INTERNATIONAL CIVIL AVIATION ORGANISATION

AFI ATM VISION 2045

FUTURE

CONCEPT OF OPERATIONS

Version 1.0

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

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PREFACE

Aviation is an integral part of society, connecting people and transporting goods worldwide, and an important driver of economic growth and sustainable development, improving the standard of living of people around the world through the safe and reliable operations. Forecasts confirm robust traffic growth within the next 20-30 years as will be enabled by positive economic, political, and societal changes.

The global ANS system has witnessed significant improvements in recent decades. For the air transport system to continue to contribute to social development and economic progress globally, a safe, secure, efficient, and sustainable ANS system with limited impact on climate change must transform from conceptual approaches of the previous century.

The sustainable growth objective within the international air transport system relies heavily on a high performing and seamless global ANS (Air Navigation System). The global ANS supports the safe and orderly development of international civil aviation through the collaborative integration of humans, information, technology, facilities, and services.

Within the technical scope, the system comprises aerodrome operations, air traffic management, meteorology, aeronautical information and search and rescue services supported by air, ground and space-based Communications, Navigation and Surveillance (CNS) capabilities. Within the operational scope, the system encompasses en-route to en-route operations to integrate airport operations and flight turnaround. Within the community scope, the system comprises all stakeholders involved in the provision of, or requiring the use of, air navigation resources.

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

The sole purpose of aviation has over the years been linked to the transportation of passengers and cargo worldwide. However, the emergence of multiple airspace users, different vehicles and business models has birthed complexities in the decision-making processes of ANSPs. Customer satisfaction which is paramount in any business can only be met if the decision-making process is managed flexibly. Therefore, ANSPs are required to enable their customers and key stakeholders to make their own decisions anchored on predefined performance management systems that can meet the new demand.

The AFI ATM vision 2045 and future concept of operations outlines evolution of the AFI ANS for all stakeholders to ensure that no State or stakeholder is left behind. Therefore, the development of the AFI ATM Vision and future concept of operations in alignment with the AFI ATM Master Plan will enable implementation planning for the seamless flow of air traffic in the AFI region.

The AFI ATM vision 2045 and future concept of operations will provide significant insight to the AFI regional implementation planning strategy while the implementation process and timelines will cascade from the AFI ATM Master Plan implementation strategy, and States will support the regional implementation harmonisation objective through the development of national aviation Master Plans and an agreeable funding model.

RECORD OF AMENDMENTS AND CORRIGENDA

AMMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

EXECUTIVE SUMMARY

Aviation is facing a period of transformational change in the next 30 - 40 years, Thus Aerodrome, ATM, and flight operations must gear up for this evolutionary change considering all technological disruptors. The AFI ATM vision and future concept of operations will reflect ultimate objectives of the Air Navigation System, encompassing ATM, CNS, AIM, AGA and MET systems as well as the emerging opportunities and challenges stemming from user's expectations and requirements including technological developments.

The global ANS system has witnessed significant improvements in recent decades. For the air transport system to continue to contribute to social development and economic progress globally, a safe, secure, efficient, and sustainable ANS system with limited impact on climate change must transform from conceptual approached of the previous century.

A thorough account of the status of the current ATM system provides significant context in terms of the AFI region States' levels of ATM and infrastructure implementation, considering the (BBB) Basic Building Blocks, (GANP) Global Air Navigation Plan and the (ASBU) Aviation System Blocks Upgrades recommended for implementation as may be deemed suitable and viable for the AFI region.

The AFI ATM Vision and future Concept of Operations development considers the future operating environment while ensuring alignment with the Global Air Traffic Management Operational Concept's vision statement, to achieve an interoperable global (national and regional) ATM system, for all users during all phases of flight, which meets agreed levels of safety, provides for optimum economic operations, is sustainable and meets national security requirements.

As with the Global operational concept, the AFI ATM future operating environment and concept of operations must be visionary and inclusive of industry. Many of the current initiatives and objectives will continue to form part of the AFI ATM and infrastructure projects implementation throughout the planning horizon. To this end, the concept of operations must be evolutionary and user requirements and expectations considered in implementation planning efforts.

The continued growth of traffic in the AFI region has necessitated the need to improve safety, capacity, efficiency, and sustainability that will enable optimal utilisation of airspace. To achieve this feat, recent technology has enabled the use of Performance Based Navigation (PBN) as opposed to conventional ground-based navigation. In this context, the AFI plan has the objective of a future harmonised global navigation capability based upon area navigation (RNAV) and Performance Based Navigation (PBN), supported using Global Navigation Satellite Systems (GNSS).

The speed of technological advancement will drive the capability and capacity to harness continued support of social wellbeing, accommodate increasing demand and new types of demand, including emerging, new, and adapted business models.

Technology Roadmap provides an overview and assessment of technology opportunities to modernise the way airspace is structured and transformed by the technology used to manage air traffic. Modernising airspace, which means both route design and new tools and technologies, will make air traffic management more efficient, helping reduce the impact air traffic has on industry and the environment, and supporting future growth.

Trajectory-Based Operations represents a shift from present operations towards the use of a shared, collaboratively developed trajectory which more closely meets airspace users' objectives, access to user preferred trajectories and serves as the basis for decision-making across the ATM system participants. Therefore, TBO provides an opportunity to shift operations towards greater predictability with flight-impacting decisions being coordinated across concept components, with highest priority for separation provision.

Along with Cyber technologies comes threat and insecurities affecting all ATM systems and infrastructure, cyber vulnerability remains a critical challenge thus the objective to ensure secure internet connectivity for information exchange between ATM and flights in FF-ICE and TBO perspective. It is necessary that the AFI Region be prepared for the sunset of FPL-2012 as projected by 2034.

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

The move towards the Internet of Things (IoT) will ensure that information will no longer be the limitation, and the focus will shift to who can make the best decisions resulting in improvements to the total system performance. This will be possible because constraints will be minimised owing to the increased accuracy and availability of data, considering all inputs to the system and the absence of coordination limitations with everyone connected to the network.

This information rich environment will propel CDM in a network-centric context to enable management by trajectory and ultimately improving Aerodrome, ATM and flight operations. Additionally, this information will play a fundamental role in the extremely interconnected systems that will progressively enable autonomous operations and human-machine collaboration.

ABBREVIATIONS AND ACRONYMS

A-CDM	Airport Collaborative Decision Making
AFCFTA	African Continent Free Trade Area
AFCAC	African Civil Aviation Commission
A-SMGCS	Advanced Surface Movement Guidance and 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
AFI	African Indian Ocean region
AFIS	Aerodrome Flight Information Services
AFTN	Aeronautical Fixed Telecommunication Network
AGA	Aerodrome and Ground Aids
AIDC	ATS Interfacility Data Communication
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
AIRGCOM	Air-Ground Communications
AIS	Aeronautical Information Services
AIXM	Aeronautical Information Exchange Model
AMAN	Arrival Manager
AMHS	ATS Message Handling System
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
AO	Aerodrome Operations
AOM	Airspace Organisation and Management
APIRG	AFI Planning and Implementation Regional Group
APV	Approach Procedure with Vertical guidance
ARES	Airspace Reservation
ASBU	Aviation System Block Upgrade
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFCM	Air Traffic Flow Capacity Management
ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Services
ATS/DS	ATS Direct Speech
ATM	Air Traffic Management
ATM SD	Air Traffic Management Service Delivery Management

AU	African Union
AUO	Airspace User Operations
AWACS	Airborne Warning and Control System
AWOS	Automated Weather Observing System
BA	Business Aviation operations
BBB	Basic Building Blocks
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Service Organisation
CAT	Category
CCO	Continuous Climb Operations
CDM	Collaborative Decision Making
CDO	Continuous Descent Operations
CLAM	Cleared Level Adherence Monitoring
CM	Conflict Management
CMAC	Civil and Military ATM Cooperation
CNS	Communication, Navigation and Surveillance
CONOPS	Concept of Operations
CPDLC	Controller Pilot Data Link Communication
CTA	Controlled Time of Arrival
CTO	Controlled Time Over
DCB	Demand and Capacity Balancing
DFMC	Dual Frequency Multi-Constellation
DMAN	Departure Manager
DME	Distance Measuring Equipment
ESAF	Eastern and Southern Africa
EVS	Enhanced Vision System
FDPS	Flight Data Processing System
FF-ICE	Flight and Flow – Information for Collaborative Environment
FIR	Flight Information Region
FIS	Flight Information Service
FIXM	Flight Information Exchange Model
FMP	Flow Management Position
FMS	Flight Management System
FPL	Flight Plan
FRA	Free Route Airspace
FUA	Flexible Use of Airspace
GA	General Aviation operations
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan

GBAS	Ground Based Augmentation System
GAST-C	GBAS Approach Service Type-C
GAST-D	GBAS Approach Service Type-D
GGCOM	Ground-Ground Communications
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HMI	Human Machine Interface
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFP	Instrument Flight Procedure
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Information Management
IOC	Initial Operational Capability
IPS	Internet Protocol Suite
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ITU	International Telecommunications Union
KHz	Kilohertz
KPA	Key Performance Area
LR-ATFM	Long Range-ATFM
MA	Military Aviation operations
MET	Meteorology
MLAT	Multilateration
MSSR	Monopulse Secondary Surveillance Radar
NASP	National Aviation Safety Plan
NDB	Non-Directional radio Beacon
NM	Nautical Mile
NOTAM	Notice To Air Men
OLDI	On-Line Data Interchange
OPMET	Operational Meteorology
PBN	Performance Based Navigation
PSR	Primary Surveillance Radar
RAM	Route Adherence Monitoring
RASP	Regional Aviation Safety Plan
RIMS	Ranging and Integrity Monitoring Station
RNAV	Area Navigation
RNP	Required Navigation Performance

RWY	Runway
SAATM	Single African Ait Transport Market
SATCOM	Satellite Communications
SAR	Search And Rescue
SARPs	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SDG	Sustainable Development Goal
SEI	Safety Enhancement Initiatives
SMS	Safety Management System
SSP	State Safety Plan
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
STCA	Short Term Conflict Alert
SYSCO	System Supported Coordination
SWIM	System Wide Information Management
TBFM	Time Based Flow Management
TBM	Time Based Management
TBO	Trajectory Based Operations
TMA	Terminal Control Area
TS	Traffic Synchronisation
TSAT	Target Start-up Approval Time
TTA	Target Time of Arrival
TTO	Target Time Over
TTOT	Target Take Off time
TWR	Aerodrome control Tower
TWY	Taxiway
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
VCS	Voice Communication System
VDL	VHF Data Link
VoIP	Voice over Internet Protocol
VNAV	Vertical Navigation
VPN	Virtual Private Network
VOR	VHF Omnidirectional Range
VSAT	Very Small Aperture Terminal
WACAF	Western And Central Africa
XML	Extensible Markup Language
WAM	Wide Area Multilateration
YD	Yamoussoukro Declaration

GLOSSARY OF TERMS

Airport Collaborative Decision Making (A-CDM) – A concept which aims at improving Air Traffic Flow and Capacity Management (ATFCM) at airports by reducing delays, improving the predictability of events, and optimising the utilisation of resources.

Arrival Management (AMAN) – A term used for the process of safely and effectively arranging arrivals into a smooth and efficient flow for landing at a destination airport

Aviation Safety Block Upgrades (ASBU) – The ICAO Global Air Navigation Plan (GANP) (Doc 9750) is 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

Airspace Management – The process by which airspace options are selected and applied to meet the needs of the ATM community.

Air Traffic Management (ATM) – The dynamic, integrated management of air traffic and airspace- safely, economically, and efficiently- through the provision of facilities and seamless services in collaboration with all parties.

Air Traffic Flow Management (ATFM) – The regulation of air traffic in order to avoid exceeding airport or air traffic control capacity in handling traffic, and to ensure that available capacity is used efficiently.

Air Traffic Management System – A system that provides ATM through the collaborative integration of humans, information, technology, facilities, and services, supported by air and ground- and/or space-based communications, navigation, and surveillance.

ATM community – The aggregate of organisations, agencies or entities that may participate, collaborate, and cooperate in the planning, development, use, regulation, operation, and maintenance of the ATM system.

Capability – The ability of a system to provide a service or perform a function that, either on its own or with other services or functions, can deliver a definable level of performance. This level of performance is measurable within a framework of performance indicators and safety requirements.

Capacity – The maximum number of aircraft that can be accommodated in a given time period by the system or one of its components (throughput).

Collaborative decision-making (CDM) – represents the means for collaboration and cooperation between several stakeholders, such as ANSPs and airports, in order to improve the provision of ATS, often between several connected FIRs. Through this process, ATM community members affected by any decision, share information related to that decision and agree on and apply the decision-making approach and principles. The overall objective of the process is for the ATM system as a whole to improve its performance while balancing against the individual performance needs of individual ATM community members.

Continuous Climb Operation (CCO) – An operation, enabled by airspace design, procedure design and ATC, in which a departing aircraft climbs without interruption, to the greatest possible extent, by employing optimum climb engine thrust, at climb speeds until reaching the cruise flight level.

Continuous Descent Operation (CDO) – An operation, enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix /final approach point.

Note 1. — An optimum CDO starts from the top of descent and uses descent profiles that reduce segments of level flight, noise, fuel burn, emissions, and controller/pilot communications, while increasing predictability to pilots and controllers and flight stability.

Note 2. — A CDO initiated from the highest possible level in the en-route or arrival phase of flight will achieve the maximum reduction in fuel burn, noise, and emissions

Conflict – Any situation involving an aircraft and a hazard in which the applicable separation minima may be compromised.

Conflict horizon – The extent to which hazards along the aircraft's future trajectory are considered for separation provision.

Constraint – Any limitation on the implementation of an "operational improvement."

Continuity – The probability of a system performing its required function without unscheduled interruptions during the intended period of operations.

Delay – The difference between actual block time and ideal block time.

Demand – The number of aircraft requesting to use the ATM system in a given time period.

Departure Manager (DMAN) – A planning system to improve departure flows and increase predictability at an airport by calculating the Target Take Off Time and Target Start-up Approval Time for each flight, taking multiple constraints and preferences into account.

Efficiency – The ratio of the cost of ideal flight to the cost of procedurally constrained flight.

Enablers – Initiatives, such as (new) technologies, systems, operational procedures, and operational or socio-economic developments, which facilitate the implementation of operational improvements or of other enablers.

Gate to gate – A concept where the air traffic operations of ATM community members are such that the successive planning and operational phases of their processes are managed and can be achieved in a seamless and coherent way.

Operational Concept – For the purposes of this document, an operational concept is defined as:

- A high-level description of the ATM services necessary to accommodate traffic at a given time horizon;
- A description of the anticipated level of performance required from, and the interaction between, the ATM services, as well as the objects they affect; and
- A description of the information to be provided to agents in the ATM system and how that information is to be used for operational purposes.

Operational Concept Vision – To achieve an interoperable global ATM system, for all users during all phases of flight, which meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements.

Safety Case – Both the argument and the document that contend that the level of safety attained will satisfy the safety requirements. It intelligently and coherently argues the degree of safety achieved at any point of a system's life cycle by making rational and coherent reference to the documented results of the system safety approach defined below.

Separation minima – The minimum displacements between an aircraft and a hazard which maintain the risk of collision at an acceptable level of safety.

Separation mode – An approved set of rules, procedures and conditions of application associated with separation minima.

Separation provision – The tactical process of keeping aircraft away from hazards by at least the appropriate separation minima.

System Wide Information Management (SWIM) – consists of standards, infrastructure ad governance enabling the management of the ATM-related information and its exchange between qualified parties via interoperable services.

Traffic synchronisation – Traffic synchronisation concerns the management of the flow of traffic through merging and crossing points, such as traffic around major aerodromes or airway crossings.

Time Based Management (TBM) - A methodology for managing the flow of air traffic through the assignment of time at specific points for an aircraft. TBM applies time to manage and condition air traffic flows to mitigate demand/capacity imbalances and enhance efficiency and predictability of the NAS. Where implemented, TBM tools will be used to manage traffic even during periods when demand does not exceed capacity. This will sustain operational predictability and assure the regional/national strategic plan is maintained.

Time-Based Flow Management (TBFM) - A foundational Decision Support Tool for time-based management in the en route and terminal environments.

Trajectory Based Operations (TBO) – A concept enabling globally consistent performance-based 4D trajectory management by sharing and managing trajectory information. TBO will enhance planning and execution of efficient flights, reducing potential conflicts and resolving upcoming network and system demand/capacity imbalances early. It covers ATM processes starting at the point an individual flight is being planned through flight execution to post flight activities.

Unmanned Aerial Vehicle (UAV) – An unmanned aerial vehicle is a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot-in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous.

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Part I – INTRODUCTION.

1 Purpose of Document.

The AFI ATM Vision 2045, future Concept of Operations (CONOPS) is a document describing the Operational Concept of the AFI region by detailing overall concept level guidance to ensure consistent development and establishment of seamless (ANS) Air Navigation System.

The AFI ATM vision, future CONOPS fits into the AFI ATM Master Plan by formulating and describing the evolution of future AFI ATM system. The ATM Master Plan will outline the essential operational and technological changes that will contribute to achieving a seamless AFI ANS and strategic objectives.

The ATM vision and CONOPS will thereby bridge the aspirations of the AFI ATM Master Plan with practical solutions capable of achieving the objectives of the ATM Master Plan. The ATM Vision 2045, future concept of operations is the common reference for all operationally related tasks and will be subject to refinements as validation of concept elements are assessed with respect to delivery of expected performance.

The AFI vision and CONOPS will be aligned with the (ASBU) Aviation System Block Upgrades and 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).

The operational concept will summarise the expected targets for operations within the AFI region, while explaining several operational plans and benefits that will be offered to the region and stakeholders in the short, medium, and long- term.

1.1 Scope and Objectives.

The AFI ATM vision 2045, future CONOPS will introduce a phased approach to concept development, validation and deployment aligned to the AFI ATM Master Plan. The operational steps defined in this document will help identify specific, manageable, scalable, implementable ATM goals which will enhance operational improvements that offer benefits to the ATM community.

The AFI ATM vision, future CONOPS describes in sufficient detail the ATM operations envisaged in the AFI region so that it allows civil and military airspace users, service providers, ATM and aviation industry including (CAA) Civil Aviation Authorities to gain common understanding of the operational characteristics and capability requirements of ATM and the main changes of the future in operating practices.

The AFI ATM vision 2045, future CONOPS covers the complete ATM process from early planning through flight execution and post flight activities. It should be noted that the concepts described in this document may only apply to operational environments where they provide clear benefits to ATM and are practicable. There may in some instances exist optional solutions that can be applied to gain the same operational benefit.

1.2 Document Structure.

The document consists of six main parts into which the operational concepts are discussed in the context of the AFI ATM Master Plan.

Part I – Current ATM Environment

Part II – Vision and Future ATM Operating Environment

Part III – Concept of Operations

Part IV – Conclusions and Recommendations

Part V – References

1.3 Intended readership.

The AFI ATM vision, future CONOPS intended readership is twofold:

- Primarily, the AFI partners and stakeholders critically involved in the development and validation of the AFI Vison 2045, future Concept of Operations and the AFI Master Plan documents.
- Secondly the global ATM community in order to learn and understand how the AFI region intends to develop and implement ATM systems to meet the overarching goals of the aviation industry.

1.4 Relation to International and Regional Initiatives.

The Global Air Navigation Plan (GANP) was developed in collaboration with and for the benefit of all aviation stakeholders as a key contributor to the achievement of ICAO’s Strategic Objectives. The GANP relates with the Sustainable Development Goal (SDG) 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.

The International Civil Aviation Organisation (ICAO) further developed the global ATM operational concept describing the future ATM concepts applicable on a global basis. The AFI vision and future concept of operations is developed with reference to the ICAO Global ATM Operational Concept (GATMOC) and the Aviation System Block Upgrades (ASBU) initiative as a programmatic framework that develops a set of ATM solutions or upgrades taking advantage of current equipage, establishes a detailed transition plan while enabling global interoperability.

ASBU comprise of a suite of modules, organised into flexible and scalable building blocks. Block upgrades describe a way to apply the concepts defined in the ICAO GANP (Doc 9750) with the goal of implementing regional performance improvements.

It includes the development of technology roadmaps, to ensure that standards are mature and to facilitate the synchronisation between air and ground systems, as well as between regions. The ultimate goal is to achieve global interoperability.

The following upgrades have been defined:

- BBB = Basic Building Block (baseline)
- Block 0 = from 2013
- Block 1 = from 2019
- Block 2 = from 2025
- Block 3 = from 2031
- Block 4 = from 2037

The AFI Vison and Concept of Operations relate mainly to ASBU blocks 1 and 2.

6th ASBU Structure:

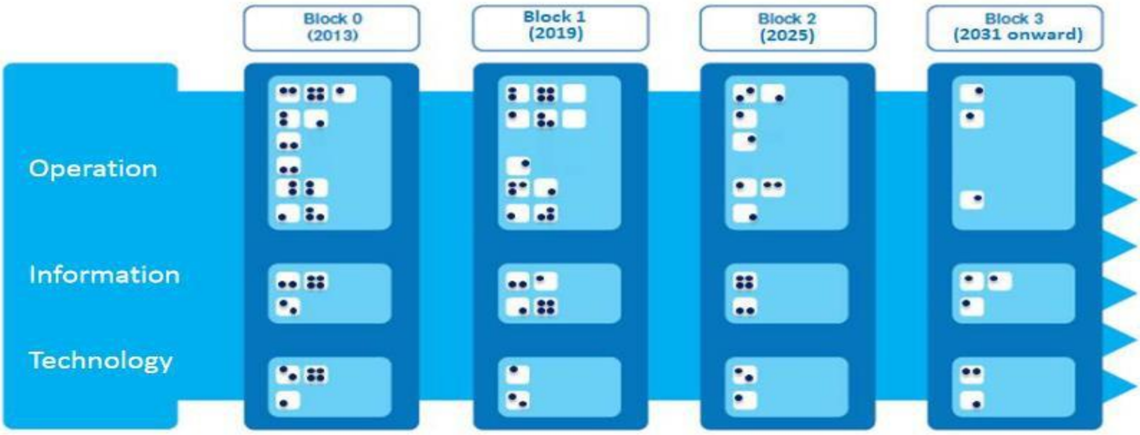


Figure:1 ASBU Blocks, Threads, Modules, and Elements.

On a regional level, the AFI ATM vision 2045, future concept of operations relates with the liberalisation of Intra-Africa air transport services signed by 7 African Member States when the Yamoussoukro Declaration (YD) was adopted. The YD provides;

- The full liberalisation of intra-African air transport services in terms of market access, the free exercise of the third, fourth and fifth freedom traffic rights for scheduled and freight air services by airlines.
- The full liberalisation of frequencies, tariffs, and capacity.
- It also provides eligibility criteria for African community carriers, safety and security standards, mechanisms for fair competition and dispute settlement as well as consumer protection.

The Yamoussoukro Declaration has evolved towards the establishment of a Single African Air Transport Market (SAATM) under the leadership of the African Union (AU) and African Civil Aviation Commission (AFCAC) as the designated Executing Agency. AFCAC has developed measurable performance indicators to evaluate the implementation of SAATM.

With the full implementation of the Yamoussoukro Declaration, ultimately, the single market will evolve into a '**common aviation area,'** calling for:

- ➢ the abolition of bilateral air service agreement between Member States for intra-Africa traffic with airlines able to fly any intra-African routes based on economic and financial considerations of the market;
- ➢ facilitation of trade in services and free movement of goods;
- ➢ enhanced cross-border investment in the industry;
- ➢ recognition of community airlines owned by African nationals with efficient and effective regional safety oversight agencies;
- ➢ application of high safety, security, and technical standards;
- ➢ harmonised competition regulation; and
- ➢ the revision of visa requirements to enable the free movement of Africans in the Continent.

The single air transport market will also guarantee the basic rights of the consumer with a dispute settlement mechanism through negotiation and arbitration, with a Board of Appeal and an Arbitration Tribunal to be established.

The benefits of establishing a single air transport market are well documented from international experiences in other continents like the Single European Air Transport Market and the liberalised air transport market in Latin America. Air transport can open and connect markets, facilitating trade and enabling African firms to link into global supply chains. It plays an especially pivotal role in just-in-time global manufacturing production and in speeding fresh produce from agricultural communities to appropriate markets. Enhancing air connectivity can help raise productivity, by encouraging investment and innovation, improving business operations and efficiency.

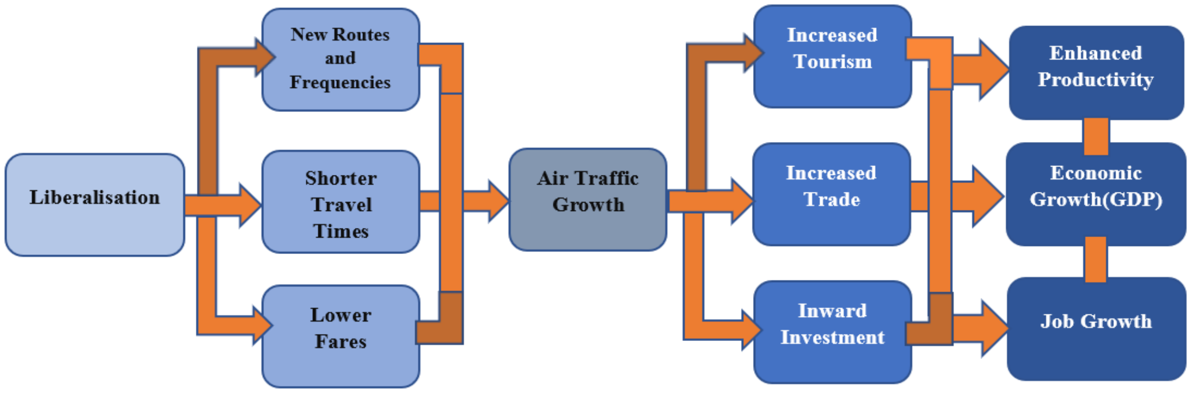


Figure 2- Schema of the benefits of full Air Transport Liberalisation.

The Single African Air Transport Market is based on a policy of full liberalisation. Liberalisation is expected to increase air service levels, increase route competition resulting in lower fares, which in turn stimulates additional traffic volumes, facilitates tourism, trade, investment, and other sectors of the economy, and brings about enhanced productivity, economic growth, and increased employment.

The AFI ATM vision 2045, future CONOPS further relates to the Civil Air Navigation Services Organisation (CANSO) Africa ATFM Implementation Plan referred to as the 'CANSO Mombasa ATFM Roadmap.' In order to achieve the AFI seamless sky, the introduction of Air Traffic Flow Management (ATFM) processes was identified as a major requirement for the region. Focusing on the implementation of collaborative ATFM in the region would ensure efficient traffic flows and address system disruption caused by human and natural phenomena.

With this background, CANSO has been actively supporting ANSPs around the world in the implementation of ATFM/CDM practices in an effort to improve safety and efficiency of air transport. The support provided by CANSO includes but not limited to, concept of operations development, demand and capacity optimisation and post- operations analysis.

CANSO through its key stakeholders (African ANSPs, CAAs, IATA and ICAO) agreed and resolved to develop the strategy to implement ATFM in the African region in Mombasa, Kenya. The roadmap document describes a range of tools, systems and processes required to successfully establish ATFM in Africa. The CANSO Mombasa ATFM roadmap is an important mechanism for managing anticipated air traffic growth efficiently and effectively. The document calls for strong partnership, collaboration, and the creation of a platform capable of data and information sharing, and stakeholder commitment to achieve seamless operations in Africa.

ATFM is not currently utilised in most of Africa's regional airspace. However, with the projected traffic growth within the African continent, there is need to use ATFM as it is a key enabler for safety, efficiency, cost effectiveness and reduction of environmental impact of ATM. ATFM will facilitate efficient operations between States and will enhance proactive planning for the projected future traffic.

1.5 Safety Management.

Safety must continue to occupy a pre-eminence of place of topmost priority in aviation in the AFI Region. Therefore, a detailed concept that would enable the implementation of a comprehensive process for safety management must be evolved. This is necessary to assist the ATM Community to achieve efficient and effective outcomes in operations.

The management of aviation safety in the AFI Region would have its basis in the AFI Region Aviation Safety Plan (RASP – AFI) as well as States National Aviation Safety Plans (NASP) that have collectively drawn largely from the goals and priorities of the subsisting Global Aviation Safety Plan (GASP).

Needless to emphasise, that the flexibility and dynamism of the safety management initiative would be in accordance with the identified goals, targets, and indicators of the RASP – AFI at all times.

Continuous improvement of safety, continuous reduction in fatalities and risk of fatalities is a central objective of the AFI aviation safety management. While all stakeholders/ATM Community would facilitate its implementation through coordinated Safety Enhancement Initiatives (SEIs). Consequently, the AFI aviation safety management initiative will be systematic and data-driven through a diligent implementation of State Safety Programme (SSP) and industry's Safety Management System (SMS). While the former is an essential component of States Safety Oversight function, the latter is a service providers' responsibility.

However, for effective safety management, the capability of all members of the AFI ATM Community would be strengthened through regular training, workshops, and additional procedures. This would assist States within the AFI Region to prioritise Safety Enhancement Initiatives (SEIs) to establish and sustain effective safety oversight capability and effectively address operational safety risks.

1.6 Limitations to the Concept.

The operational working methods and concepts should be defined taking into consideration the level of equipped aircraft, ground support tools and infrastructure needed to deliver the expected benefits. It is cardinal to note that this takes place in a mixed environment with equipped and non-equipped aircraft, operating at different aircraft performance levels with different levels of ground support tools and infrastructure.

Part II – CURRENT ATM ENVIROMMENT

2.1 Airspace Organisation and Management.

Airspace Management is defined as a planning function with the primary objective of maximising the utilisation of available airspace by dynamic time sharing and, at times, the segregation of airspace among various categories of users based on short term needs. The main objective of Airspace Management is to maximise the efficient use of airspace while maintaining the level of safety applicable to air traffic operations within the airspace.

All airspace is the concern of ATM and will be a usable resource. The organisation, flexible allocation and use of airspace will be based on the principles of access an equity. On this basis, any restriction on the use of any particular volume of airspace will be considered transitory. Airspace organisation will establish airspace structures in order to accommodate the different types of air activity, volume of traffic, and differing levels of service. The principles of organisation will be applicable from the most complex to the least complex airspace.

Airspace management is the process by which airspace options are selected and applied to meet the needs of the ATM community, Key conceptual changes include;

- All airspace will be the concern of ATM and will be a usable resource;
- Airspace management will be dynamic and flexible;
- Any restriction on the use of any volume of airspace will be considered transitory; and
- All airspace will be managed flexibly, airspace boundaries will be adjusted to traffic flows and should not be constrained by national of facility boundaries.

Airspace Management in the AFI region is performed at three main levels, with each level impacting and interrelated as described below;

- **Strategic Level:** At this level, stakeholders predominately deal with the establishment of predetermined airspace structures. At this level individual States define and regularly review their national airspace policies on the basis of national and international airspace users and ANSPs. The related tasks involved include the establishment of an airspace organisation, planning and creation of permanent and temporary airspace structures to mention but a few.
- **Pre- Tactical Level:** At this level, stakeholders focus on the day-to-day allocation of airspace according to user requirements. The related tasks include daily allocation of airspace and communication of airspace allocation data to all the concerned parties.
- **Tactical Level:** At this level, stakeholders manage the use of the airspace in real time, allowing safe separation of civil and military traffic. This means activating, deactivating, or reallocating in real-time airspace allocated at pre-Tactical level, and the resolution of specific airspace problems and/or individual traffic situations between the civil or military. The related tasks include the prompt exchange of data with or without system support between the relevant civil and military ATS units, in order to permit a safe and expeditious conduct of both civil and military flights.

2.1.1 FRA (Free Route Airspace)

A specified airspace within which users may freely plan a route between a defined entry point and a defined exit point, with the possibility to route via intermediate (published or unpublished) significant point, without reference to the ATS route network, subject to airspace availability. Within this airspace, flights remain subject to air traffic control.

AFI region has developed and regularly amends the AFI FRA Concept of operation document (CONOPS) which provides a basis for a common understanding of the FRA concept together with a detailed description of the basic requirements to enable safe and harmonised implementation of FRA in AFI region, at both national and regional levels.

The FRA CONOPS encompasses various FRA implementation scenarios that will;

- Meet the Safety Objectives;
- Be compatible with existing operations;
- Be sustainable through further development;
- Be capable of expansion/connectivity to/with adjacent airspace; and
- Be capable of being exported to other regions.

AFI states have also conducted a Gap Analysis in order to assess their capacity to implement FRA and have an overall picture of possible challenges to be addressed during implementation such as:

- CNS/ATM supporting infrastructure.
- ATC conflict detection and resolution tools.
- Need for enhanced coordination between ANSPs for FRA beyond the FIR boundaries; enhanced civil military coordination, etc.
- Appropriate changes to Airspace design concept (entry/exit/intermediate waypoints) and ATS Letters of Procedures updates.
- Dedicated training on the new operational issues (conflict detection, coordination, procedures, etc.)

Enablers

The enablers are:

- Appropriate System Support - enhancement for the purposes of Flight Planning and ATFM in the future;
- Procedures - enhanced procedures where necessary for operations within FRA and at its interfaces;
- Adaptations to airspace structures;
- Adaptations to airspace management procedures; and
- No additional equipment requirements or flight planning procedures changes are foreseen for aircraft operators. Nevertheless, modifications to flight planning systems may be required to ensure that full benefit of the FRA can be realised.

AFI States FRA Implementation readiness status.

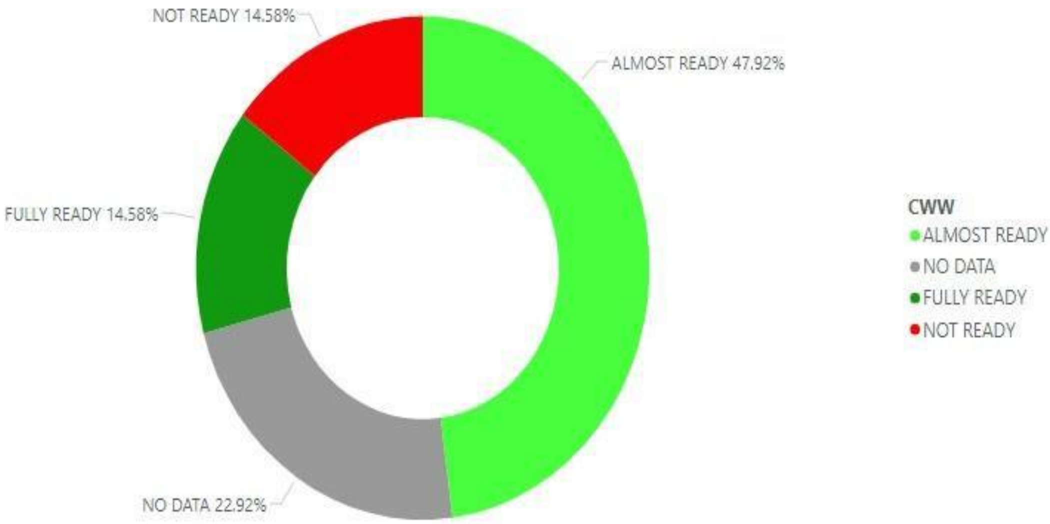


Figure 3 – FRA Implementation readiness in the AFI Region

2.1.2 Civil and Military ATM Coordination and FUA Implementation.

The AFI region levels of CMAC and FUA implementation is deemed exceptionally low, following the recently conducted GAP analysis and implementation considerations surveys it can be surmised that majority of AFI States are yet to begin feasibility assessments to support implementation planning. AFI ICAO RO have conducted Civil/Military ATM cooperation and FUA workshops/seminars to assist States with national coordination efforts to ensure efficient implementation planning.

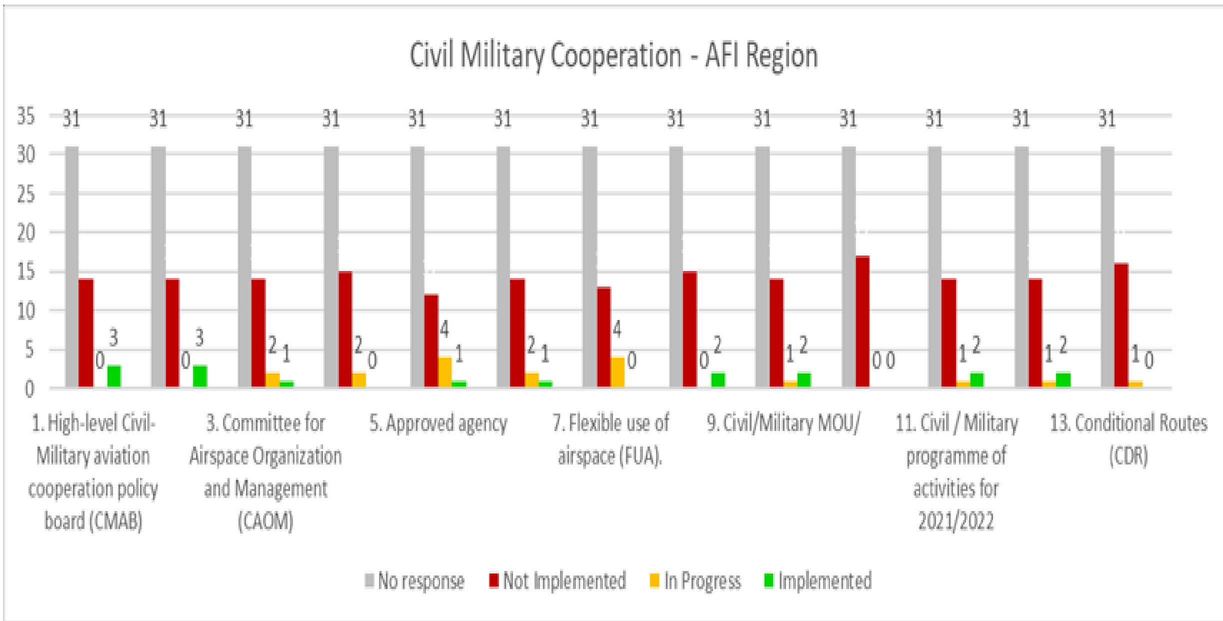


Figure 4 – Status of CMAC and FUA Implementation in the AFI Region

2.2 Demand and Capacity Balancing

Demand and capacity balancing is the strategic evaluation of system wide traffic flows and aerodrome capacities to allow airspace users to determine when, where and how they operate. However, this is achieved by mitigating conflicting needs for airspace and aerodrome capacity.

Demand and capacity building is a collaborative process which allows for the efficient management of air traffic through the use of information on system wide air traffic flows, weather, and assets. Demand and capacity balancing is undertaken at the strategic, pre-tactical and tactical stages defined as follows:

- **Strategic Stage** – At the strategic stage, demand and capacity balancing will respond to the fluctuations in schedules and demands, including the increasing globalisation of traffic patterns, as well as the seasonal changes of weather and major weather phenomena. Through collaborative decision making, assets will be optimised in order to maximise throughput, thus providing a basis for predictable scheduling.

- **Pre-Tactical Stage** – At the pre-tactical stage, demand and capacity balancing will evaluate the current allocation of ATM service provider, airspace user and aerodrome operator assets and resources against the projected demands. Through collaborative decision making, when possible, adjustments will be made to assets, resource allocations, projected trajectories, airspace organisation, and allocation of entry/exit times for aerodromes and airspace volumes to mitigate any imbalance.

- **Tactical Stage** – At the tactical stage, demand and capacity balancing will focus more closely on demand management to adjust imbalances. It will consider weather conditions, infrastructure status, resource allocations, and disruptions in schedules that would cause an imbalance. Through collaborative decision making, these actions will include dynamic adjustments to the organisation of airspace to balance capacity, dynamic changes to the entry/exit times for aerodromes and airspace volumes, and adjustments to the schedules by users.

In this regard, advance demand and capacity balancing information is made available to all airspace users and service providers, including aerodrome operators, to establish a common understanding of needs and capabilities. This allows for the development of collaborative strategies that will be more responsive to the situation.

For the AFI Demand and Capacity Balancing to be properly rooted in the fabric of the AFI ATM Community, developing a forecast is a key process with other members of the Community. This is in order to identify needs and agree on plan to close identified gaps consequent on those needs. The forecast will be developed in collaborative manner, so is the approach and the methodology for the forecast. As part of the collaborative effort, the AFI ATM Community members will agree to use the same forecast tool or scenarios as basis for setting performance targets and estimating future performance.

Consequently, the aggregate capacity of AFI aerodrome and airspace volume will be collaboratively collated and declared to achieve a balance that will improve efficiency and optimise capacity. The intrinsic factors that negatively impact the decision-making process with respect to demand and capacity building in the AFI ATM environment include;

- **Limitation of real-time operational decision making** - In trying to balance demand and capacity, decisions are made based on available information that may be constantly changing, often as decisions are being made.
- **Limited window of opportunity -** Decisions made in balancing demand with capacity are often made quickly because the opportunity to achieve a solution is usually associated with a brief window of opportunity.
- **Inaccuracy of prediction -** Decisions are made regarding future states of the system, which can only be estimated based on current data. For example, weather, which often reduces the capacity of airspace resources, cannot be accurately predicted, nor can its precise impact on airspace resources be known in advance.

- **Stochastic nature of air traffic patterns -** Air traffic patterns are highly complex. The effect of any one action on the overall flow of traffic cannot be modelled with certainty.

2.3 Conflict Management

In the ICAO scope, the function of conflict management is to limit, to an acceptable level, the risk of collision between aircraft and hazards. Hazards that an aircraft will be separated from will include; other aircraft, terrain, weather, wake turbulence, incompatible airspace activity while surface vehicles and other obstructions on the apron and manoeuvring area.

Conflict management is applied in three layers:

- Strategic conflict management
- Separation provision
- Collision avoidance

Strategic conflict management is the first layer of conflict management and is achieved through airspace organisation and management, demand and capacity balancing and traffic synchronisation components. The term 'strategic' is used to mean 'in advance of tactical.' Strategic conflict management aims at reducing the need to apply separation provision to an appropriate level as determined by the ATM system design and operations thereby reducing controller workload. This aim can be further achieved by creating a balance to preserve the optimal business/mission trajectory.

Separation provision is the second layer of conflict management and is the tactical process of keeping aircraft away from hazards by applying the least and more appropriate separation minima. Separation provision is merely used when strategic conflict management cannot be used efficiently. The separation minima allow for single and dynamic values that are determined from defined parameters by using a separation minima formula. Defined minima are necessary for the development of decision- support tools, which require values by which hazards must be avoided.

Collision avoidance is the third and final layer of conflict management and must activate when the separation mode has been compromised. This layer of conflict management is not part of the separation provision and therefore collision avoidance systems are not included in the calculated level of safety required by separation provision. However, collision avoidance systems play a paramount part of the ATM safety management, and their functions and applicable separation mode must be compatible but independent.

The key conceptual changes anticipated in the AFI region include;

- Strategic conflict management will reduce the need for separation provision to a designated level;
- The ATM system will minimise restrictions on user operations; therefore, the predetermined separator will be the airspace user, unless safety or ATM system design requires a separation provision service;
- The role of separator may be delegated, but such delegations will be temporary;

- In the development of separation modes, separation provision intervention capability must be considered;
- The conflict horizon will be extended as far as procedures and information will permit; and
- Collision avoidance systems will be part of ATM safety management but will not be included in determining the calculated level of safety required for separation provision.

The AFI region in collaboration with CANSO has embarked on the Mombasa ATFM implementation plan as a means to achieve strategic conflict management in the region. The roadmap is planned to establish an integrated regional ATFM system which will enable AFI stakeholders to collaborate through CDM and A-CDM to optimise traffic flow.

CDM will play a cardinal role in strategic conflict management as decisions will be made by amalgamating all pertinent and accurate sources of information ensuring that the data best reflects the situation at hand while all stakeholders are given the opportunity to influence the decision. While CDM is currently used within Africa, there are no specific CDM procedures that have been developed.

If correctly implemented, CDM will improve the overall performance of ATM systems in the region by fostering collaboration among stakeholders by focusing on the management of constraints, inefficiencies and unforeseen circumstances that may affect system capacity.

2.4 Performance Based Navigation (PBN)

Performance Based Navigation (PBN) is the highest priority of the ICAO Global Air Navigation Plan (GANP) and is prominent within the plans of APIRG. The AFI Regional Air Navigation System Implementation Action Plan approved in 2013 encouraged States to implement Block 0 modules applicable to their specific operational needs and categorises the 18 ASBU Block 0 modules based on the urgency of their implementation (Essential, Desirable, Specific or Optional).

The AFI PBN Regional Roadmap/Plan provides guidance to air navigation service providers, airspace operators and users, regulators, and international organisations, on the expected evolution of the regional air navigation system in order to allow planning of airspace changes, enabling ATM systems and aircraft equipage. It takes due account of the operational environment of the AFI Region.

During transition to Performance-Based Navigation (PBN), sufficient ground infrastructure for conventional navigation systems should remain available. Before existing ground infrastructure is considered for removal, users should be given reasonable transition time to allow them to equip appropriately to attain a performance level equivalent to PBN. States should approach removal of existing ground infrastructure with caution to ensure that safety is not compromised. This should be guaranteed by conducting safety assessments and consultations with the users.

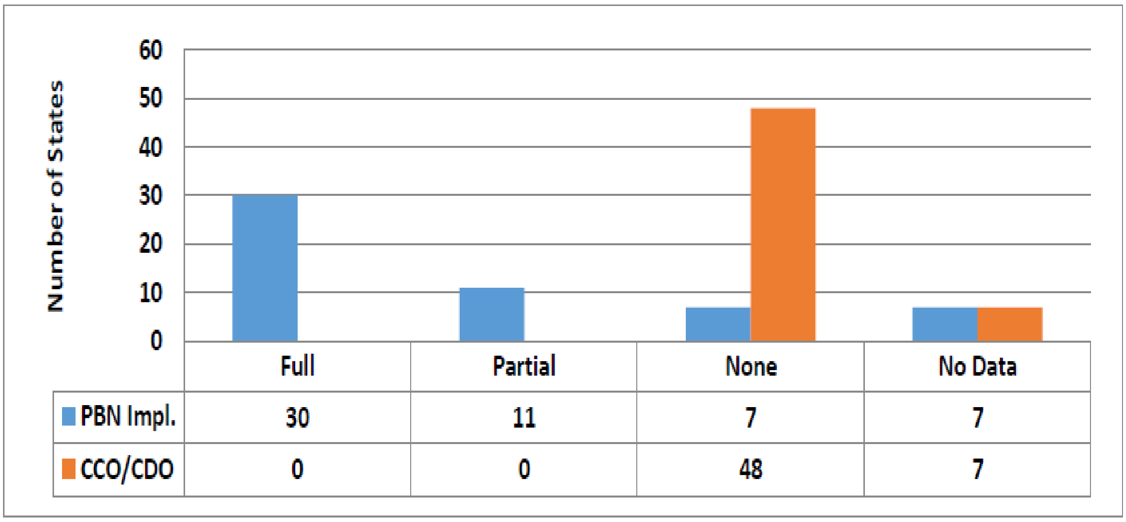
The AFI region aims to establish a more coherent air navigation planning system by implementing among other issues, considerations on selected navigation specifications, related navigation infrastructure, communication, surveillance, obstacle clearance and route spacing which adequately address user requirements.

2.5 Continuous Climb Operations/ Continuous Descend Operations (CCO/CDO)

Continuous Descent Operations (CDOs) and Continuous Climb Operations (CCOs) are performance-based arrival and departure procedures, respectively, that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity.

The ICAO ASBU modules related to Continuous Descent Operations (CDO) and Continuous Climb Operations (CCO), i.e. B0-CCO and B0-CDO as one of its highest priorities, with the ASBU framework noting that 'opportunities to optimise throughput, improve flexibility, enable fuel-efficient climb and descent profiles, and increase capacity at the most congested areas should be a high-priority initiative in the near-term.

Major airports now employ both CDOs and CCOs, often in conjunction with the implementation of PBN procedures, although this is not a pre-requisite. In the AFI region, implementation of Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO) procedures has not started to take full advantage of PBN approach procedures.



	Full	Partial	None	No Data
PBN Impl.	30	11	7	7
CCO/CDO	0	0	48	7

Figure 5 – PBN and CCO/CDO Implementation status in the AFI Region

2.6 Airspace User Operations

Airspace User Operations represent all the activities undertaken by those organisations and individuals who have access to and operate in the airspace which is managed for ATM purposes in accordance with ICAO and national procedures. The main types of civil airspace user operations are:

- **Scheduled Airline Operations / Organisation (A).** The most extensive organisation for Airspace User Operations is run by Airlines with a worldwide network. The daily operations of these Airlines, with up to thousands of flights per day all over the world, require a lot of flexibility. To give the best possible service to their passengers, maintaining punctuality and a high quality of service, Airlines must run and to maintain a complex organisation. This category regroups Cargo, Regional, Network, Charter, and Low-cost operators.

- **Business Aviation Operations / Organisation (BA).** Another important segment of Airspace Users is Business Aviation, which concerns the operation or use of aircraft by companies for the carriage of passengers or goods as an aid to the conduct of their business.

- **Military Aviation Operations / (MA).** Determined by strategic objectives dealing with National and International security and defence policies and commitments, the operation or use of military/State aircraft (combat aircraft, military air transport aircraft, tankers, AWACS, training aircraft, helicopters) concern Air defence and policing flights, Search and rescue, instructional and training flights, combined air operations as part of complex scenarios and UAS operations for which special use of airspace may be needed.

- **General Aviation Operations / Organisation (GA),** which operates civilian aircraft for purposes other than commercial passenger transport, including personal, business, and instructional flying, represents another type of Airspace Users.

2.7 Aerodrome Operations

While the focus of airports is to increase capacity and efficiency, occasional delays and reduced throughput brought about by poor visibility may hinder this. Most of today’s aerodromes operate in a fragmented manner where one part of an airport doesn’t necessarily know what is going on in the other part of the aerodrome. There is need for airports to get a better understanding and overview of how an airport needs to operate while also improving internal coordination to avoid inefficiencies caused by the ‘silo effects.’

As an integral part of the ATM system, the aerodrome must provide the needed ground infrastructure including, inter alia, lighting, taxiways, runway, and runway exits, precise surface guidance to improve safety and to maximise aerodrome capacity in all weather conditions. The ATM system will enable the efficient use of the capacity of the aerodrome airside infrastructure.

Efficient aerodrome operations are key in achieving the AFI vision and enabling a safe, secure, and economic sustainability of aerodrome operations within the AFI region. This can be achieved by the application of key conceptual changes such as;

- The reduction of runway occupancy time;
- The ability to manoeuvre safely in all weather conditions whilst maintaining capacity;
- The use of precise surface guidance to and from the runway in all conditions; and
- The position (to an appropriate level of accuracy) and intent of all vehicles and aircraft operating on the manoeuvring and movement areas will be known and available to the appropriate ATM community members.

The aerodrome and ground aids implementation heatmap below provides the current implementation status in the AFI region in Airfield Lighting / Visual aids for navigation, Electric power supply systems, Perimeter fences, EOC and Mobile C P, CRG Screening Equipment, Pax/Bag Screening Equipment, MRTD, CRG Term Design Capacity, AD ARFFS CAT, Pax Term Design Capacity, Apron Capacity, Pavement Strength (A/NA), RWY/TWY Dimensions (A/NA) and Certification.

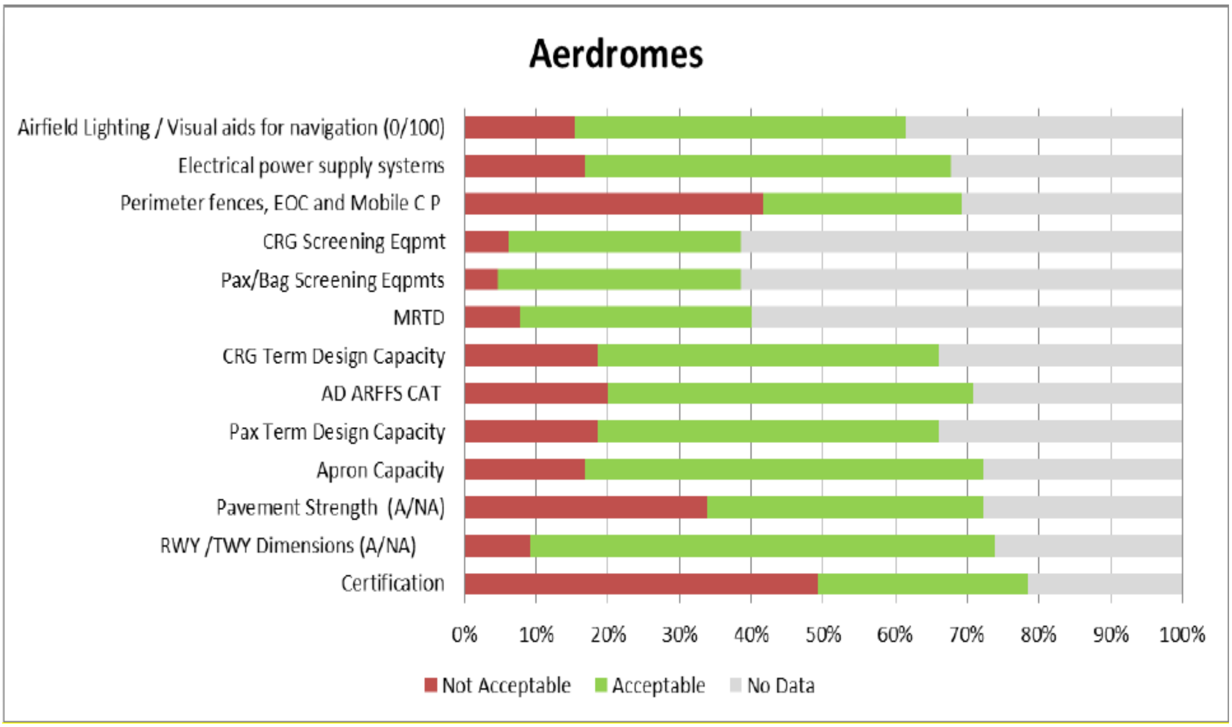


Figure 6 – AGA implementation heatmap in the AFI Region

2.8 Aviation System Block Upgrades (ASBU)

The ICAO Global Air Navigation Plan (GANP) (Doc 9750) is 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 over the outlook period.

The GANP represents a rolling, 15-year strategic methodology which leverages existing technologies and anticipates future developments based on State/industry agreed operational objectives. The GANP is supported by the Aviation System Block Upgrades (ASBUs), which refer to the target availability timelines for a group of operational improvements (technologies and procedures) that will eventually realise a fully harmonised Global Air Navigation System.

The following upgrades have been defined:

- BBB = Basic Building Block (baseline)
- Block 0 = from 2013
- Block 1 = from 2019
- Block 2 = from 2025
- Block 3 = from 2031
- Block 4 = from 2037

In line with the Terms of Reference, the AFI concept of operations is aligned with the developments outlined in the GANP and the ASBU Blocks 0 to 2, while maintaining flexibility in terms of the specific requirements of the region.

2.9 ASBU and CNS Implementation heat map.

The ASBU and CNS implementation heatmap below provides the current implementation status in the AFI region in SAR, MET, AIM, ATM, Ground-Ground communication, Air-Ground communication, Navigation, Surveillance and Spectrum.

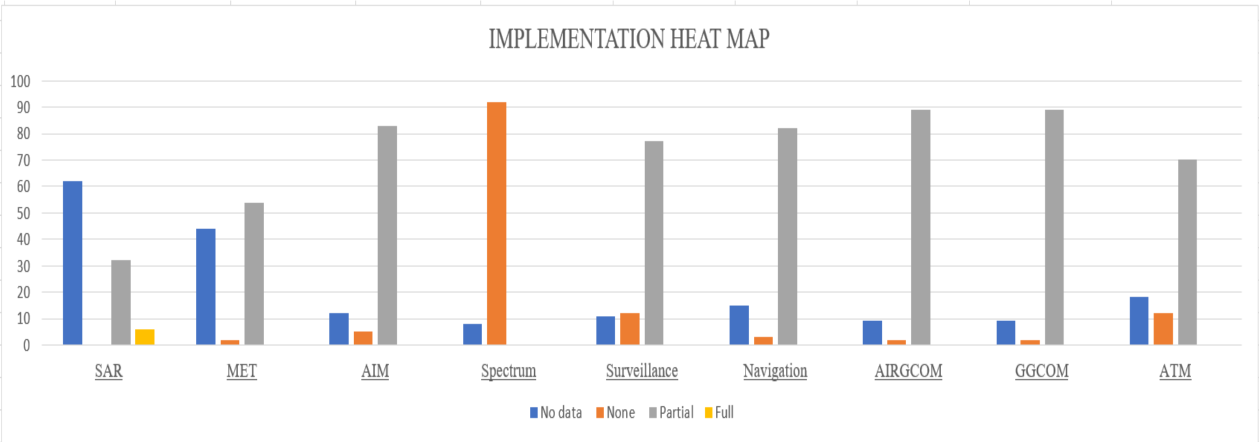


Figure 7 – ASBU and CNS Implementation heatmap in the AFI Region

Part III – THE VISION AND FUTURE ATM OPERATING ENVIRONMENT

The AFI vision 2045, future concept of operations development will consider the future operating environment while ensuring alignment with the Global Air Traffic Management Operational Concept's (ICAO Doc 9854) vision statement,

> "To achieve an interoperable global (national and regional) air traffic management system, for all users during all phases of flight, which meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements"

As with the Global operational concept, the AFI future operating environment and concept of operations must be visionary and inclusive of industry. Many of the current initiatives and objectives will continue to form part of the AFI ATM and infrastructure projects implementation throughout the planning horizon. To this end, the concept of operations must be evolutionary.

3.1 Seamless ANS operations

In order to meet current and future needs of the African Airspace, AFI vision on seamless operation must enable achievement of safety, efficiency, security, and sustainability objectives. Air navigation, whether national, regional, or international, is governed by safety objectives and performance criteria whose standards and best practices are applied worldwide by ICAO. The multidimensional needs for improving air navigation, combined with the increasing pressure from airspace users to have the most optimal possible routes, are motivating operators to consider optimised traffic flow conditions while improving safety and efficiency.

Considering global traffic demand forecast and industry requirements, growing recommendations for the development of a seamless African sky are based on two expectations,

- collaboration between stakeholders to enable coordination and planning of the various steps and actions for the achievement of seamless operations; and
- Interoperable systems (ground and space), including procedures that support seamless ANS operations.

The concept proposes a gradual approach that begins with a cooperative model, and its implementation aims to create a homogeneous continuum of upper airspace that promotes harmonised ANS operations with the same level of performance and significant benefits for States, service providers, and industry.

3.1.1 Free Route Airspace (FRA)

The overall scope of the Free Route Airspace (FRA) concept is to provide an enabling framework for the harmonised implementation of FRA in AFI region whenever a State / ANSP, a group of States / ANSPs decides to proceed with such implementation.

Based on the AFI FRA Gap analysis outcome and traffic flows analysis, AFI states have identified the prevailing conditions for FRA implementation and agreed to develop a regional action plan/roadmap to fill the gaps for the operationalisation of FRA concept.

The FRA concept forms the basis for a common understanding for all ATM partners involved in FRA implementation. The FRA concept encompasses various FRA implementation scenarios that will;

- Meet the Safety Objectives;
- Be compatible with existing operations;
- Be sustainable through further development;
- Be capable of expansion/connectivity to/with adjacent airspace; and
- Be capable of being exported to other regions.

3.1.2 Civil and Military ATM Cooperation (CMAC) and Flexible Use of Airspace (FUA)

AFI region is steadily implementing the Flexible Use of Airspace, the airspace management concept 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. Airspace is recognised as a finite resource to both Civilian and Military. With rapid growth of air traffic flow, States are faced with the challenge of managing their limited airspace in a way that accommodate both Civil and Military requirements on use of airspace. A closed Civil/Military ATM Cooperation is an enabler to Flexible Use of Airspace which provides a resolution on sharing the limited resource.

3.1.3 FUA Benefits.

- Increase flight economy by enabling direct flight or more efficient flight level across segregated airspace;
- Increase airspace capacity by providing more ATS routes during a specific time period;
- Reduce ATC workload by enhancing ATS route network and associated sectorisation;
- Provide more flexible and closely airspace reservation in line with military operational requirements.

It is recommended that the AFI regional civil and military ATM coordination and flexible use of airspace implementation efforts are adequately supported. CMAC and FUA concept awareness, application and implementation guidance remain key to support regional planning, considering the ATM objectives, requirements, and expectations where implementation pursuance must ensure equitable airspace access.

3.2 Demand and capacity balancing

For effective demand and capacity balancing, AFI Region will take cognisance of, and continue to monitor the forecast of African Union (AU) on all its economic integration initiatives, particularly the Africa Continental Free Trade Agreement (ACFTA) as well as global initiatives, especially the UN Sustainable Development Goals (SDGs) as they would impact movement of passenger and cargo traffic.

This would enable the Region to strategically examine AFI-wide air traffic flow management, understanding demand against capacity constraints.

This effort will allow all AFI Aviation stakeholders (identified elsewhere in this document as ATM Community Members) to determine;

- When to operate
- Where to operate
- How to operate including the type of equipment to deploy, while mitigating conflicting and sometimes competing needs for airspace and aerodrome capacity.

Through the use of a regional information database on air traffic flow, weather, and access, the collaborative process that will determine the AFI demand and capacity balancing will achieve efficient management of air traffic flow.

At the pre-tactical stage, through collaborative decision making, adjustment will be made to assets, resource allocations, projected trajectories, airspace organisation and allocations of entry/exit time at aerodrome and airspace volume to mitigate any imbalance.

At the tactical or actual implementation stage, actions will include dynamic adjustments to the organisation of airspace to balance capacity, dynamic changes to the entry/exit times to aerodrome and airspace volumes and adjustment to the schedule of the users.

Central to the AFI ATFM CONOPS implementation it is essential to underscore the dynamism of demand and capacity balancing process. It is also critical to highlight the importance of CDM that AFI must employ to support application of processes to develop more efficient airspace planning and improved procedures. The ideal outcome being improved efficiency, optimised delay sharing and to provide greater flexibility and predictability for AFI operations.

3.3 ATM service delivery

The AFI ATM service delivery management will operate seamlessly from gate-to-gate for all phases of flight and across all service providers. The ATM service delivery management component will address the balance and consolidation of the decisions of the various other processes/services, as well as the time horizon at which, and the conditions under which these decisions are made. Flight trajectories, intent and agreements will be important components to delivering a balance of decisions.

Key conceptual changes in the AFI ATM service delivery include:

- Services to be delivered by the ATM service delivery management component will be established on an as-required basis subject to ATM system design. Where services are established, they will be provided on an on-request basis;
- ATM system design will be determined by collaborative decision-making and system-wide safety and business cases;
- Services will be delivered by the ATM service delivery management component through collaborative decision-making, balance and optimise user-requested trajectories to achieve the ATM community's expectation; and
- Management by trajectory will involve the development of an agreement that extends through all the physical phases of the flight.

3.4 Traffic Synchronisation

Traffic synchronisation refers to the tactical establishment and maintenance of a safe, orderly, and efficient flow of air traffic. Traffic synchronisation encompasses both the ground and airborne part of ATM and will constitute a flexible mechanism for capacity management by allowing reductions in traffic density and adjustments to capacity in response to variations in demand. Traffic synchronisation will be applicable and tailored to all airspace and aerodromes where the optimised ordering and sequencing of traffic are critical to accommodate demand.

Traffic synchronisation, conflict management and demand and capacity balancing are interrelated and will become fully integrated, leading to a continuous and organised flow of traffic. Traffic synchronisation will make use of integrated and automated assistance to surface, departure, arrival, and en-route management to ensure an optimum traffic flow. The objective will be to eliminate choke points and, ultimately, to optimise traffic sequencing to achieve maximisation of runway throughput.

Traffic synchronisation, together with the other ATM components, will contribute to the efficient handling of traffic from gate to gate. There will be dynamic 4-D trajectory control and negotiated conflict-free trajectories. These techniques will reduce the need for traditional path stretching in high traffic density areas and will reduce the adverse impact this has on economy and efficiency.

3.5 CNS Enablers

3.5.1 Communication

Aeronautical communication plays a critical role in the civil aviation ecosystem as it forms the backbone of all CNS applications. Therefore, the regional vision concludes that aeronautical communication is expected to move from voice communications toward data driven communication that allows automated systems to communicate with each other without human intervention to improve Collaborative Decision Making (CDM) within the civil aviation community and move the industry closer to performance-based operations. It is envisaged that voice communication together with the SWIM infrastructure will in future converge to ATN/IPS and run over an aviation dedicated VPN to improve security.

A dedicated satellite communication infrastructure for Aviation applications remains an aspiration of the regional ATM community and the regional community will thus continue to pursue these frequency bands in support of safety of life. To achieve these future expectations the regional ATM community will need to ensure that the current and future CNS technologies Spectrum requirements are protected through the International Telecommunication Union (ITU).

The vision captures key requirements from industry and matches those requirements against candidate technologies for current and future implementation. These requirements include regulatory requirements, aircraft requirements and ground operations requirements to facilitate a holistic air communication system. Key drivers of this vision include the provision of appropriate communication infrastructure to support future air traffic environments and the provision of consistent, globally aligned, solutions to enable the goal of a seamless ATM system.

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 communication

I. 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.
- 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 SATCOM.

II. 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) Mode 2 and the Aeronautical Telecommunication Network (ATN).

III. 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 in 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 ATS centres (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.
- 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).
  - 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.

3.5.2 Navigation

The continued growth of traffic in the AFI region has necessitated the need to improve safety, capacity, efficiency, and sustainability that will enable optimal utilisation of airspace. To achieve this feat, recent technology has enabled the use of Performance Based Navigation (PBN) as opposed to conventional ground-based navigation. In this context, the ICAO GANP has the objective of a future harmonised global navigation capability based upon area navigation (RNAV) and Performance Based Navigation (PBN), supported using Global Navigation Satellite Systems (GNSS).

Performance-Based Navigation (PBN) is a framework for defining a navigation performance specification along a route, during a procedure, or in airspace within which an aircraft must comply with specified operational performance requirements. It provides a simple basis for the design and implementation of automated flight paths and for airspace design, aircraft separation, and obstacle clearance. It further offers a straightforward means to communicate the performance and operational capabilities necessary for the utilisation of such paths and airspace.

Within the framework of performance-based navigation, the aviation industry has defined area navigation (RNAV) and required navigation performance (RNP) specifications that can be satisfied by a range of navigation systems. RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency, and sustainability.

The AFI region will deploy navigation technologies in accordance with the ICAO GANP which outlines the migration path for the implementation of PBN. The AFI airspace will have to maintain some conventional navigational aids. The ILS is key to mitigate GNSS outages and further support precision approaches while the DMEs are necessary for the optimisation of the existing network to support PBN operations. The ultimate navigation plan is to deploy GNSS technology both in terminal and en-route airspace to support RNAV and RNP operations in the AFI airspace.

GNSS Augmentation systems

ABAS, an aircraft-contained augmentation system that augments and/or integrates the information obtained from GNSS receivers with other navigation information available on board the aircraft. The most common form of ABAS is Receiver Autonomous Integrity Monitoring (RAIM) which monitors the integrity of the GNSS signals and automatically flags the insufficient integrity for aircraft operations. In some aircraft, ABAS also integrates information from other on-board sensors, such as Inertial Navigation System (INS) and/or barometric altimeters, with information derived from GNSS signals in updating aircraft positions. By utilising already on-board system in a self-contained manner, ABAS is currently the most cost-effective augmentation system for GNSS.

ABAS usage in combination with Barometric VNAV (Baro-VNAV) during RNP APCH approach operations to respectively provide horizontal and vertical guidance down to LNAV/VNAV minima can be of significant benefit to the region.

ICAO SARPs supporting the use of SBAS to augment single-frequency GPS are well matured and currently effective. The dual-frequency, multi-constellation (DFMC) GNSS capability upgrade for SBAS is now being developed under ICAO and should be imminently available. There are two types of vertically guided approach operations that can be enabled by SBAS, namely Localizer Performance with Vertical Guidance (LPV) and LNAV/VNAV. LPV operations enabled by SBAS use geometric vertical guidance using altitude information derived from augmented GNSS and do not rely on QNH-setting by pilot.

It is possible that the AFI region will be able to take advantage of GBAS to upgrade approach operations from CAT I capability to category CAT II/III capability. The use of CAT II/III approaches should be prioritised at the largest airports and implemented only where there is a positive business case. GBAS supports additional operational flexibility through provision of displaced thresholds and multiple glide path approaches. A GBAS, unlike an ILS, can provide precision approach capability to multiple runways ends at an airport. The emergence of multi-frequency/constellation GNSS may start to be developed to enhance approach procedures within the vision outlook period.

Implementation considerations and deployment planning of GBAS ground station must be a collaborative effort ensuring consultation with airspace users and operators prior to making any investment decisions. Where applicable, ANSPs should ensure system interoperability among ILS localizer, VOR and GBAS VDB operating at the same airport by performing an appropriate frequency coordination and technical validation. Nowadays, only GBAS GAST-C is available and there are some GBAS GAST-C stations in operation over the world. Although GBAS GAST-C would be eligible for the AFI region as far as the technical point of view is concerned, it would be prudent to perform a deeper ionospheric study to finalise the GBAS technical feasibility.

SBAS DFMC can be envisaged to be used to augment the GPS and Galileo constellations with L1 and L5 frequencies. However, to be fully compliant with the 99% availability requirement over the whole AFI region, RIMS will have to be deployed within the African States.

Nonetheless, if CAT II/III approaches are required at major airports, GBAS GAST-D could thus be an alternative to ILS and SBAS DFMC.

3.5.3 Surveillance

The AFI Surveillance strategy must link the Global Air Navigation Plan for ATM/cns systems and the AFI Plan including industry strategies for the national civil aviation surveillance applications. It must also describe the future evolution of the surveillance system as a component of the regional Air Traffic Management system.

Surveillance system implementation should be done under the premise of global harmonisation, while considering the operational requirements and relevant cost-benefit analysis.

To meet the present and future ATM requirements and expectations, the vision will consider the following surveillance systems

- Non – Cooperative surveillance systems
- Cooperative surveillance Systems

The civil aviation industry is supported by the ATM community that encompasses a wide range of stakeholders, i.e. aircraft operators, service providers, aircraft and avionics and infrastructure manufacturers. Each of these user groups have diverse, specific, and sometimes conflicting requirements and expectations. The ATM system must mature to improve safety, efficiency, and sustainability. Emerging technologies will meet the requirements of the developing ATM requirements considering systems technological advancement and functionality.

As the ATM requirements increase, new systems and concepts emerging 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 them still maturing. The regional surveillance strategies must identify the goals and initiatives for surveillance within the region, considering the aspects above.

It is based on expressed ATM operational requirements taking a gate-to-gate approach, recognising the large variety of aircraft with different operational capabilities seeking to operate at optimum performance levels by exploiting the benefits of new and rationalised existing systems. The need for regional harmonisation and compliance to ICAO standards and provisions in order to achieve the desired safety, efficiency, and sustainability improvements remain a key driver of the regional vision.

3.6 Technology Roadmap

Technology Roadmap provides an overview and assessment of technology opportunities to modernise the way airspace is structured and transform the technology used to manage air traffic. Modernising airspace, which means both route design and new tools and technologies, will make air traffic management more efficient, helping reduce the impact air traffic has on industry and the environment, 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 global air navigation system.

These Roadmaps provide guidance for infrastructure planning (and status) by indicating on a per-technology basis, the need for and readiness of:

- existing infrastructure;
- ICAO Standards and guidance material;
- demonstrations and validations;
- initial operational capability (IOC) of emerging technologies; and
- global implementation

While the various Block Upgrade Modules 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 their associated benefits can be achieved.

To meet the future ATM requirements and expectations, and compliment the ASBU Modules, the vision considers 10 roadmaps covering five areas of the Technology Roadmaps of the GANP:

3.6.1 Communication

Roadmap 1- Air-Ground Data Link Communication consists of two basic categories: Safety-related ATS services where performance requirements, procedures, services and supporting technology are strictly standardised and regulated, and information-related services where performance requirements, procedures and supporting technology are less critical.

Roadmap 2**-** Ground-Ground Communication and Air-Ground Voice Communication which will provide for ground-ground voice communications migrating to Voice-over Internet Protocol (VoIP) while Air-ground voice communications will migrate from HF to SATCOM in oceanic and remote regions.

3.6.2 Navigation

Roadmap 3**-** Navigation strategy which depicts the expected evolution of navigation infrastructure and avionics will require dedicated technology with conventional and satellite-based enablers. 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 GANP has the objective of a future harmonised global navigation capability based on area navigation (RNAV) and performance-based navigation (PBN) supported by the global navigation satellite system (GNSS). Infrastructure rationalisation planning will be collaborative effort ensuring user requirements and expectations are considered.

Roadmap 4- Performance-Based Navigation (PBN) which depicts the migration paths for the implementation of PBN levels and precision approaches for the following operations: en-route oceanic and remote continental, en-route continental, TMA arrival/departure, and approach. Collaborative implementation planning is essential as States will have different requirements; some may need to move quickly to the most demanding PBN specification while others will be able to satisfy airspace users' requirements with a basic specification. PBN Implementation and specifications should consider airspace users' capabilities following a CDM approach.

3.6.3 Surveillance

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

Roadmap 6- AIR-AIR SURVEILLANCE which will provide for Advanced situational awareness applications using ADS-B In/Out and will be used for basic airborne (delegated) separation and limited self-separation in remote and oceanic airspace. The airborne part of the surveillance system will become more important and should be "future proof" and globally interoperable in order to support the various surveillance techniques which will be used. The twin demands of increased traffic levels and reduced separation will require an improved form of ADS-B.

3.6.4 Information Management

Roadmap 7 SWIM, Flight & Flow, AIS/AIM, Meteorology and Time **-** Information Management which will provide for full 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.

3.6.5 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

Roadmap 10- Airborne Safety Nets On-Board Systems which will provide for Airport moving maps and cockpit display of traffic information that will be supported with technologies such as ADS-B, Enhanced Vision systems (EVS) and Synthetic vision systems (SVS) for aerodrome use will be available in the cockpit.

Part IV – THE FUTURE CONCEPT OF OPERATIONS

4.1 Concept of Operations (CONOPS)

The AFI region will adopt harmonised concept components that will be integrated to form the future ATM system. The AFI operational concepts through the implementation of Aviation System Block Upgrades will determine the future whilst establishing the current environment:

- Airspace Organisation and Management (AOM)
- Aerodrome Operations (AO)
- Demand/Capacity Balancing (DCB)
- Traffic Synchronisation (TS)
- Conflict Management (CM)
- Airspace User Operations (AUO)
- Air Traffic Management Service Delivery Management (ATM SD)
- Information Management (IM)

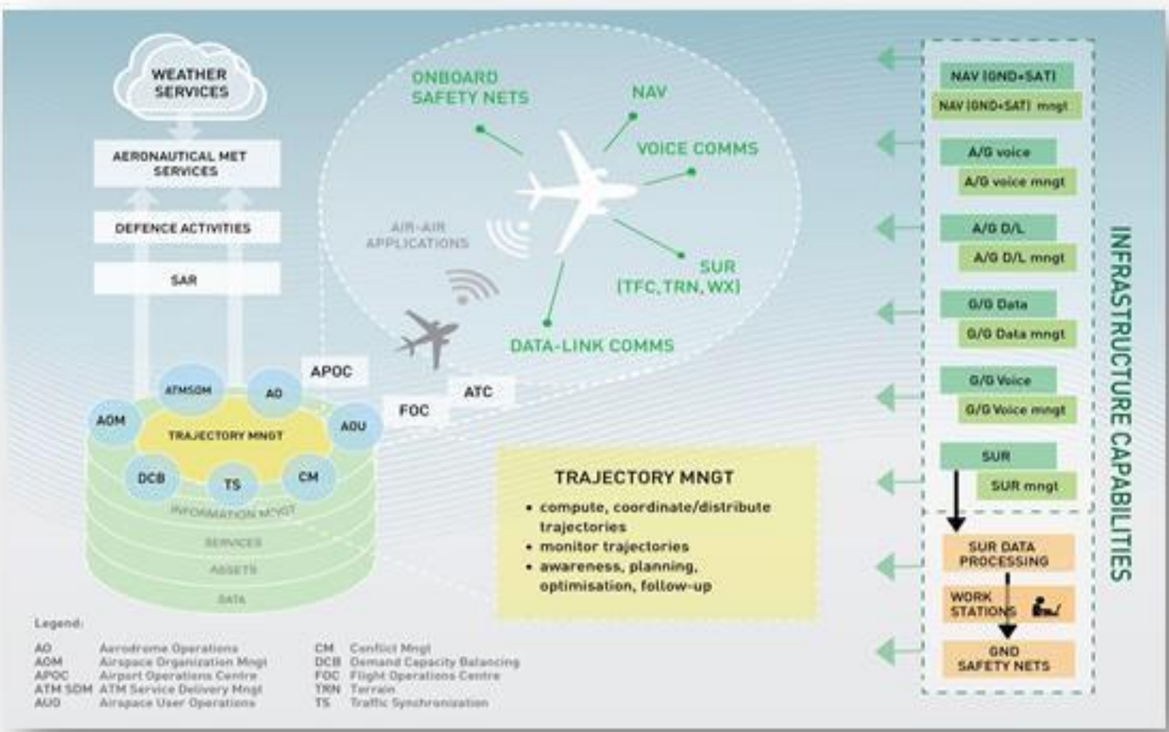


Figure 8: ATM Concept Components

The ATM community's expectations will guide the development of the future ATM system within AFI region. It is crucial that the evolution to the global ATM system be driven by the necessity to meet the ATM community's requirements and expectations while also enabling the concept application with the appropriate technologies. Strategic imperatives will enable AFI region to significantly move towards realisation of the AFI ATM vision and desired outcome. These are as follows,

- Safety (Safety is the highest priority in aviation)
- Access and equity (All airspace users have the right of access to the ATM resources)
- Participation by ATM community (Continuous involvement in the planning, implementation, and operation of the system)
- Cost effectiveness (while balancing the varied interests of the ATM community)
- Capacity (The inherent capacity to meet airspace user demands at peak times and locations while minimising restrictions on traffic flow)
- Predictability (Ability of airspace users and ATM service providers to provide consistent and dependable levels of performance)
- Global interoperability (Global standards and uniform principles to ensure technical and operational interoperability)
- Security (Protection against threats, intentional or unintentional acts)
- Flexibility (Ability of all airspace users to modify flight trajectories dynamically and adjust departure and arrival times)
- Efficiency (Cost-effectiveness of gate-to-gate flight operations from a single-flight perspective)
- Environmental (Protection of the environment by considering noise, gaseous emissions, etc.)

The evolution of the AFI ATM future concept of operations must be systemically aligned with industry long-term view on the value of aviation whilst enabling the development of regional smart regulation to sustain value proposition.

4.2 Flight operations in a digitally rich environment.

In a safety-critical environment, the capacity of the system relies on the ability to exploit air navigation resources which are somewhat limited. A move towards a more tactical data environment is required in order to unlock the inherent capacity of the system by allowing more scheduled flights.

The AFI region will endeavour to enhance its information system by avoiding poor information systems that allow a handful of flights in order to eliminate the possibility of diversions, excessive holding and sector overloads which usually result from the lack of sufficient information to provide tactical levels of planning. The lack of digitally rich environment further provides limited airspace and runway capacity constraints which lead to flight delays, inconvenienced (dissatisfied) passengers and failed opportunities to accommodate demand.

Therefore, ANSPs and Governments must embrace the opportunities that digital technologies are creating in order to unlock substantial benefits for the aviation community.

Opportunities

The use of digital technologies in aviation provides the possibility of minimised constraints in the use of the limited air navigation resources and enhanced quality of information, thereby increasing the capacity of systems while improving safety.

The emergence of these technologies improves the quality of data and information while increasing data storage that enhances processing capabilities that allow a wider distribution of information in real time to all key stakeholders. This allows for stakeholders to participate in the decision-making process by enabling the design of specific decision-supporting tools and automation required in concerted decision-making processes in ATM.

The use of advanced digital technologies in aviation has the potential to enable a vast array of capabilities ranging from automated support systems to highly sophisticated systems that use machine learning able to enhance aircraft and air navigation systems to perform complex tasks in support of human operators.

Aviation is further embracing the notion of full connectivity that seeks to connect anything that can be connected. Full connectivity provides many alternatives to the way we design our air navigation system infrastructure. Rather than ANSPs providing sensors and dedicated CNS infrastructure, advancements in computing, data and information exchange can be used to make the services and infrastructure more integrated, agile, and scalable.

Challenges

The improvement of quality data and information that is based on dedicated aviation applications, automation and requires large investment by aviation stakeholders. Additionally, when this information is made available, it is largely limited to front line actors either by dedicated ground connections or by air – ground data communication. This unfortunately depicts the poor state of data and information exchange and the cost of point- to- point communications when compared to other technologies used in society at large. The lack of data and information sharing beyond the local settings means the system operates in an isolated manner even though capacity is improved locally due to richer information on constraints. This fragmentation results in multiple views and disjointed operations caused by isolated automation and fit-for-purpose systems supporting only a loose network approach.

Automation generally improves operations to a greater extent; however, this leads to conflicting approaches, leaving many potential benefits unachieved at airspace boundaries – both geographic and time boundaries. This can be observed when a time-based arrival tool for an airport schedule is disrupted by a more strategic initiative which balances demand and capacity. Although automation is necessary, the return on investment in digital technologies is further subjected to the comprehensive and full utilisation of generated digital information.

4.3 Time Based Management enabled by an information revolution.

Time Based management is a concept focused on flight efficiency, predictability and environment which is identified as Key Performance Area (KPA) in the development of the AFI seamless airspace. The goal is to build a time synchronised and predictable AFI ATM system where all key stakeholders and partners are aware of operational situations, business and collaborate to optimise the network.

This is attainable by prioritisation for arriving aircraft together with the extensive use of datalink and deployment of trajectory-based operations. When and where required, Controlled Time of Arrival (CTA) will be used to sequence traffic and /or Controlled Time Over (CTO) for en-route traffic synchronisation.

The use of the Arrival Manager (AMAN) system is primarily designed to provide automated sequencing support for handling traffic arriving at an airport to optimise the runway capacity and/or to regulate the flow of aircraft entering the airspace such as a TMA.

AMAN systems help to make the best use of available capacity at an airport and provides more efficient and predictable arrival management process which in turn reduces low-level holding and tactical intervention thereby leading to lower fuel consumption, less noise and pollution.

The AMAN system uses data from several systems, including Flight Data Processing Systems (FDPS) and Radar Data Processing Systems (RDPS). A combination of flight-plan information, radar information, weather information, local airspace and route information, and an aircraft performance model in its trajectory prediction are used to produce a ‘planned’ time for any individual flight.

A Departure Manager (DMAN) is planning system that helps to improve departure flows and increase predictability at an airport by calculating the Target Take Off Time (TTOT) and Target Start-up Approval Time (TSAT) for each flight, taking multiple constraints and preferences into account.

DMAN considers scheduled departure times, slot constraints, runway constraints and airport factors. In doing so, it improves traffic predictability and reduced the time between Off-Block-Times and take-off, thereby improving cost efficiency and environmental sustainability, as well as safety by reducing the amount of aircraft taxiing simultaneously.

Time Based Management is also supported by Time Based Flow Management (TBFM), a decision support tool in the en route and terminal environment. TBFM enables the ability to schedule aircraft within a stream of traffic to reach a defined constraint point (e.g. meter fix/meter arc) at specified times, creating a time-ordered sequence of traffic. The scheduled times allow for merging of traffic flows, while minimising coordination, reducing the need for vectoring/holding, and efficiently utilising airport and airspace capacity. The TBFM schedule is based on current aircraft estimated time of arrival at key defined constraint points based on wind forecasts, aircraft flight plan, the desired separation at the constraint point and other parameters. The schedule applies time-based spacing only when needed to maintain the desired interval at one or more constraint points.

Opportunities

The opportunities presented by the use of time-based flow management include;

- Arrival Management and Departure Management are synchronised, and the overall efficiency is additionally improved by including multi-airport operations in the arrival and departure metering
- Prioritisation of arrival time is achieved through the consideration of arrival times from planning phase to execution phase.
- Departure times are defined to enable the aircraft to meet the Target Time of Arrival/Target Time Over (TTA/TTO).
- Arrival Management is extended to support the management of arrival flows further out from the destination airport.
- The allocation of CTA, flown with high accuracy, improves the performance and reliability of Arrival Management.
- Delegation to Flight Crew of the task of spacing from a designated target aircraft improves airspace throughput. The spacing parameter expressed to Flight Crew may be in distance or preferably in time.
- The allocation of Controlled Time Over (CTO), flown with high accuracy to sequence traffic or control Airspace Reservation (ARES) activation, improves the performance and reliability of Airspace Management.
- Traditional flight planning is complemented by more detailed information from the airspace users. The airline operational flight plan and the on-board trajectory information are used to feed the ground tools and thereby improve the operational predictability of trajectories.
- Automated tools allow a continuous monitoring of traffic demand and evaluation of traffic complexity, through occupancy and ATC Workload assessment.

Challenges

The opportunities presented by the use of time-based flow management include;

- AMAN/DMAN system requires accurate information about the status of individual flights and airport resources, which are found in different systems in order to calculate reliable and accurate sequencing.

- The Airport Collaborative Decision-Making (A-CDM) platform supports this information exchange, and so DMAN and A-CDM systems should be integrated to support optimised pre-departure sequencing with information management systems for airspace users.

4.4 Trajectory-Based Operations (TBO) enabled by a full connectivity through the internet of aviation.

Trajectory Based Operation, or more specifically 4D Trajectory Management, facilitates a fundamental shift away from the management of flights through tactical intervention towards a more strategic focus on planning and intervention by exception.

This enables the effective dynamic adjustment of airspace characteristics in order to meet predicted demand, whilst aiming to keep any distortions to the Business/Mission Trajectories to the absolute minimum, as well as providing sufficient flexibility for optimisation purposes.

One key requirement of the future ATM system is to consider the trajectory of an aircraft during all phases of flight and to manage the interaction of that trajectory with other trajectories or hazards. This would achieve the optimum system outcome with the minimal deviation from the user-requested flight trajectories.

The communication capabilities necessary to enabled TBO where, real-time information sharing between concerned stakeholders and facilitating dynamic trajectory negotiations will be delivered by flight and flow of information for a collaborative environment (FF-ICE) in a System-Wide Information Management (SWIM).

FF-ICE defines information requirements for flight planning, flow management and trajectory management. FF-ICE will replace Current FPL format and AIDC. Flight information and associated trajectories are principal mechanisms by which ATM service delivery will meet operational requirements. FF-ICE will have global applicability and will support all members of the ATM community to achieve strategic, pre-tactical and tactical performance management.

Opportunities

Trajectory-Based Operations represents a shift from present operations towards the use of a shared, collaboratively developed trajectory which more closely meets airspace users' objectives and serves as the basis for decision-making across the ATM system participants. Therefore, TBO provides an opportunity to shift operations towards greater predictability with flight-impacting decisions being coordinated across concept components, with highest priority for separation provision.

AFI region must explore using the Flight Information Exchange Model (FIXM) to exchange ATFM-related data attributes central to the distributed ATFM concept of operations. This would require, evaluation of the suitable ATFM Network application in order to determine regional FIXM Extension for AFI and to include ATFM-related data attributes suitable for regional operations.

FF-ICE implementation intends to also correct FPL-2012 limitations in terms of quantity of information shared and fight planning.

The exchange of real-time flight/flow information will assist and support all components of the ATM operational concept that require flight information such as demand and capacity balance, conflict management, airspace organisation and management, airport operations, airspace user operations, traffic synchronisation etc.

Challenges

As a key enabler of TBO, the next evolution involves initiatives for the management of flight trajectories in the post-departure phase. A collaborative and investigative work on long-range ATFM (LR-ATFM) is required to explore incorporating long-haul flights into the regional ATFM framework. The regional initiatives will aim to widen the current local ATFM horizon, including regional implementation considerations and coverage to improve air traffic regulation and management. The ability to regulate airborne flight trajectories adds to the equation to provide a more complete ATFM solution. It also contributes to improved distribution of delays and results in more efficient management of flights through early delay absorption during cruise phase.

Along with Cyber technologies comes threat and insecurities affecting all ATM systems and infrastructure, cyber vulnerability remains a critical challenge thus the objective to ensure secure internet connectivity for information exchange between ATM and flights in FF-ICE and TBO perspective. It is necessary that the AFI Region be prepared for the sunset of FPL-2012 as projected by 2034.

4.5 Total performance management system focused on the business needs.

The sole purpose of aviation has over the years been linked to the transportation of passengers and cargo worldwide. However, the emergence of multiple airspace users, different vehicles and business models has birthed complexities in the decision-making processes of ANSPs. Customer satisfaction which is paramount in any business can only be met if the decision-making process is managed flexibly. Therefore, ANSPs are required to enable their customers and key stakeholders to make their own decisions anchored on predefined performance management systems that can meet the new demand.

Opportunities

ANSPs will be required to take advantage of the information rich environment by fully optimising decision-making process and satisfying the needs of airspace users. Unlike before, the availability of information among airspace users on the ground and in the flight deck has immensely improved due to enhanced information gathering focused on providing ANSPs with bigger and more accurate information that can enable better decision making on behalf of airspace users.

Processes and procedures will be developed to shift and enable the operator to manage the right trajectory, while ANSPs focus on managing constraints and air navigation resources. With this improved total system performance in mind, the entire focus will shift to who is best positioned and able to make decisions.

Even with shared information, there are aspects of each flight that may be unique to the operator. Therefore, despite this pool of rich information, a situation in which only ANSPs make decisions based on inputs will be suboptimal.

The move towards the Internet of Things (IoT) will ensure that information will no longer be the limitation, and the focus will shift to who can make the best decisions resulting in improvements to the total system performance. This will be possible because constraints will be minimised owing to the increased accuracy and availability of data, considering all inputs to the system and the absence of coordination limitations with everyone connected to the network.

Challenges

Due consideration and care must be taken so that users with the fastest information technology capabilities do not dominate the process but provide the advantages of being fast movers to all key players and stakeholders in the system. It is evident that achieving the optimum decision-making scenario would require new and sustainable approaches that would ensure access and equity among players in the system.

A gradual introduction of “market rules” that do not negatively impact the overall performance of network, access and equity would be preserved to accommodate existing demand. These market rules would eventually replace the simple rules of rationing air traffic flow management and time-based scheduling

Part V – CONCLUSION AND RECOMMENDATIONS

The AFI ATM vision 2045, future concept of operations outlines evolution of the AFI ANS for all stakeholders to ensure that no State or stakeholder is left behind. Therefore, the development of the AFI ATM vision and future concept of operations in alignment with the AFI ATM Master Plan will enable implementation planning for the seamless flow of air traffic in the AFI region.

As with the global operational concept, the AFI ATM vision 2045, future concept of operations must be visionary and inclusive of industry. Many of the current initiatives and objectives will continue to form part of the AFI ATM and infrastructure projects implementation throughout the planning horizon. To this end, the concept of operations must be evolutionary.

The ATM community's requirements and expectations will guide the development of the future ATM system within AFI region. It is crucial that the evolution to the global ATM system be driven by the necessity to meet the ATM community's requirements and expectations while also enabling the concept application with the appropriate technologies.

AFI region must embrace the opportunities that digital technologies are creating in order to unlock substantial benefits for the aviation community. The advancement of technology improves the quality of data and information while increasing data storage that enhances processing capabilities that allow a wider distribution of information in real time to all key stakeholders. This allows for stakeholders to participate in the decision-making process by enabling the design of specific decision-supporting tools and automation required in concerted decision-making processes in ATM.

The AFI ATM vision 2045, future concept of operations will provide significant insight to the AFI regional implementation planning strategy while the implementation process and timelines will cascade from the AFI ATM Master Plan and implementation strategy, and States will support the regional implementation harmonisation objective through the development of national aviation master plans and an agreeable funding model.

The AFI ATM vision 2045, future concept of operations in outlining the evolution of the AFI seamless air navigation system will ensure that no State or stakeholder is left behind. The development of the AFI ATM vision 2045, future concept of operations and AFI ATM Master Plan must be harmonised and aligned in order to support implementation planning and the seamless flow of air traffic in the AFI region, while also enabling the attainment of the safety, efficiency, security, and sustainability objectives.

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