PBN
Implementation Plan
SIERRA LEONE

FIRST EDITION

June 2015

Foreword

Preface

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1. Background

Ground based navigation aids (Navaids) have been the basis of IFR navigation for aircraft since the Second World War. Sierra Leone has relied upon a network of ground based navigation aids (NDB, VOR/DME and ILS), which aircraft use to navigate along fixed routes (route navigation) and to conduct instrument approach procedures to land at aerodromes.
Ground based navigation systems limit the safety and efficiency of aircraft operations because of their inherent characteristics e.g. with the exception of ILS, they do not support approaches with vertical guidance. Ground navaids are constrained by the location, accuracy, terrain and other performance limitations associated with the aid.
To overcome the constraints of route navigation new navigation specifications have been developed to provide performance specifications firstly through RNAV specifications and more recently Required Navigation Performance (RNP). These are based on new navigation technologies including Global Navigation Satellite System (GNSS) and onboard aircraft systems. Area navigation allows an aircraft to fly any pre-defined path with high accuracy. The flight path is usually defined as a straight line between two points in space but some systems also have the capability to accurately fly curved paths. Area navigation systems generally have linear lateral performance requirements and they are recognised as necessary enablers to optimise aircraft operations, increase terminal area safety and provide flexibility in placement of aircraft flight path to minimise aircraft noise intrusion on the community.
The key difference between the RNAV and RNP specifications is the onboard performance monitoring and alerting function that is associated with RNP.
The PBN concept represents a major shift from sensor-based to performance-based navigation.
The significant improvements in navigational performance provided by RNP and four dimensional trajectory (4DT - includes time dimension) will also be utilised by modern ATM systems to improve the sequencing of IFR Flights. Any sequencing delays that are needed in the future will be managed in a more strategic manner so that excess fuel burn can be minimised. This will deliver reduced operating costs to aircraft operators and improved environmental outcomes to both the local and global community.

2. Area Navigation (RNAV)

2.1 Capabilities

RNAV is the less capable of the two families of PBN navigation specifications. RNAV is suited to current and legacy aircraft operations however as a stand-alone specification it is insufficient to support many of the new Air Traffic Management (ATM) applications envisaged in strategic plans (eg: 3D, 4D ATM concepts).

2.1.1 RNAV Specifications

(a) RNAV 10: intended for use in continental airspace
(b) RNAV1: intended for use in Terminal airspace

RNAV specifications do not require on board navigation performance monitoring and alerting. RNAV tracks (e.g.: RNAV 5, RNAV 2, RNAV 1) will normally require monitoring by ATC surveillance systems to achieve desired performance and separation safety standards. This requirement implies near universal surveillance coverage for RNAV specifications. In oceanic airspace this surveillance is provided by ADS-C and in domestic airspace by a network of radar systems (PSR & SSR).
The surveillance of domestic airspace will also include WAM (Wide Area Multilateration) and ADS-B when these systems are approved and operational.

2.2 Current status of RNAV operations in Sierra Leone

RNAV and RNP procedures have not been implemented within Sierra leone airspace.

3. Benefits of RNAV and Global Harmonization

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include:

• Reduces need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.

• Avoids need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive.

• Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement).

• Clarifies the way in which RNAV systems are used.

• Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.
RNAV and RNP specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects. Specifically, RNAV and RNP may:

• Increase safety by using three-dimensional (3D) approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.

• Improve airport and airspace access in all weather conditions, and the ability to meet environmental and obstacle clearance constraints.

• Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight management systems (FMS) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.

• Improve efficiency and flexibility by increasing use of operator-preferred trajectories airspace-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.

• Reduce workload and improve productivity of air traffic controllers.

Performance-based navigation will enable the needed operational improvements by leveraging current and evolving aircraft capabilities in the near term that can be expanded to address the future needs of aviation stakeholders and service providers.

4. Challenges

4.1 Increasing Demands

There is increasing demand for the introduction of PBN considering the complexity involved with civil & military operations, increase in international operations (scheduled and non scheduled flights.), increases in general aviation operations, development of new aerodromes, etc.

4.1.1 En route

- Roberts FIR plans to meet the migration targeted date from AIS to AIM by 2018.
- Roberts FIR has introduced GNSS Procedure in 2012(Conakry) and 2013(Liberia) and plans to do the same in Sierra Leone by December 2015 and to fine tune it to provide links to join the international routes. Fine tuning shall be based on RNAV5 Spec & RNAV1 where required,
- Roberts FIR plans to design the PBN RNAV Routes based on RNAV5 and RNAV1 where operationally required.

4.1.2 Terminal Areas (Departures and Arrivals)

- Sierra Leone plans to design better SIDS/STARS based on RNAV1 & Basic RNP1 to increase operations to a single runway. This awaits WGS-84 resurvey.
- ATCO workload will be reduced by designing better procedures (SIDS/STARS) based on RNAV-1 & Basic RNP-1.
- ATCO/Pilot communication will be reduced by having better communication equipment and procedures in place.
- The numbers of internal routes will be increased (with reduced separation) by creating parallel routes between cities.

4.1.3 Approach

- Sierra Leone plans to increase operations on a single runway by use of better GNSS/PBN SIDS/STARS based on RNP APCH with Baro-VNAV or RNP AR APCH (in mountainous areas).
- ATC workload will be reduced using better designed PBN procedures (SIDS/STARS) based navigation specification above. Sierra Leone has plans to carry out a GNSS procedure design.
- Sierra Leone plans to provide a better link to the TMA and enroute structure using SIDS/STARS above.

4.2 Efficient Operations

Aviation being fastest mode of transport, it is embraced the world over. Passengers and cargo alike have increased tremendously and the trend is uphill. This calls for increase in the number of aircraft that fly in the sky and there appears to be a scramble for airspaces, on the runways, during landings and during take-offs phases of flights. There is need therefore for a very efficient mode of operations in the airspaces. The only system that can provide such efficient operation is the Performance based Navigation. So efficient operations are expected in the approach phase, terminal areas, enroute and the continental navigations of aircraft.

4.2.1 En route

- Fuel savings can be achieved by providing more direct routes based on the use of well-designed routes based on RNAV5 and RNAV1.
- Carbon emissions can be reduced by use of shorter routes and CDOs which is achieved by better procedure design (based on RNAV-5 and RNAV-1), better aircraft equipment and better fuel.
- Maximisation of the use airspace can be achieved by creating more routes-including parallel routes with reduced separation. This requires better procedure designers and procedure designs based on RNAV-5 and RNAV-1.
- Current NAVAIDS shall be maintained and shall be used in emergencies as a fall-back position when aircraft loses their equipage.

4.2.2 Terminal Areas

- Fuel and time is saved by using better and shorter approaches to the end of the runway. This is achieved by a good procedure design based RNAV-1 and Basic RNP-1.

- Better and simpler method shall be applied to avoid and simplify issues of airspace restrictions. This is achieved by better procedure designs based on RNAV-1 and RNP-1.

- Increase capacity by maximising the use of airspace. This can be achieved by use of reduced separation and better PBN Procedure designs based on RNAV-1 and Basic RNP-1.

- Landing is expedited by avoiding the unnecessary holding of aircraft in the holding stacks. Achieved by use of better PBN Procedures.

Note: All the points above require specialized procedure design skills based on the navigation specifications.

4.2.3 Approach

- Time and fuel is saved by the use of short approaches to the runway ends. This can be attained using the PBN procedure designed based on RNP APCH (with Baro-VNAV) or RNP AR APCH(where applicable)

- Separation standards can be reduced but efficiency maintained by requiring better aircraft equipage, GBAS and well-designed PBN procedures.

- Continuous Descent Approach (CDA) profile shall be maintained by well-designed PBN procedures that are executed by aircraft with the right equipage.

- Incidences/near misses/air misses or even delays can be reduced by the operators adhering to the laid down PBN procedures while flying aircraft with correct equipage. Air navigation service providers shall also provide the right training to the controllers and other stakeholders.

4.3 Environment

Geared towards protecting the environment against:

- Sound/noise,

- carbon dioxide emissions,

- the protection of gazetted/restricted areas,

The above can be achieved by using better aircraft with better fuel and being more efficient. The aircraft has to be flown in a well-designed PBN procedures based on the navigation specifications applicable to the airspace concerned. The PBN procedure be well designed by well trained personnel.

5. Implementation

This plan provides a high-level strategy for the evolution of navigation capabilities to be implemented in two timeframes: mid term (2013-2016) and Long term (2017 and Beyond). The strategy rests upon two key navigation concepts: Area Navigation (RNAV) and Required Navigation Performance (RNP). It also encompasses instrument approaches, Standard Instrument Departures (SID) and Standard Terminal Arrivals (STAR) operations, as well as en-route continental, oceanic and remote operations. The section on Long-term initiatives discusses integrated navigation, communication, surveillance and automation strategies.
To avoid proliferation of new navigation standards, Uganda and other aviation stakeholders in the AFI region should communicate any new operational requirements with ICAO HQ, so that it can be taken into account by the ICAO Study Group in charge of PBN.

Near Term (2008-2012), Mid Term (2013-2016) and Long Term (2017 and Beyond) Key Tasks

The key tasks involved in the transition to performance-based navigation are:

• To establish navigation service needs through the Long term that will guide infrastructure decisions and specify needs for navigation system infrastructure, and ensure funding for managing and transitioning these systems.

• To develop and adopt a national policy enabling additional benefits based on RNP and RNAV.

• To identify operational and integration issues between navigation and surveillance, air-ground communications, and automation tools that maximize the benefits of RNP.

• To support mixed operations throughout the term of this Roadmap, in particular considering navigation system variations during the near term until appropriate standards are developed and implemented.

• To support Civil/Military coordination and develop the policies needed to accommodate the unique missions and capabilities of military aircraft operating in civil airspace.

• To harmonize the evolution of capabilities for interoperability across airspace operations.

• To increase emphasis on human factors, especially on training and procedures as operations increase reliance on appropriate use of flight deck systems.

• To facilitate and advance environmental analysis efforts required to support the development of RNAV and RNP procedures.

• To maintain consistent and harmonized global standards for RNAV and RNP operations.

5.1 Medium term strategy (2013-2016)

Phase one:

In the medium term, initiatives focus on investments by operators in current and new aircraft acquisitions, in satellite-based navigation and conventional navigation infrastructure as well as investments by SLCAA . Key components include wide-scale RNAV implementation and the introduction of RNP for en route(Roberts FIR), terminal, and approach procedures.

The medium term strategy will also focus on expediting the implementation and proliferation of RNAV and RNP procedures. As demand for air travel continues at healthy levels, choke points will develop and delays at the major airports will continue to climb. RNAV and RNP procedures will help alleviate those problems.
Continued introduction of RNAV and RNP procedures will not only provide benefits and savings to the operators but also encourage further equipage.

The Civil Aviation Authority-Sierra Leone as a matter of urgency shall ensure that SLAA adhere to the new flight plan procedures to accommodate PBN operations. This particularly addresses fields 10 and 18.

Operators will need to plan to obtain operational approvals for the planned Navigation Specifications for this period. Operators shall also review Regional PBN Implementation Plans from other Regions to assess if there is a necessity for additional Operational approvals.

5.1.1 En route

5.1.1.1 Oceanic and remote continental
5.1.1.2 Continental

For airspace and corridors requiring structured routes for flow management, Roberts FIR will review existing conventional and RNAV routes to transition to PBN RNAV-5 or where operationally required RNAV-2/1.

5.1.2 Terminal Areas (Departures and Arrivals)

RNAV reduces conflict between traffic by consolidating flight tracks. RNAV-1/Basic RNP-1 SIDs and STARs improve safety, capacity, and flight efficiency and also lower communication errors.
Sierra Leone will plan, develop and implement RNAV-1 SIDs and STARs, at major airports and make associated changes in airspace design. In addition, Sierra Leone will implement Basic RNP-1 SIDs and STARs.

RNAV-1 will be implemented in airspace where there is sufficient surveillance coverage and Basic RNP-1 where there is no such coverage.
Where operationally feasible, Sierra Leone should develop operational concepts and requirements for continuous descent arrivals (CDAs) based on FMS Vertical Guidance and for applying time of arrival control based on RNAV and RNP procedures. This would reduce workload for pilots and controllers as well as increase fuel efficiency.

PBN SIDs and STARS would allow the following:

- Reduction in controller-pilot communications;

- Reduction of route lengths to meet environmental and fuel efficiency requirements;

- Seamless transition from and to en-route entry/exit points;

- Sequence departures to maximize benefits of RNAV and identify automation requirements for traffic flow management, sequencing tools, flight plan processing, and lower data entry activities.

5.1.3 Approach

The application of RNP APCH is expected to be implemented in the maximum possible number of aerodromes. To facilitate a transitional period, conventional approach procedures and conventional navigation aids should be maintained for non PBN equipped aircraft during this term.

Sierra Leone should promote the use of APV Operations (Baro-VNAV or SBAS) to enhance safety of RNP Approaches and accessibility of runways.

The application of RNP AR Approach should be limited to selected runways where obvious operational benefits can be obtained due to the existence of significant obstacles.

5.1.4 Helicopter Operations

Apart from a contingency of military helicopters, there are very few helicopters for civil operations. The PBN operations for helicopters shall then be developed for civil operations as and when the time comes.

5.1.5 Summary of phase one medium term strategy

Airspace	Navigation Specifications	Navigation Specifications Where operationally required
En-route Oceanic	RNAV-10	RNP-4
En-Route Remote Continental	N/A	N/A
En-Route Continental	RNAV-5	RNAV-1
TMA Arrival/Departure	-RNAV-1 in a surveillance environment(GFLL) -Basic RNP-1 in non-surveillance environment.	
Approach	RNP APCH with Baro-VNAV(FOR GFLL) or RNP AR APCH if required(in mountainous areas)	

5.1.6 Implementation Targets (Effective dates are subject to changes)

	Navigation Specifications.	Where applicable	Effective date	100% Application
APPROACH	RNP APCH (with Baro-VNAV/LNAV)	UV207 UB614	Dec 2015(GNSS Trial)	Dec 2016
	RNP AR APCH	N/A	N/A	N/A
TERMINAL (SID/STARS)	RNP 1	GFLL	Dec,2015	Jan,2016
	RNAV 1	GFLL	June,2016	Dec, 2016
ENROUTE	RNAV 5	Continental	April,2016	Dec,2016
	RNP 1	Domestic	N/A	N/A

Phase two

In the mid-term, increasing demand for air travel will continue to challenge the efficiencies of the air traffic management system.

While the hub-and-spoke system will remain largely the same as today for major airline operations, the demand for more point-to-point service will create new markets and spur increases in low-cost carriers, air taxi operations, and on-demand services. Additionally, the emergence of Very Light Jets is expected to create new markets in the general and business aviation sectors for personal, air taxi, and point-to-point passenger operations. Many airports will thus experience significant increases in unscheduled traffic. In addition, many destination airports that support scheduled air carrier traffic are forecast to grow and to experience congestion or delays if efforts to increase their capacity fall short. As a result, additional airspace flexibility will be necessary to accommodate not only the increasing growth, but also the increasing air traffic complexity.

The mid term will leverage these increasing flight capabilities based on RNAV and RNP, with a commensurate increase in benefits such as fuel-efficient flight profiles, better access to airspace and airports, greater capacity, and reduced delay. These incentives, which should provide an advantage over non-RNP operations, will expedite propagation of equipage and the use of RNP procedures.

To achieve efficiency and capacity gains partially enabled by RNAV and RNP, Sierra Leone and aviation industry will pursue use of data communications (e.g., for controller-pilot communications) and enhanced surveillance functionality, e.g. ADS-Broadcast (ADS-B). Data communications will make it possible to issue complex clearances easily and with minimal errors. ADS-B will expand or augment surveillance coverage so that track spacing and longitudinal separation can be optimized where needed (e.g., in non-radar airspace). Initial capabilities for flights to receive and confirm 3D clearances and time of arrival control based on RNP will be demonstrated in the mid-term. With data link implemented, flights will begin to transmit 4D trajectories (a set of points defined by latitude, longitude, altitude, and time.) Stakeholders must therefore develop concepts that leverage this capability.

5.2.1 En route

5.2.1.1 Oceanic and remote continental
5.2.1.2 Continental
The review of en-route airspace will be completed by 2016.

Implementation
By the end of the mid-term other benefits of PBN will have been enabled, such as flexible procedures to manage the mix of faster and slower aircraft in congested airspace and use of less conservative PBN requirements.

Automation for RNAV and RNP Operations

By the end of the mid term enhanced en route automation will allow the assignment of RNAV and RNP routes based upon specific knowledge of an aircraft's RNP capabilities. En route automation will use collaborative routing tools to assign aircraft priority, since the automation system can rely upon the aircraft's ability to change a flight path and fly safely around problem areas. This functionality will enable the controller to recognize aircraft capability and to match the aircraft to dynamic routes or procedures, thereby helping appropriately equipped operators to maximize the predictability of their schedules.

Conflict prediction and resolution in most en route airspace must improve as airspace usage increases. Path repeatability achieved by RNAV and RNP operations will assist in achieving this goal. Mid-term automation tools will facilitate the introduction of RNP offsets and other forms of dynamic tracks for maximizing the capacity of airspace. By the end of the mid-term, en route automation will have evolved to incorporate more accurate and frequent surveillance reports through ADS-B, and to execute problem prediction and conformance checks that enable offset manoeuvres and closer route spacing (e.g., for passing other aircraft and manoeuvring around weather).

5.2.2 Terminal Areas (Departures and Arrivals)

During this period, either Basic RNP-1 or RNAV-1 will become a required capability for flights arriving and departing major airports based upon the needs of the airspace, such as the volume of traffic and complexity of operations. This will ensure the necessary throughput and access, as well as reduced controller workload, while maintaining safety standards.
With RNAV-1 operations as the predominant form of navigation in terminal areas by the end of the mid-term, Sierra Leone will have the option of removing conventional terminal procedures that are no longer expected to be used.

Terminal Automation

Terminal automation will be enhanced with tactical controller tools to manage complex merges in busy terminal areas. As data communications become available, the controller tools will apply knowledge of flights' estimates of time of arrival at upcoming waypoints, and altitude and speed constraints, to create efficient manoeuvres for optimal throughput. Terminal automation will also sequence flights departing busy airports more efficiently than today. This capability will be enabled as a result of PBN and flow management tools. Flights arriving and departing busy terminal areas will follow automation-assigned PBN routes.

5.2.3 Approach

In the mid-term, implementation priorities for instrument approaches will still be based on RNP APCH and RNP AR APCH and full implementation is expected at the end of this term. The introduction of the application of landing capability, using GBAS (currently non PBN) is expected to guarantee a smooth transition towards high performance approach and landing capability.

5.2.4 Helicopter operations

Apart from a contingency of military helicopters, there are very few helicopters operated for civil operations. The operations for helicopters shall then be developed for civil operations as and when the time comes.

5.2.5 Medium term Phase two strategy summary

Airspace	Navigation Specifications	Navigation-specifications where operationally required

En-Route Oceanic	RNAV-5	RNP-2
En-Route Remote Continental	RNAV-5	RNP-2
En-Route Continental	RNAV-2, RNAV-5	RNAV-1
TMA Arrival/Departure	-Expand RNAV-1, or basic RNP-1 application(GFLL)	
Approach	-Expand RNP APCH with (Baro-VNAV) and APV(GFLL)	

5.2.6 Implementation Targets

- RNP APCH (with Baro-VNAV) or APV runways12/30 at GFLL by December 2016.
- RNAV-1 or RNP-1 SID/STAR for runawys12/30 at GFLL by December 2015
- Implementation of additional RNAV/RNP Routes as required

5.3 Long term strategy (2017 and beyond)

The Long-term environment will be characterised by continued growth in air travel and increased air traffic complexity.
No one solution or simple combination of solutions will address the inefficiencies, delays, and congestion anticipated to result from the growing demand for air transportation. Therefore, Sierra Leone and key Stakeholders need an operational concept that exploits the full capability of the aircraft in this time frame.

5.3.1 Long Term Key Strategies (2017 and Beyond)

Airspace operations in the Long term will make maximum use of advanced flight deck automation that integrates CNS capabilities. RNP, RCP, and RSP standards will define these operations.
Separation assurance will remain the principal task of air traffic management in this time frame. This task is expected to leverage a combination of aircraft and ground-based tools. Tools for conflict detection and resolution, and for flow management, will be enhanced significantly to handle increasing traffic levels and complexity in an efficient and strategic manner.

Strategic problem detection and resolution will result from better knowledge of aircraft position and intent, coupled with automated, ground-based problem resolution. In addition, pilot and air traffic controller workload will be lowered by substantially reducing voice communication of clearances, and furthermore using data communications for clearances to the flight deck. Workload will also decrease as the result of automated confirmation (via data communications) of flight intent from the flight deck to the ground automation.

With the necessary aircraft capabilities, procedures, and training in place, it will become possible in certain situations to delegate separation tasks to pilots and to flight deck systems that depict traffic and conflict resolutions. Procedures for airborne separation assurance will reduce reliance on ground infrastructure and minimize controller workload. As an example, in IMC an aircraft could be instructed to follow a leading aircraft, keeping a certain distance. Once the pilot agreed, ATC would transfer responsibility for maintaining spacing (as is now done with visual approaches).

Performance-based operations will exploit aircraft capabilities for "electronic" visual acquisition of the external environment in low-visibility conditions, which may potentially increase runway capacity and decrease runway occupancy times.
Improved wake prediction and notification technologies may also assist in achieving increased runway capacity by reducing reliance on wake separation buffers.

System-wide information exchange will enable real-time data sharing of NAS constraints, airport and airspace capacity, and aircraft performance. Electronic data communications between the ATC automation and aircraft, achieved through data link, will become widespread—possibly even mandated in the busiest airspace and airports. The direct exchange of data between the ATC automation and the aircraft FMS will permit better strategic and tactical management of flight operations.

Aircraft will downlink to the ground-based system their position and intent data, as well as speed, weight, climb and descent rates, and wind or turbulence reports. The ATC automation will uplink clearances and other types of information, for example, weather, metering, choke points, and airspace use restrictions.

To ensure predictability and integrity of aircraft flight path, RNP will be mandated in busy en route and terminal airspace. RNAV operations will be required in all other airspace (except oceanic).

Achieving standardized FMS functionalities and consistent levels of crew operation of the FMS is integral to the success of this Long-term strategy.

The most capable aircraft will meet requirements for low values of RNP (RNP 0.3 or lower en route). Flights by such aircraft are expected to benefit in terms of airport access, shortest routes during IMC or convective weather, and the ability to transit or avoid constrained airspace, resulting in greater efficiencies and fewer delays operating into and out of the busiest airports.

Enhanced ground-based automation and use of real-time flight intent will make time-based metering to terminal airspace a key feature of future flow management initiatives. This will improve the sequencing and spacing of flights and the efficiency of terminal operations.

Uniform use of RNP for arrivals and departures at busy airports will optimize management of traffic and merging streams. ATC will continue to maintain control over sequencing and separation; however, aircraft arriving and departing the busiest airports will require little controller intervention. Controllers will spend more time monitoring flows and will intervene only as needed, primarily when conflict prediction algorithms indicate a potential problem.

More detailed knowledge of meteorological conditions will enable better flight path conformance, including time of arrival control at key merge points. RNP will also improve management of terminal arrival and departure with seamless routing from the en route and transition segments to the runway threshold. Enhanced tools for surface movement will provide management capabilities that synchronize aircraft movement on the ground; for example, to coordinate taxiing aircraft across active runways and to improve the delivery of aircraft from the parking areas to the main taxiways.

5.3.2 Summary of Long Term Key Strategies (2017 and Beyond)

The key strategies for instituting performance-based operations employ an integrated set of solutions.

• Airspace operations will take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and FMS.

• Aircraft position and intent information directed to automated, ground-based ATM systems, strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution).

• Strategic and tactical flow management will improve through use of integrated airborne and ground information exchange.

• Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information available through data link to ground automation.

• Real-time sharing of National Air Space (NAS) flight demand and other information achieved via ground-based and air-ground communication between air traffic management and operations planning and dispatch.

• Overall system responsiveness achieved through flexible routing and well-informed, distributed decision-making.

• Systems ability to adapt rapidly to changing meteorological and airspace conditions.

• System leverages through advanced navigation capabilities such as fixed radius transitions, RF legs, and RNP offsets.

• Increased use of operator-preferred routing and dynamic airspace.

• Increased collaboration between service providers and operators.

Operations at the busiest airports will be optimized through an integrated set of capabilities for managing pre-departure planning information, ground-based automation, and surface movement.

• RNP-based arrival and departure structure for greater predictability.

• Ground-based tactical merging capabilities in terminal airspace.

• Integrated capabilities for surface movement optimization to synchronize aircraft movement on the ground. Improved meteorological and aircraft intent information shared via data link.

5.3.3 Key Research Areas

The aviation community must address several key research issues to apply these strategies effectively.

These issues fall into several categories:

Navigation

• To what extent can lower RNP values be achieved and how can these be leveraged for increased flight efficiency and access benefits?

• Under what circumstances RNAV should be mandated for arriving/departing satellite airports to enable conflict-free flows and optimal throughput in busy terminal areas?

Flight Deck Automation

• What FMS capabilities are required to enable the future concepts and applications?

• How can performance-based communication and surveillance be leveraged in the flight deck to enable Long-term strategies such as real-time exchange of flight deck data?

Automation

• To what extent can lateral or longitudinal separation assurance be fully automated, in particular on final approach during parallel operations?

• To what extent can surface movement be automated, and what are the cost-benefit trade-offs associated with different levels of automation?

• To what extent can conflict detection and resolution be automated for terminal ATC operations?

Procedures

• How can time of arrival control be applied effectively to maximize capacity of arrival or departure operations, in particular during challenging wind conditions?

• In what situations is delegation of separation to the flight crews appropriate?

• What level of onboard functionality is required for flight crews to accept separation responsibility within a manageable workload level?

Airspace

• To what extent can airspace be configured dynamically on the basis of predicted traffic demand and other factors?

• What separation standards and procedures are needed to enable smoother transition between en route and terminal operations?

• How can fuel-efficient procedures such as CDAs be accomplished in busy airspace?

Glossary

3D	Three-Dimensional
4D	Four-Dimensional
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
ATC	Air Traffic Control
CDA	Continuous Descent Arrival
CNS	Communications, Navigation, Surveillance
EFVS	Enhanced Flight Visibility System
GA	General Aviation
GBAS	Ground-Based Augmentation System
GLS GNSS	(Global Navigation Satellite System) Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LNAV	Lateral Navigation
LPV	Localizer Performance with Vertical Guidance
NAS	National Airspace System
NAVAID	Navigation Aid
NM	Nautical Miles
PBN	Performance Based Navigation
RCP	Required Communications Performance

RF	Radius-to-Fix
RNAV	Area Navigation
RNP	Required Navigation Performance
RNPSORSG Operational	Required Navigation Performance and Special Requirements Study Group
RSP	Required Surveillance Performance
SAAAR Required	Special Aircraft and Aircrew Authorization
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival
VLJ	Very Light Jet
VNAV	Vertical Navigation
WAAS	Wide Area Augmentation System

RF	Radius-to-Fix
RNAV	Area Navigation
RNP	Required Navigation Performance
RNPSORSG Operational	Required Navigation Performance and Special Requirements Study Group
RSP	Required Surveillance Performance
SAAAR Required	Special Aircraft and Aircrew Authorization
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival
VLJ	Very Light Jet
VNAV	Vertical Navigation
WAAS	Wide Area Augmentation System

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