation Plan (ICAO Doc 9750) and the accompanying Aviation System Block Upgrades (ASBUs).

The plan encouraged States to implement those Block 0 Modules applicable to their specific operational needs the 18 ASBU Block 0 Modules based on the urgency of their implementation categorised, Essential, Desirable, Specific, or Optional.

This plan and the associated projects and initiatives undertaken by the Africa-Indian Ocean (AFI) Planning and Implementation Regional Group (APIRG) are considered when developing the technical plan for AFI ATM Master plan in the short, medium, and long term.

Identification and prioritization of ASBU Elements relevant to the AFI Region.

The identified elements are grouped in the following categories:

(1) *Essential* (E): These are the elements that provide substantial contribution towards global interoperability, safety, or regularity.
(2) Desirable (D): These are the elements that, because of their strong business and/or safety case, are recommended for implementation almost everywhere.
(3) Specific (S): These are the elements that are recommended for implementation to address a particular operational environment or mitigate identified risks.
(4) *Optional (O):* These are the ASBU modules that address particular operational requirements and provide additional benefits that may not be common everywhere.

The allocated priority for implementation within the AFI Region is based on the following criteria. Priority 1 = immediate implementation; Priority 2 = recommended implementation.

The AFI Technical plan has been aligned with the GANP 6th Edition. The plan is arranged into four parts: Information, Operational, CNS Technology & Services and supporting Technologies.

5.1 Information

The goal of the AFI ATM Operational Concept (CONOPs) is to achieve a net-centric operation where the ATM community network is considered as a series of nodes – including the ATS, airlines operations, and airport operations – providing or using information exchanged for a common situational awareness enhancement.

Aircraft operators with flight/airline operational control centre facilities must share information while the individual user will be able to do the same via applications running on any suitable personal device. The support provided by the ATM network will, in all cases, be tailored to the needs of the end user concerned.

The sharing of information of the required quality and timeliness in a secure environment is an essential enabler for the ATM target concept. The scope extends to all information that is of potential interest to ATM including trajectories, surveillance data, aeronautical information, meteorological data, etc.

System-wide information management (SWIM) is an essential enabler for ATM applications. It provides an appropriate infrastructure and ensures the availability of the information needed by the applications run by the members of the ATM community. The related geo-referenced/time-stamped, seamless, and open interoperable data exchange relies on the use of common methodology and the use of a suitable technology and compliant interoperable system interfaces.

SWIM implementation must make possible the deployment of advance end-user applications in line with applicable exchange protocols as it will provide extensive information-sharing and the capability to find the right information regardless of the data provider within the ATM system value chain.

Cyber-security is an increasingly significant performance area capability requirement over the outlook period and of ever-growing importance in the migration to information management.

This section documents information that is required to create an environment that promotes enhanced safety and efficiency as listed above. Detailed elements are shown in Part A of Appendix I.

5.2 Operational

This section of the plan documents the nature of operational requirements for enhanced safety, capacity efficiency and sustainability. Detailed elements are shown on Part B of Appendix I and are divided into;

- **ACAS** - Airborne Collision Avoidance System.
- **ACDM** -Airport Collaborative Decision Making.
- **APTA** -Improve arrival and departure operations.
- **CSEP** -Cooperative Separation
- **DATS** -Digital Aerodrome Air Traffic Services.
- **FRTO** -Improved operations through enhanced en-route trajectories.
- **GADS** -Global Aeronautical Distress and Safety System (GADSS).
- **NOPS** -Network Operations.
- **OPFL** -Improved access to optimum flight levels in oceanic and remote airspace.
- **RSEQ** -Improved traffic flow through runway sequencing.
- **SNET** -Ground-based Safety Nets.
- **SURF** -Surface operations.
- **TBO** -Trajectory-based operations.

5.3 CNS Technology and Services

This section of the plan documents the technological requirements for enhanced safety, efficiency, and sustainability. Detailed elements are shown on Part C of Appendix I and are divided into;

- Communication infrastructure & ATS Communication service.
- Navigation systems.
- Surveillance systems.

5.3.1 Communication

Air-ground data link services fall into two basic categories:

a) Safety-related ATS services where performance requirements, procedures, services and supporting technology are strictly standardised and regulated; and
b) Information-related services where performance requirements, procedures and supporting technology are less critical.

In general, the enablers (link media technologies) will be developed and deployed based on the need to support safety related ATS services.

To prepare for long term period, research and development is needed in the short term and medium time frames; there are three areas of investigation where standards are being developed:

a) Airports – a ground-based high capacity airport surface data link system is currently under development. The Aeronautical Mobile Airport Communications System (AeroMACS) is based on IEEE 802.16/WiMAX standard).
b) SATCOM – a new satellite-based data link system targeted at oceanic and remote regions. This link may also be used in continental regions as a complement to terrestrial systems. This could be a dedicated ATS SATCOM (e.g. European ESA Iris initiative) system or a multi-mode commercial system (e.g. Inmarsat Swift Broadband, Iridium).
c) Terrestrial (terminal and en-route) – a ground-based data link system for continental airspace is currently under investigation. This has been termed the aeronautical L-band digital aeronautical communications system (L-DACS).

In addition, studies are needed to a) review the role of voice communications in the long-term concept (primarily data centric); and to b) consider the need to develop a new appropriate digital voice communication system for continental airspace.

5.3.2 Navigation

Navigation concepts such as RNAV, RNP and PBN provide a range of options for the use of navigation technology. As these are very much dependent on local requirements, this section will provide a narrative description of the considerations for the use of navigation technology.

Conventional radio navigation aids (VOR, DME, NDB, ILS) are in widespread use globally, and most aircraft are equipped with the relevant avionics. The vulnerability of GNSS signals to interference has led to the conclusion that there is a need to retain some conventional radio navigation aids or an alternative navigation service solution as a back-up to GNSS.

Mitigating the operational impact of a GNSS outage will rely primarily on the use of other constellation signals or employing pilot and/or ATC procedural methods, while taking advantage of on-board inertial systems and specific conventional radio navigation aids. In the case of a general GNSS outage in an area, reversion to conventional radio navigation aids and procedures could result in capacity or flight efficiency reduction. In such cases where there is a loss of signals from a specific constellation, the reversion to another constellation could allow maintaining the same PBN level.

The implementation of PBN will make area navigation operations the norm. DME is the most appropriate conventional radio navigation aid to support area navigation operations (i.e. assuming DME Multilateration on-board capability), since it is currently used in multi-sensor avionics for this purpose. DME installations and their coverage will need to be optimized. Similarly, ILS remaining widely used, will provide, where available, an alternate approach and landing capability in case of GNSS outage.

a) Current navigation infrastructure.

i. The current navigation infrastructure comprising VOR, DME and NDB navigation beacons was initially deployed to support conventional navigation along routes aligned between VOR and NDB facilities. As traffic levels increased, new routes were implemented which in many cases necessitated additional navigation facilities to be installed.

ii. As a result, navigation aid deployment has been driven by economic factors and has led to a non-uniform distribution of navigation aids with some regions, notably North America and Europe, having a high density of navigation aids with many other regions having a low density, and some areas having no terrestrial navigation infrastructure at all.

iii. The introduction of RNAV in the last decades has led to setting up new regional route networks that no longer relied on these conventional radio navigation aids infrastructure thus allowing wider flexibility to tailor the route network to the traffic demand. This essential move has clearly stopped the direct link between the ground-based navaids and the route network in the busiest air traffic regions.

iv. With the continuous evolution of aircraft navigation capability through performance-based navigation, and the widespread use of GNSS positioning, regions of high traffic density no longer need as high a density of navigation aids.

b) Future terrestrial infrastructure requirements.

i. The GANP has the objective of a future harmonized global navigation capability based on area navigation (RNAV) and performance-based navigation (PBN) supported by the global navigation satellite system (GNSS).

ii. The optimistic planning that was considered at the time of the Eleventh Air Navigation Conference for all aircraft to be equipped with GNSS capability and for other GNSS constellations to be available, together with dual frequency and multi-constellation avionics capability being carried by aircraft have not been realized.

iii. The current single frequency GNSS capability provides the most accurate source of positioning that is available on a global basis. With suitable augmentation as standardized within Annexes, single frequency GNSS has the capability to support all phases of flight. The current GNSS has an extremely high availability, although it does not have adequate resilience to several vulnerabilities, most notably radio frequency interference and solar events causing ionospheric disturbances.

iv. Until a solution to this adequate resilience problem is available, it is essential that a terrestrial navigation infrastructure, suitably dimensioned to be capable of maintaining safety and continuity of aircraft operations, be provided.

v. The FANS report from April 1985 stated: “The number and development of navigational aids should be reviewed with the aim of providing a more rational and more cost-effective homogeneous navigation environment.”

vi. The status of aircraft equipage for PBN operations supported by GNSS and terrestrial navigation aids, together with the availability of the ICAO PBN Manual and the associated design criteria provide the necessary baseline to commence the evolution to the homogeneous navigation environment envisaged within the FANS Report.

c) Infrastructure rationalisation planning.

i. It had initially been expected that the rationalization of the legacy navigation infrastructure would have been a consequence of a top-down process where the implementation of PBN and GNSS within volumes of airspace would result in navigation aids being made totally redundant so they could simply be switched off.

ii. All stakeholders generally agree that PBN is “the right thing to do” and although PBN offers the capability to introduce new routes without additional navigation aids, it remains difficult to justify the case for full scale implementation of PBN within a volume of airspace, unless there are capacity or safety issues to be addressed.

iii. Many States have utilized PBN to implement additional routes as they are required to secure gains in capacity and operational efficiencies. This has resulted in volumes of airspace which contain a combination of new PBN routes and existing conventional routes.

iv. It is now clear that for numerous reasons, which include being unable to establish a positive business case for a large-scale airspace redesign, a top down PBN implementation followed by infrastructure rationalization will take many years to complete, if ever.

v. As an alternative strategy, a bottom-up approach should be considered as at the end of each navigation aid’s economic life, an opportunity exists to consider if a limited PBN implementation to alleviate the need for the replacement of the facility is more cost-effective than replacement of the navigation aid.

vi. The replacement cost opportunity only presents itself if the navigation aid is fully depreciated and replacement is considered: it therefore arises on a 20-25-year cycle. To realise any cost-saving, rationalization opportunities need to be identified and the necessary route changes planned and implemented to enable the facilities to be decommissioned at the end of their lifetime.

vii. This bottom-up approach to rationalization also provides a catalyst to start the airspace transition to a PBN environment, facilitating future changes to optimize routes to deliver gains in efficiency such as shorter routings and lower CO_2 emissions.

viii. In planning for the rationalization of navigation infrastructure, it is essential that all stakeholders’ needs, and operational uses of the infrastructure be considered. This may include military instrument flight procedures, aircraft operational contingency procedures, such as engine failure on take-off, and used for VOR-based separations in procedural airspace or general aviation.

ix. Additional guidance on navigation infrastructure rationalization planning is provided in Annex 10, Volume I, Attachment H, entitled “*Strategy for rationalization of conventional radio navigation aids and evolution toward supporting performance based navigation*”.

d) GNSS infrastructure.

GNSS is the core technology that has led to the development of PBN. It is also the basis for future improvements in navigation services. The core historical constellations GPS and GLONASS have been in operation for well over a decade, and SARPs in support of aviation operations are in place. Other core constellations, e.g. the European Galileo and China's BeiDou, are being developed. Multi-constellation, multi-frequency GNSS has clear technical advantages that will support the provision of operational benefits. To realise these benefits, ICAO, States, ANSPs, standards bodies, manufacturers and aircraft operators need to coordinate activities to address and resolve related performance issues.

i. An Aircraft Based Augmentation System (ABAS) will also be used to augment GNSS on-board aircraft but is not presented in the gap analysis as it is deployed by airlines.
ii. Ground Based Augmentation Systems (GBAS) CAT I based on GPS and GLONASS is available in the Russian Federation and, based on GPS, on some airports in several States. SARPs for GBAS CAT II/III are available. Related research and development activities are ongoing in different States. It is also challenging for GBAS to support a high availability of precision approach, particularly in equatorial regions. GBAS is provided to support precision approach and landing operations at specific airports, in particular Category I operation utilizing GBAS Approach Service Type C (GAST-C), with the improved accuracy, integrity, and availability of satellite navigation. DFMC GBAS will provide the solution to this challenge. DFMC GBAS SARPs are not expected before 2030, and related avionics solutions before 2035. However, States that have undertaken research and feasibility studies are encouraged to continue in the short term, outcomes of which can provide recommendations to the region on suitability for implementation.
iii. Satellite-Based Augmentation System (SBAS) based on GNSS is available in North America (WAAS), Europe (EGNOS), Japan (MSAS) and will soon be available in Africa (Augmented Navigation for Africa-ANGA), India (GAGAN), South Korea (KASS), Australia/New Zealand (SouthPAN) and the Russian Federation (SDCM). Several thousand Localizer Performance with Vertical Guidance (LPV) and Localizer Performance (LP) approach procedures are implemented. SBAS typically supports APV operations but can also support precision approach (Category I) operations. However, it is challenging for SBAS to support precision approach operations in equatorial regions using single-frequency GPS because of ionospheric effects.

5.3.3 Surveillance

The important development trends of the AFI ATM Vision 2045 will be that:

(1) Different techniques will be mixed to obtain the best cost-effectiveness depending on local constraints.
(2) Cooperative surveillance will use technologies currently available using 1030 and1090 MHz RF bands (SSR, Mode-S, WAM and ADS-B).
(3) While refinements to capabilities may be identified, it is expected that the surveillance infrastructure currently foreseen could meet all the demands placed upon it.
(4) The airborne part of the surveillance system will become more important and should be "future proof" and globally interoperable to support the various surveillance techniques which will be used.

(5) There will be growing use of downlinked aircraft parameters bringing the following advantages:

- Clear presentation of call-sign and level.
- Improved situational awareness.
- Use of some downlinked aircraft parameters (DAPs) and 25 ft altitude reporting to improve surveillance tracking algorithms, including safety nets.
- Display of vertical stack lists.
- Reduction in radio transmission (controller and pilot).
- Improved management of aircraft in stacks.
- Reductions in level busts.

(6) Functionality will migrate from the ground to the air.

5.4 Supporting Technologies

5.4.1 Avionics

A key theme with the avionics evolution is the significant increase in capability that is possible through the integration of various on-board systems/functions.

Communication, navigation, and surveillance systems are becoming more interconnected and interrelated. For example, GNSS provides positioning to navigation, surveillance, and several other avionics functions, creating both common mode concerns as well as opportunities for synergies. In addition to harmonizing the evolution of CNS capability deployment, there is an increasing need to ensure that new digital CNS systems do not introduce undue complexity while ensuring that advanced CNS capabilities can be supported with the required level of robustness, in a failure-tolerant and cost-effective manner.

5.4.2 ATM systems and Automation

The ICAO Global Air Navigation Plan does not yet provide any technology roadmap for the automation system to support the harmonised implementation of the ICAO Aviation System Block Upgrade (ASBU) elements. However, some changes to the automation systems are already brought about by changes in the other ICAO technology roadmaps in Communication, Navigation, Surveillance, and Information Management, as described below.

5.4.3 Communication.

The changes expected in the Communication domain are described in section 5.3.1 of this document. They will impact the ATC systems as follows:

Migration from AFTN to AMHS for the exchange of ATS-related messages:

(a) Once the migration from AFTN to AMHS has been completed, the ATC systems will have to accommodate this change to cover all ATS-related messages exchanges.

(b) Additionally, the AMHS capability will provide enhanced services in support of the ATS operations; the ATC systems will therefore have to evolve to support the exchange of XML-based messages that will introduce significant operational improvements, such as OPMET, digital NOTAM and Flight Object.

(c) It is therefore important to anticipate and prepare for this evolution by identifying the type and format of data that will need to be exchanged using AMHS and verifying that AMHS will support these data exchanges, including at the IP network level.

Implementation of AIDC for flight coordination and transfer of flights between adjacent ATS Units:

(d) The ATS Interfacility Data Communication (AIDC) communication protocol will have to be implemented in the Flight Data Processing Systems (FDPS) of ATC systems.

(e) In line with the approach recommended in the ASBU FICE-B0/1, improvements in this area are key to increasing ground-ground integration, which is the enabler for an increased interoperability, improved efficiency, and capacity.

(f) AIDC connections should be put into operation at the international level between ACC and the eight adjacent ACCs wherever possible.

(g) The implementation of these international connections will require bilateral initiatives between to operate AIDC between their ATS Units. However, these bilateral initiatives might have to face constraints at different levels:

- At the communication infrastructure level where the proper links will have to be available;
- At the ATM system level where software upgrades may be required; and
- At the legal/operational level where agreements need to be put in place for the exchange of AIDC data.

5.4.4 Navigation

The changes expected in the Navigation domain are described in Section 5.3.2 of this document. The use of GNSS core constellation system together with a GNSS augmentation system will not impact the ATC systems. However, the Monitoring Aids functions of the ATC systems might have to be modified to adjust the deviation and separation tolerances for RNP aircraft capabilities.

5.4.5 Surveillance

The changes expected in the Surveillance domain are described in Section 5.3.3 of this document. They will impact on the ATC systems as follows:

(a) Deployment of ADS-B ground stations:
The AFI States should deploy ADS-B ground stations to provide full coverage above in the upper airspace. The ATC system deployed in the ACC will have to be upgraded as required to support this initiative. A Multi-Sensor Data Fusion should be operationally deployed to integrate data from multiple sensors of various natures (PSR, MSSR, and ADS-B) to form a single system track for each aircraft.

(b) Satellite-based ADS-B:

The use of satellite-based ADS-B is recommended for consideration in the long-term to improve the surveillance coverage at the lower levels. As above, the ATC systems should be upgraded as required to support this initiative.

(c) Surveillance data sharing

Cross-boundary sharing of surveillance data is recommended to improve surveillance coverage or redundancy, and coordination, using the existing surveillance infrastructure and taking into account new surveillance means deployed. The ATC systems should be upgraded as required to support any initiative related to surveillance data sharing.

5.4.6 Information Management

The changes expected in the Information Management domain are discussed in Section 5.1 of this document. They will impact on the ATC systems as follows:

(a) **SWIM**:

While preparations are underway to develop IT based exchange protocols to enable the dissemination of aviation data to key stakeholders in a service oriented architecture. Development of SWIM standards and infrastructure governance will enable AFI region to align implementation planning effort in alignment with the APIRG AAO-SG and IIM-SG projects. Initial SWIM deployment is likely to occur in the medium term, and the ATC systems will have to be upgraded to support SWIM exchanges using the latest data standards (AIXM, AIDX, FIXM, IWXXM, etc). to enable the information management and exchange objective in a collaborative environment.

(b) **AIS to AIM transition**:

The transition from AIS to AIM should progress and the ATC systems will have to be upgraded to support the integration with the AIM system using the latest AIXM standard.

(c) **Integration of MET information**:

The ATC systems will have to accommodate the integration of MET data to support the planned automated decision processes or aids.

PART VI

IMPLEMENTATION ROADMAP

6. Roadmap summary

This chapter used the recommended evolutions contained in the technical plan including consideration of the AFI Vision 2045 future concept of operations as inputs to develop an Implementation roadmap for the ATM/cns and supporting infrastructure and the evolution of ANS operations within the AFI region. This part does not define any new tasks; rather, it specifies more precisely the timescales for the implementation of the tasks defined in the technical plan.

This implementation roadmap has been divided into thematic modules which analysed interdependencies that will guide the AFI region to understand the relations between the evolutions recommended in the technical plan and ASBU elements.

The implementation roadmap has been organised in three main themes as follows:

(1) Information

(2) Operational

(3) Technology

Each theme is split into several elements in alignment with ASBU block improvement elements. The elements are reflective of the structure of the technical plan and comprises the timelines in which each element will be implemented.

6.1. Implementation Roadmap and Timelines

The implementation roadmap only considered the short term (2024-2027) improvement requirements as defined in the technical plan. This implementation phase includes initiatives that can be implemented in a relatively short period, and that will immediately unlock airspace capacity within the AFI region airspace/airports and improve operational safety, efficiency, and sustainability performances. The short term includes the implementation of ASBU Block 0 and Block 1 concepts.

The implementation of the short term improvement initiatives including BBBs as a baseline will prepare the AFI region states to transition into the medium term (2028 -2035) evolutionary concepts.

The implementation plan is attached as Appendix II to this document.

PART VII

HUMAN PERFORMANCE CONSIDERATIONS AND CAPACITY BUILDING

7 Introduction

Human Performance (HP) in aviation represents the human contribution to system performance and refers to how people perform their work. Throughout the aviation system, people are both the source of some of the risks and an integral part of identifying and managing all risks.

How we support HP is informed by Human Factors (HF). HF is concerned with the application of what we know about human beings, their abilities, characteristics, and limitations, to the design of equipment they use, environments in which they function and jobs they perform.

HP-related areas of work are dispersed across a range of topics including:

(1) Collection and analysis of safety data
(2) Change management and introduction of new systems
(3) Fatigue management
(4) HP considerations in automated systems
(5) Safety risk management
(6) Personnel Training and Licensing

Key concepts that highlight contribution to the aviation system that provide a foundation for approaches and actions that support HP included, human performance principles, human centred design and system thinking. The Aviation system must enable the development of appropriate processes to address negative safety consequences through evaluation of HP considerations and ensure that these are embedded in the State Safety Programmes.

The implementation of recruiting and training aspects should be accomplished through ensuring availability of necessary resources, including finances, manpower, etc. Aviation professionals have an essential role in the transition to, and successful implementation of the AFI ATM Master Plan. The system changes will affect the work of many skilled personnel in the air and on the ground, potentially changing their roles and interactions and even requiring new proficiencies to be developed.

Therefore, it is crucial to ensure that recruiting and training are developed using a competency-based framework, fatigue-related risk is managed appropriately, and safety data, including the reporting of hazards, is collected, analysed, and acted upon within ATM Seamless systems. Furthermore, with the expected growth of aviation, it is critical that enough qualified and competent personnel are available to ensure a safe and efficient aviation system.

It is therefore critical that the improvement concepts being developed in line with the GANP take into account the strengths and weaknesses of existing and future skilled personnel at every juncture. All actors with a stake in a safe air transportation system will need to intensify efforts to manage risks associated with human performance and the sector will need to proactively anticipate interface and workstation design, training needs and operational procedures while promulgating best practices. In support of this, the AFI region will work with key stakeholders ensure that personnel are trained utilizing competency-based training methods as prescribed in the appropriate ICAO manuals.

The AFI region has recognised these factors, and thus the consideration of human performance, as an essential element, in the context of the block upgrades requirements will continue to evolve through State Safety Programme (SSP) and industry Safety Management Systems (SMS) approaches.

Amongst other priorities, the management of change pertinent to the block upgrades improvements and evolutions should include human performance-related considerations in the following areas:

(1) Initial training, competence and/or adaptation of new/ active operational staff;
(2) New roles and responsibilities and tasks to be defined and implemented;
(3) Social factors and management of the cultural changes linked to increased automation.

Human performance needs to be embedded both in the planning and design phases of new systems and technologies as well as during implementation. Early involvement of operational personnel is also essential. Sharing of information regarding the various aspects of human performance and the identification of human performance risk management approaches will be a prerequisite for improving safety outcomes. This is particularly true in today's aviation operational context and the successful implementation of the aviation system block upgrades and other new systems into the future.

Widespread and effective management of human performance risks within an operational context cannot be achieved without a coordinated effort from regulators, industry service providers, and operational personnel representing all disciplines.

When considering the key factors supporting an 'aviation culture', it is important to acknowledge that no 'national culture' is perfectly aligned with 'aviation culture', so there will always be a need for gap analysis and changes where development of an appropriate in culture is required, hence an optimal 'aviation culture' requires a system-wide approach, that creates an organic, learning, and safe environment to be implemented.

7.1 Training Areas

The following training areas have been identified to support seamless operations in the AFI region:

(1) Aeronautical Information Management (AIM)
(2) Air Traffic Flow Management (ATFM)
(3) Airspace Design
(4) Airspace Management
(5) Automation Systems
(6) Aviation and Environment
(7) Awareness raising project management.
(8) CNS/ATM
(9) Collaborative Decision Making (CDM)/Facilitation.
(10) Communication

(11) English Proficiency
(12) Flexible Use of Airspace (FUA)
(13) Navigation
(14) Operational Procedures
(15) Aviation Safety
(16) Search & Rescue (SAR)
(17) Security of ATM/CNS systems
(18) Surveillance
(19) Air Traffic Management (ATM)
(20) Aeronautical Meteorology (A-MET)
(21) Traffic forecasting and cost-benefit analysis techniques
(22) Civil/Military coordination
(23) Human Factors in aviation

7.2 Training Needs Assessment

Needs Analysis (NA) is the orderly processes of identifying the difference that exist between actual and desired work performance based on current and future technologies. It becomes a Training Needs Analysis (TNA) when used more specifically to confirm the role of training to improve performance.

The International Civil Aviation Organization (ICAO) created a website for Training Needs Assessment (TNA) to help Members assess their needs for training. It is therefore intended for aviation stakeholders and ICAO Member States that want to confirm how training can help address human performance issues.

States and aviation stakeholders to conduct individual training needs assessment and identify areas of priority dependant on availability of resources.

7.3 Human Performance Considerations.

To leverage human performance, states are encouraged to undertake ergonomic analyses to transition seamlessly to new technological adoptions. This is accomplished through models that analyse factors impacting productivity. Ergonomic analysis often includes discussions of models of system performance such as Software-Hardware-Environment-Liveware (SHEL) (International Civil Aviation Organization – ICAO Doc 9859 and Circular Human Factors Digest No. 1 "Fundamental Human Factors Concepts", Circular 216-AN/131) SHEL models can help us to understand the impact of human performance on the system's performance, and how to optimize the system for better results. These models can also help us to identify potential problems before they occur. This allows organizations to proactively address issues and ensure that the transition to new technologies is smooth and efficient.

Personnel competence is directly corelated to the continuous competence development program implemented by the States. Recommendations of the AFI ATS Competency Study group recommended AFI States to;

- Identify differences in training programs and develop and mechanism to harmonize training and abridging programs.
- Through industry stakeholders, to develop a plan on accelerating training on emerging issues in AFI, key among them, CISM, Human Factors, threat, and error management.
- Incorporate abridging programs, OJT, recurrency and continued proficiency evaluation as per ICAO Doc 10056 in their training programs.

PART VIII

COST-BENEFIT ANALYSIS

8. Introduction

As a general rule, prior to any significant system change, a cost/benefit analysis (CBA) would be conducted to demonstrate the value, negative or positive, of the proposed change.

A CBA of the transition to an AFI Seamless ANS environment will be developed when the Seamless ANS Plan has been accepted by APIRG on behalf of all African States. Although each State retains responsibility for their sovereign airspace, acceptance of the Seamless ANS Plan by APIRG, on behalf of all States, creates an obligation on each State, as far as practicable, to follow the agreed upgrade path.

Although a CBA for the region would not be possible due to the complexity of the task, it was felt necessary to demonstrate, at a high level, the benefits of the proposed Seamless ANS Plan as presented in the following sections.

8.1. Cost Benefit Analysis – Generalities.

The programmes related to the AFI ATM Master Plan implementation involve a combination of capital investment in new infrastructures, operating expenditure, and the creation of working groups to define new operational procedures and ensure the coordination and convergence of ATM provision among Member States.

The CBA focusses on comparing the financial costs and benefits of the implementation of the ATM Master plan project and does not discuss non-monetary benefits such as safety gains, reduced environmental impact and indirect induced economic growth.

Consistent with the investment, operational and organisational recommendations developed within this report, each programme has been broken down into a number of underlying activities at which level the cost estimation has been undertaken.

The overall projects generate benefits from productivity enhancements and cost-efficiencies, as well as safety and environmental gains.

8.2. ANSPs

As providers of Air Navigation Services (ANS), ANSPs bear the biggest part of the initial costs of putting in place new infrastructures and defining new operational structures and institutions. This analysis is based on the understanding that most costs are financed by ANSPs and can subsequently be recovered through improved cost-efficiencies as well as through ANS charges, which are collected from airspace users.

The financial impact on ANSPs is ideally zero. This is determined by the combination of capital and operating expenditure incurred, and by the cost recovery mechanism through which ANS charges are collected from airspace users:

(1) Capital expenditure related to programs involving infrastructures investment. Capital expenditure is annualised linearly over an average economic lifetime of 10 years, beginning when the program becomes operational. For the purpose of the business case, it is assumed that capital investment items will be replaced at the end of their economic lifecycle, at the same cost and cost of capital as initially assumed. This leads to a continuous capital expenditure/depreciation cost from entry into operation until the end of the project horizon, unless otherwise specified.
The CBA considers the incremental effect of the investment, which means that investment is considered in isolation. This is necessary because the cost for each individual ANSP of maintaining and upgrading existing infrastructure, existing capital expenditure plans and depreciation schedules are not known.

(2) It must be noted that the cost estimates for ATM and communication related investment are specific to the conditions of each country, depending on existing installations and communications infrastructures that could be upgraded, different technologies and solutions that can achieve the same objective, commercial negations with providers, potential collaborations between countries, etc.

(3) Operating expenditure refer to the costs of implementing, operating, and maintaining new equipment. The actual expenditures incurred by each ANSP are likely to vary significantly, depending on today's cost and personnel structure of ANSPs, equipment to be replaced, traffic growth, etc. ANSPs in the AFI region are likely to operate on different cost curves or on different segments of the same cost curve. For example, with a given ATCO productivity and workload, an ANSP might be able to accommodate a number of additional movements, or none at all.

(4) In addition to the operating expenditure impact of specific programs, the CBA considers global costs of ANS provision to increase with traffic growth at an elasticity of 0.75 – this figure considers that infrastructure costs increase at a factor <1 as traffic grows. On the other hand, staff costs, which constitute about half of ANSP costs, grow at almost the same rate as traffic.

(5) The CBA assumes the investment case to yield cost-efficiency gains of 2% per year as new technologies, procedures and economic regulations are deployed. This is slightly higher than cost-efficiency gains currently achieved in the context of the Single European Sky and reflects the opportunity for efficiency improvements in less mature ANSPs.

Working groups: Programmes require extensive preparation and coordination within and among Member States in the AFI region and other stakeholders. The staff requirements associated to this effort is assumed to be supported from current ANSP, CAA, and military and government structures, without the need for hiring or committing additional human resources. However, it is assumed that ANSP staff needs to participate in specific IATA and ICAO compliant training programs and dedicated meetings in addition to existing training and meeting formats. This assumption has been made under the presumption to minimise the additional effort generated by the project and to make best use of existing staff, meeting formats, training programs and existing ICAO collaborations for the provision of consultancy and expertise. Still an assumption has been made about the likely incremental cost impact for ANSPs of participating in additional training and meetings.

Interests: Costs are recovered from airspace users deferred by two years, consistent with the ANS charges regimes applicable in many advanced economic ANS regulations. To avoid cash flow issues, this interim period of two years needs to be bridged by finance. Annualization of capital costs also leads to financing arrangements that are assumed to be provided at an interest rate of 8.7%, based on an average for several AFI Member States and as provided by the World Bank.

Airspace user revenues are a function of traffic volumes and ANS unit charges. Traffic volumes are considered as an exogenous factor in this CBA. One of the aims of the AFI Master Plan is to reduce the overall distance flown by airspace users, leading to a reduction in the number of service units and negatively affecting the overall revenue from ANS charges. ANS unit charges are determined by dividing an ANSP's planned cost base by the forecasted number of service units. Therefore, both, traffic volumes and cost base affect ANS unit charges, which in turn affect overall ANSP revenues.

The CBA considers traffic in accordance with the traffic forecast presented in Section 2 of this report. The expected increase of traffic (in movements) of 5.6 % annually will therefore distribute the increasing cost base of AFI ANSPs across a growing number of service units, ideally offsetting the rise in cost bases and stabilising ANS charges. This would invariably lead to the improvement of ANS provision with gains such as optimised flight paths and efficiencies with its attendant operational cost reduction for the airspace users.

8.3. Airspace users

Airspace users represent a key stakeholder group in the context of this project, given that airspace users rely on and largely finance the effective provision of ANS. When undertaking new investment in new infrastructure, and operational procedures and institutional change, ANSPs and CAAs have to assess how far this will benefit airspace users. They need to assess if the benefits for commercial and private aviation justify the costs incurred, and if costs can be recovered without unrealistically inflating unit rates. The focus of this CBA is on civilian airspace users and commercial airlines, which are the main beneficiaries of this project and are impacted by variations in unit rates.

The financial impact on Airspace Users is determined by the balance of financial savings derived from operational benefits generated by seamless operations, and financial costs from growing unit rates and potential investment in airborne navigation and communication equipment:

1. Distance flown by airspace users is expected to be reduced as a result of improved airspace structure and operation. This does not only lead to a reduction in fuel burn, but also in-flight time, affecting direct operating costs such as fuel costs, crew costs, aircraft, and engine operating hours, and ANS costs. The CBA quantifies fuel cost savings and overall ANS charges.

2. Flight deck workload can be significantly reduced by some of the projects, for example related to communication and the transmission of data from the ANS provider to the aircraft and vice-versa. Flight planning will become less complex for both flight deck and back-office staff. The CBA does not assign any monetary value to this benefit, which is mainly related to safety.

3. Disruption incidents and delays have been known to be reduced by improved design and operational procedures in highly congested areas and at the interface between upper and lower airspace. While these types of improvement can be economically and reputationally beneficial for airspace users, they are of marginal economic importance for the upper airspace, especially when considering the vastness of the airspace over the AFI States.

4. The ATM Master Plan initiatives have been identified with the aim of modernising ATM and CNS infrastructure and enabling traffic growth, in accordance with the forecasts presented in Section 2 of this report. As a result, one of the main benefits for commercial airlines is being able to grow their business in line with the long-term market potential. The resulting increase in revenue and profits is dependent on a multitude of factors in the management of these airlines. The CBA does therefore not quantify the financial impact of market growth on airspace users.

5. It is worth noting that high rates in traffic growth make most of the investments proposed under this project mandatory – without investment, safe and efficient ANS provision could not be guaranteed and would in fact become incompliant with ICAO ASBU blocks. This will generally lead to declining unit rates as traffic increases but will also be affected by the investment scenario and other factors.

6. Capital expenditure/ Equipage costs may be incurred by aircraft operators that need to upgrade airborne navigation and communication equipment to comply with the standards proposed under this project. Such costs can be considerable for a specific aircraft when retrofitted. It must be noted however, that the AFI Master Plan project aligns with the requirements of ICAO ASBU Blocks, meaning that aircraft operating beyond the confines of the AFI States would in most cases need to abide by these requirements even without this project. Furthermore, with most commercial airlines having a useful life of 25 to 30 years, we expect that most aircraft will have the required equipage level by default at the time that new requirements apply. However, operators of regional aircraft, where equipage could be optional, might be forced to upgrade old fleets.

8.4. States

States, including CAAs, government organisations and military, play a critical role in the implementation of the project through their contribution to working groups aimed at defining new structures and procedures. It is assumed that the effort related to the project is supported by existing staff and meeting structures. Therefore, there is no incremental cost involved for the State.

Also, there are no direct monetary benefits for the oversight and regulation activities of CAAs. Nonetheless, States in general are expected to enjoy indirect and induced economic benefits from the implementation of the project. These benefits include:

(1) Safety impacts: Implementing the projects proposed in the ATM Master Plan initiative contributes to greater safety for operating airlines, passengers, and airport employees.

(2) Environmental impacts: By optimising airspace design and putting in place improved operational measures, the average distance flown by airspace users can be reduced by at least 1.4% on international flights. This leads to a reduction in fuel-burn and CO2 emissions.

Other societal factors: By enhancing ATM capabilities, capacities in the upper airspace will be enhanced, local bottlenecks in the interface with lower airspace and approaches to major airports and metropolitan areas will be removed, and operating costs for airlines reduced. This enables growth opportunities for airlines – particularly in the budget airline sector - and ultimately contributes to the affordability of air travel and mobility.

PART IX

SAFETY CONSIDERATIONS

9. The GASP

Safety is a top priority in aviation. The purpose of the Global Aviation Safety Plan (GASP) (ICAO Doc. 10004) is continual improvement of safety and an associated reduction in the number of accidents and related fatalities within the international civil aviation system, by guiding the development of a harmonized aviation safety strategy and developing and implementing regional and national aviation safety plans. A safe aviation system contributes to the economic development of States and their industries. The GASP promotes the implementation of States' national safety oversight system, a risk-based approach to managing safety as well as a coordinated approach to collaboration between States, regions, and industry.

States are encouraged to support and implement the GASP as the strategy for the continuous improvement of global aviation safety. The GASP includes the global aviation safety roadmap, which serves as an action plan to assist the aviation community in achieving its goals through a structured, common frame of reference for all relevant stakeholders. Each region and each State should use the GASP to develop a Regional Aviation Safety Plan and national aviation safety plan, respectively,

9.1. Purpose of the GASP

The vision of the GASP is to achieve and maintain the aspirational safety goal of zero fatalities in commercial operations by 2030 and beyond, which is consistent with the United Nations' 2030 Agenda for Sustainable Development. The plan's mission is to continually enhance international aviation safety performance and resilience by providing a collaborative framework for States, regions, and industry. This is supported by a series of goals:

- Goal 1: Achieve a continuous reduction of operational safety risks.
- Goal 2: Strengthen State safety oversight capabilities.
- Goal 3: Implementation of effective State safety programmes.
- Goal 4: Increase collaboration at the regional level to enhance safety.
- Goal 5: Expand the use of industry programmes and safety information sharing networks.
- Goal 6: focuses on the appropriate infrastructure needed to support safe operations.

The GASP policy principles aim at the following commitments:

- The implementation of ICAO's strategic objectives;
- Aviation safety is the highest priority;
- A tiered approach to safety planning is carried out;
- State safety programme and safety management systems implementation;
- Global aviation safety priorities are defined;
- Regional and State air safety priorities are defined;
- GASP objectives and safety performance enablers are identified;
- Use of objectives and safety performance enablers are defined;

- Cost benefit and financial issues are analysed; and
- Review and evaluation of aviation safety planning are regularly carried out.

9.2. Global high-risk categories of occurrences

To mitigate the risk of fatalities, States, regions and industry need to address the G-HRCs. The selection of types of occurrences is based on actual fatalities from past accidents, high fatality risk per accident or the number of accidents and incidents. The following G-HRCs, in no particular order, have been identified in the 2023 - 2025 edition of the GASP:

a) Controlled Flight Into Terrain (CFIT);

b) Loss of Control In-flight (LOC-I);

c) Mid-Air Collision (MAC);

d) Runway Excursion (RE); and

e) Runway Incursion (RI).

9.3. Relationship with Regional and National Aviation Safety Plans

The GASP establishes a global strategy for improving aviation safety. It presents global goals and G-HRCs. The GASP presents a global perspective, its content needs to be adapted to meet regional needs. To do so, each region should produce a RASP. The RASP presents the strategic direction for the management of aviation safety at the regional level (or "for a region") for a set period. It outlines to all stakeholders where the different regional entities involved in the management of aviation safety should target resources over the coming years. The RASP should be developed in line with the GASP goals, targets and G-HRCs. However, it should be based on the region's own risk assessments and address the region's specific operational safety risks and organisational challenges.

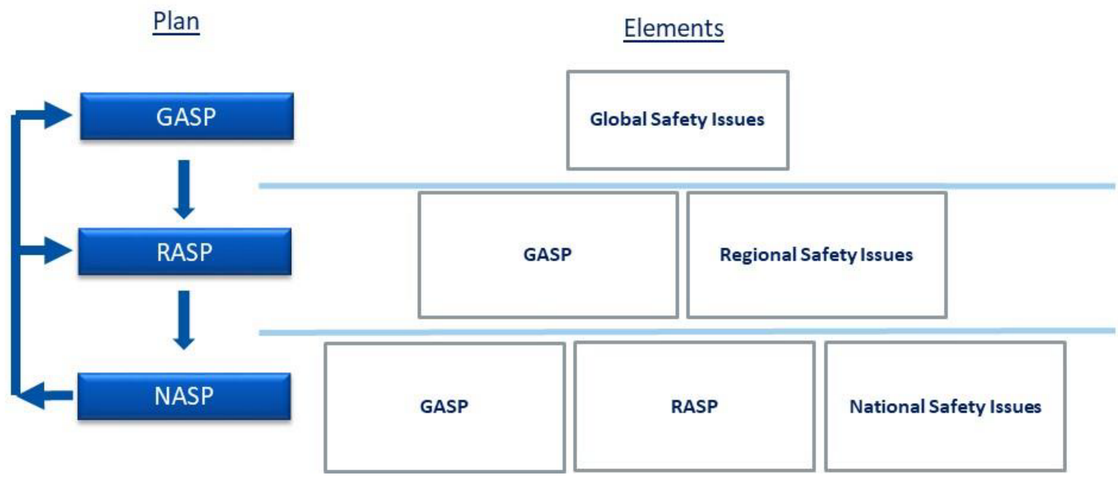

Figure 7-2. Relationship between the GASP, the RASP and the NASP

9.4. Global Aviation Safety Roadmap

The global aviation safety roadmap previously serves as an action plan to assist the aviation community in developing RASPs and NASPs, in line with the GASP goals, through a structured, common frame of reference for all relevant stakeholders. The global aviation safety roadmap outlines specific safety enhancement initiatives (SEIs) associated with the GASP goals and targets, as well as the Global High-Risk Categories (G-HRC) occurrences.

The global aviation safety roadmap is composed of:

i) Organizational challenges — this part of the roadmap (referred to as the ORG roadmap provides SEIs to meet GASP goals (and associated targets) related to States' safety oversight capabilities and the implementation of SSPs, as well as industry's implementation of SMS, and contains two distinct components, in line with the GASP goals, to address safety management responsibilities:

- State safety oversight system; and
- SSP, including service providers' SMS.

ii) Operational safety risks — this part of the roadmap (referred to as the OPS roadmap) provides SEIs to meet the GASP goal (and associated target) related to a continuous reduction of operational safety risks, and actions to address the G-HRCs presented in the GASP.

9.5. The Safety Plan

In line with the Safety Management concept laid out in the AFI Region CONOPS, safety and its rigorous implementation shall be central to aviation in the Region. The aim is to achieve continuous improvement of safety in the region. The RASG-AFI shall be the engine room and the main driver behind the planning and implementation of appropriate safety enhancement initiatives (SEIs) at regional level.

9.5.1. RASG-AFI

As a body, the Regional Aviation Safety Group AFI is composed of:

a. States
b. Regional Entities and
c. Industry

The RASG-AFI is a clearing house, by building on works done by states, regional organisations and RSOO. It serves as regional cooperating forum where an amalgamation of global, regional, national and industry safety efforts is sought towards the enhancement of aviation safety in the RASG-AFI and the world at large.

The diligent monitoring of the Abuja Safety Targets for successful implementation by states shall be a role the RASG-AFI must continue to assume in partnership with AFCAC. As a regional body saddled with safety management, the RASG-AFI in collaboration with AFCAC shall assist the political authorities within the region to revise the Abuja Safety Targets to align with the Global Aviation Safety Plan (GASP) and lay out the strategy to support the prioritization and continuous improvement of aviation safety.

The regional bodies continue to manage safety in aviation in the region through reactive, proactive, and predictive manners supported by data collection and analysis. The plan in the long term, is to foster and strengthen the proactive approach to safety, but ultimately the predictive safety management in the AFI Region.

For clarity purposes, the reactive safety management approach draws conclusions from accident data submitted by established sources and provided recommendations for resolving the safety deficiencies by means of mitigating and corrective measures.

Proactive safety management approach draws largely from the outcomes of ICAO USOAP CMA, AIAG and other entities within the region concerned with safety monitoring and reporting including RSOO and IATA. This approach also relies on reported incidents by states and airlines to identify emerging safety risks in the region leading to an informed identification of regional priorities and prioritization of Safety Enhancement Initiatives (SEIs).

However, in predictive safety management approach, the bottom line is to make sense of it from seemingly disjointed data and nib the occurrence in the bud. The objective is to identify safety concerns before accidents or incidents occur. To develop timely mitigation and preventive measures before it degenerates to accidents by making sense of data collected through careful analysis.

The RASG-AFI shall identify, from an array of data, the region's High-Risk Categories of Occurrences (HRC) in alignment with the GASP and assist states by identifying data collection methods for each of them. The regional safety targets shall be identified, and Safety Enhancement Initiatives (SEIs) proffered, and their implementation modalities highlighted to achieve the desired results.

This brings about the need for Safety Performance Measurement (SPM) in the region. Some elements the RASG-AFI must use to measure safety performance as delineated in the GASP are:

(1) Number of fatalities

(2) Accident rate

(3) Fatal accident rate

(4) Priority PQs for safety oversight system

(5) Safety oversight index

(6) SSP foundational PQs

(7) PQs related to safety management.

To achieve an effective and efficient safety performance measurement, data sharing culture is a key component whose collective implementation would be coordinated and encouraged by RASG-AFI. This is necessary in fulfilment of GASP assertion that safety information and exchange is at the center of safety performance measurement. This will flow from an entrenched:

1) Mandatory incident reporting system and
2) Voluntary incident reporting system

The RASG-AFI will drive the initiative for the computation and revision, when necessary, of the Target Level of Safety (TLS) to maintain the integrity and validity of operations in airspace where reduction had been approved in vertical separation. It shall also coordinate Height Monitoring for safety assurance of aircraft operations in the RVSM airspace.

The RASG-AFI shall implement its safety management obligations through a properly articulated safety plan as contained in a Regional Aviation Safety Plan (RASP-AFI) that will align with the Global Aviation Safety Plan (GASP) in its revision cycle and priorities.

Utilizing a safety management software with capability for data collection from remote sources and analysis of data from a central position shall be a line the RASG-AFI will toe to encourage states to share safety data at all strata. This is to ensure that all safety data cards are laid on the table for assessment and analysis.

To report its safety status, the RASG-AFI will publish on an annual basis the AFI Safety Report.

States

The fulcrum of AFI State's safety management strategy would be a manageable National Aviation Safety Plan (NASP) that draws from the RASP-AFI and in alignment with the GASP.

States should ensure implementation of State Safety Programme (SSP) as in line with the Revised Abuja Safety Targets. Accordingly, each state shall establish SSP for the management of safety to achieve an Acceptable Level of Safety Performance (ALOSP) in civil aviation. For emphasis, the SSP shall include the following components:

- State safety policy and objective
- State safety risk management
- State safety assurance
- State safety promotion

For effective implementation of SSP, it shall be data driven. To that end, states shall spare no resource to ensure the deployment of appropriate data-collection and data-analysis tool for the purpose.

Such tool shall have adequate capacity for data collection, data analysis and data sharing to be able to interface with the regional safety management data gathering tool and initiative.

States shall progress from reactive safety management approach to proactive and ultimately to predictive safety management approach. This shall be achieved by the active guidance and support of the RASG-AFI.

The data collected for SSP shall be the active ingredient states shall use for setting safety targets and for selecting Safety Performance Indicators (SPIs) in alignment with the RASP-AFI and the GASP. Therefore, service providers shall approach safety management from a common and coordinated front.

When SSP is efficiently implemented and oversight capability is significantly improved by states, they would have established sound footing on the roadmap to achieve GASP goals. Subsequently, inconsistencies and duplication of efforts would be reduced, and states will use Roadmaps as basis for NASP. It would also serve as a common frame of reference for all relevant stakeholders.

To that effect, states shall work along the line of Organisation (ORG) Roadmap in the provision of SEIs to meet GASP goals that directly impact:

- State Safety Oversight capabilities
- SSP implementation and
- SMS implementation for industry

States shall similarly work along the line of Operation (OPS) Roadmap to provide SEIs to meet GASP goal related to continuous reduction of operational safety risk and SRM activities to address HRCs.

9.5.2. Service providers

Industry is an important stakeholder in the safety management matrix in the AFI Region. As at now, it composed of, but not limited to:

(1) Certified Aerodrome Operators
(2) Air Navigation Service Providers
(3) Commercial Air Transport Operators
(4) Ground Handling Services Companies
(5) Maintenance and Repair Organisations
(6) Meteorological Agencies
(7) Approved Training Organisations

Fundamental to service provision is equipment and technologies. In line with system safety approach to safety management, where maximum effectiveness and efficiency of action are obtainable from activities implemented in the early phases of any system’s life cycle. Safety plan along that line will start for AFI service providers from conception through implementation to operation allowing different players and discipline to make decisions thereto bearing in mind different operational criteria. That way the outcome will positively impact the professionals, their procedures, their enabling technologies, indeed the interaction of the flow of information necessary for the performance of their tasks.

It is with the interplay of this consideration and the requirements of the GASP that the service providers must implement SMS in line with the Revised Abuja Safety Targets and in accordance with the RASP and GASP.

Consequently, as outlined in Annex 19, the SMS framework is comprised of four (4) components and twelve (12) elements. The four components from which the twelve elements derived are:

(1) Safety Policy and Objectives

(2) Safety Risk Management

(3) Safety Assurance

(4) Safety Promotion

In very simple term, service providers shall develop and maintain a process that ensures that hazards associated with their aviation products and services are identified. Hazard identification is based on a combination of reactive, proactive, and predictive method of data collection. Service providers shall develop and maintain a process that ensures analysis, assessment and control of the safety risks associated with the identified hazards. SMS shall be data-driven in accordance with the AFI CONOPS. The possibility of the use of uniform SMS software throughout the region may be pursued for long term implementation. When achieved, it has the advantage of harmonizing data collection and analysis as well as ease the difficulties associated with States' submission of safety data.

The elements of safety risk management of service providers' SMS shall be:

- Hazard identification
- Safety Risk Assessment and Mitigation

Therefore, as in State's SSP, SMS implementation shall be to develop data collection and analysis capabilities, derivation of causation or contributory factors through data analysis then referring to SEIs in the ORG or OPS Roadmap as detailed in the subsisting RASP and GASP.

9.5.3. Training and Human Factors

Training, human capacity development and performance enhancement is at the very heart of SSP State safety Promotion and SMS Safety Promotion components. They are essential for enhancement of human factor in personnel performance of predictably more complex and complicated tasks. As air traffic increases and ultimately doubled as forecast, there is a high probability of corresponding reduction in safety. Therefore, training of personnel and upgrade of Approved Training Organisation (ATO) shall occupy the front burner. This is necessary for the attainment of the safety initiatives highlighted in the AFI CONOPS.

PART X

CONCLUSIONS AND RECOMMENDATIONS

Recommendations

To achieve the safety targets of the AFI region and the technological evolution milestones outlined in the AFI vision 2045, the region is required to heed recommendations to implementation planning in line with of the AFI ATM master plan the following recommendations are proposed.

10.1 Information

a) **MET**

Meteorological observations in support of flexible airspace management, improved situational awareness, collaborative decision-making, and dynamically optimized flight trajectory planning including meteorological observations information in support of automated decision processes or aids and performance based requirements, involving meteorological information, meteorological information translation, ATM impact conversion and ATM decision support.

States are to ensure that MET information and its translation can support automated decision processes. These elements AMET B0/1, B0/2, B0/3 and B0/4 are recommended to be completed by 2025 at the latest. The elements of AMET B1/1 AMET B1/2, AMET B1/3 and AMET B1/4 must be completed by 2027 at the latest.

b) **DAIM**

The main purpose of this element is to ensure that aeronautical data and information comply with quality standards to meet the needs of airspace users and support the safety of flight operations. States implementing improvements within the short term may implement within their applicable ASBU DAIM B1/1, DAIM B1/2, DAIM B1/3, DAIM B1/4, DAIM B1/5 DAIM B1/6 and DAIM B1/7 timelines, however, states are required to implement by 2027 at the latest.

c) **FICE**

To improve the efficiency of coordination and transfer of control between ATS units. It is recommended that states consider prioritising the implementation of AIDC as a DAIM B1/1 to B1/7 elements by the end of 2027 as a baseline for migration into medium term.

d) **SWIM**

To define the requirements for an information service provider to make aviation-related information available as an information service. It is recommended that in the short to medium term, AFI States coordinate the regional implementation planning in alignment with the APIRG AAO-SG and IIM-SG projects. The alignment planning will ensure harmonised development and implementation of SWIM exchange protocols i.e. (AIXM) Aeronautical Information Exchange Model, (FIXM) Flight Information Exchange Model, (IWXXM) ICAO Meteorological Information Exchange Model and (AIDX) Aviation Information Data Exchange.

10.2 Operational

a) **ACAS**

To provide airborne collision avoidance as a last resort safety net for pilots. It is recommended that states prioritize the implementation of ACAS B1/1 by the end of 2027 as a prerequisite baseline for ACAS B2/1 and ACAS B2/2.

b) **ACDM**

To generate common situational awareness, which will foster improved decision making within aerodromes, by sharing relevant surface operations data among the local stakeholders involved in aerodrome operations. Airport CDM operations will be enriched by enhanced arrival information from the ATM network, and at the same time, network operations will benefit from more accurate departure information from CDM airports.

It is recommended that states implement the elements underlined in ACDM B0/1 and ACDM B0/2 in line with the Mombasa AFTM roadmap by the end of 2025. However, note must be taken of the element improvement requirements and evolution in the medium term and ensure implementation is completed by the end of 2027.

c) **APTA**

This element represents the use of PBN in design of approach procedures to provide more flexibility to airspace planners to manage the use of airspace, and to facilitate access to airports which will includes the provision of instrument approach procedures with vertical guidance in support of stabilised approaches. PBN approaches with advanced functionality allow for the introduction of more flexible approaches including the use of RF legs within the Final Approach Segment and RNP.

It is recommended that a survey to determine the capability of operators to implement RNP and the desired NAVSPEC within the terminal area, in preparation for the transition to RNP 1 for SID/STARs and RNP APCH. This recommendation must however be taken into cognisance during the development of the AFI PBN roadmap. States must therefore ensure the implementation of the elements in APTA B0/1, B0/2, B0/4, B0/5, and_B0/8 are completed by 2025 at the latest. Other elements in B0/3, B0/6 and B1/1, B1/4 and B1/6 must be completed by 2027.

d) **DATS**

To provide ATS at aerodromes not from a traditional on-site tower, but remotely from either a local or a distant location. The service provided may be a control service or flight information service as appropriate.

It is recommended that, States desiring to implement DATS B1/1 timelines as defined in the GANP should endeavour to do so within the short-term timeline of 2027 if implementation targets can be achieved.

e) **FRTO**

Direct routings are established with the aim of providing airspace users with additional flight planning route options on a larger scale across FIRs such that overall planned leg distances are reduced in comparison with the fixed route network. The Free Route Airspace (FRA) concept brings significant flight efficiency benefits and a choice of user preferred routes to airspace users.

As a step to full trajectory-based operations, the FRA concept brings increased flight predictability, reduced uncertainty for the ATM network function, which in turn can lead to potential capacity increases for ATM, which will also benefit the user.

It is recommended that States complete the implementation of the FRTO B0/1 B0/2, B0/3 and B0/4 elements by 2025 while the implementation within the short term of the FRTO B1/1 to FRTO B1/7 elements is harmonized in line with the AFI FRA roadmap.

f) **CSEP**

To improve traffic situational awareness in all phases of flight. It is recommended that elements CSEP B1/1 CSEP B1/2, CSEP B1/3 and CSEP B1/4 are implemented and enabled by the evolutions of ADS-B IN capabilities and associated applications in the short term.

g) **GADSS**

To provide support to the ATSU Alerting Service in areas without ATS surveillance with an update rate of the aircraft position of at least once per 15 mins. The objective is to assist the relevant stakeholders in the timely identification and location of aircraft in distress, to reduce reliance on the procedural methods for determining aircraft position and helping to ensure the availability and sharing of aircraft position data.

It is recommended that in oceanic areas without automatic surveillance, ATSU Alerting Service is supported with aircraft tracking capability GDAS B1/1 is implemented by the aircraft operator. States encouraged to ensure the implementation of GDAS B1/2 within the short term.

h) **SNET**

To assist the air traffic controller in preventing collision between aircraft, using position data from ground surveillance and flight intent reported by aircraft.

It is recommended that States within which there is little, or no surveillance must implement SNET B0/1 B0/2 B0/3 and B0/4 with appreciable levels of automation by the end of 2025. States that require to implement SNET B1/1 must endeavour to do so by 2027 at the latest.

i) **SURF**

To improve safety and efficiency during ground operations by providing proper indications to pilots and vehicle drivers with the aim to reduce taxi time, fuel burn, and potential mistakes. Detection by the ATCO of potentially unsafe situations regarding runway operations.

It is recommended that States must implement SURF B0/1 basic ATCO tools to manage traffic during ground operations by 2025. States are however encouraged to complete the implementation of all elements of SURF B0/2 and SURF B0/3 where desirable and SURF B1/1, B1/3, B1/4, and B1/5 where operationally beneficial by 2027 at the latest.

j) **TBO**

Provides for more efficient flight operation by using time-based scheduling versus more tactical measures such as holding to manage tactical synchronization. Strategic and tactical time based management are introduced via initial decision-making processes for network operations (demand capacity balancing) and runway sequencing. Provides initial support to network operations by integrating network applied constraints into local arrival and departure management. Overall operations are still locally conducted with time-based decision-making tools.

States are encouraged to ensure adequate preparation is conducted in the short term and implementation of related elements is prioritised and support studies to enable the harmonised implementation planning of TBO in the medium term.

k) **WAKE**

To safely optimise the separation minima to be applied between groups of aircraft due to wake turbulence on arrival and departure phases of flight. States are encouraged to implement the WAKE modules as defined within the GANP ASBU timelines however note should be taken that the implementation of these elements within the fifth edition of the GANP is a prerequisite baseline to the migration to WAKE B2 elements in the medium term from 2028 onwards.

10.3 Technology

a) ASUR

To support the provision of Air Traffic Services and operational applications at reduced cost and increased surveillance coverage. Where required, surveillance coverage in locations where ground stations establishing is not possible or not currently provided, implementation of ASUR B1/1 must be completed by end of 2027 at the latest. Implementation of ASUR-B0/3 and ASUR-B1/1 must be supported by an operational assessment and cost benefit analysis.

b) COMI

The Aircraft Communications Addressing and Reporting System (ACARS) is a digital datalink system for transmission of messages between aircraft and ground stations via VHF or satellites. SATCOM established to provide surveillance and communications where VHF usage is not possible or practical. Additionally, enable provision of a more modern, more efficient, cost-effective, and robust data communications network infrastructure.

It is recommended that States comply with the AFI short-term timelines with the implementation of COMS B0/1 to B0/7 by the year 2025 and consider the evolution to COMS B1/1 to B1/4 where desirable to be completed by 2027 at the latest.

Whereas approximately 86% of AMHS system capability has been completed, it is recommended that AFI States prioritise the migration to AMHS and ensure implementation completed by 2027 at the latest.

c) COMS

Supports reduction of voice channel congestion and increase of capacity in domestic airspace, and improvement of communication and surveillance including performance-based reduced separation minima in procedural airspace.

It is recommended that states continue the implementation of the ADS-C and CPDLC (FANS 1/A) in the short term where desired and ensure implementation of COMI-B1/1, B1/2 and B1/3 including the FANS 1/A+ CPDLC and ADS-C systems (along with associated air-ground network and physical layers) and considerations for the use of SAT VOICE applications.

d) NAV

Support non-precision (LNAV) and vertically guided (LNAV/VNAV) approaches with BaroVNAV and other terminal and enroute navigations, supports precision approach and landing operations at a specific airport and PBN in all phases of flight with an increased accuracy, integrity, and availability performances.

Where considered desirable, State’s consideration of applicability of the NAV B0/1, B0/2, B0/3, B0/4 and NAV B1/1 elements for Augmentation Systems within the short term should continue. The outcomes of the research and studies on the NAV B0 and B1 augmentation system will inform the recommendation and implementation decision in preparation for the evolution timelines in the midterm.

10.4 Safety

To enable the implementation of the GASP, AFI region and its member States must develop a Regional Aviation Safety Plan (RASP) and National Aviation safety Plans (NASP) respectively. To achieve the long-term goal of predictive safety management in the AFI Region, States are encouraged to deploy digital data collection mechanisms.

10.5 Environmental Considerations

Through implementation of the ASBU modules outlined in the regional master plan, AFI States to take environmental management system requirements into consideration in preparation for the ever-growing support of environmental protection strategies and the goals to curb carbon emissions.

To enable attainment of the net-zero emissions objectives ICAO has agreed that airlines will use the (CORSIA) Carbon Offsetting and Reduction Scheme for International Aviation and members agreed to a collective goal of net zero international aviation by 2050. A significant milestone, not just for the future of flying, but for the wider international commitment to achieve net zero international aviation.

10.6 Human Performance and Capacity Building

States are encouraged to emphasize the use of Competency Based Training (CBT) to enhance resource utilization and optimize productivity. AFI states are encouraged to undertake "ergonomic audit” (the process of evaluating the human factor/ergonomic influence in a situation), as improved technologies are implemented in accordance with this Masterplan.

10.7 Monitoring and Evaluation

It is recommended that a mechanism be adopted to develop a digital platform to ensure the monitoring of implementation and the evaluation of the effectiveness of the improvements. States' active participation will enable the monitoring and evaluation objective.

Conclusion

The AFI ATM Master plan provides the opportunity for the States to plan their ATM improvements and deployment of technology that meets future demands of achieving a seamless ATM environment. To attain the goals set for the region, it is important to ensure that all States work within the framework outlined by adopting the benefits from research and development available.

An integrated, harmonized and globally interoperable ATM system cannot be achieved if States do not conduct their activities in tandem with each other. A strategic outlook of 2045 and beyond has therefore been set for States in this document to guide them towards achieving the targets outlined in the ATM Masterplan implementation roadmap.

The strategic outlook is adopted to enable States to examine their current situation regarding traffic flows and CNS capabilities and to align their improvements to the airspace in a simplified manner through the harmonization of technologies that will provide airspace users seamless services regardless of geopolitical boundaries.

To this end, the document defines the regionally adopted concepts of operations to be implemented by States to meet the future ATM requirements in line with user expectations. The AFI ATM Master plan includes implementation considerations in the technical plan and the implementation roadmap in alignment with the AFI ATM Vision 2045, future CONOPS, AFI Air navigation plan and the GANP.

References

Doc 9750 Global Air Navigation Plan

Doc 9854 Global Air Traffic Management Operational Concept

Doc 10004 Global Aviation Safety Plan

Annex 10 Aeronautical Telecommunications

Annex 11 Air Traffic Services (particularly Chapter 2 [2.1 and 2.30], and Attachment C)

ASBU Document

Doc 4444 Procedures for Air Navigation Services Air Traffic Management (PANS ATM)

Doc 8071 Manual on Testing of Radio Navigation Aids Volume 2

Doc 9613 Performance-based Navigation Manual

Doc 9882 Manual on ATM System Requirements

Doc 9883 Manual on Global Performance of the Air Navigation System

Doc 9906 Quality Assurance Manual for flight Procedure Design Volume 5

Doc 9971 Manual on Collaborative Air Traffic Flow Management

Annex 6 Operation of Aircraft

Doc 8168 Procedure for Air Navigation Service Aircraft Operations Volume I Flight Procedures

Doc 8168 Procedure for Air Navigation Service Aircraft Operations Volume II Flight Procedures

Doc 9931 Continuous Descent Operations (CDO) Manual

Doc 9993 Continuous Climb Operations (CCO) Manual

Annex 1 Personnel Licensing

Circular 214 Fundamentals on Human Factors

Circular 227 Training of Operational Personnel on Human Factors

Circular 241 Human Factors in ATC

Circular 249 Human Factors in CNS and ATM Systems

Circular 318 Language Testing Criteria for Global Harmonization

Circular 323 Guidelines for Aviation English Training Programmes

Doc 9835 Manual on the Implementation of ICAO Language Proficiency Requirements

Doc 9966 Fatigue Risk Management Systems

Annex 19 on Safety Management System

Doc 9854 Air Traffic Management Operational Concept

Global Aviation Safety Plan 2020 – 2022

AFI Safety Report 2020

ICAO Safety Strategy 2007

Appendices

Appendix I - Technical Plan

Appendix II - Implementation Roadmap

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