ICAO

# CAPACITY & EFFICIENCY

# Air Navigation Report

2014 Edition

# A Coordinated Approach to Air Navigation System Evolution

Dependable access to air transport services is a key enabler of improved social and economic prosperity worldwide. The complementary safety and efficiency aspects of air navigation service provision are fundamental to this dependability, and therefore essential strategic priorities for ICAO.

To ensure continuous improvement in the safety of the global aviation network, the ICAO Global Aviation Safety Plan (GASP) establishes consensus-based targets tailored to the existing capacities and near- and long-term objectives of world States and regions. These targets are also carefully aligned to ensure effective strategic coordination of related activities across the entire global sector.

In the context of an assured safety environment under its first Global Plan, ICAO seeks to ensure the delivery of efficient and comprehensive air navigation services under its complementary Global Air Navigation Plan (GANP).

Developed to reflect and align the agreed series of technologies, procedures and system-wide capabilities needed to meet the significant capacity challenges of the next 15 years, the GANP organizes these requirements into a flexible series of performance improvements and timelines. These were agreed to through ICAO during the 2011–2013 timeframe by States, airline and airport operators, civil air navigation service providers, aircraft manufacturers and many other stakeholders in the global aviation system, and have become known as the ICAO aviation system block upgrades (ASBUs).

The ICAO ASBUs simultaneously accommodate variations in regional traffic needs and projections, existing and projected technological capabilities, aircraft and avionics attrition planning, and many other factors while assuring interoperability across the entire global air transport network. This assurance of global interoperability while providing flexible and agreed routes to future capability requirements is considered essential to all of aviation's safety and efficiency objectives.

A further important benefit of more efficient routes and aircraft is decreased fuel reliance and emissions. As aviation's climate impacts become an increasing concern based on the projected doubling of global flights to 60 million a year now projected by 2030, efficiency will increasingly become not only a matter of how quickly a passenger or business can connect to the world, but also a factor in the very quality of the world they connect to.

In light of all these important safety and efficiency goals, ICAO has sought to drive improved accountability and transparency with respect to how the global network is succeeding against its strategic goals. We began to issue the annual ICAO Safety Report in 2011, and have now introduced this annual ICAO Air Navigation Report to begin measuring global aviation's progress against its consensus-driven ASBU, Performance-based Navigation (PBN) and other efficiency priorities.

This document will evolve as our global system evolves, and we encourage all State and industry stakeholders to take note of its annual results and to suggest new areas where it might provide additional metrics. Our system has always progressed most successfully when we have cooperated toward shared goals, and ICAO looks forward to your inputs and feedback as our reports continue to align with the full needs of our global community.



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This report is not intended to be exhaustive and represents the first attempt in providing a global overview of the status of implementation of the air navigation system. The document will be updated on an annual basis and the accuracy associated with the information shown is intended to increase in line with an improved air navigation performance measurement, monitoring and reporting strategy. The report tries to demonstrate the achieved results, the existing successful initiatives and to stimulate possible future projects.

**About ICAO:**

The International Civil Aviation Organization (ICAO) is a UN specialized agency, created in 1944 upon the creation and signing by 52 States of the *Convention on International Civil Aviation* (Chicago Convention).

Today, ICAO works with the Convention's 191 Signatory States, in close conjunction with global industry and aviation organizations, to develop international Standards and Recommended Practices (SARPs) which are used by States when they develop their legally-binding national civil aviation regulations.

There are currently over 10,000 SARPs reflected in the 19 Annexes to the Chicago Convention which ICAO oversees, and it is through these SARPs and ICAO's complementary assistance and coordination work that today's global air transport network is able to operate over 100,000 daily flights, safely, efficiently and securely in every region of the world.

# Contents

# Executive Summary

## Traffic Overview

Some 3.1 billion passengers made use of the global air transport network for their business and tourism needs in 2013. The annual passenger total was up approximately 5% compared to 2012 and is expected to reach over 6.4 billion by 2030, based on current projections.

The number of aircraft departures reached 33 million globally last year, establishing a new record and surpassing the 2012 departure figure by more than one million flights. Scheduled passenger traffic grew at a rate of 5.2% (expressed in terms of revenue passenger-kilometres or RPKs).

This recent upswing is attributed primarily to positive economic results globally and improved business and consumer confidence during 2013 in several major economies. ICAO's analyses in this area also revealed that emerging economies grew more slowly than expected.

*Regional Results*

The Asia-Pacific Region remains the world's largest air transport market based on the 2013 figures, with a 31% share of total traffic representing an increase of 7.2% over 2012.

Despite a better economic climate in Europe and North America, the traffic of the European and North American airlines increased less than the world average, growing at 3.8% and 2.2%, respectively. The Middle East remains the fastest growing air transport market in the world, with its traffic expanding over 2013 at a rate of 11.2% compared to 2012, accounting for 9% of global RPKs.

*International Passenger*

International traffic grew by 5.2% in 2013, with the highest levels of growth registered by the airlines of the Middle East (10.9%) followed by the Latin America and Caribbean region (8.6%). African carriers recorded the third highest regional growth rate at 7.4%.

Globally, the international air transport market was still dominated by European airlines, which accounted for 38% of international traffic. Asia-Pacific airlines ranked second in this category at 27%.

*Domestic Passenger*

Domestic traffic increased by 5.1% compared to 2012, with airlines from North America (47%) and the Asia-Pacific (37%) accounting for a combined 83% of worldwide domestic traffic.

Asia-Pacific domestic results were 10% higher than in 2012, driven mainly by Chinese carriers, which account for approximately 60% of the region's total market.

### Table A: Regional passenger traffic and capacity growth, market shares and load factors in 2013*

| | International | | Domestic | | Total | | | |
|---|---|---|---|---|---|---|---|---|
| | Revenue Passenger Kilometres | | | | | | ASKs | LFs |
| | Traffic Growth | Market Share | Traffic Growth | Market Share | Traffic Growth | Market Share | Capacity Growth | Load Factors |
| Africa | ↑ 7.4% | 3% | ↑ 4.2% | 1% | ↑ 7.0% | 2% | ↑ 5.2% | 69.6% |
| Asia and Pacific | ↑ 5.2% | 27% | ↑ 9.6% | 37% | ↑ 7.2% | 31% | ↑ 6.7% | 77.2% |
| Europe | ↑ 3.8% | 38% | ↑ 3.7% | 8% | ↑ 3.8% | 27% | ↑ 2.6% | 79.9% |
| Latin America and the Caribbean | ↑ 8.6% | 4% | ↑ 4.2% | 7% | ↑ 6.3% | 5% | ↑ 5.0% | 76.1% |
| Middle East | ↑ 10.9% | 13% | ↑ 16.1% | 1% | ↑ 11.2% | 9% | ↑ 11.5% | 76.9% |
| North America | ↑ 6.2% | 14% | ↑ 1.9% | 46% | ↑ 2.2% | 26% | ↑ 1.9% | 83.0% |
| **World** | ↑ **5.2%** | **100%** | ↑ **5.1%** | **100%** | ↑ **5.2%** | **100%** | ↑ **4.6%** | **79.1%** |

ASKs: Available Seat-kilometres LFs: Passenger Load Factors

* *These figures are preliminary and cover scheduled commercial services only. The statistics are applicable to the traffic by region of airline domicile.*

*Freight Traffic*

On the air cargo side, global traffic volumes expressed in freight tonne-kilometres (FTKs) saw an increase of about 1%, or approximately 51 million tonnes of freight carried.

Asia-Pacific airlines had the largest share of global FTKs, but saw a contraction in overall freight volume — similar to what was experienced by North American carriers.

The Middle East remained the region with the fastest air cargo traffic growth when comparing 2013 against 2012 results, accounting for 12% of global FTKs.

## System Overview

Air transport capacity, expressed in available seat-kilometres (ASKs), increased globally by 4.6% in 2013. Average passenger load factor increased slightly in 2013, by about one-half a percentage point compared to 2012, or 79.1%.

*Capacity and Efficiency Priorities: PBN*

The implementation of Performance-based Navigation has increased in momentum but remains less than optimal. Detailed PBN results are found on page 11, in addition to success stories from States on page 16.

PBN remains the sector's highest air navigation priority and a key enabler of more flexible use of the airspace, expanded use of continuous climb and continuous descent operations (CCO/CDO), improved route spacing and deconfliction, and environmental benefits through associated noise and emissions reductions.

ICAO has made all required documentation on PBN available to States and operators, and continues to consolidate related guidance material and other resources in special PBN implementation kits, or 'iKits', while providing direct implementation assistance through special PBN Go Team visits conducted with partnering organizations. In 2014, new online courses and procedure design criteria will also be available.

### *Capacity and Efficiency Priorities: CCO/CDO*

The application of CCO and CDO continues on course with many States having implemented variations based on their local requirements. CCO and CDO deliver many operational efficiency benefits in the terminal area, permitting aircraft to operate without altitude restrictions during departure or arrival phases, resulting in less noise exposure and reductions in fuel burn and greenhouse gas emissions. Results in this area, along with success stories from various States and facilities, are on page 21.

### *Capacity and Efficiency Priorities: ATFM*

Air traffic flow management (ATFM) enables air traffic management (ATM) efficiency and effectiveness, especially in higher-density airspace, and contributes to the safety, efficiency, cost effectiveness, and environmental sustainability of ATM systems. Reporting against progress in this area is still in its nascent stages, with ICAO and States having agreed for the time being to use metrics reflecting the percentage of flight information regions (FIRs) within which all ACCs utilize ATFM measures. It is also difficult to develop common baselines because its application is location-specific and implementation is being carried out by States in different ways.

This first edition of the Air Navigation Report simply contains a map showing States that have applied AFTM to any extent, as well as AFTM success stories that will help States and operators understand how and why it is now being applied. This section of the report is found on page 24.

### *Capacity and Efficiency Priorities: AIS/AIM Transition*

Another high-priority area for air navigation progress is the transition from Aeronautical Information Services (AIS) to Aeronautical Information Management (AIM). This is a strategic positioning initiative to drive the delivery of improved aeronautical information in terms of quality, timeliness and the identification of new services and products to better serve aeronautical users.

With main AIM implementation targets set for the 2016 time period, Phase I provisions fall short of full AIM capability — focusing instead on establishing a clear path to the full digital provision of existing AIS products and services. ICAO has kept its regional surveys on AIM implementation simple to ensure global harmonization and consistency, focusing on AIRAC adherence monitoring, overall quality and World Geodetic System — 1984 (WGS84) implementation.

The European and North Atlantic (EUR/NAT) Region has seen the most progress on the three indicators. Full results and AIM success stories are found on page 29.

## ICAO Implementation Support Packages

Besides the PBN iKits previously mentioned, ICAO also provides additional one-stop guidance and resource packages to assist with the implementation of other objectives, notably the ASBU Block 0 iKit and the Aircraft Operators Certificate iKit. Additional iKits offered are more directly related to safety assistance and goals, such as the ICAO Runway Safety and Safety Management iKits.

# Integrated Global and Regional Reporting

Performance measurement is an integral aspect of aviation's pursuit for continuous improvement. Measuring performance not only provides an idea of how the entire aviation system is behaving, but it also offers a feedback mechanism for future tactical adjustments or action plans towards the targets contained in the ICAO Global Safety and Air Navigation Plans.

Reporting on a global scale is intrinsically complex but serves to develop consensus on the status of global initiatives, allowing for direct feedback on the implementation of the Global Plans. Measuring performance at the regional level is just as important, however, as it allows for a more in-depth look at how local approaches and variations affect each safety and air navigation environment. This type of feedback is key to how ICAO's regional offices prioritize their resources and work programmes towards desired operational results.

The ICAO Air Navigation Report therefore consists of qualitative and quantitative data and analysis and addresses relevant air navigation system performance areas. This inaugural 2014 edition provides the status of operational measures for performance improvement and related implementation progress, in accordance with State operational requirements and selected Block 0 priority modules.

It focuses on air navigation priorities stressed in the Fourth Edition GANP such as Performance-based Navigation (PBN), Continuous Descent Operations (CDO), Continuous Climb Operations (CCO), Aeronautical Information Management (AIM), Air Traffic Flow Management (ATFM) and estimated environmental benefits accrued from operational improvements based on the ICAO Fuel Savings Estimation Tool (IFSET).

## Annual and Interim Distinctions

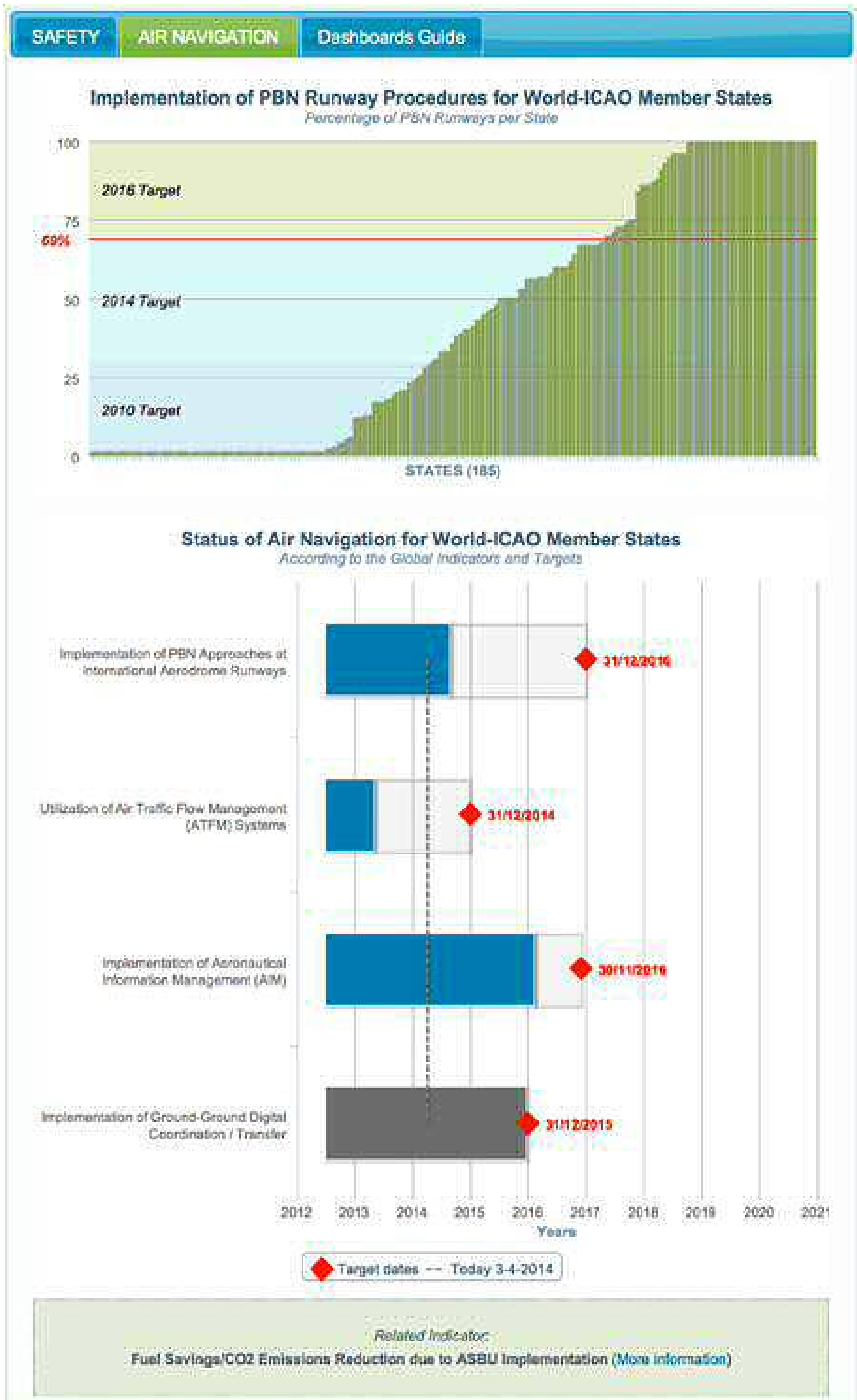
The objectives of ICAO's annual Safety and Air Navigation Reports and the Organization's newly-implemented online Regional Performance Dashboards are similar, mainly in the sense that they aim to provide helpful snapshots and most recent best practices associated with various operational environments and objectives. They differ, however, in their scope, context and timing — all important considerations when interpreting and acting on the results contained in each reporting method.

The Performance Dashboards present up-to-date regional implementation results, highlighting what States and groups of States are achieving in collaboration with their respective Planning and Implementation Regional Groups (PIRGs) and Regional Aviation Safety Groups (RASGs). Their ultimate intention, besides ICAO's basic measurement, accountability and transparency goals, is to help motivate aviation groups and stakeholders to continue to participate in and improve upon the applicable cooperative programmes being implemented at the regional level.

The dashboards are available on the ICAO public safety and air navigation websites, as well as on each Regional Office website.

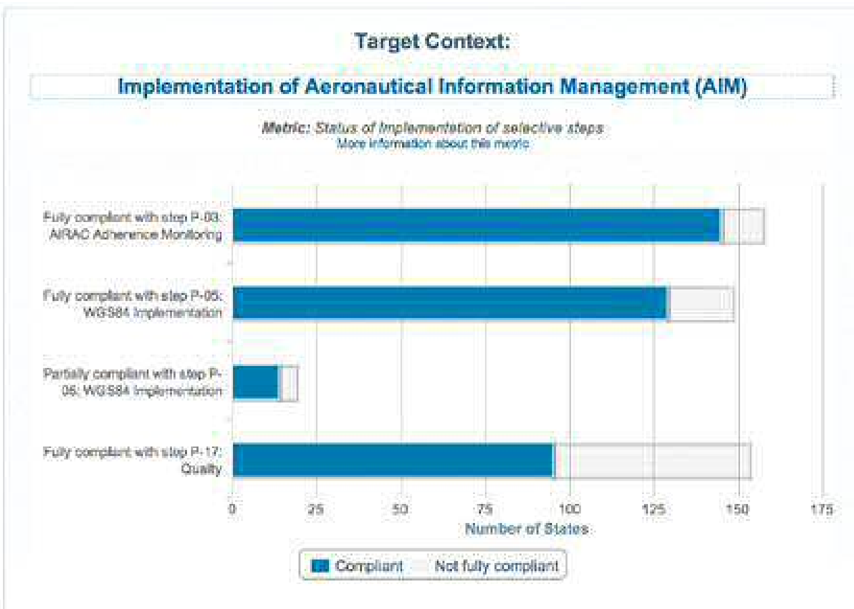
## Regional Dashboards Overview

### Figure 1: Air Navigation Regional Performance Dashboard for all ICAO Member States, according to Global indicators and targets



The dashboards also provide more detailed information through a secondary bar chart for each indicator, which is visible upon clicking the respective blue bar. This chart provides users with information on the context of the indicator, the metric used, and the values for each type of measurement used. Again, this allows users to have a more concrete idea on the level of implementation at the regions.

## Figure 2: Drill-down Chart for the Implementation of AIM for the World




The dashboards provide a glance of both Safety and Air Navigation strategic objectives, using a set of indicators and targets based on the regional implementation of the GASP and the GANP. These are the common set of measurements for the first version of the dashboards, which will expand to more region-specific metrics as they are endorsed.

## Table 1: Initial Set of Indicators for the first version of the Regional Performance Dashboards

| SAFETY | AIR NAVIGATION |
|---|---|
| State Safety Oversight System | Performance-based Navigation |
| Significant Safety Concerns | Air Traffic Flow Management |
| Accidents | Aeronautical Information Management |
| Aerodrome Certification | Ground-Ground Digital Coordination/Transfer |
| State Safety Programme | ASBU Environmental Benefits |

# Global Air Navigation Priorities

## Performance-based Navigation (PBN)

The implementation of PBN is presently the global aviation community's highest air navigation priority. The PBN concept offers significant benefits including improved safety through more straight-in instrument approaches with vertical guidance, increased airspace capacity, increased airport accessibility, more efficient operations, reduced infrastructure costs, and reduced environmental impact. PBN is not a stand-alone concept; it is one of the elements that supports the strategic objectives of the Airspace Concept, together with Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM).

PBN is a key enabler for the implementation of many of ICAO's Aviation System Block Upgrade (ASBU) performance improvement areas. It is an essential component to improving airport operations through ASBU modules B0-APTA — Optimization of Approach Procedures Including Vertical Guidance and B1-APTA — Optimized Airport Accessibility.

PBN is additionally essential in enabling more efficient flight paths through trajectory-based operations, mainly as it supports the application of modules B0-CDO and, B1-CDO and, B0-CCO and B0-FRTO, all of which contribute to significant efficiency, capacity and environmental benefits. CDO and CCO are therefore considered as priority PBN monitoring elements.

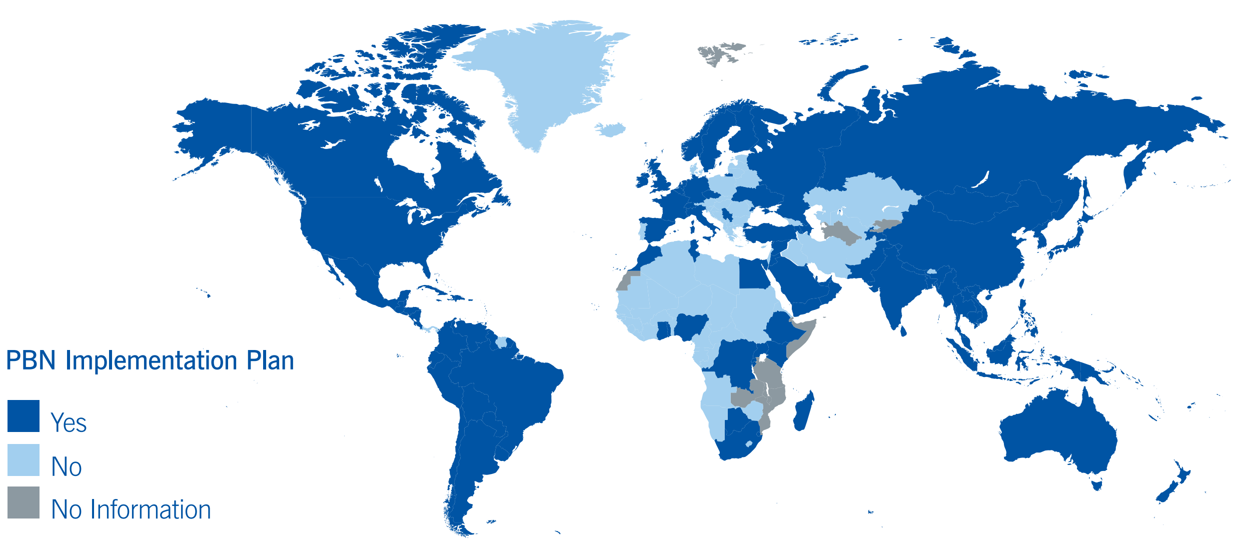
*Implementation Status and Targets for PBN*

Implementation of PBN continues to grow throughout the world as a result of ICAO Assembly Resolution A37-11 which resolved that:

> States complete an implementation plan as a matter of urgency to achieve:
>
> 1. Implementation of RNAV and RNP Operations (where required) for en route and terminal areas according to established timelines and intermediate milestones;
>
> 2. Implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV-only minima, for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30% by 2010, 70% by 2014; and
>
> 3. Implementation of straight-in LNAV-only procedures as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5,700 kg or more.

**Figure 3: Global Status of PBN Implementation Plans**

Based upon ICAO Regional Offices inputs



*PBN Implementation Plans - Status*

As of the end of 2013, 102 countries have committed to PBN by publishing a State PBN Implementation Plan, as shown in the schematic map above (Figure 3).

These plans are a key indicator of the commitment by all stakeholders within a State to improve safety and efficiency through PBN, normally identifying short-, medium- and long-term objectives for implementation including both terminal and en route initiatives.

These plans are essential for providing timelines that allow appropriate preparation by all stakeholders. In some cases, the plans are also supported by business cases and/or cost-benefit analyses.

*PBN Approaches*

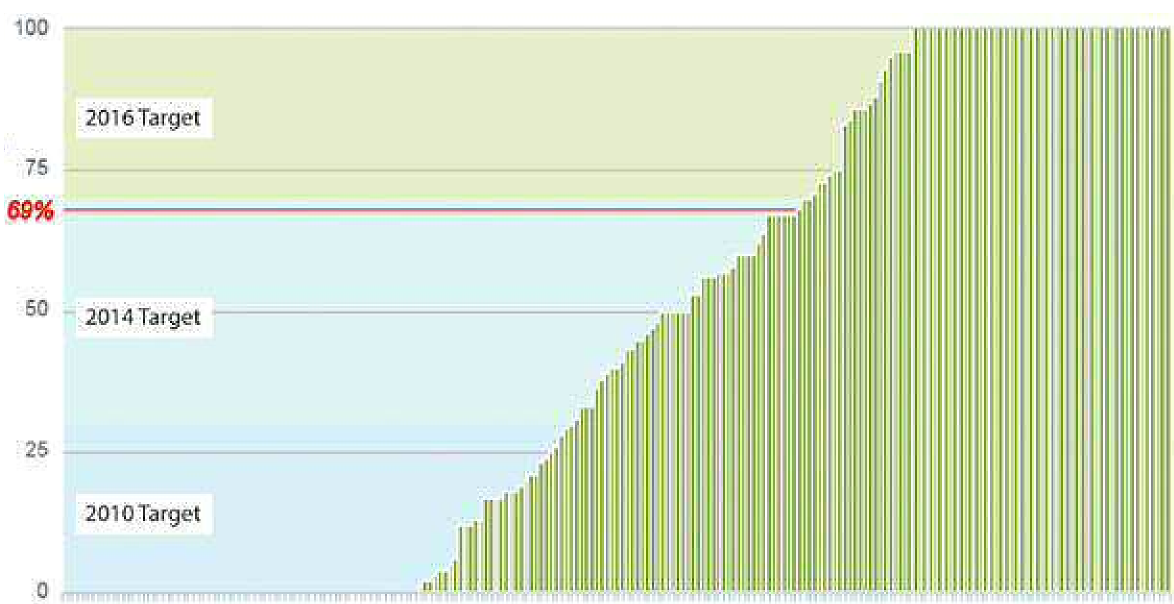
Information on the growth of PBN in the terminal area is indicated in the figures below. Overall, there has been a significant rise in the number of runways that now have PBN capability.

Figure 4 indicates the percentage of PBN instrument runways per country with the global average being 69%. Note that some countries have no PBN instrument runways.

Figure 5 indicates the current status of global PBN implementation, with respect to the number of international instrument runways today that now have PBN instrument procedures. While this information is encouraging, the value is distorted by certain States which have a large number of runways and are more progressive with implementing PBN.

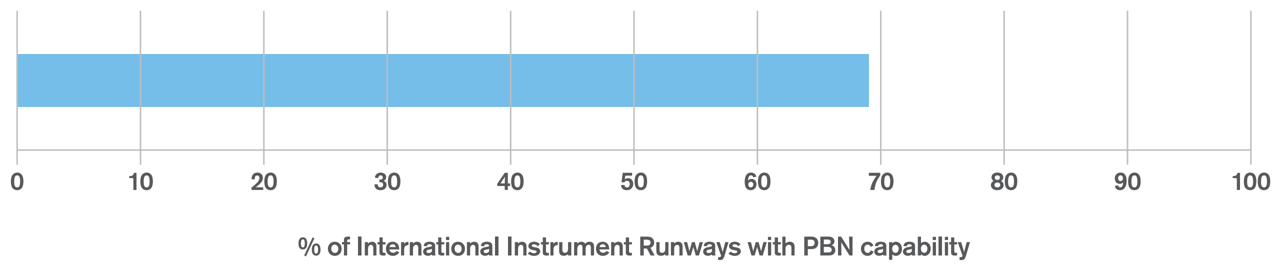
## Figure 4: Distribution Chart — Percentage of PBN Runways per Country for World[1]

Based upon Jeppesen data



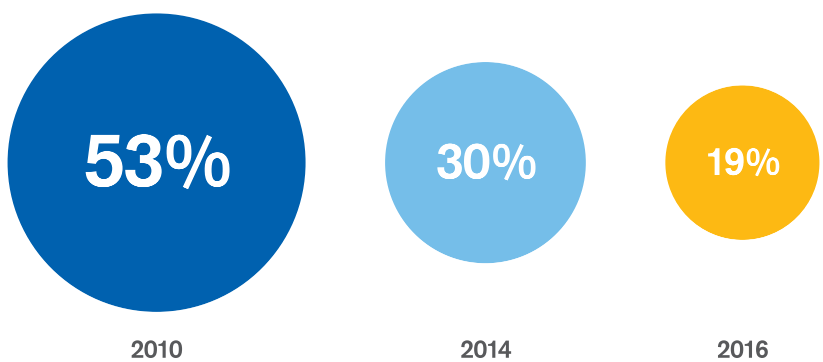
## Figure 5: Global PBN Implementation[1]

Based upon Jeppesen data




## Figure 6: Percentage of States Meeting the Resolution Targets for Applicable Years

Based upon Jeppesen data

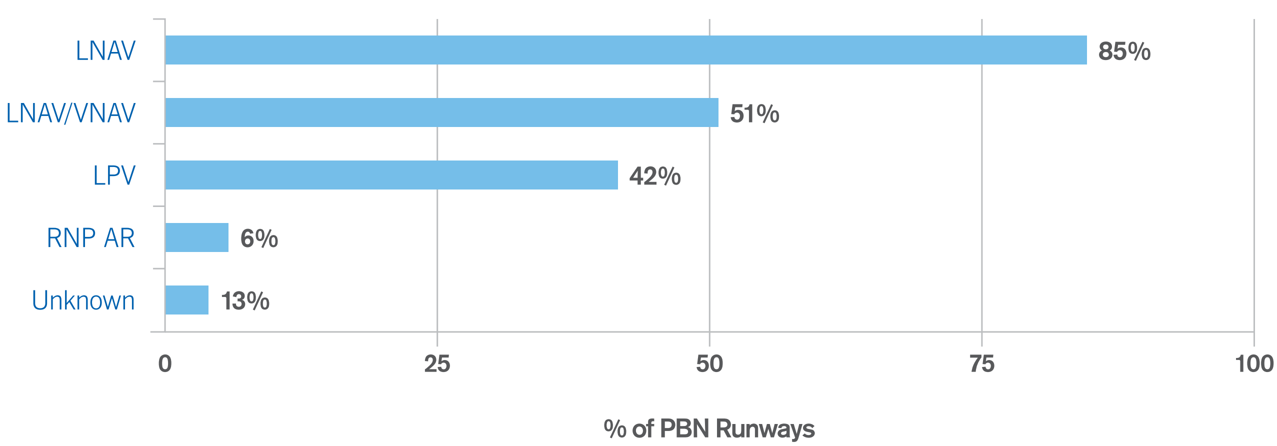



The percentage of ICAO Member States that are meeting the A37-11 resolution targets provides a more accurate picture of the global state of PBN implementation. As shown in Figure 6, currently only 53% of all States meet the 2010 resolution targets related to PBN approaches; only 30% meet the 2014 resolution target, and only 19% meet the full 2016 resolution target. This information raises concerns regarding progress of State PBN implementation; continued support from ICAO and its partners must be provided in order for States to meet the targets.

There are various types of PBN instrument approach procedures that can be implemented. The percentage of PBN runways by approach type is shown in Figure 7. This chart is in relation to the Global PBN Implementation for the world (69%).

## Figure 7: Global Average of State PBN Approaches by Type[2]

Based upon Jeppesen data

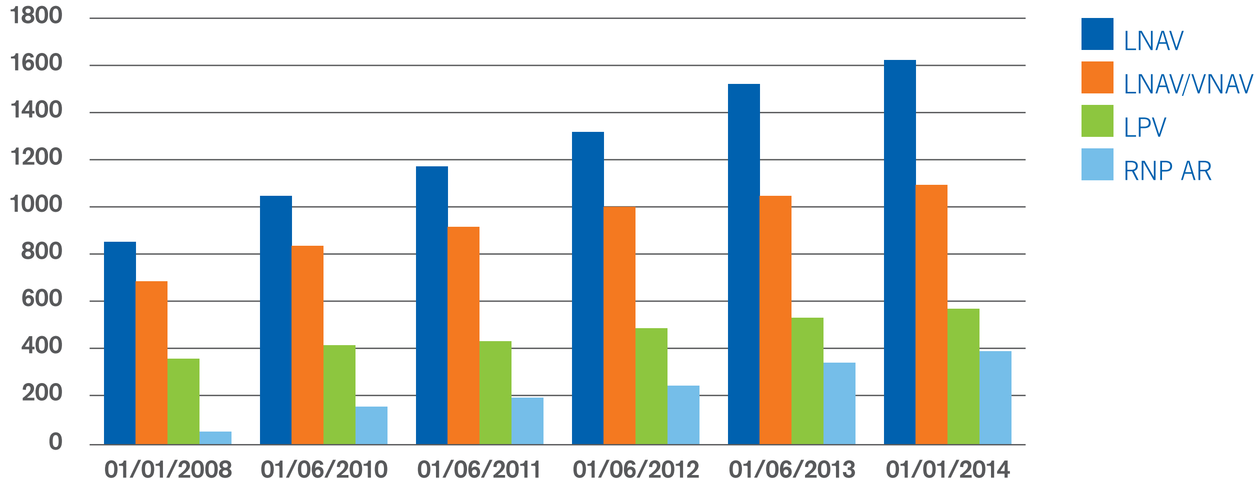



[1] *Global PBN implementation is the percentage of PBN runways per country for the world, limited to airports with ICAO 4-letter codes.*

[2] *See more on* https://portal.icao.int/space/Pages/PBN-Status.aspx

## Figure 8: Growth in Global Number of PBN Approaches Employed 2008–2014[3]

Based upon Jeppesen data




*PBN Departures and Arrivals*

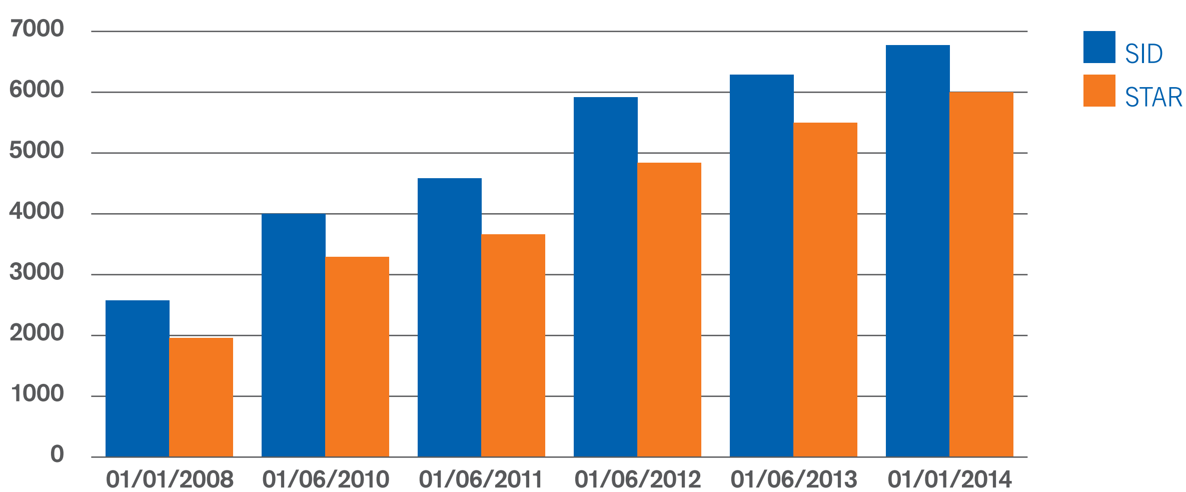
The flexibility of the PBN concept becomes very apparent in regard to the design of airport arrival and departure routes. PBN enables more flexible use of airspace, permits expanded use of CCO/CDO, improves route spacing and de-confliction, and facilitates environmental benefits with reduced fuel burn and emissions.

Standard Terminal Arrivals (STARs) can be designed to deconflict with departures to allow CDO and to connect with instrument approach procedures, resulting in constant descent until the intermediate approach phase. Standard Instrument Departures (SIDs) can be designed to avoid arrival routes and incorporate continuous climb profiles to the en route altitude. A practical metric for assessing progress with PBN implementation with respect to the arrival and departure phases is the annual increase in published PBN SIDs and STARs.

There has been significant growth in published PBN approach and departure procedures, with the change ranging from 130–180% over the past 5 years (Figure 9). Today, PBN SIDs and STARs represent approximately 40% of the total published instrument arrivals and departures.

## Figure 9: PBN SID and STAR Growth 2008–2014

Based upon Jeppesen data




[3] *The benchmark for PBN implementation is 2008. It was the first year after publication of the PBN Manual and when measurement commenced.*

*PBN En route*

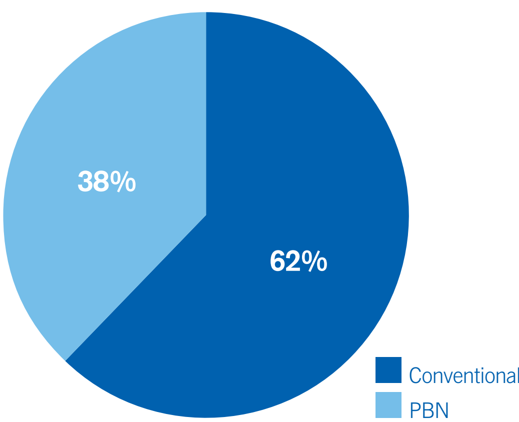
Airspace redesigned using the PBN concept can lead to greater airspace capacity and operational efficiency in both the en route and terminal environments. In the en route phase, the implementation of PBN routes can lead to shorter distances between points (efficiency) and closer route spacing (capacity) depending on the PBN specification used.

As PBN routes are not dependent upon ground-based navigation aids, it can facilitate the design and implementation of User Preferred Routes that are calculated based on various factors resulting in more optimized routing, as compared to fixed routes.

The main metric for measuring increased capacity and efficiency in the en route phase is through the growth in PBN routes (Figure 10). As well, there may be specific examples whereby the existence of specific PBN routes can be quantified for reduced route mileage and increased capacity (traffic flow).

### Figure 10: PBN versus Conventional Route Types, Globally

Based upon Jeppesen data




*Summary*

While PBN capability has generally increased significantly throughout the world, there are some notable disparities between States with respect to implementation. It is also disappointing to see that some States today have yet to develop a practical PBN Implementation Plan, considering the benefits that PBN provides. ICAO encourages States to place a high priority on developing/implementing their plans and meeting the targets of A37-11.

Nevertheless, the continuous growth in PBN instrument procedures of all types, approaches, arrivals and departures, reflects an overall positive trend and supports the importance placed on PBN by all stakeholders. With 69% of the world's runways now having PBN, it means that the rate of implementation is on track to meet the interim 2014 goal of 70%. The global percentage of routes that are now PBN enabled as compared to conventional is also very positive, as it indicates a trend towards more optimized and user-preferred routing, as well as increased airspace utilization. It also means that the aircraft's navigation capability is being fully applied to enable the most efficient flight operation.

Overall, there has been significant progress with PBN since monitoring first began in 2008. In less than five years, PBN has become the preferred concept of operation for most States and stakeholders. It will continue to grow and will soon be fully implemented throughout the globe.

## *Ongoing PBN Assistance*

*PBN GO Teams*

The Global Performance-based Navigation (PBN) Task Force (TF) was jointly established by ICAO and IATA with the objective to build upon the global and regional structures which have already been put in place for PBN implementation, and to produce tools and enablers to facilitate and expedite the work. Recognizing that additional support to States would be required, the Global PBN TF agreed to the formation of "GO Teams" as a key means of providing knowledge and expertise from a pool of service providers, regulators, and industry subject matter experts to assist States with PBN implementation.

In the first phase (2010–2012), the GO Teams visited 9 locations, covering all ICAO Regions and involving more than 300 PBN experts worldwide. These visits assessed the status of PBN plans, existing PBN operational approval processes, airspace concepts, CNS infrastructure, ATM, CDO implementation, PBN instrument flight procedures and training. These visits were extremely successful in expanding the understanding of PBN and resulted in specific recommendations for the States involved.

Because of this early success, ICAO and IATA agreed to launch a second phase of GO Team activities. The objectives of this phase were twofold; improve State and stakeholder expertise in two main PBN areas — operational approval and airspace concept design/development. The GO Team visits in this phase included Miami (for CAR/SAM), South Africa, Thailand, United Arab Emirates and China.

ICAO is now reassessing the PBN support it provides to States, with the aim of delivering a broader package of services and products to assist them with implementation, and thus help them meet the targets of A37–11.

*Flight Procedures Programme*

In 2009, ICAO established the Flight Procedure Programme (FPP) Office in Beijing, China, in order to accelerate the implementation of Performance-based Navigation (PBN) and address instrument flight procedure-related issues in the Asia and Pacific regions, thereby realizing significant safety, access, efficiency, and environmental benefits from PBN. This office focused on assisting States in developing their instrument flight procedures with quality assurance of the procedures and specific training for procedure designers.

In 2013, the office was upgraded to an ICAO regional sub-office with an expanded mandate to improve air traffic management performance across the APAC region. In the past year, over 170 students from fifteen countries in the Asia-Pacific region received training in procedure and airspace design, operations approval and quality assurance in support of PBN implementation.

As a result of the success of the APAC example, ICAO, in cooperation with the Directorate General for Civil Aviation of France and L'Agence pour la sécurité de la navigation aérienne en Afrique et à Madagascar (ASECNA), initiated the formation of an African-Indian Ocean FPP Office in Dakar, Senegal with the aim of improving safety and efficiency of instrument flight procedures in Africa. The mandate of this office is similar to the APAC FPP Office but also includes provision of training on regulatory processes to approve instrument flight procedures as well as the validation and quality assurance process, specific PBN training for ATC and ATM staff, and finally, training on PBN operational approvals for aircraft.

*Selected PBN Success Stories*

## RNP and RNP-AR Instrument Approaches in Australia

The implementation of RNP and RNP — Authorization Required (AR) approach procedures throughout the world has helped improve airport accessibility in terrain and obstacle rich environments, improve terminal airspace design through increased flexibility, reduce flight delays and air traffic congestion. This has led to the significant improvements in operational efficiency with corresponding reductions in fuel burn and GHG emissions. Australia has been a front runner in the deployment of this PBN capability. As an example, the Brisbane Green project which was the world's first integration of RNP into a busy terminal airspace environment has led to significant savings in the first 18 months of operation:

- 125,700 gallons of fuel;
- 1,100 tonnes of $CO_2$ emissions; and
- 4,200 minutes of airborne flight time.

Today, RNP procedures are deployed at 16 Australian airports with approximately 120 procedures being used on a daily basis. This has led to substantial savings for the airlines in fuel burn as well as significant improvements in noise reduction/avoidance at airports with RNP procedures.

## Application of PBN in Brazil

Brazil's SIRIUS programme is a major restructuring project of the en route and TMA airspace that incorporated the PBN concept to optimize air traffic flow between the main Brazilian Terminal Airspaces (TMAs). The project involved the restructuring of the route network among the polygon encompassed by Vitoria, Belo Horizonte, Brasília, São Paulo (SP) and Rio de Janeiro (RJ) TMAs, with a total area of 250,000 SQ.NM affected.

Project implementation was divided into two phases: route restructuring (first phase) and RJ and SP TMA restructuring (second phase).

The first phase was implemented in 2012 with the restructuring of RNAV 5 routes and the adoption of additional parallel routes. Because of this, the SID/STAR procedures needed adjustments to be linked to the new routes. Approximately 250 procedures were amended.

For the second phase (implemented in late 2013), new procedures for RJ and SP TMAs were published, and a complete rearrangement of the air traffic flow was instituted through the creation of new entrance and exit sectors for these TMAs.

- 43 routes created or realigned;

- 198 new SID/STARs published; and,
- Approximately 650 procedures published or modified over a period of three years.

The project also incorporated the concept of flexible use of conditioned airspace during night or in idle periods, allowing significant reductions in distance flown (between 30 to 50 NM) in the various portions of the affected airspace.

Some of the other benefits of the Sirius programme included:

- Implementation of RNP APCH (Baro/VNAV) and RNP AR APCH procedures for the largest five airports in both TMAs resulting in increased safety, efficiency and airport accessibility;
- New control sectors in the APP and ACC areas were created for approaches and departures which enhanced traffic flow and increased ATC capacity;
- The total reduction of approximately 930 NM in air miles flown resulted in annual savings of 203,000 metric tons of jet fuel. In environmental terms, this means a reduction of 640,000 tons of $CO_2$ per year; and
- Significant noise reduction through the application of stabilized descents and trajectories projected over the sea and de-populated areas.

The success of the programme can be directly attributed to the application of the Collaborative Decision Making (CDM) process, which involved over 1,000 personnel from all stakeholder areas.

## Terminal Airspace Redesign in Canada

In 2012, the redesign of the airspace in the busiest air traffic corridor, the Windsor-Toronto-Montreal corridor, has resulted in a complete RNAV environment with segregated en route airways, more efficient descent profiles and approaches, and a more flexible terminal airspace design that allows improved balancing of traffic on the main parallel runways. In addition, it affords a rearrangement of flight profiles to avoid noise sensitive areas.

The changes improve customer service by leveraging the efficiency and capacity benefits of PBN and modern avionics capabilities. Through extensive collaboration with all Stakeholders and the use of both flight and ATC simulation, the changes showed that implementation would:

- Reduce cumulative flight time by over 10 hours daily based on current traffic volumes;
- Reduce Greenhouse Gas (GHG) emissions by 14,300 metric tons; and
- Reduce aircraft fuel burn by 5.4 million liters and $CDN 4.3 million annually.

In addition, the terminal airspace at Calgary International Airport is currently undergoing major redesign to accommodate a new parallel runway that will be operational in spring 2014. This redesign, which takes advantage of PBN and modern flight deck technology, will result in new RNAV arrival and departure routes, new RNAV STARs, and the revocation of conventional airways and instrument procedures.

## PBN Improvements in China

China continues to implement the short-, medium- and long-term objectives of its PBN Implementation Plan. Over 80 PBN instrument procedures are now operational at various airports. At Juizhai airport, PBN procedures have significantly increased accessibility in a terrain-challenged location.

At Hong Kong, PBN procedures have resulted in reduced noise levels over highly populated areas, and shorter track miles leading to reduced fuel burn and $CO_2$ emissions. Similarly, PBN arrivals, departures and approaches have now been implemented at Macau.

All weather operations have been improved for the Guangdong airport through the application of PBN procedures for arrival and departure. This improvement included the merging of RNP with ILS approach procedures, resulting in a reduced track distance by up to 14 NM, as well as the implementation of a PBN approach to a runway currently without an instrument procedure, allowing increased airport accessibility.

Sanya Airport (ZJSY) is another good example of the benefits that can be achieved from PBN implementation. Sanya Airport has a single runway 08/26; Runway 08 is equipped with ILS/DME, but RWY 26 only has an NDB non precision approach, with high minima. Working closely with Airbus, RNP APCH procedures were designed and published for both runway ends for safety and improved accessibility. The approach minima for RWY 26 was lowered from 450m to 200m and resulted in a significant reduction in delays and missed approaches, especially during the typhoon season.

## European Initiatives

Italy has taken advantage of PBN to provide more direct routings in domestic airspace. New and amended RNAV 5 routes have been implemented resulting in an average savings of 3 NM per route. New RNAV STARs and SIDS at Olbia, Sardinia and Venice have achieved track mile reductions and enabled CCO and CDO. New RNP APCH procedures have been implemented at Rome (Leonardo da Vinci), Milan (Linate and Malpensa), and Venice to improve airport accessibility.

New PBN approaches at Yerevan International Airport in Armenia have resulted in both safety and efficiency benefits. The procedures provide straight-in lateral and vertical guidance, reducing the requirement for circling and resulting in a reduction of missed approaches by 4%. The environmental benefits include a savings of 10 min flying time, 41 kg of fuel and 128 kg of $CO_2$ emissions per missed approach.

In France, over half of all IFR runway ends are equipped with PBN approaches, with the goal to have all equipped by 2016. France plans to replace 50 CAT I ILS with RNP APCH procedures by 2015. RNAV SIDs and STARS have been gradually implemented into 15 TMAs since 2008.

RNP APCH procedures have been implemented at the Santander Airport in Spain. These procedures provide vertical guidance and improved minima over the existing non-precision procedures that are based on conventional navigation aids. Additional RNP APCH procedures are planned for Almeria, Seville and Valencia airports in 2014.

## PBN and the Indian Sub-continent

PBN procedures have been implemented at all major Indian airports to enhance safety and efficiency of aircraft operations. This includes RNAV-1 SIDs and STARs at 15 major airports. Air traffic between metro cities has grown at a tremendous pace resulting in airspace congestion and inefficient operations particularly at higher flight levels. To address this congestion, Airports Authority of India (AAI) has implemented direct city-pair routes between Metro Airports, thereby saving flying time and fuel, and resulting in reduced $CO_2$ emissions. AAI has also developed a robust PBN implementation strategy in line with the ICAO regional PBN implementation plan.

## Kazakhstan PBN Assessment

A recent ICAO EUR PBN Task Force visit to Kazakhstan assessed the overall status of PBN implementation in the country. As this was primarily a technical assistance initiative, the Task Force team included representatives from ICAO, EUROCONTROL and Industry.

The Task Force assessed five main areas; PBN operational approval process, current airspace concept; instrument flight procedure design and process, current route structure, and existing PBN training. The Task Force provide a detailed list of recommendations that included:

- Establishment of a national PBN Implementation Team;
- A prioritized list of where PBN approach procedures should be implemented;
- Implementation of RNAV 5 (based on GNSS) for the whole en route airspace; and
- Development of regulations, procedures and processes to support PBN operational approval.

As a result of the visit, Kazakhstan now has a clear way forward for the development of a State PBN Implementation Plan, the necessary areas that need to be addressed by the plan and the priorities for PBN deployment to improve both safety and efficiency.

## New RNAV 2 Parallel Routes in Korea

A cost-benefit analysis has been conducted on newly implemented RNAV 2 parallel routes Y711 & Y722 to verify the benefit derived by implementing area navigation (RNAV) routes with 8NM lateral separation. The estimated benefit by the end of 2013 was determined to be:

- Airlines direct operating cost savings – USD 19.13 million
- Environmental benefit from reduced aircraft emission ($CO_2$ only) – USD 0.37 million
- Passenger value of time – USD 8.16 million
- Total estimated cost benefit – USD 27.66 million

The benefits are expected to increase as the traffic volume and the number of passengers is forecast to increase annually by 3.44 and 4.33%, respectively. Based on this trend, the estimated benefits from 2013 through 2022 are as follows:

- Airlines direct operating cost savings – USD 223.77 million
- Environmental benefit from reduced aircraft emission – USD 4.31 million
- Passenger value of time – USD 99.33 million

## Peru Benefits from PBN

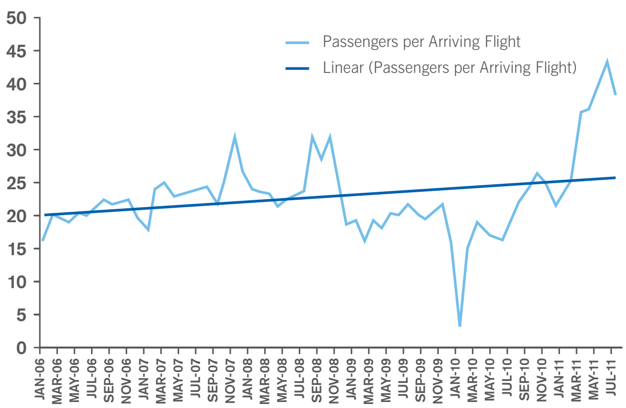
A seamless and fully PBN route (departure, en route, arrival and approach) between Cuzco and Lima, in Peru, is saving participating airlines, on average, 19 track miles. 6.3 minutes of flight time, 200 kg of fuel and 640 kg of $CO_2$ emissions per flight. Implemented in 2012, the PBN paths also enabled increased capacity at Lima's Jorge Chavez International Airport, while reducing the carbon footprint at Cuzco, the access point to the popular tourist destination of Machu Picchu.

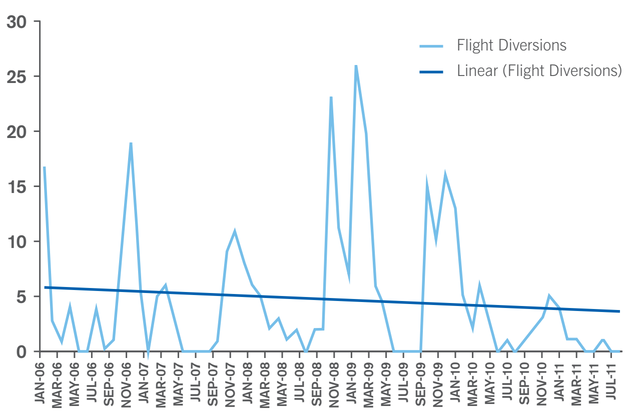
## Economic Benefits from PBN Implementation in South Africa

As a result of the implementation of two RNP approaches at Pietermaritzburg Airport in South Africa, the overall viability of this airport changed from a negative to a positive business situation, mainly because the RNP approaches increased airport accessibility and facilitated an improved and more reliable air service for the community. It also resulted in increased passenger utilization and development of new aviation-related enterprises. New jobs were created and the overall economic situation improved significantly.

Primarily because of the benefits of PBN, this airport has now become a thriving aviation activity that is contributing to the overall economic turnaround of the area.

### Figure 11: Passengers per Arriving Flight and Flight Diversions - Pietermaritzburg Airport



## PBN Implementation in the United States

The Greener Skies over Seattle Initiative, which involves expanding the use of Optimized Profile Descents, RNAV arrivals and RNP approaches into Seattle-Tacoma International Airport, is forecast to achieve significant benefits. Demonstration flights have already achieved fuel savings of between 90 and 180 kg per flight, with estimated annual fuel savings to be almost 6500 tonnes of fuel and reduced $CO_2$ emissions of over 22,000 tonnes. In addition, overflight noise exposure will be reduced for approximately 750,000 people living in the affected flight corridor.

At Dallas/Fort Worth International Airport, the application of PBN with the "RNAV off the ground procedure" enables a 15–20% increase in departures per hour through the reduction in separation between aircraft from 3 to 1 NM. As a result, American Airlines is saving USD 10–12 million annually using this procedure. In addition, pilot-controller communications have decreased by 40%, which significantly reduces the risk of miscommunication.

The Denver metroplex area (7 airports) now has a network of 51 PBN procedures designed to provide more direct routes, deconflict the airspace, save fuel and reduce emissions. The procedures are enhancing safety with more stabilized approaches that reduce the number of go-arounds by 35%. In addition, arrivals to Denver International are saving 100–200 pounds of fuel per flight which equates to an estimated annual reduction of 4.4–8.8 million pounds and 13.8–27.6 pounds of $CO_2$ emissions.

### *Next Steps*

The current rate of implementation, as highlighted by the success stories, provides validation of the importance of PBN in enhancing safety and improving operational efficiency. The reductions in fuel burn and environmental emissions (noise and $CO_2$ emissions), through the application of PBN, provide the necessary quantification and impetus for all States to implement PBN as soon as possible.

Initiatives by ICAO and partners such as assessments, workshops, GO Team visits, online training courses, FPP Offices and iKits have been valuable tools for States to utilize for PBN implementation. Significant progress has been made on a global basis. However, there are some regions and States where PBN implementation is lacking or even non-existent. These are the areas where ICAO and its partners must concentrate their efforts.

PBN is still a work in progress. Additional provisions, design criteria, guidance material and consolidation are required to simplify all aspects of implementation. ICAO must continue to lead these efforts with the assistance of States and organizations that provide the essential expertise to develop, refine and consolidate the PBN provisions.

Over the next triennium, ICAO will focus on five next steps:

- The need for guidance material, workshops and symposia.
- Computer-based learning packages.
- Formal training courses to ensure that PBN requirements and Standards are fully understood and properly implemented.
- Active, coordinated support for continuing Standards development and amendment.
- Support in order to ensure harmonized and integrated implementation of related technologies and support tools to optimize performance capability objectives.

# Continuous Descent Operations (CDO), Continuous Climb Operations (CCO)

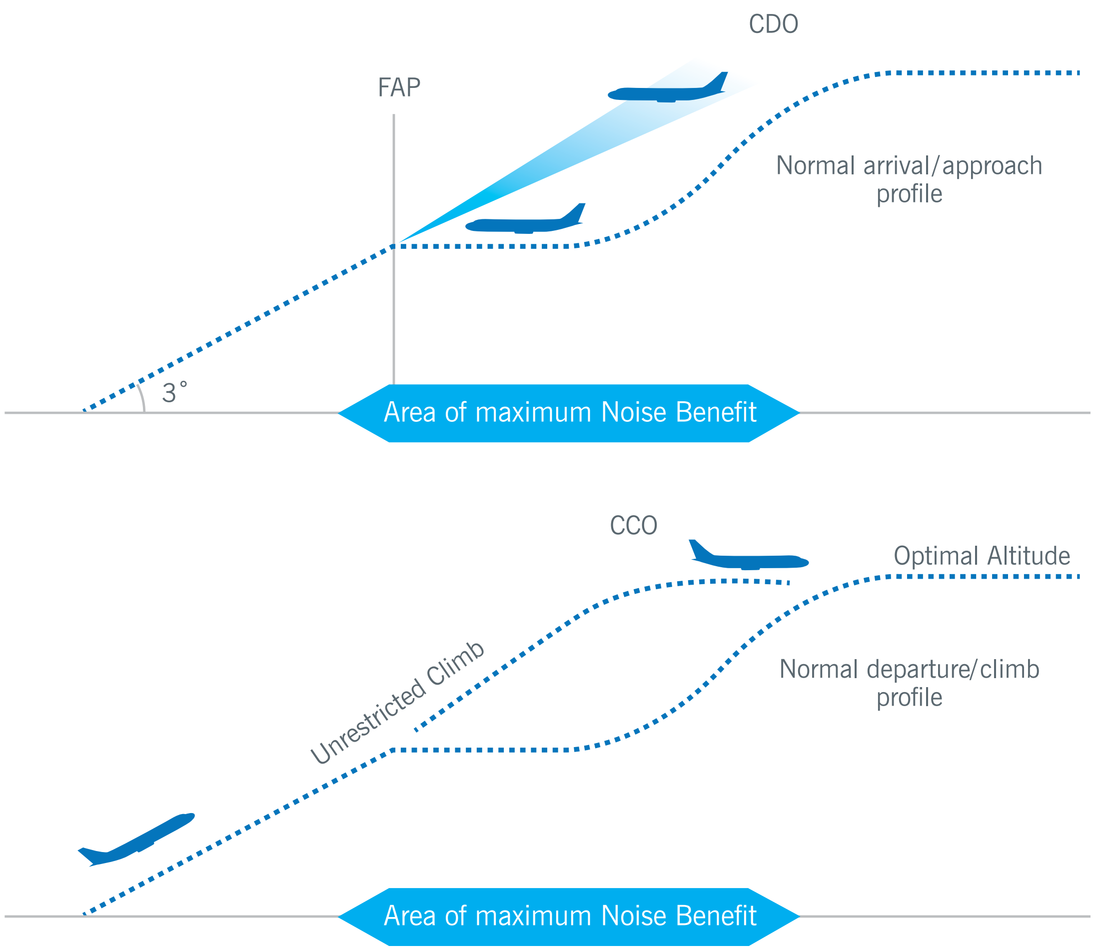
*Making the Terminal Area More Efficient*

Application of CCO and CDO has led to many operational efficiency benefits in the terminal area. The fact that aircraft can operate without altitude restrictions during departure or arrival phases and thus optimize their flight profile results in less noise exposure and reductions in fuel burn and greenhouse gas emissions. Today, many States have implemented variations of both CDO and CCO.

*CDO features optimized profile descents at minimum engine thrust settings, resulting in reduced fuel burn, greenhouse gas (GHG) emissions and noise levels. Performance-based Navigation or PBN functionality also ensures that the lateral path can be adjusted to avoid noise sensitive areas.*

*CCO enables aircraft to reach and maintain its optimum altitude/Flight Level, without interruption in the climb (level off). This results in reduced noise, fuel burn and GHG emissions, and optimizes the departure phase of flight. PBN functionality also allows for the lateral path to be adjusted to avoid noise sensitive areas.*

### Figure 12: CCO and CDO Concepts



*Selected CCO/CDO Success Stories*

*Examples of Environmental Benefits from CDO Implementation*

The implementation of Continuous Descent Operations (CDO) at various airports throughout the world is reaping significant benefits in fuel savings and reduction in greenhouse gas (GHG) emissions.

In Europe, detailed studies and flight tests have indicated significant savings are possible with the implementation of CDO. In Prague, benefits are estimated at 65–96 kg of fuel, and 200–300 kg of $CO_2$ emissions per flight (based on A319, A320 and A321 aircraft). This equates to a potential annual savings of 1,400 tons of fuel and 4,600 tons of $CO_2$ emissions.

In Dublin, Ireland, the implementation of an innovative point merge air traffic management system, a form of CDO, has provided savings of 5.5 million Euros to airlines during 2013. This technology has practically removed the need to place aircraft in holding patterns during busy arrival periods. An independent study concluded that airlines landing in Dublin in 2013 saved 127 kg of fuel (409 kg of $CO_2$) per flight and reduced their fuel requirement by 19.1%. As well, the length of the flight was reduced by 11 miles on average, a 17% savings.

In India, instrument flight procedures for Continuous Descent Operations (CDO) have been implemented at Ahmadabad and Mumbai airports. The annual savings in fuel, operating costs and environmental emissions for the Ahmadabad airport alone are shown in the table below:

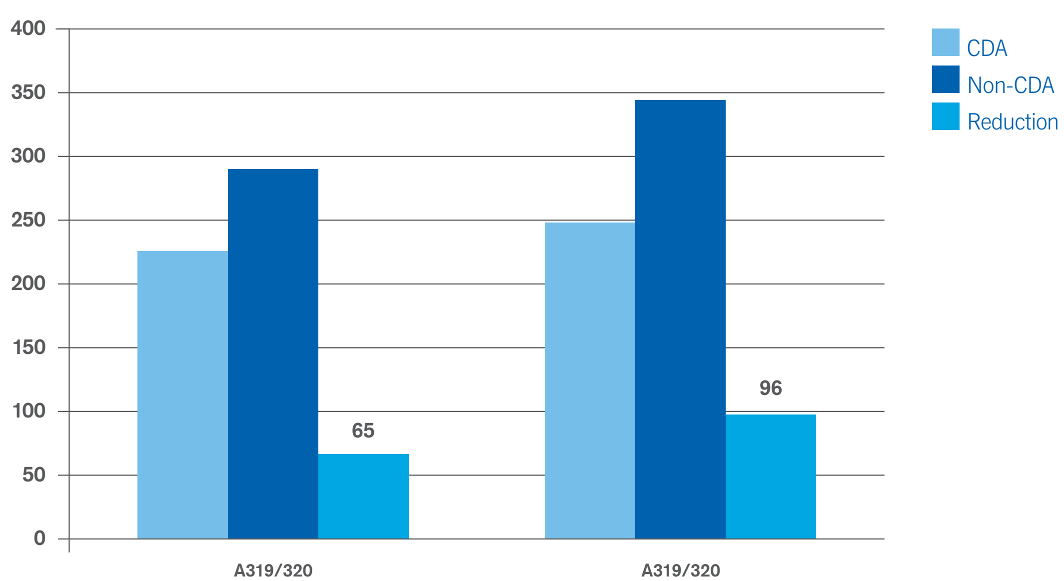
### Table 2: Annual Savings in Fuel, Costs and Environmental Emissions – Ahmadabad Airport

| | |
|---|---|
| Annual fuel savings | 1,164 Tonnes |
| Annual cost savings | 1.3 Million USD |
| Reduction in emission | 3,678 Tonnes |

(Based on Data for CDO operations at Ahmadabad)

In Korea, Point Merge CDO is averaging about 16% fuel savings/flight which equates to a reduced fuel consumption of 62.0 kg (200 kg of $CO_2$) per arrival at Incheon International Airport. As well, flight predictability was increased and ATCO workload was significantly reduced, which resulted in overall improved situational awareness and quality of service.

### Figure 13: Kgs of Fuel Saved per Flight – Prague



In the United States, CDO or continuous descent arrivals have been in development since 2002, and have been implemented in various locations such as Louisville, Atlanta, Los Angeles, Phoenix and Seattle. From the environmental perspective, there are significant reductions in noise from higher altitudes and lower thrust settings and emissions due to less fuel burn. As an example, Los Angeles CDO implementation is achieving an average fuel savings of 20–30 kg/flight and a $CO_2$ emissions reduction of 400–600 kg/flight.

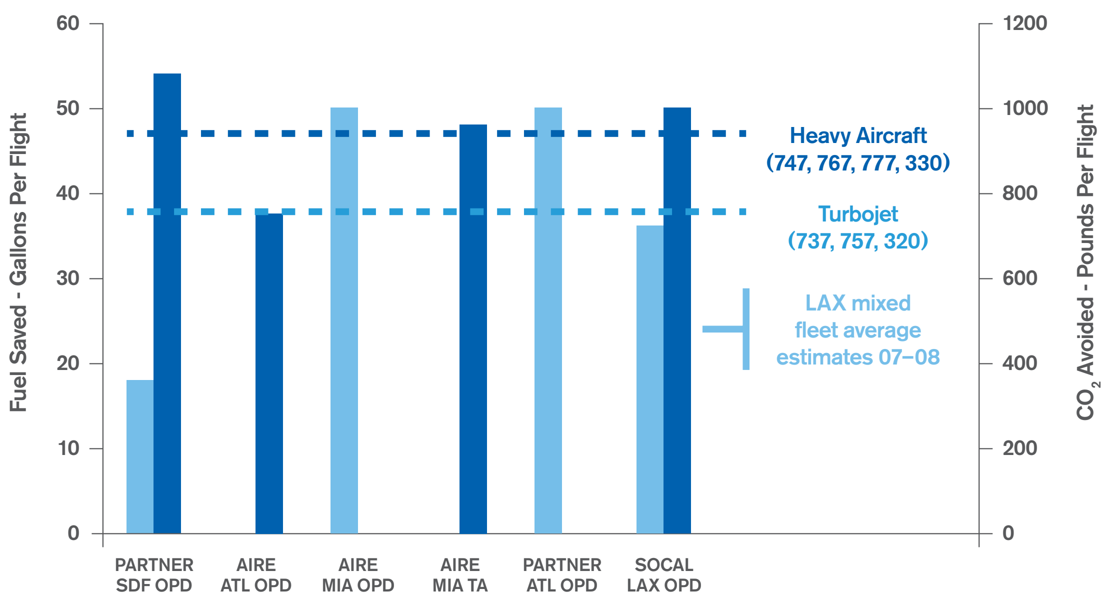
At Phoenix's Sky Harbor Airport, the FAA has converted four primary arrival routes into Optimized Profile Descents (OPD) which means the aircraft begin a smooth glide from high altitude airspace using minimal engine power instead of approaching the airport in the conventional, stair-step fashion. US Airways estimates it saves 500 lbs of fuel per OPD arrival which equates to an annual savings of USD 14.7 million and 51,000 tons of $CO_2$ emissions.

*Summary*

PBN has allowed for the implementation of CDO and CCO operations due to the flexibility it provides in the design of arrival and departure procedures. Through the deconfliction of these procedures, more constant descent and constant climb operations can be conducted leading to reduced fuel burn, $CO_2$ and noise emissions, and Pilot/ATCO workload.

As shown in the success stories, the benefits of these types of operations can be significant. Even so, the amount of global CCO/CDO implementation today is minimal. All States, in consultation with their stakeholders, should be assessing their terminal airspace operations to determine where CCO and CDO can be implemented using PBN, to improve operational efficiency and reduce environmental impact from aviation.

## Figure 14: CDO Fuel Savings - Los Angeles International Airport



# Air Traffic Flow Management (ATFM)

## *The Concept*

Air Traffic Flow Management is an enabler of air traffic management (ATM) efficiency and effectiveness. It contributes to the safety, efficiency, cost effectiveness, and environmental sustainability of an ATM system.

ATFM aims at enhancing safety by ensuring the delivery of safe densities of traffic and by minimizing traffic surges. Its purpose is to balance traffic demand and available capacity.

ATFM relies on the clear definition of capacities (i.e. number of flights that can be handled by an airport or an en route sector), as well as on the analysis of forecasted traffic flows (number of traffic flows that are expected in an airport or in an en route sector). ATFM therefore relies on the exchange of information related to flight plans, airspace availability and capacity. With ATFM, the various system stakeholders collaborate to reconcile system resource constraints with economic and environmental priorities.

ATFM solutions span from minor and limited aircraft speed variations to major ground delay programmes. ATFM is a scalable process that can be designed to overcome all type of hurdles, from local capacity shortages to major and systemic imbalances between demand and capacity.

## *ATFM: Global Status of Implementation*

Measuring the status of implementation of ATFM is not an easy task. In principle, the metric that provides an accurate depiction of the ATFM status of implementation is the *"% of FIRs within which all ACCs utilize ATFM measures"*. However, at the current stage, this type of data is not available worldwide. This edition of the report therefore simply indicates the presence of ATFM in the world and next editions will be updated with the indicated metric.

To date, ATFM is used in areas of traffic congestion. Europe and the United States form the geographical bulk of its use, but it is now also being used in several other States such as Australia, Brazil, Japan and South Africa. As traffic grows, an increasing number of States are moving towards its implementation. Although this is a positive development, it also generates another challenge. Because of their far reaching effects, ATFM actions need to be coordinated between States. ATFM systems therefore need to be compatible and interoperable. Ensuring a swift and coherent development of ATFM is one of the major challenges for the ATM industry in the coming years.

**Figure 15: ATFM Status of Implementation – "Where ATFM Exists"**

Based upon ICAO Regional Offices inputs

*Selected ATFM Success Stories*

## ATFM in Australia

A major issue for the aviation industry, particularly in the Asia Pacific region, is increasing air traffic demand in a relatively capacity-constrained environment. This challenge requires ensuring demand and capacity are aligned and the environmental impact of aviation operations is minimized. In 2010, Airservices Australia established two key programmes of work to address the challenges of demand and capacity.

The Airport Capacity Enhancement (ACE) programme was established to address issues of delay and congestion at Australia's busiest airports. This ACE programme is closely based on the European ACE (Airside Capacity Enhancement) model, which UK NATS has used at its busiest airports. The programme is conducted in close collaboration with airlines and airport operators. Airservices drew on the expertise of UK NATS to help support the Australian ACE programme, with NATS conducting an operational performance assessment for four of Australia's busiest airports (Sydney, Melbourne, Brisbane and Perth). Using these reports, Airservices has developed a series of initiatives to improve the capacity of each airport. This programme has so far delivered benefits at Melbourne and Perth, with a 5.3% and 3.3% increase in airport capacity, respectively.

Also in 2010, Airservices established the Collaborative Decision Making (CDM) programme. The CDM programme seeks to establish an overall CDM capability for Australia and comprises three broad stages:

1. Air Traffic Flow Management (ATFM) - tools and procedures to better identify and manage demand and capacity imbalances.

2. Airport Collaborative Decision Making (A-CDM).

3. Arrival and Departure Management.

In stage 1 of the CDM programme, Airservices replaced its previous Central Traffic Management System, which established ground delay programmes at Sydney and Perth airports, with an advanced ATFM application. Where arrival demand of flights exceeds the available airport arrival capacity, the system adjusts the departure times of flights to reduce airborne holding. Airline operators access the revised departure times using a direct interface, adjust and optimize their flights within the system, and then reschedule their flights as required.

Ground delay programmes are now operating for arrivals to Sydney, Perth and Brisbane airports, with Melbourne airport implementation in early 2014. This process has delivered benefits for arrivals to Sydney airport, with an 11% reduction in average airborne arrival delay.

The success of these programmes highlights the operational and environmental benefits that can be delivered through effective and collaborative management of demand and capacity.

## ATFM in Brazil

From 1985 to 1995, Brazil experienced an average traffic growth rate of 5% (up to 7.5% for cargo). During the same period, aircraft takeoffs and flown trajectories increased by some 3.7 and 5.8% respectively.

The Brazilian Air Navigation Management Center (CGNA) was created in 2005 to cope with the increase in the level of traffic and to meet the ever growing demand for capacity. The CGNA, part of the Air Force Command, is responsible for airspace management and the conduct of other activities related to air navigation.

With the establishment of the CGNA, Brazil decided to implement CDM based on the United States air traffic management concept. The Brazilian CDM now involves representatives from airlines, the National Civil Aviation Agency (ANAC) and airports. Their collective mission is to solve problems as they arise in any ATFM phase.

## ATFM in NAM and CAR Regions

The development of harmonized Air traffic Flow Management (ATFM) initiatives across North American (NAM) and Caribbean (CAR) States/Territories led to the successful and cost-effective implementation of ATFM during periods when demand for access to airspace and/or airports exceeded capacity. The work being done to harmonize demand and capacity balancing measures is a significant step in enhancing safety and efficiency, and increasing airspace capacity.

Collaboration between Air Navigation Services Providers (ANSPs) and users has been the key to success for ATFM within the ICAO NAM/CAR Regions.

The ATFM tools and procedures have improved operational capacity by increasing airspace throughput, reducing delays, increasing operational gate-to-gate predictability, improving safety, and reducing the environmental footprint of aerospace operations.

ANSPs and users collect and analyse operational and safety data to identify areas for tool development and enhancement. Tools are developed and modeled to support performance metrics.

On a tactical basis, the collaborative decision-making (CDM) process is the building block for ATFM initiatives. ANSPs and users conduct collaborative teleconferences in near-real time (every 2 hours) to develop, implement, and revise the tactical operations plan. This process includes identification of demand issues and system/facility level of constraint.

Through ATFM tools such as air traffic sequence metering, ground delay and airspace flow programmes (AFPs), a strategy is developed to address areas of compacted demand. This approach increases predictability of system operations, allows users to determine appropriate business decisions, enhances safety by reducing possible system overcapacity situations, and prevents impact from the "ripple" of delays through the system.

100% of NAM/CAR Flight Information Regions (FIRs) participate in periodic teleconferences thereby improving coordination of air traffic services (ATS) and aerodrome capacity. The ATFM strategy includes a regional operational concept and regional agreements that allow implementation of demand and capacity balancing measures to reduce airborne and ground delays, fuel burn and $CO_2$ gas emissions.

## ATFM in South Africa

In March 2007, the Air Traffic and Navigation Services (ATNS) decided on a new and complex centralized Air Traffic Flow Management system after determining that all the existing air traffic flow management options would not meet their required needs.

The system that was designed for ATNS allows tactical planning by tracking demand against available capacity. Pre-tactical conditions are integrated in a system that assesses demand and available capacity. The Central Airspace Management Unit (CAMU) uses the information to maximize the use of available capacity when airspace conflicts arise. CAMU's ATFM system is fully integrated into an advanced ATM system. It enables automated strategic, pre-tactical and tactical ATFM.

The South African ATFM service provides:

- Centralized management, allocation of available capacity and forward notice of abnormal capacity situations (e.g. extreme weather conditions);
- Tools to implement multiple delay programmes that limit cost implications to airspace users in abnormal capacity situations.
- Relief for air traffic controllers of a significant part of the workload, providing lower stress levels during control operations.
- Timely and accurate information to aircraft operators on any event affecting the flow of air traffic and capacity of the airspace, along with propositions of effective solutions to minimize delays or traffic rerouting.
- Improved capacity, increased sector productivity and reduced support costs.
- Improved information distribution and coordination with the ATC system and other users, resulting in improved "system-wide" decision-making.
- Expedited airport arrival, departure, taxiway and aircraft turnaround processes.
- Integration of all airspace users in ATM processes.

## ATFM in Thailand

From 2010 to 2013, the average traffic growth increased from 12 to 16% per annum. With the integration of the Association of Southeast Asia Nations (ASEAN) into the ASEAN Economic Community (AEC), it is expected that traffic will continue to increase at the same rate, placing intense pressure on the air navigation services infrastructure in Thailand. In this fast growing environment, Air Traffic Flow Management (ATFM) is becoming a crucial element of air navigation service provision.

ATFM operations in Thailand began in July 2007 with the development, implementation and operation of ATFM procedures for westbound aircraft through Afghanistan airspace during busy nighttime hours using the Bay of Bengal Collaborative ATFM system (BOBCAT). Aeronautical Radio of Thailand Ltd (AEROTHAI), Thailand's Air Navigation Service Provider (ANSP), operated the BOBCAT system on behalf of States, ANSPs and aircraft operators involved.

From its operational implementation in July 2007 to December 2013, and based on IATA estimates, the ATFM procedure contributed to a savings of 90 million kilograms of fuel, equating to some 360 million kilograms of carbon dioxide emissions and USD 90 million in airline operating costs. Other operational benefits include orderly traffic flow, flight operations predictability and workload optimization.

In addition to the operation of ATFM procedures using the BOBCAT system, Thailand, where aircraft movement is dominated by international traffic, reinforced its collaboration with regional and international aviation stakeholders to further develop CDM/ATFM. Recent developments include:

- Collaboration with States, ANSPs, airport operators, aircraft operators and aviation stakeholders to develop CDM information sharing and exchange.
- Collaboration with States and ANSPs, airport operators, aircraft operators and aviation stakeholders, under Asia-Pacific Economic Cooperation (APEC) Air Traffic Management Emissions Reduction Project, to evaluate economic and operational benefits of CDM/ATFM implementation and suggest pathways for implementation.
- Contribution in the European Union – ASEAN Air Transport Integration Project towards seamless ATM operations.
- Civil–Military collaboration towards the Flexible Use of Airspace concept to enhance airspace capacity.
- ATS system automation upgrade with operational implementation planned in 2015.

## ATFM in the United States

The Federal Aviation Administration is responsible for planning, directing, implementing, overseeing, and continuously monitoring all programmes related to air traffic control systems used by the FAA at the Air Traffic Control System Command Center (ATCSCC) and throughout the United States.

To increase efficiency in FAA-managed airspace during periods of increased holiday demand, the FAA worked in partnership with the U.S. Department of Defense for the release of special use airspace above 24,000 feet for use by commercial and private aviation. The added capacity has eased delays during one of the busiest travel periods of the year, saving time and money for passengers and airlines while reducing fuel burn. During the 2012 winter and 2013 Thanksgiving holiday seasons nearly 600 flights took advantage of this increased capacity.

The ATCSCC is the focal point for development and collaboration of daily Traffic Management Initiatives and Programmes to manage periods of high air traffic demand and areas of weather impacting air traffic routes, and airports. The ATCSCC coordinates these initiatives with the involved air traffic control facilities, and both commercial and private aviation customer groups. During 2013, the ATCSCC implemented the following:

**Ground Delay Programme** — a traffic management procedure in which flights are assigned departure delays to manage demand at their arrival airports, and to preclude extensive airborne holding delays while en route. During 2013, the ATCSCC implemented 932 GDPs.

**Airspace Flow Programme** — work from a real-time list of flights filed into a constrained en route area and distributes delays only to the affected flights to meter demand through impacted airspace. During 2013, the ATCSCC implemented 89 AFPs.

**Communication Hotlines** — allow involved air traffic control facilities and aviation customers to coordinate directly during specific airport or regional events. During the summer of 2013, the ATCSCC convened more than 140 such hotlines.

**Reroutes** — recommended and required reroutes off normal air traffic tracks are provided to manage unusual volume or avoid severe weather. During the summer of 2013, the ATCSCC issued more than 3,350 such reroutings.

These traffic management initiatives and programmes highlight the benefits that have resulted through collaboration with our aviation partners to increase efficiencies in FAA managed airspace.

*Next Steps*

With higher traffic levels there is a greater need for ATFM to maximize the efficiency of air navigation and to manage the strain that traffic growth places on ATM system.

The number and variety of examples presented above illustrate that States are generally well aware of the importance of ATFM, and are aware of the steps to take when the need for ATFM becomes evident. ICAO will continue supporting the development of ATFM worldwide to assist States in ensuring timely implementation of what is now recognized as a key enabler of traffic growth.

However, managing traffic flows has far reaching effect that extend well beyond traditional State borders. And as ATFM nodes appear around the world, it is essential to ensure they are interoperable and capable of communicating with one another.

While many efforts are currently being put into ATFM implementation, additional work may be needed, and further guidance at both the international and regional levels will have to be developed.

# Aeronautical Information Management (AIM)

*The Importance of the Transition Roadmap from AIS to AIM*

The current roadmap for transitioning from AIS to AIM is intended to serve as a strategic positioning initiative to facilitate the continuing improvement of aeronautical information services in terms of quality, timeliness and the identification of new services and products to better serve aeronautical users. It sets a baseline for establishing strategies and other initiatives to advance the AIM objectives globally and should place the future AIM in a position to better serve airspace users and ATM in terms of their information management requirements.

The transition roadmap has been developed with an intended implementation horizon of 2016. Consequently, the activities associated with the current roadmap fall short of a full AIM capability, but provide a path to digital provision of current AIS products and services. The articulation of a new roadmap is deemed necessary and should not represent a change in direction but serve as an extension to the existing roadmap. In this connection, the current roadmap serves as the evolutionary beginning of an eventual full transition to an AIM service that is fully integrated with other ATM services and functions.

With this in mind, the existing roadmap provides a fundamental pre-requisite for the ordered transition to an AIM environment. It supports and facilitates the generation and distribution of aeronautical information in digital form, provides a foundation for measuring performance and outcomes, assists States in implementation and uses an evolutionary approach building on the work of States, Organizations, and industry. The further development of the roadmap will be guided by the Global Air Navigation Plan and Global ATM Operational Concept.

*Consolidation Phase: Global Status of Implementation*

During Phase I of the transition to AIM, steps are taken to strengthen the solid base provided by existing Standards by enhancing the quality of the existing products. During this phase the foundation is formed, without which it is not possible to build the overall AIM Infrastructure.

Through the support of the ICAO Regional Offices, surveys have been conducted to acquire information on the transition status from AIS to AIM at a global level. The surveys highlight that an important number of States have made significant progress in the completion of the implementation of Phase I.

Below are the steps of Phase I which are essential to build the foundation for a future AIM infrastructure:

1. Compliance with step P-03 — AIRAC adherence monitoring;

2. Compliance with step P-17 — Quality;

3. Compliance with step P-05 — WGS84 implementation.

The surveys focus on these three milestones and all the results are related to the specific area of interest of each Regional Office.

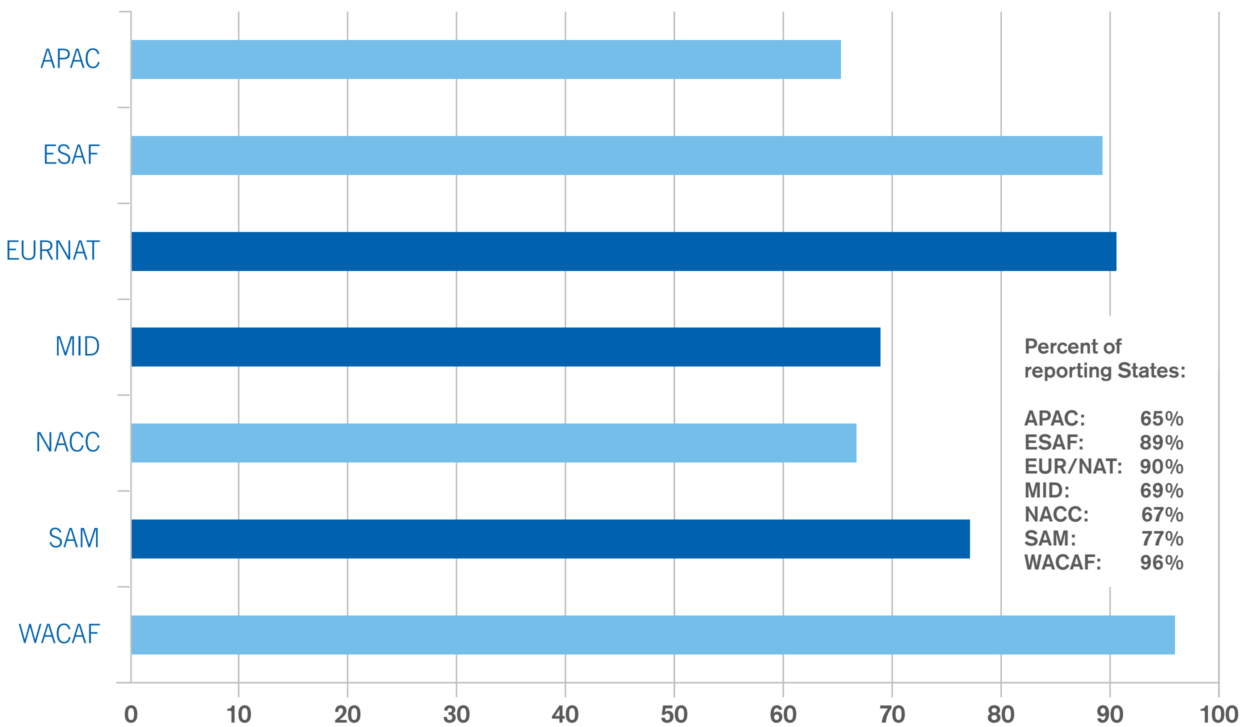
With regard to steps P-03 and P-17, States have been asked to report on their "full compliance" or "non-compliance.

Step P-05 has been surveyed with more accuracy. States fully recognize the importance of using a common horizontal and vertical reference frame to facilitate the exchange of data between different systems, to provide data that is useable by GNSS systems and to implement PBN; and they realize that the target of having 100% of coordinates in the WGS-84 reference system is achievable. The expression of all coordinates in the AIP and charts using WGS-84 requires significant effort and therefore those States that are "partially compliant" to step P-05 and still in progress with their transition have also been taken into account.

According to the information acquired from the three surveys, the EUR/NAT Region has made the most progress in the implementation of Phase I of the Transition Roadmap, with 90% of States being compliant with the three steps mentioned above. In Africa, several States have not completed all Phase 1 Steps. In the ESAF area, 89% of the reporting States have made significant progress, while in the WACAF area, 96% of the reporting States have taken steps forward. The MID region made interesting progress, with 69% of States compliant with steps P-03, P-05, and P-17. In the SAM region, 77% of States are compliant with the three steps of Phase I, while in the NACC region, 67% of the reporting States have progressed in implementation. Finally, the APAC region has declared 65% of the reporting States as compliant with the three steps.

## Figure 16: Consolidation Phase — Status of implementation

Based upon ICAO Regional Offices inputs



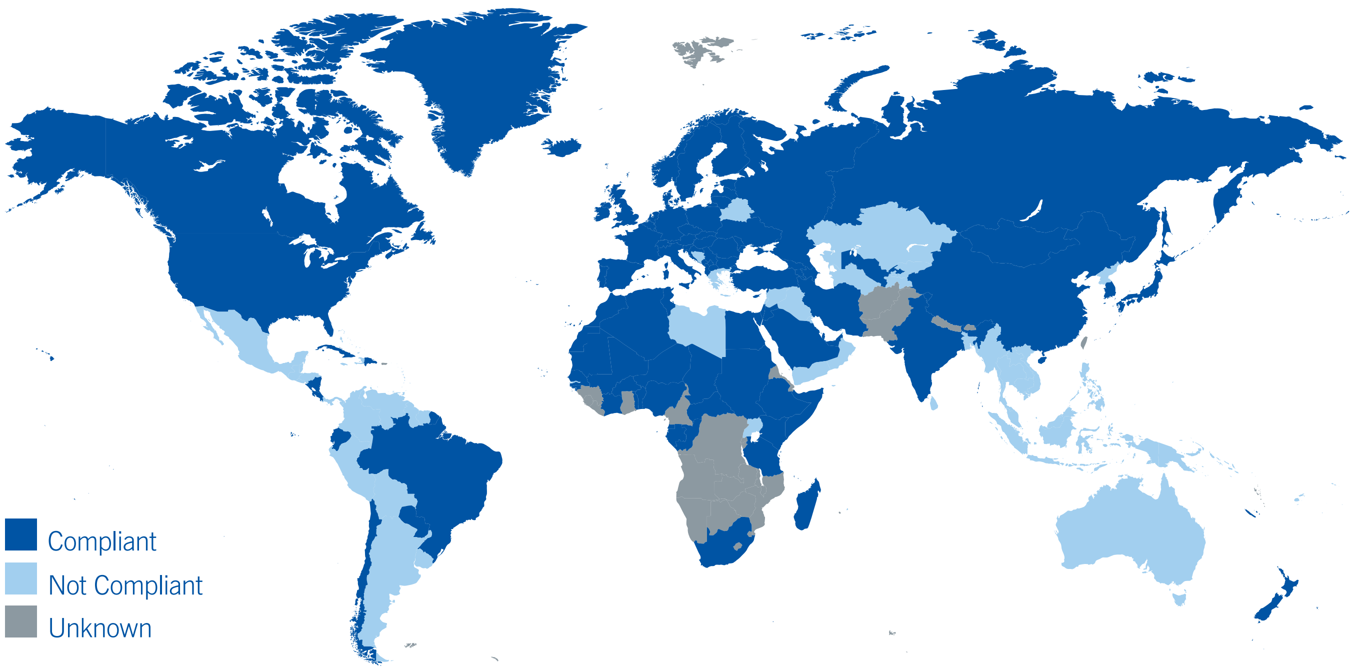
The three maps (Figure 17, 18, 19) show the status of phase 1 roadmap implementation for steps P-17, P-03, and P-05 by State.

A significant number of States confirm that they are encountering or expect to encounter some difficulties during the transition from AIS to AIM, such as financial constraints in terms of making the required investments, manpower expertise, institutional issues, implementation of data quality (including data integrity monitoring) according to ICAO provisions, awareness and commitment of data originators, etc.

### Figure 17: Status of Compliance with P-17 – Quality ("Consolidation Phase")

Based upon ICAO Regional Offices inputs

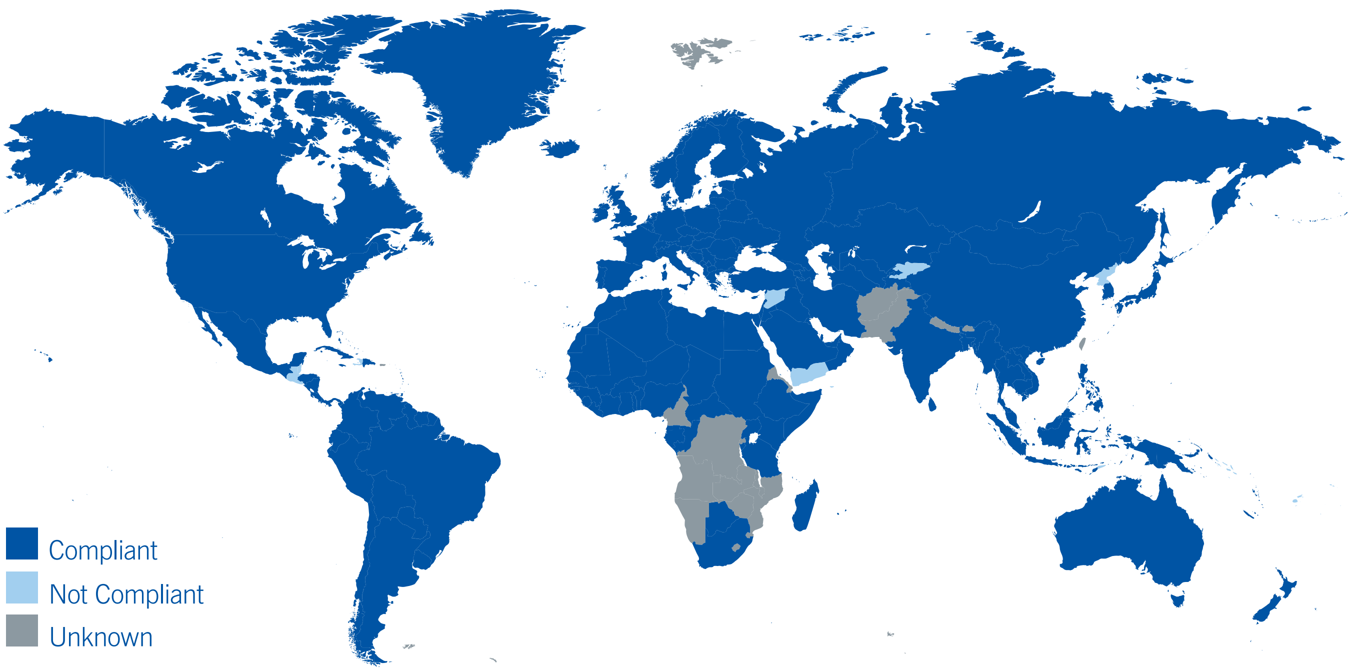
(See more on http://gis.icao.int/Appsilver/QUALITYP17/)



### Figure 18: Status of Compliance with P-03 – AIRAC Adherence Monitoring ("Consolidation Phase")

Based upon ICAO Regional Offices inputs

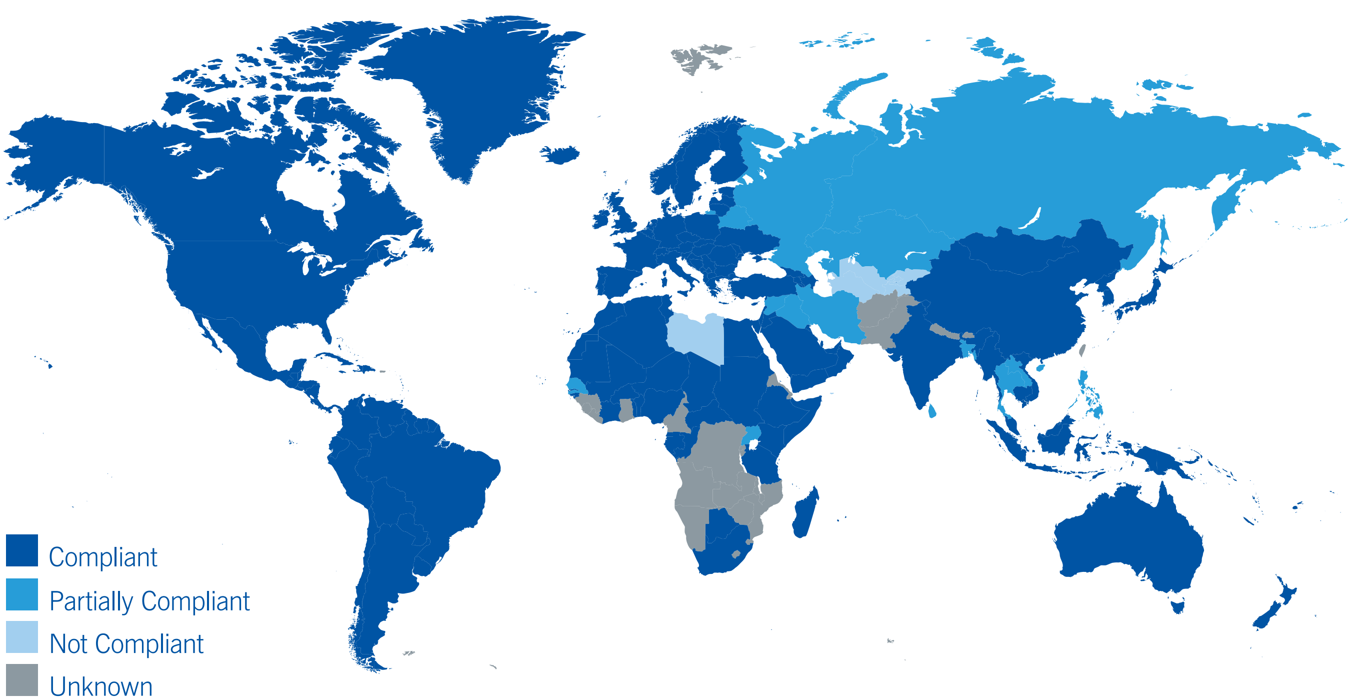
(See more on http://gis.icao.int/Appsilver/AIRACP03/)




### Figure 19: Status of Compliance with P-05 – WGS84 Implementation ("Consolidation Phase")

Based upon ICAO Regional Offices inputs

(See more on http://gis.icao.int/Appsilver/WGS84P05/)



*Selected AIM Success Stories*

## The Impact of the AIS/AIM Transition in Africa through the Implementation of the AFI/CAD Concept

The growing importance of aeronautical information is recognized throughout Africa. Yet just as in many other parts of the world, its quality and timeliness may not meet the ICAO Standards and Recommended Practices (SARPs) detailed in Annex 15.

At the First Global AIS Congress held in Madrid, Spain in 2006, it became apparent that all States find the implementation of this demanding set of requirements to be a challenge. As a consequence of that, the AFI Regional Study Group on the Establishment of a Centralized AFI Region AIS Data base (AFI CAD) was organized by the Regional Offices in Dakar and Nairobi.

In 2006, the ICAO Regional Office in Dakar, in collaboration with the IATA Regional Office in South Africa, organized the first meeting of AFI CAD which addressed the main objectives of providing guidance for the establishment of a Centralized AFI Region AIS Data base (similar to the European Aeronautical Data Base):

- Satisfy the requirements of the AFI Air Navigation Plan for the improvement of the overall speed, accuracy, efficiency and cost-effectiveness in the development of an integrated automated AIS System; and

- Obtain a general standardization of procedures, products and services to users, in order to avoid potential divergences, incompatibilities and duplication of efforts in the AFI Region.

The related studies were finalized in 2010, when the AFI CAD business plan was completed.

To engage in intra-regional and interregional cooperation for an expeditious transition from AIS to AIM in a harmonized manner, ASECNA is progressively developing a Regional AIS Database (in accordance with the AFI-CAD Concept) to accommodate all the States in the Western and Central African Region. In addition, South Africa has invited AFI States to join the South African Regional AIS Database as a means to further enhance the AIM implementation process within the AFI Region.

Currently, the AFI Planning and Implementation Regional Group (APIRG) has endorsed the possibility of AFI States migrating to the ASECNA Regional AIS Database as well as the possibility of migrating to the South African Regional AIS Database.

Finally, States in the AFI Region have endorsed the creation of a working group with specific terms of reference to implement ASECNA's development of a Regional AIS Database intended to accommodate all States in the WACAF Region and ATNS's development of a Regional AIS Database intended to accommodate AFI States wishing to enhance the AIM implementation process.

## COCESNA AIM Challenge

In Central America, COCESNA, an air navigation service provider serving six States since 1960, has developed an important project to integrate the aeronautical information in Central America in an electronic AIP (eAIP). The document is available on the website www.cocesna.org/ais.php. This important effort has made it possible to provide timely and useful information for stakeholders and civil aviation users.

The aeronautical information management (AIM) concept requires that all aeronautical information, including that currently held in AIPs, be stored as individual standardized data sets to be accessed by user applications. The distribution of aeronautical data sets will be defined by new services provided by the future AIM. This will constitute the future integrated aeronautical information package that will contain the minimum regulatory requirements to ensure the information flow necessary for safety, regularity and efficiency of international air navigation.

COCESNA already has a transition plan to AIM approved by the Central America Air Navigation Agency (ACNA) and forwarded to the ICAO NACC Regional Office.

Some of the steps that have been taken to advance the transition from AIS to AIM are listed below:

- Important progress has been achieved through the use of Geographic Information Systems (GIS) in the development of digital aeronautical charts of the Central American AIP;

- All AIM developments are supported in the use of the Aeronautical Information Exchange Model (AIXM) which has been tested and validated;

- COCESNA AIM has had a certified quality management process under ISO 9001–2008 since 2007.

The steps taken by COCESNA highlight the importance of facilitating the generation and distribution of aeronautical information, which serve to improve the safe and cost-effective accessibility of air traffic services worldwide.

## Aeronautical Data Quality: the European Experience from Improvement Activities to Regulation

Present and future improvements in navigation are dependent on aeronautical data and require access to aeronautical information of a significantly higher quality than is currently available. The improvement of aeronautical data quality and integrity to meet the levels required by International Civil Aviation Organization (ICAO) has been a longstanding issue.

To solve this issue, EUROCONTROL launched several consecutive activities — the AIS AHEAD programme and the Controlled and Harmonised Aeronautical Information Concept (CHAIN) — that aim to improve the accuracy and quality of aeronautical data and its management from the point of origination to publication as well as to subsequently improve the processes across the aeronautical data chain.

Objectives of activities were achieved through an increase in awareness of the stakeholders, the development of a suite of guidelines, and the provision of implementation support and training. The success achieved was further solidified by the promulgation of the European regulations on aeronautical data quality.

Regulation 73/2010, adopted by the European Commission, lays down requirements on the quality of aeronautical data and aeronautical information (ADQ) for the Single European Sky (SES). The ADQ supplements and strengthens the requirements of the ICAO's Annex 15 — *Aeronautical Information Services*. The overall concept behind ADQ is to provide quality data and to implement the essential requirements of the SES Interoperability Regulation with a particular focus on the use of a common dataset and transfer of data in a common digital format.

A number of specifications were required to support specific regulatory provisions and to provide all technical details necessary to comply with the regulation. Besides a number of standards already in place (e.g. ISO QMS), five additional specifications were required and the following were developed by EUROCONTROL:

1. Electronic AIP
2. Data Assurance Levels
3. Aeronautical Information Exchange
4. Data Quality Requirements
5. Data Origination

EUROCONTROL supports States in the implementation of the regulation through the "ADQ Implementation Support Cell", which acts as a focal point for stakeholders to access a range of activities and materials and to pose their questions and seek clarification. More information on this initiative can be found at: www.eurocontrol.int/adq.

### *Next Steps*

Shifting from a paper-based, manually transacted AIS to a digitally-based, network-enabled AIM will require more than providing an electronic AIS platform. The transition from AIS to AIM will change from the current focus on delivering products to delivering services and managing information in a way that can be used by a wider variety of aviation users. The current roadmap details the path to providing a digitally-based AIS system and is a critical step in moving towards a full AIM environment. The next phase will require the extension of the current roadmap to embrace a service-oriented focus with emphasis on building on the foundational elements introduced, particularly in phases 1 and 2 of the current roadmap. This will allow AIM to fully support a future system-wide information management (SWIM) network.

# Environmental Benefits

## Preliminary Estimate of Fuel and $CO_2$ Emissions Savings from Block 0 Implementation

*Background: Current System Efficiency and Analysis Objectives*

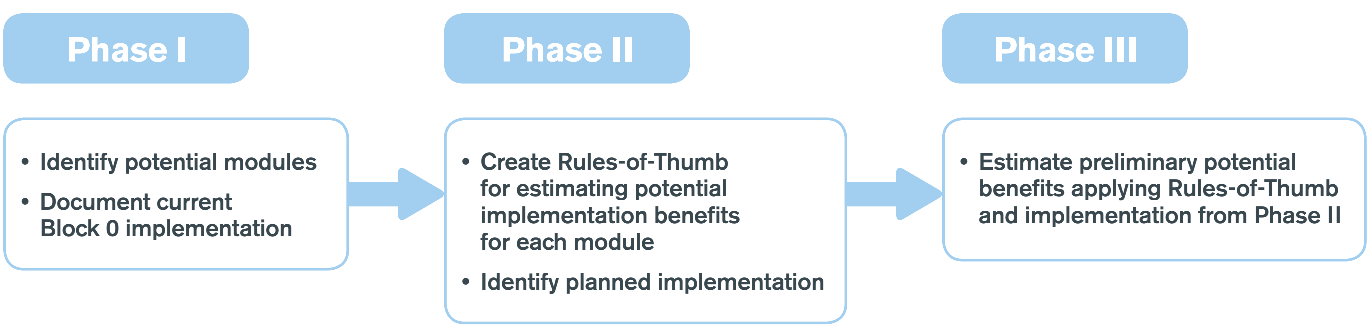
In 2010, the global Air Traffic Management (ATM) system was between 87% and 90% efficient[1]. On average, globally, each flight that operates consumes between 10% and 13% more fuel than it needs to. Over the next 20 years[2], the number of flights that the system will have to handle is expected to double. Imposing this growth in traffic on today's ATM system, with no improvements, would result in efficiency degrading at a rate of 2% per decade[1], which is believed to translate into a 1% degradation in ATM system efficiency every 5 years.

The driver behind many of the elements of ASBU Block 0 is increased system capacity as well as improved environmental efficiency, in order to accommodate the forecast global increase in air traffic. ICAO's Committee on Aviation Environmental Protection (CAEP) has undertaken a preliminary analysis to estimate the potential range of fuel and $CO_2$ savings that could be delivered by the planned implementation of Block 0 modules in the timeframe of 2013 to 2018. This preliminary analysis provides a high-level, conservative estimate of those benefits.

The preliminary ASBU analysis was carried out in three phases, as shown in Figure 20. First, all modules defined in Block 0 were evaluated to determine if they would be likely to deliver fuel savings; this list is shown in Table 3.

Then, rules-of-thumb were developed for the fuel savings associated with each of the modules. Information was also collected on the current and planned implementation of those modules. The rules-of-thumb were then applied, as appropriate, to estimate the fuel savings.

**Figure 20: ASBU Fuel and $CO_2$ Savings Analysis Approach**




1 *Report of the ICAO CAEP Independent Experts Operational Goals Group, Doc 10021*
2 *ICAO Global Air Transport Outlook to 2030 and trends to 2040, Circular 333, AT/190*

### Table 3: Block 0 Modules Included in this ASBU Analysis[3]

| Module | Title | Benefits |
|---|---|---|
| **B0-CDO** | Continuous Descent Operations | Reduced fuel burn on arrival |
| **B0-FRTO** | Free Route Operations | Reduced in-flight fuel burn |
| **B0-RSEQ** | Runway Sequencing | Reduced airborne holding and taxi-out time |
| **B0-CCO** | Continuous Climb Operations | Reduced fuel burn during climb |
| **B0-NOPS** | Network Operations | Reduced fuel burn in all phases of flight, including taxi |
| **B0-TBO** | Trajectory-based Operations | Reduced in-flight fuel burn |
| **B0-WAKE** | Wake Turbulence Separation | Reduced taxi-out time and reduced in-flight fuel burn |
| **B0-ACDM** | Airport Collaborative Decision-making | Reduced taxi-out time |
| **B0-ASUR** | Alternative Surveillance | Reduced in-flight fuel burn |
| **B0-OPFL** | Optimum Flight Levels | Reduced in-flight fuel burn |

*Preliminary Results*

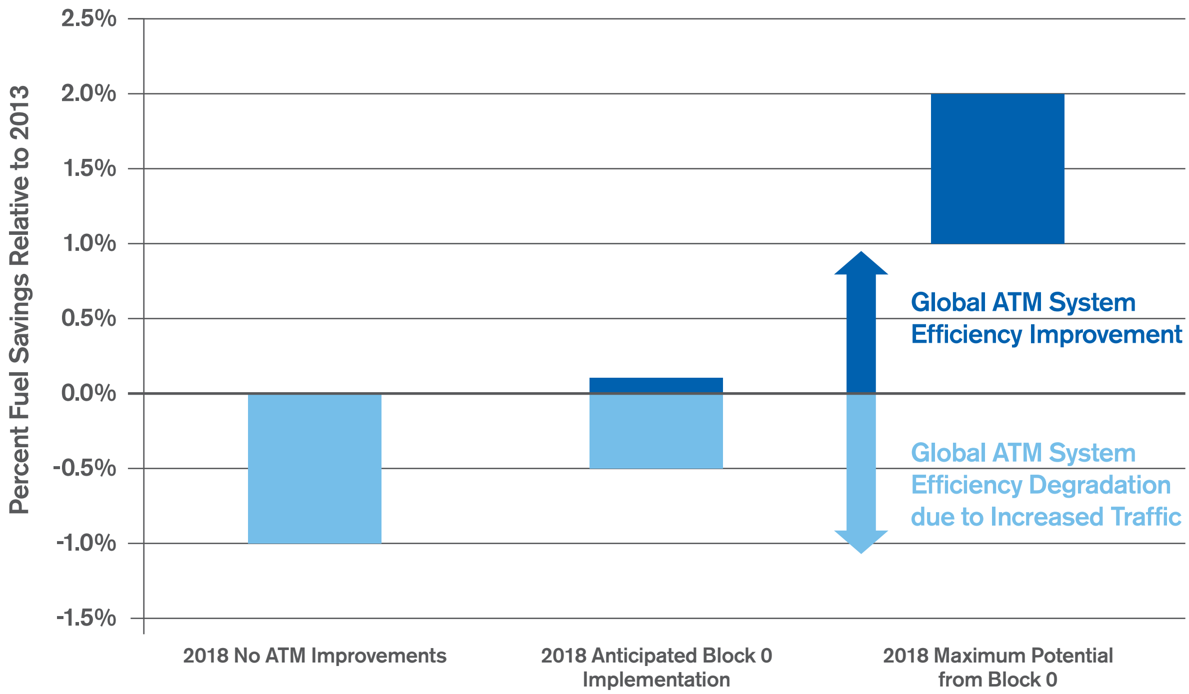
The preliminary analysis showed that the planned implementation of ASBU Block 0 modules by 2018 could result in between 2.3 and 4.1 million metric tonnes (Mt) of fuel being saved every year. This corresponds to between 7.3 to 12.9 Mt of $CO_2$ emissions. Fuel savings of this magnitude would save airspace users up to USD 4.0 billion (EUR 2.9 billion) in fuel costs annually[4]. This corresponds to a potential 0.5% to 1.1% reduction in overall fuel use and $CO_2$ emissions in the Block 0 timeframe.

The analysis also indicates that total fuel use and $CO_2$ emissions could be reduced by 2.0% to 3.0% if all of the Block 0 modules listed in Table 3 were implemented world-wide by 2018. These upper-bound benefits correspond to savings of 22.7 to 33.2 Mt of $CO_2$, or up to USD 10.1 billion (EUR 7.5 billion) in fuel costs annually. Figure 21 puts these results in context with the effects of the increased pressure on the global ATM system from the projected growth in traffic.

3 *The results presented in this article reflect a preliminary analysis of environmental benefits from the modules listed in this table. In addition, the following modules are also likely to deliver fuel and $CO_2$ emissions savings: B0-AMET (Meteorological information supporting enhanced operational efficiency and safety), B0-APTA (Optimization of Approach Procedures including vertical guidance), B0-DAIM (Service Improvement through Digital Aeronautical Information Management), B-FICE (Increased Interoperability, Efficiency and Capacity through Ground-Ground Integration) and B0-SURF (Safety and Efficiency of Surface Operations). A robust analysis of environmental benefits from all 15 of these modules is currently underway by CAEP, the results from which will be reported in a future edition of this report.*

4 *Based upon EUROCONTROL standard CBA inputs, IATA fuel price and USD/EUR exchange rate (30/09/2013)*

### Figure 21: Preliminary Global Fuel Savings from ASBU Block 0 Implementation




*Conclusion*

Taking into account an assumed efficiency degradation of 1% in the period 2013 to 2018, the current planned implementation of ASBU Block 0 modules may not prevent a net loss in ATM system efficiency. CAEP has estimated that this level of implementation combined with the projected growth in traffic will result in between a 0.5% total degradation in system efficiency to a 0.1% improvement. However, full global implementation of the studied ASBU Block 0 modules in the five years between 2013 and 2018 could enable a net gain in ATM efficiency of between 1.0 to 2.0%, even when considering the projected growth in air traffic and resultant pressure on the global ATM system.

## Estimated Fuel Savings/$CO_2$ Emissions Reduction Analyses (based on IFSET)

Operational measures are one of the instruments available to States to improve fuel efficiency and reduce $CO_2$ emissions. The ICAO Fuel Savings Estimation Tool (IFSET) has been developed by ICAO to assist the States to estimate fuel savings in a manner consistent with the models approved by ICAO's Committee on Aviation Environmental Protection (CAEP) and aligned with the Global Air Navigation Plan.

IFSET is not intended to replace the use of detailed measurement or modelling of fuel savings, where those capabilities exist. Rather, it is provided to assist those States without such facilities to estimate the benefits from operational improvements in a harmonized way.

### *How IFSET Works*

The ICAO Fuel Savings Estimation Tool has the ability to capture the difference in flight trajectory performance in terms of fuel consumption before and after implementation of operational improvements at the local, regional or global level.

Fuel savings can be enabled through the implementation of operational improvements in the general categories listed in Table 4.

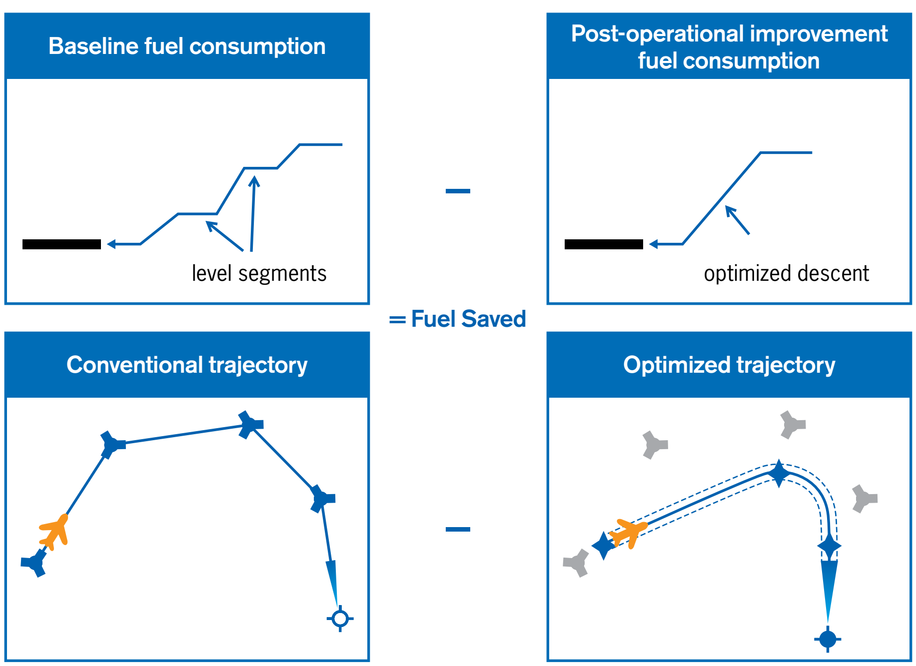
**Table 4: Operational Improvements to be Evaluated by IFSET**

| |
|---|
| • Reduced cruise distance or time |
| • Availability of optimal (preferred) altitude |
| • Reduced taxi time |
| • More efficient departure and approach/arrival procedures |

Simplifying assumptions are made regarding, inter alia, aircraft weight, aircraft centre of gravity (CG), engine thrust setting, meteorology, airframe/engine combinations, etc. As a result, the tool is not suitable for assessing the effects related to aircraft weight, thrust settings, or differences between aircraft/engine models.

The tool is intended to report differences in fuel consumption based on the comparison of two scenarios and therefore it is not appropriate to use the tool to compute the absolute fuel consumption for a specific procedure.

**Figure 22: Notional Illustration of Fuel Savings**



*Our Focus*

ICAO has performed specific fuel savings and $CO_2$ emissions reduction analyses in cooperation with the following agencies and airport authorities:

1. ASECNA – L'Agence pour la Sécurité de la Navigation aérienne en Afrique et à Madagascar, the agency for aerial navigation safety in Africa and Madagascar

2. COCESNA - Corporacion Centroamericana de Servicios de Navegación Aérea, the Central American Agency for Air Navigation Services

3. Airport Authority of India

The analyses have been conducted by computing the fuel consumed in two different scenarios. For each scenario, the number of operations by aircraft category was requested from the various service providers.

Also requested, where relevant, were:

- Time spent or distance flown at a specific altitude
- Top of descent altitude and bottom of descent altitude
- Base of climb altitude and top of climb altitude
- Distance flown in a climb or descent procedure

The analyses conducted in cooperation with ASECNA and COCESNA were performed using IFSET. The Airport Authority of India performed the assessment by using IFSET and other detailed measurement and modelling fuel savings applications.

*Operational Improvements and Fuel Savings*

## ASECNA

*Background*

The continued growth in air travel in the AFI Region creates an increasing demand on the air traffic management system of the Region.

Constant improvements to the air traffic management system are necessary to enhance efficiency while maintaining or improving levels of safety.

As part of the plan to improve the efficiency of the ATM system in the AFI Region, ASECNA, along with its eighteen member States, has undertaken several initiatives to redesign airspace and implement new operational concepts to increase capacity and reduce fuel consumption and carbon emissions.

In the Indian Ocean RNAV airspace was implemented between FL290 and 410 inclusive. The FIRs involved are Antananarivo, Beira, Johannesburg Oceanic, Mauritius and Melbourne FIR.

In the EUR/SAM corridor, Reduced Vertical Separation Minimum (RVSM), Required Navigation Performance 10 (RNP 10) and ADS were implemented. The FIRs involved are Canarias, Sal, Dakar Oceanic, Atlantic and Recife.

In the South Atlantic, implementation of RVSM and the Random RNAV Routing Area (AORRA) was realized.

In the continental airspace, the implementation of the red carpet routes, using the RNP 10 capability, allowed reduction in lateral separation between routes and more direct routes between city pairs located in Europe, Africa and South America.

The operational improvements mentioned above make possible more efficient flight through the use of optimum altitudes and shorter routes, also allowing them to take advantage of tailwinds that contribute to reduction in fuel consumption. The operational improvements were implemented throughout the period from 2005 to 2011 and savings were obtained through reduced fuel consumption.

*Provision of FIR Data*

To assess the reduction in fuel burn between 2005 and 2011, ASECNA provided ICAO with FIR traffic data covering level segments in the ASECNA airspace. With this data, fuel savings achieved during the 2005–2011 period were estimated using the ICAO Fuel Savings Estimation Tool (IFSET).

*Methodology*

The methodology adopted to arrive at the estimated fuel savings is detailed below:

- **Step 1** - Match aircraft types in the ASECNA FIR database to IFSET aircraft categories
- **Step 2** - Use IFSET and the time elapsed between Entry and Exit as indicated in the ASECNA FIR database to estimate fuel burn for each flight
- **Step 3** - Group flights by Origin, Destination and aircraft category, estimate the number of flights and the fuel burn for the years 2005 and 2011.
- **Step 4** - For the year 2011, estimate the fuel burn had the fuel burn per flight (for the same Origin, Destination and aircraft category) remained the same as in 2005.
- **Step 5** - Fuel savings are equal to the difference between the estimated fuel burn in 2011, as arrived at in Step 3, and the estimated fuel burn had the fuel burn per flight (for the same Origin, Destination and aircraft category) remained the same as in 2005 as arrived at in Step 4.

Combinations of origin, destination and aircraft category not existing in both 2005 and 2011 were excluded from the analysis.

*Savings in fuel and associated environmental benefits*

In total, there were 2,158 unique combinations of origin, destination and aircraft category representing 232,250 flights for the year 2011. These origin-destination pairs were available in both 2005 and 2011. In addition, based on the FIR data provided, ASECNA airspace handled more traffic with 92,316 additional movements in 2011 compared to 2005.

Using the methodology indicated, the analysis using IFSET indicates that on 149,018 flights, there was a decrease in fuel burn while on the remaining there was an increase.

### Table 5: ASECNA Fuel Consumption Calculations Results

| Year | Area | Fuel burn (mill Kg) | $CO_2$ emissions (mill Kg) |
|---|---|---|---|
| 2005 | EUR/SAM | 445 | 1,405 |
| | Continental/SAT | 981 | 3,097 |
| 2011 | EUR/SAM | 385 | 1,215 |
| | Continental/SAT | 897 | 2,832 |

| Operational Improvement | 2011 Movements | Area | Net Fuel Savings (mill Kg) | $CO_2$ Savings (mill Kg) | % Savings During 2005–2011 |
|---|---|---|---|---|---|
| RVSM/RNP 10 | 32,490 | EUR/SAM | 60 | 189 | 13.5% |
| RVSM/Red carpet routes (RNP 10), AORRA | 199,760 | Continental/SAT | 84 | 265 | 8.6% |
| **Total** | **232,250** | **All Areas** | **144** | **455** | **10.1%** |

The net benefits or savings in fuel burn is estimated at around 144 million Kg of fuel between 2005 and 2011 mostly through the shortening of level segments. Other reasons for the variance are changes in speeds and in fuel burn on account of differential altitudes between 2005 and 2011.

The resulting environmental benefits translate into a reduction of around 455 million Kg of $CO_2$ during the 2005 to 2011 period.

Table 5 summarizes the improvements made and the benefits achieved in terms of fuel savings and $CO_2$ reductions.

## COCESNA

*Background*

The States of Central America manage their upper airspace through the Central American Corporation for Air Navigation Services (COCESNA), whose member countries are: Guatemala, Belize, El Salvador, Honduras, Nicaragua and Costa Rica. COCESNA has the clear objective of promoting the adoption of technology, improving the air traffic management system and supporting the creation of regulatory frameworks.

The Central American FIR has experienced significant growth over the last two decades. This unprecedented growth in air traffic and the forecast for growth call for enhancement in safety, efficiency and increase of capacity. To address the optimum utilization of available airspace needed to meet the demand for airspace capacity, several operational measures have been put into place over the past years.

On 22 October 2009, a new RNAV route was implemented (route UZ30) and all the 18 RNAV 10 routes in the CENAMER FIR/UIR (COCESNA) became RNAV 5, which helped in the optimum use of the airspace.

Some of the States that are part of COCESNA made changes in their airspaces:

- El Salvador established improved arrival and departure flows that helped in the climb and descend part of the flight; this allowed more freedom in managing these phases of flight.
- In January 2009, four new RNAV/RNP 0.3 approach procedures, one RNAV Approach procedure, and six RNAV STAR procedures were established in Honduras.
- In addition, in January 2012, two GNSS RNAC V routes were implemented in Guatemala as part of the airspace reorganization.

*Provision of FIR Data*

To assess the reduction in fuel burn between 2007 and 2012, COCESNA provided ICAO with FIR traffic data covering different segments of the COCESNA airspace. This FIR data was used to generate the estimated fuel savings achieved during the 2007–2012 period using the ICAO Fuel Savings Estimation Tool (IFSET).

*Methodology*

The methodology adopted to arrive at the estimated fuel savings is detailed below:

- **Step 1** - Match aircraft types in the COCESNA FIR database to IFSET aircraft categories

- **Step 2** - Use IFSET and the time elapsed between Entry and Exit as indicated in the COCESNA FIR database to estimate fuel burn for each flight

- **Step 3** - Group flights by Origin, Destination, estimate the number of flights and the fuel burn for the years 2007 and 2012.

- **Step 4** - For the year 2012, estimate the fuel burn had the fuel burn per flight (for the same Origin, Destination) remained the same as in 2007.

- **Step 5** - Fuel savings are equal to the difference between the estimated fuel burn in 2012 as arrived at Step 3 and the estimated fuel burn had the fuel burn per flight (for the same Origin, Destination) remained the same as in 2007 as arrived at Step 4.

Combinations of origin and destination not available in both 2007 and 2012 were excluded from the analysis.

*Savings in Fuel and Associated Environmental Benefits*

Using the described methodology, it was seen that for comparable routes the fuel burn in 2007 was 223 million Kg as compared to 186 million Kg in 2012. This translated into a savings in fuel burn of around 37 million Kg (116 million Kg of $CO_2$) over the five-year period. On an annualized basis, the savings during the 2007–2012 period was around 3%.

The analysis showed that the main reason of fuel savings is a much more flexible use of the airspace in 2012 and also the ability to fly smaller and/or more fuel efficient aircraft relative to the route in 2012 compared to 2007. The ability of air traffic controllers to authorize aircrafts on shorter direct routes to their destination has proven to be effective. Other reasons for the variance are changes in speeds and in fuel burn due to differential altitudes between 2007 and 2012.

Aircraft have been flying more often at their optimum flight levels with the improvement of ACC Radar coverage over the years. An example is the Grand Cayman Islands where, after the installation of the Grand Cayman Islands radar, separation between aircraft at the same flight level was reduced to 5 NM.

In addition to the efficiencies achieved from the navigational and operational improvements indicated above, based on the FIR data provided, COCESNA airspace handled more traffic with over 35,000 additional movements in 2012 compared to 2007.

## India

*Background*

India has witnessed a tremendous growth in air traffic in the last decade and is poised to grow at a rate of 11% in the next five years. This significant growth has called for enhancements in safety and efficiency and increased capacity of airspace and airports in India.

Performance-based navigation procedures have been implemented at all major airports. India has implemented RNAV-1 SIDs and STARs in nine major airports and six more will be implemented by the end of 2013.

Air traffic between Metro cities has grown at tremendous pace resulting in airspace congestion, particularly at higher levels, and flights being cleared at non-economic levels.

To address the congestion, AAI implemented direct city-pair routes between Metro Airports, using its avionics and ground equipment capabilities. This has resulted in savings in flying time and fuel, as well as reducing carbon emissions.

Considering the inherent safety, operational efficiency in PBN procedures, AAI has developed a PBN implementation strategy in line with the ICAO regional PBN implementation plan. In addition to increasing operational efficiency, safety and capacity of airspace, the PBN procedures have resulted in significant fuel savings and reduction in carbon emissions. Upper airspace in Chennai FIR has been restructured with five upper ACC sectors and six lower ACCs. The main highlights of the project include operating multiple sectors of air traffic control from a single centre at Chennai covering the en route phase of the flights, integration of 10 radars, complete ATS automation with various advanced controller decision support tools and remote operation of VHF from Chennai. The integration of radars facilitates direct routing of flights thereby reducing flight distance/time and saving fuel for the airlines. The minimum distance between aircraft is reduced through application of radar separation minima, including in the en route phase, which helps increase capacity of airspace. Upper airspace harmonization of the Kolkata, Delhi and Mumbai FIRs is planned for execution in the near term.

Procedural design for continuous descent operations (CDO) permitting aircraft to descend continuously from the cruising level with minimum engine thrust has been implemented at Ahmadabad and Mumbai. By permitting continuous descent until touchdown, operational efficiency of the aircraft is considerably increased and fuel consumption is reduced.

AAI has also led an environmental initiative called INSPIRE (The Indian Ocean Strategic Partnership to Reduce Emission) which is a collaborative network of partners and organizations across the Indian Ocean and Arabian Sea Region dedicated to improving the efficiency and sustainability of aviation.

INSPIRE has identified User Preferred Routes (UPR) as one of the initiatives for reducing emissions in the en route phase of flight. Depending on the prevailing weather conditions at the time, UPR allows an airline to fly along what it judges to be the most efficient route for each type of aircraft used. The system helps to improve operational efficiency by providing each aircraft with an optimal flight path and shortening flight times and reducing carbon emissions. The Corporate Environmental Management Unit has been set up by AAI with the prime focus on noise, emissions, waste, water and wildlife management towards a green environment at all airports and airspace.

Other initiatives have been taken and measured; all the results of the assessment are shown in Table 6.

*Savings in Fuel and Associated Environmental Benefits*

All the consolidated estimated benefits associated with the major initiatives and operational improvements have been measured through the ICAO Fuel Savings Estimation Tool (IFSET) together with other detailed measurement and modelling fuel savings applications. Table 6 shows the results of the computation.

## Table 6: Consolidated Estimated Benefits from the Major Initiatives

| ANS improvements | Fuel Saving (per year in tonnes) | Carbon Emission Reduction (per year in tonnes) | Cost Savings (per year in Million $) | Remarks |
|---|---|---|---|---|
| 50 NM RHS | 104,573 | 330,449 | 114.98 | 16 routes |
| RNAV 5 | 14,637 | 46,251 | 16.06 | Q1 to Q13 |
| NEW DOMESTIC ROUTES | 9,889 | 31,248 | 10.95 | 8 routes |
| RNP 10 | 11,662 | 36,851 | 12.78 | L875,756,516,899,518 |
| THREE RWY OPS | 13,140 | 41,480 | 1.30 | Delhi |
| UPPER AIRSPACE HARMONIZATION | 18,060 | 57,060 | 19.90 | Chennai FIR |
| INSPIRE | 218 | 688 | 0.20 | Based on 1031 UPR flights |
| PBN | 22,836 | 72,162 | 25.11 | Based on 6 Airports |
| ENHANCED SURVEILLANCE | 14,500 | 45,800 | 16.00 | RHS on W20 and R460 |
| CDO | 1,164 | 3,678 | 1.30 | Based at Ahmadabad ops |
| CONNECTOR Routes | 4,095 | 12,941 | 3.65 | V1 to V32 |
| **TOTAL** | **213,610** | **674,242** | **222** | |

*Conclusions*

Understanding and quantifying the benefits from operational improvements is important in order to monitor whether the improvement measures already implemented are meeting their objectives in terms of fuel burn and emissions reduction. It is also important to understand the potential benefits from planned improvements (for example, through the development of business cases) in order to justify decision-making that could result in the planned improvements actually being implemented.

In this regard, IFSET provides a robust platform for estimating the incremental fuel burns and has demonstrated its capability of providing a reasonable estimate of changes in fuel consumption in a manner comparable to that of more sophisticated approaches.

The next steps call for encouraging the use of IFSET, or other similar tool, for the necessary estimation of environmental benefits in order to support a coordinated global effort towards reduction of the aviation impact on climate change.

# Success Stories

## Implementation of 80 PBN-based User Preferred Trajectories in the AFI Region

In 2010, the AFI Planning and Implementation Regional Group (APIRG) established a Performance-based Navigation Route Network Development Working Group (PRND) under the coordination of the ICAO Regional Offices, to undertake a comprehensive review and update of the AFI ATS route network. The goal was to create a more efficient regional network using PBN and remove the existing inefficiencies that are inherent with a predominately ground-based navigation route system.

The membership of the PRND included States, air navigation services providers and users' representatives. The related work was based on the airspace users' statement of preferred trajectories in the AFI Region.

Despite a number of implementation challenges, PBN has gained considerable importance and familiarity with all States and ANSPs in the region. Between 2010 and 2013, more than 80 ATS route trajectories based on PBN were agreed to (between States/Users/ICAO) through facilitation by the IATA Route Labs, iFLEX initiatives, ATM Coordination Meetings and other complementary initiatives. Close to 80% of the trajectories have been implemented. In August 2013, six new RNAV 10 routes were implemented to support the re-delineation of the Khartoum Flight Information Region between Sudan and South Sudan, resulting in a more direct and efficient route structure for airspace users.

The PRND also agreed on 76 new trajectories totalling about 94,000 nautical miles, with each trajectory reducing route distance by several nautical miles. In addition, the PRND targeted trajectories which were over four hours long, in order to provide for much needed flexibility in routing and to take advantage of favourable winds on long distances across the AFI Region.

The Working Group also agreed to implement immediately an additional 23 ATS routes pending formal processing and approval. These routes include seven transitional oceanic routes connecting Beira FIR.

To support all of the above ATS routes and the recent re-organization of Mozambique airspace, over two hundred and 80 five-letter name codes (5LNCs) were allocated and validated by the ICAO ESAF Regional Office.

The potential benefits to be generated are still under review with the users (IATA); however, in 2012, potential annual savings for only one airline was estimated to be 2,150 million tonnes of $CO_2$, based on twice daily service over the Atlantic Ocean.

States will continue to be guided by the Regional PBN Implementation Plan adopted by the APIRG, as updated and aligned with the ICAO Aviation System Block Upgrades (ASBUs).

## Asia and South Pacific Initiative to Reduce Emissions (ASPIRE Project)

The Asia and Pacific Initiative to Reduce Emissions (ASPIRE) is a partnership of air navigation service providers focused on environmental stewardship in the region. The ASPIRE partnership was initiated by the signing of the ASPIRE Joint Statement of Purpose by Airservices Australia, Airways New Zealand and the Federal Aviation Administration at the Singapore Airshow in February 2008. The partnership has since grown to include the Civil Aviation Bureau, Japan (JCAB), the Civil Aviation Authority of Singapore (CAAS), and Aeronautical Radio of Thailand Limited (AEROTHAI).

The ASPIRE Partners have conducted a series of five gate to-gate "ASPIRE Green Flights" successfully demonstrating the potential for fuel and emissions savings. Although the green flights represented the best-case or ideal scenario due to the removal of controllable constraints — a practice not feasible in daily operations — most of the procedures used are available on a daily operational basis for a variety of city-pair routes throughout the Asia Pacific Region. In 2010, the ASPIRE Partners agreed to a proposal for the ASPIRE Daily program, identifying city-pair routes where key elements of the ASPIRE best practices are utilized.

ASPIRE Daily Best Practices are procedures and services that a) have proven fuel and emissions savings and b) are available on a daily basis to participating, equipped flights either by pilot request (e.g. DARP), or with no action required by the flight crew (e.g. Reduced Oceanic Separation).

The ASPIRE Daily Best Practices include:

1. **User-Preferred Routes (UPRs):** UPRs are directly attributable to the implementation of ground and airborne improvements such as automated conflict prediction, conformance monitoring and automatic dependent surveillance (ADS).

2. **Dynamic Airborne Reroute Procedure (DARP):** DARP allows aircraft operators to calculate revised profiles from the aircraft's present position to any subsequent point in the cleared route of flight in order to realize savings in fuel or time.

3. **30/30 Reduced Oceanic Separation:** Qualified aircraft are given increased access to optimum flight profiles through separation reductions.

4. **Time-based Arrivals Management:** By reducing arrival congestion, there is less need for inefficient fuel techniques such as low altitude vectoring and aircraft holding.

5. **Arrivals Optimization:** Minimizes fuel burn for the arrival segment by enabling each jet to fly the optimum track to Top of Descent (TOD) and Optimized Profile Descent (OPD) from TOD to a 6 mile final for the landing runway.

6. **Departure Optimization:** Minimizes fuel burn for the departure segment by enabling each jet to fly the optimum profile to the Top of Climb (TOC).

7. **Surface Movement Optimization:** Reduced quantities of fuel burned and emissions during the surface movement phase of flight.

An example of ASPIRE Green Flight is the one between Tokyo (Haneda) and San Francisco (flight number JAL2), which is operated by Japan Airlines (JAL).

According to JAL estimates, 200 lbs per flight of fuel savings can be expected through the utilization of UPR by JAL2 and 1,000 lbs per flight through Tailored Arrivals. Furthermore, an additional 70 lbs per flight can be saved by applying 30/30 to JAL2 with RNP 4, compared to existing 50/50 with RNP 10 based on the estimation by a Japanese research institute.

In total, it is estimated that JAL2 can save more than 212,000 lbs per year utilizing these best practices.

This means that the JAL2 flight alone, a one-way flight from Tokyo to San Francisco in low density traffic, can contribute to savings of about 300,000 kg in $CO_2$ emissions per year.

## Collaborative Environmental Initiative (INSPIRE Project)

The environmental initiative INSPIRE (The Indian Ocean Strategic Partnership to Reduce Emission) has identified User Preferred Routes (UPR) as one of the initiatives for reducing emissions in the en route phase of flight. Depending on the prevailing weather conditions at the time, UPR allows an airline to fly along what it judges to be the most efficient route for each type of aircraft used. The system helps to improve operational efficiency by providing each aircraft with an optimal flight path and shortening flight times and reducing carbon emissions.

The Corporate Environmental Management Unit has been set up by AAI with a prime focus on noise, emissions, waste, water and wildlife management towards a green environment at all airports and airspace.

| INSPIRE | |
|---|---|
| Fuel savings | 218 Tonnes |
| Cost savings | 0.2 Million USD |
| Carbon Emission reduction | 688 Tonnes |

(Based on Data for 1031City-Pair flight ops till Feb 13)

## ATS Interfacility Data Communication (AIDC) Implementation in the Caribbean and North American Regions

A communications and data interchange infrastructure significantly reduces the need for verbal coordination between Air Traffic Service Units (ATSUs). ATS Inter-facility Data Communications (AIDC), or similar automation provides the means by which automated data exchange can be harmonized between ATS units within a region.

The impetus of the automation requirement stems from the increasing traffic levels transiting between member State Flight Information Regions (FIRs). The North American and Caribbean Regional Performance-Based Air Navigation Implementation Plan (RPBANIP) has encouraged States and Air Navigation Service Providers (ANSPs) to implement data communication between ATS providers as a means to improve safety and efficiency.

The increasing traffic demand between FIRs prompts the need to improve efficiency and accuracy for ATC providers. Developing a harmonized process and defining protocols for exchanging data between multiple States, Territories and International Organizations within and across regions is critical to achieving this objective. As ATS providers develop their automation systems, consideration should be given to meeting the capabilities identified within an interface specification such as an Interface Control Document (ICD). The ICD for Data Communications between ATS Units in the Caribbean and South American Regions (CAR/SAM ICD) was developed by ICAO.

The NAM ICD members have realized automation gains that provide significant safety and efficiency benefits. An example of implementation is the Miami automation interface with the Havana Area Control Center (ACC), where an estimated 50% reduction in air traffic controller (ATCO) workload has been achieved by ATCOs working the border sectors at the Miami Center. Additional benefits include:

a. Reduced readback/hearback errors during coordination;

b. Reduced “controller to controller” coordination errors and language barrier issues; and,

c. Increased support for performance-based navigation initiatives and emerging technologies through automation.

The North American automated flight data message set found in the NAM ICD is used operationally between Canada and United States; Mexico and United States; Cuba and United States; and in the near term is scheduled between Cuba and Mexico. One of the strengths of the NAM message set is the scalability of the functionality.

The NAM ICD allows an automated interface to be constructed with a minimum of 2 messages, known as Class 1, which consists of the Current Flight Plan (CPL) message and the Logical Acknowledgement Message (LAM).

Currently, Class 2 interfaces exist between the Canadian ACCs of Vancouver, Edmonton, Winnipeg, Toronto, and Moncton, employing cross-border interfaces with corresponding the United States FAA Air Route Traffic Control Centers (ARTCCs) in Seattle, Salt Lake City, Minneapolis, Cleveland, Boston, and Anchorage. Class 1 is used between Houston, Albuquerque and Los Angeles ARTCCs and Mexico’s Merida, Monterrey, and Mazatlan ACCs, and for interface between Miami ARTCC and Havana ACC. Both the NAM and the traditional AIDC messaging were updated to reflect ICAO Flight Plan 2012.

## Philippines FIR Business Case

A comparison of the benefits achieved between the “business as usual” case and the implementation of ASBU Block 0 across in the Philippines provides an illustration of the net benefits of the ICAO model.

In the current situation, the four busiest airports in the Philippines — *Ninoy Aquino International (NAIA)(Manila), Mactan-Cebu International, Francisco Bangoy (Davao) and Diosdado Macapagal (Clark)* — handle nearly 28 million passengers per year. 90% of these passengers pass through NAIA (75%) and Mactan-Cebu (15%) airports; 50% of these passengers are domestic.

The analysis has been completed but has yet to be shared with relevant stakeholders to verify the assumptions and accuracy of the output.

The economic benefits of implementing the ASBU Block 0 to NAIA airport are related to fuel savings and the opportunity cost of delay to passengers. The fuel savings achieved by implementing ASBU Block 0 are 19,512,700 kg in Taxi out Phase and 41,482,980 kg in TMA Phase for a total fuel savings of 60,995,680 kg (59,9 M$); while the opportunity cost of delay to passengers (based on low scenario) is 14,2 M$ in Taxi out phase and 11 M$ in TMA/Arrival phase.

The total benefit of implementing ASBU Block 0 to the users of NAIA is evaluated at 85,2 M$ per annum.

## UAE Experience in Use of Flexible Use of Airspace (FUA)

The Emirates UAE FIR has witnessed a tremendous growth in air traffic in the last decade and is poised to grow at a rate of 7% in the next five years, which is much higher than the world average. This unprecedented growth in air traffic in the last decade and the growth forecast call for enhancement in safety, efficiency and increase of capacity of airspace and airports in UAE.

Currently 53% of the UAE airspace is controlled by the military. Around 10% of all air traffic is military controlled.

In order to help facilitate the large predicted increase in traffic density over the next decade, further coordination with the military is required for extended use of Flexible Use of Airspace. This will continue to provide additional airspace capacity as well as save both time and fuel for air traffic.

The Emirates UAE has embarked on an ANS improvement strategy with the objective of ensuring safety, efficiency and cost-effectiveness of aircraft operations with environmental benefits on a long-term and sustainable basis.

The following blocks of UAE airspace has been defined for the use of both Military and Civil air traffic:

**Airspace OMR 50**[1]
The introduction of flexible use of this block of airspace enables commercial airlines to take a shorter route to, for example, the Far East. One route passes through this area.

**Airspace OMR 51**[1]
The introduction of flexible use of this block of airspace enables commercial airlines to take a shorter route to, for example, the Far East. Two routes pass through this area.

**Airspace OMR 54 (Empty Quarter)**[2]
The introduction of a permanent route through this block of airspace controlled by the military allows commercial airlines (special permission required) with RNAV 1 equipage to take a shorter route to destinations in Africa and South America thus saving time, fuel and reduction of emissions. Two routes pass though this area.

**Airspace OMR 90**[2]
The introduction of flexible use of this block of airspace enables commercial airlines to take a shorter route to Africa and South America, for example. One route passes through this area.

- The UAE Military is an important member of the National Airspace Advisory Committee (NASAC).
- A permanent Military Liaison Officer available in the Sheikh Zayed Air Navigation Centre (SZC).
- The Military has full access to the operational system.

*Benefits*

Benefits from the introduction of dedicated civil routes through OMR 54 (see Table 7 below).

A total of 1,225 flights passed through M318 during October 2013.

Air traffic through the UAE FIR has grown by 9.3% from 2008 to 2009, 11.1% from 2009 to 2010 and 7.6% by 2010 to 2011.

## RNAV/Airspace Improvements Results in Increased Capacity (UAE)

Since the establishment of the Emirates Flight Information Region (FIR) in 1986, all traffic departing and overflying the Emirates FIR towards the Bahrain FIR have operated via one Air Traffic Services (ATS) route. The rapid expansion of aviation in the region, particularly in the UAE with the rapid growth of the airline operators, required the implementation of key airspace enhancement initiatives.

One of the key goals was to reduce the inefficiency of air traffic services in the area. Continuous delays and complaints from the airspace users resulted in an ATS route change in relation to the UAE / Bahrain FIR boundaries. Increasing capacity towards the west was achieved through a well-coordinated project with key goals implemented in phases:

**Phase 1 (August 2012)** included the establishment of new Standard Instrument Departures (SIDs) for traffic departing the Northern Emirates. These SIDs were linked to the Emirates FIR ATS route structure at three points, as opposed to the previous single exit point. This allowed for a 20% gain in capacity as in-trail spacing was reduced from 10 NM to 8 NM.

### Table 7: Fuel Savings

| | OMAA (Abu Dhabi) | OMDB (Dubai) | OMSJ (Sharjah) |
|---|---|---|---|
| Previous route via TANSU (G783) | 367 NM | 415 NM | 413 NM |
| M318 through OMR 54 | 292 NM | 355 NM | 363 NM |
| Saving – Distance | 75 NM | 60 NM | 50 NM |
| Saving – Distance (%) | 20% | 14% | 12% |

[1] *FUA Level 2, GCAA, civil and military stakeholders, established in 2010.*
[2] *FUA Level 1, GCAA, civil and military stakeholders, established in 2008.*

**Phase 2 (December 2012)** included the creation of an additional Air Traffic Control (ATC) Sector within the airspace. As a result, a 55% increase in capacity was immediately achieved which allowed for a combined total in excess of 110 aircraft per hour. This was most evident when comparing the 21.47 hours of westbound delay during a three-month period in 2012 to the 25 minutes delay in 2013. This was a remarkable achievement considering the fact that traffic increased by 7.6% during the same period of the year.

**Phase 3 (May 2013)** saw the extension of the three new ATS routes into the Bahrain FIR. Here too, maximum use of available airspace was achieved through designating the two northern ATS Routes as RNAV 1 which allows ATS Routes to be spaced closer. RNAV 5 traffic will, for the time being, be accepted on these routes and full RNAV 1 operations will commence as soon as an agreement is reached between UAE and Bahrain.

The airspace enhancement initiatives have resulted in more efficient operations coupled with reduced emissions and noise through:

- Three ATS routes that allow for continuous climb operations (CCOs) and better routing options;
- More available flight levels allowing airspace users to fly at more optimum altitudes;
- Traffic landing in the Bahrain FIR that is no longer required to descend early.

## ICAO Partnerships with Industry and other Standards-setting Bodies

The global aviation community has come to realize the importance of harmonizing the work effort of aviation standards-making bodies around the world. To that end, the 38th General Assembly of ICAO asked that the Organization put into place some mechanisms to ensure harmonization in the development of standards and technical specifications. Other industry standards-making bodies have been very positive about these developments, with EUROCAE, RTCA and SAe International, in particular, providing strong indications of support for these initiatives. To date, ICAO has informal working arrangements with many of these organizations, and more formal agreements in the form of Memoranda of Cooperation on specific projects and on the sharing of aeronautical information. During this triennium, ICAO will be looking to formalize many of these working arrangements and to form an overarching advisory body to coordinate with all of these organizations.

# Next Steps

## The Global Air Navigation Report at a Glance

The Global Air Navigation Report has been prepared with a global perspective and is aimed at providing an initial overview of the status of the air navigation infrastructure.

ICAO Strategic objectives have driven the general vision of the report. The main applicable strategic objective in 2013 was the Environmental Protection and Sustainable Development of Air Transport. Through this strategic objective the organization focused on fostering the harmonized and economically viable development of international civil aviation without unduly harming the environment. Consequently, this report has shown the progress to date as well as the links between the efficiency and effectiveness of international civil aviation and how the resultant reductions in fuel burn and noxious gas emissions have contributed to the reduction in international civil aviation's environmental footprint.

This first edition has reported on the initial steps taken towards a planning and implementation performance framework which prescribes reporting, monitoring, analysis and review activities, conducted on annual basis. The document represents the basis for performance monitoring relating to Aviation System Block Upgrade implementation at the regional and national levels while recognizing that it was never intended that the ASBU modules (with particular focus on the key global priorities) would have to be implemented at all facilities.

The document shows that the air navigation infrastructure has generally improved throughout the world, even though there are still some disparities between States with respect to implementation. Continuous growth has been observed and this reflects the importance placed on the air navigation priorities by all stakeholders.

Air transport today plays a major role in driving sustainable economic and social development in nations around the globe. While growth is normally a positive situation, it can be a double-edge sword. Increased air traffic impacts both airport and airspace capacity resulting in flight and ground delays, cancellations and less efficient operations (increased fuel burn, noise and environmental emissions). The report shows that there are many factors that can positively impact capacity such as ATFM, reduced separation standards, harmonized procedures, ATC best practices, airspace design and sectorization, performance-based navigation, airport accessibility, layout and infrastructure.

A general worldwide improvement to operational efficiency has been observed and there are several cases where operating costs were significantly reduced and usually accompanied by reduced fuel burn and reduced environmental emissions. For example, the application of user preferred routes can result in significant savings on a yearly basis. The report also demonstrates global interest in identifying and quantifying the initiatives that lead to operational efficiency. The implementation of PBN approach and landing with vertical guidance (APV) procedures for runways that do not currently have a procedure or runways that have a non-precision approach (NPA) with no vertical guidance are examples where both safety and operational efficiency have been enhanced.

## Next Steps for the Global Air Navigation Report

To highlight the important issues on which to focus over the 2014 to 2016 triennium, the ICAO Assembly recently expanded the Organization's strategic objectives. Of the five strategic objectives adopted, the following are of direct relevance to the Global Air Navigation Report:

- Air Navigation Capacity and Efficiency, with the aim of increasing the capacity and improving the efficiency of the global civil aviation system;
- the Economic Development of Air Transport, which aims to foster the development of a sound and economically viable civil aviation system; and,
- Environmental Protection, which strives to minimize the adverse environmental effects of civil aviation activities.

These objectives will be the focus for subsequent editions of the Air Navigation Report and progress will be measured in relation to them. As a consequence, the next steps call for an improved data collection, reporting and monitoring process.

In the meantime, ICAO, in collaboration with those States that have developed ATM improvement programmes based on the Aviation System Block Upgrades in the Global Air Navigation Plan will continue to demonstrate the results of realizing these improvements in public fora. For example, ICAO will be hosting a Block Upgrade Demonstration Showcase and Symposium (BUDSS) in Montreal from 19 to 21 May 2015 where we expect to demonstrate the end-to-end system performance based on the Block Upgrades and share the implementation data with participants. ICAO also has an active working group considering enhancements to the access and equity policy guidance and developing best practice scenarios for the funding and/or financing of the infrastructure and avionics for the block upgrades.

Finally, the results shown in this first edition will be updated and will be used to provide tactical adjustments to the work programme, as well as triennial policy adjustments to the GANP.

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