INTERNATIONAL CIVIL AVIATION ORGANIZATION

THE SECOND MEETING OF THE APANPIRG AERODROMES OPERATIONS AND PLANNING – WORKING GROUP (AOP/WG/2)

Yogyakarta, Indonesia, 3 – 5 June 2014

Agenda Item 3: Performance Framework and Metrics

REGIONAL PERFORMANCE FRAMEWORK – AIR NAVIGATION REPORTING FORM

(Presented by the Secretariat)

SUMMARY

This paper presents an overview of the Seamless ATM planning and reporting required by States, and provides an update on the progress towards the performance-based monitoring regime being implemented during 2014.

This paper relates to –
Strategic Objectives:

*A: **Safety** – Enhance global civil aviation safety*
*B: **Air Navigation Capacity and Efficiency –** Increase Capacity and improve efficiency of the global civil aviation system*
*E: **Environmental Protection** – Minimize the adverse environmental effects of civil aviation activities*

Action by the Meeting is at Para 4 to this Working Paper.

1. INTRODUCTION

1.1 The Eleventh Air Navigation Conference (September 2003), urged ICAO to develop a performance framework for Air Navigation Systems. The 35th Session of the ICAO Assembly, held in September 2004, adopted Resolution A35-15, Appendix B which urged ICAO to ensure that the future global ATM system was performance based and that the performance objectives and targets for the future system were developed in a timely manner.

1.2 Following the 37th Session of the ICAO Assembly, ICAO increased its efforts to meet global needs for airspace interoperability while maintaining its focus on safety. To this end, a planning framework for global harmonization and interoperability named the Aviation System Block Upgrade (ASBU) has been incorporated into the Fourth Edition of the Global *Air Navigation Plan (Doc 9750).* The ASBU framework includes modules describing operational improvements over a series of blocks, supported by technology roadmaps, which serve to progressively enhance many aspects of civil aviation operations.

1.3 The Asia/Pacific Seamless ATM Plan had been a key outcome from the Asia/Pacific Seamless ATM Planning Group (APSAPG). The Asia/Pacific Seamless ATM Plan incorporated the Block Zero ('0') Aviation System Block Upgrade (ASBU) elements that are now part of the Global Air Navigation Plan (Doc 9750).

1.4 APANPIRG/24 in conclusion 24/54 endorsed the *the Asia/Pacific Seamless ATM Plan Version 1.0.* The Seamless ATM Plan and associated implementation guidance material are available on the ICAO Asia/Pacific web site at: http://www.icao.int/APAC/Pages/edocs.aspx.

2. REGIONAL PRIORITIES AND TARGETS FOR AIR NAVIGATION

2.1 APANPIRG/24 noted that although the GANP has a global perspective, all ASBU modules may not be applicable to all States or Regions. Some of the modules are specialized packages that should be applied where specific operational requirements or corresponding benefits exist. Implementation priorities for Air Traffic Management enhancements will vary between regions as each has different operational environments, traffic volumes etc. Prioritization exercise could be done by individual states and regionally by APANPIRG. Guided by the Global Air Navigation Plan (GANP), APANPIRG/24 acknowledged that the regional planning process requires full involvement of States, service providers, airspace users and other stakeholders, thus ensuring commitment by all for implementation.

2.2 APANPIRG/24 further noted that the PIRG–RASG Global Coordination Meeting held on 19 March 2013 requested PIRGs to establish regional priorities and set targets and report to ICAO by May 2014. APANPIRG/24 also noted that the APAC Seamless ATM Plan spelt out the 6 regional ASBU priorities which are aligned to GANP (ASBU modules) and adopted Conclusion 24/2:

Conclusion 24/2 — Establishing Regional Priorities and Targets

That, following the PIRG - RASG Global Coordination meeting held in March 2013 APANPIRG/24 invited the Chairpersons of ATM, RASMAG, CNS, and MET sub groups to establish regional priorities and targets for the APAC Region in alignment with the GANP and APAC Seamless ATM Plan by December 2013 in order to facilitate submission to ICAO by May 2014.

2.3 In accordance with APANPIRG Conclusion 24/2, the Chairpersons of Sub-Groups (ATM, RASMAG, CNS and MET) and the Asia Pacific Seamless ATM Planning Group (APSAPG) were invited to consider the further development of Asia/Pacific Regional Priorities and Targets.

2.4 The Chairpersons of the Sub Groups agreed on the regional priorities and targets for the APAC Region which was based on the highest priority elements (**Appendix A**). In addition, all 42 Seamless ATM elements were assigned priorities (**Appendix B**).

2.5 Regional priorities and targets, along with the supporting Air Navigation Reporting Forms, will be proposed for endorsement at the APANPIRG/25.

3. AIR NAVIGATION REPORTING FORMS

3.1 APANPIRG/23 noted the developments in revising the Global Air Navigation Plan and agreed to take the revised edition of the Global Plan into account in planning and implementation of regional and national air navigation systems. APANPIRG/23 also noted that as ICAO will be migrating to the ASBU framework, consequently the Performance Framework Form will be modified to the Air Navigation Report Form (ANRF) effective from 2013.

3.2 The Air Navigation Report Forms (ANRFs) have replaced the earlier Performance Framework Forms (PFF). The ANRF is intended to be a means of setting milestones and targets, and monitoring progress with metrics for each of the key planning elements (at first, the seven priority elements). The ANRF also identifies the implementation challenges. A total of 18 ANRF corresponding to the 18 ASBU elements will be developed at the regional level and presented to APANPIRG and its Sub-Groups as appropriate for update. It should be noted that States are not expected to fill ANRF for global or regional purposes; however they are a practical solution for planning the ANS improvements at the national level.

3.3 During the planning process which took place in 2012 and 2013 in the APAC Region and led to the adoption by APANPIRG/24 of the Seamless ATM Plan v1.0, all objectives and targets pertaining to ATM performance were discussed and planned accordingly.

3.4 Two ANRF relate to AOP, namely B0-ACDM, and B0-SURF.

3.5 For B0-ACDM, in conjunction with B0-NOPS, the Seamless ATM plan V1.0 targets that all high density aerodromes should operate an A-CDM system serving the Major Traffic Flows (MTF) and busiest city pairs, with priority implementation for the busiest Asia/Pacific aerodromes (ASBU Priority 2). As a target for Nov. 2015 (Seamless ATM Plan Phase 1), high density FIRs (refer Figure 9 - Seamless ATM Plan) supporting the busiest Asia/Pacific traffic flows and high density aerodromes should implement ATFM incorporating CDM to enhance capacity, using bi-lateral and multi-lateral agreements (ASBU Priority 1). The related indicator is the percentage of high density FIRs supporting the busiest Asia/Pacific traffic flows and high density aerodromes having ATFM incorporating CDM using operational ATFM platform/s. As of November 2018 (Seamless ATM Plan phase 2), all FIRs supporting Major Traffic Flows should implement ATFM incorporating CDM to enhance capacity, using bi-lateral and multi-lateral agreements (ASBU Priority 1). The related indicator is FIRs supporting Major Traffic Flows that have implemented ATFM incorporating CDM. Both B0-ACDM and B0-NOPS ANRF should be reviewed in conjunction.

3.6 Specifically, in the case of Advanced Surface Movements Guidance Control Systems (ASMGCS), it was recognized that where weather conditions and capacity warranted, implementation of ASMGCS may not be a high priority in the Asia/Pacific except at high density aerodromes where the cost benefits of mandating this were positive (as per paragraph 5.29 of Seamless ATM Plan). This led to plan a regional Seamless objective item 40, named Safety and Efficiency of Surface Operations, as described in paragraph 7.1 (Seamless ATM Plan), and traced to the global ASBU module B0-SURF. The associated regional target is that all high density international aerodromes (100,000 scheduled movements per annum or more) should provide electronic surface movement guidance and control. The indicator is the percentage of high density international aerodromes with electronic surface movement guidance and control in accordance with the Seamless ATM Plan Phase 1.

3.7 The meeting is invited to review the draft ANRF (**Appendix C**) developed for two ASBU modules - B0-ACDM and B0-SURF and agree for submission to APANPIRG/25 in view of their adoption, recognizing that the main objectives and targets to meet for these two modules were already discussed and planned by the APAC States in the Seamless Plan V1.0. B0-ACDM ANRF will also be reviewed by ATM/SG, and B0-SURF by CNS/SG and ATM/SG.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

In view of their submission to APANPIRG/25 for adoption, the meeting is invited to:

a) note the information contained in this paper;

b) review the draft ANRF for B0-ACDM and B0-SURF accordingly; and

c) discuss any relevant matters as appropriate.

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Proposed APANPIRG Regional Priorities and Targets

Respective B0 module /Regional item	**Proposed Regional Priorities and Targets as agreed on 16-01-14 by Chairpersons of APANPIRG SGs**	**Target date (Seamless ATM Phase 1 Plan)**	**Indicators (measure progress against the target)**
B0-APTA	1. Approach: Where practicable, **all high density aerodromes** with instrument runways serving aeroplanes should have precision approaches or APV or LNAV.	100% by Nov 2015	% of international aerodromes having at least one runway end provided with APV Baro-VNAV or LPV procedures
B0-NOPS	2. Network Operations: **All High Density FIRs** supporting the busiest Asia/Pacific traffic flows and high density aerodromes should implement ATFM incorporating CDM using operational ATFM platform/s.	100% by Nov 2015	% of FIRs within which all ACCs utilize ATFM systems
B0-DATM	3. Aeronautical Information Management: ATM systems should be supported by digitally-based AIM systems through implementation of **Phase 1 and 2 of the AIS-AIM Roadmap**	100% by Nov 2015	% of Phase 1 and 2 AIS-AIM elements completed
B0-FICE	4. System Wide Information Management: All States between ATC units where transfers of control are conducted have implemented the messages ABI, EST, ACP, TOC, AOC as far as practicable.	100% by Nov 2015	% of FIRs within which all applicable ACCs have implemented at least one interface to use AIDC / OLDI with neighbouring ACCs
B0-FRTO	5. Civil/Military- Enhanced En-Route Trajectories: All States should ensure that SUA are regularly reviewed by the appropriate Airspace Authority to assess the effect on civil air traffic and the activities affecting the airspace.	100% by Nov 2015	% of FIRs in which FUA is implemented
Strategic Civil Military coordination (Regional)	6. Civil/Military- Enhanced En-Route Trajectories: All States should ensure that a national civil/military body coordinating strategic civil-military activities is established.	100% by Nov 2015	% of FIRs within which all ACCs utilise FUA techniques for operation of SUA with strategic civil/military liaison capability
Tactical Civil Military coordination (Regional)	7. Civil/Military- Enhanced En-Route Trajectories: All States should ensure that formal civil military liaison for tactical response is established.	100% by Nov 2015	% of FIRs within which all ACCs utilise FUA techniques for operation of SUA with tactical civil/military liaison capability
B0-ASUR	8. Ground Surveillance: All Category S upper controlled airspace and Category T airspace supporting high density aerodromes should be designated as non-exclusive or exclusive as appropriate ADS-B airspace requiring operation of ADS-B.	100% by Nov 2015	% of FIRs with ATS surveillance using ADS-B or SSR or MLAT where ATS surveillance is possible
B0-ASUR	9. Ground Surveillance: ADS-B or MLAT or radar surveillance systems should be used to provide coverage of all Category S-capable airspace as far as practicable, with data integrated into operational ATC aircraft situation displays.	100% by Nov 2015	% of ACCs with ATS Surveillance using ADS-B, MLAT or radar where ATS surveillance is possible and having data integrated into the ATC system situation display
B0-TBO	10. Trajectory-Based Operations-Data Link En-Route: Within Category R airspace, ADS-C surveillance and CPDLC should be enabled to support PBN-based separations.	100% by Nov 2015	% of FIRs utilising data link en-route in applicable airspace

Note:

- High density aerodromes- 100,000 scheduled movements per annum or more.
- High Density FIRs- as per Seamless ATM plan v1.0, supporting the busiest Asia/Pacific traffic flows (APANPIRG Conclusion 22/8 and 23/5 refer):
  a) South Asia: Delhi, Mumbai;
  b) Southeast Asia: Bangkok, Hanoi, Ho Chi Minh, Jakarta, Kota Kinabalu, Manila, Sanya, Singapore, Vientiane; and
  c) East Asia: Beijing, Fukuoka, Guangzhou, Hong Kong, Kunming, Incheon, Shanghai, Shenyang, Taibei, Wuhan.

Agreed Priorities
Chairperson's Sub Group on 17 January 2014

Reference	**Specification title**	**Module**	**ASBU - Module title**	**Priority agreed by Chairperson's SG 17 Jan.2014**
10	Apron Management	-	-	3
20	ATM-Aerodrome Coordination	-	-	3
30	Aerodrome capacity	-	-	3
40	Safety and Efficiency of Surface Operations (A-SMGCS Level 1-2)	B0-SURF	Safety and Efficiency of Surface Operations (A-SMGCS Level 1-2)	3
50	Arrival Manager/Departure Management (AMAN/DMAN)	B0-RSEQ	Improve Traffic flow through Sequencing (AMAN/DMAN)	2
60	ATC Sector Capacity	-	-	2
70	Airport Collaborative Decision-Making (ACDM)	B0-ACDM	Improved Airport Operations through Airport-CDM	2
-	-	B0-WAKE	Increased Runway Throughput through Optimized Wake Turbulence Separation	3
80	Air Traffic Flow Management/Collaborative Decision-Making (ATFM/CDM)	B0-NOPS	Improved Flow Performance through Planning based on a Network-Wide view	1
90	Continuous Descent Operations (CDO)	B0-CDO	Improved Flexibility and Efficiency in Descent Profiles using Continuous Descent Operations (CDOs)	2
100	Continuous Climb Operations (CCO)	B0-CCO	Improved Flexibility and Efficiency Departure Profiles – Continuous Climb Operations (CCO)	2
110	Performance-based Navigation (PBN) Approach	B0-APTA	Optimization of Approach Procedures including vertical guidance	1

120	Standard Instrument Departures/Standard Terminal Arrivals (SID/STAR)	B0-CCO B0-CDO	-	2
130	Performance-based Navigation (PBN) Visual Departure and Arrival Procedures	-	-	3
140	Performance-based Navigation (PBN) Routes	B0-FRTO	Improved Operations through Enhanced En-Route Trajectories	2
150	Performance-based Navigation (PBN) Airspace	-	-	2
160	Safety Nets	B0-SNET	Increased effectiveness of ground-based safety nets	2
170	Airborne Safety Systems	B0-ACAS	Airborne Collision Avoidance Systems (ACAS) Improvements	2
-	-	B0-OPFL	Improved Access to Optimum Flight Levels through Climb/Descent Procedures using ADS-B	3
180	Ground-based surveillance	B0-ASUR	Initial Capability for Ground Surveillance	1
-	-	B0-ASEP	Air Traffic Situational Awareness (ATSA)	2
190	Airspace classification	-	-	2
200	Flight Level Orientation Scheme (FLOS)	-	-	2
210	Flight Level Allocation Schemes (FLAS)	-	-	2
220	ATS Inter-facility Data-link Communications (AIDC)	B0-FICE	Increased Interoperability Efficiency & Capacity through Ground-Ground Integration	1
230	Automated Transfer of Control	-	-	2
240	ATS Surveillance data sharing	-	-	2
250	ATM systems enabling optimal PBN/ATC operations	B0-APTA	Optimization of Approach Procedures including vertical guidance	2
260	ATC Horizontal separation	-	-	2

270	Situation display integrating surveillance data	B0-ASUR	Initial Capability for Ground Surveillance	1
280	ADS-C, CPDLC	B0-TBO	Improved Safety and Efficiency through the initial application of Data Link En-Route	1
290	UPR and DARP	B0-FRTO	Improved Operations through Enhanced En-Route Trajectories	3
300	Aeronautical Information Management	B0-DATM	Service Improvement through Digital Aeronautical Information Management	1
310	Meteorological Information	B0-AMET	Meteorological information supporting enhanced operational efficiency and safety	2
320	ATM Managers' Performance	-	-	2
330	ATC simulators performance	-	-	2
340	Safety assessment of changes	-	-	2
350	ATM Operators' performance	-	-	2
360	Civil Military use of SUA	B0-FRTO	Improved Operations through Enhanced En-Route Trajectories	1
370	Strategic Civil Military coordination	-	-	1
380	Tactical Civil Military coordination	-	-	1
390	Civil Military system integration	-	-	2
400	Civil Military Navaids joint provision	-	-	2
410	Civil Military common training	-	-	2
420	Civil Military common procedures	-	-	2

The allocation of priority was based on factors including its importance in promoting Seamless ATM (Priority 1 = critical upgrade, Priority 2 = recommended upgrade, Priority 3 = may not be universally implemented). Source: Asia/Pacific Seamless ATM Plan V1.0.

AIR NAVIGATION REPORT FORM

HOW TO USE - EXPLANATORY NOTES

1. **Air Navigation Report Form (ANRF):** This form provides a standardized approach to implementation monitoring and performance measurement of Aviation System Block Upgrades (ASBU) Modules. The Planning and Implementation Regional Groups (PIRGs) and States could use this report format for their planning, implementation and monitoring framework for ASBU Modules. Also, other reporting formats that provide more details may be used but should contain as a minimum the elements described below. The Reporting and monitoring results will be analyzed by ICAO and aviation partners and then utilized in developing the Annual Global Air Navigation Report. The Global Air Navigation Report conclusions will serve as the basis for future policy adjustments aiding safety practicality, affordability and global harmonization, amongst other concerns.

2. **Regional/National Performance objective:** In the ASBU methodology, the performance objective will be the title of the ASBU module itself. Furthermore, indicate alongside corresponding Performance Improvement area (PIA). Consequently, for ASBU Block 0, a total of 18 ANRFs will need to be developed that reflects respective 18 Modules.

3. **Impact on Main Key Performance Areas:** Key to the achievement of a globally interoperable ATM system is a clear statement of the expectations/benefits to the ATM community. The expectations/benefits are referred to eleven Key Performance Areas (KPAs) and are interrelated and cannot be considered in isolation since all are necessary for the achievement of the objectives established for the system as a whole. It should be noted that while safety is the highest priority, the eleven KPAs shown below are in alphabetical order as they would appear in English. They are access/equity; capacity; cost effectiveness; efficiency; environment; flexibility; global interoperability; participation of ATM community; predictability; safety; and security. However, out of these eleven KPAs, for the present, only five have been selected for reporting through ANRF, which are Access & Equity, Capacity, Efficiency, Environment and Safety. The KPAs applicable to respective ASBU module are to be identified by marking Y (Yes) or N (No).

4. **Implementation Progress:** This section indicates status of progress in the implementation of different elements of the ASBU Module for both air and ground segments.

5. **Elements related to ASBU module:** Under this section list elements that are needed to implement the respective ASBU Module. Furthermore, should there be elements that are not reflected in the ASBU Module (example: In ASBU B0-A CDM, Aerodrome certification and data link applications D-VOLMET, D-ATIS, D-FIS are not included; Similarly in ASBU B0-AIM, note that WGS-84 and eTOD are not included) but at the same time if they are closely linked to the module, ANRF should specify those elements. As a part of guidance to PIRGs/States, the FASID (Volume II) of every Regional ANP will have the complete list of all 18 Modules of ASBU Block 0 along with corresponding elements, equipage required on the ground and in the air as well as metrics specific to both implementation and benefits.

6. **Implementation Status (Ground/Air):** Planned implementation date (moth/year) and the current status/responsibility for each element are to be reported in this section. Please provide as much details as possible and should cover both avionics and ground systems. If necessary, use additional pages.

7. **Implementation Roadblocks/Issues**: Any problems/issues that are foreseen for the implementation of elements of the Module are to be reported in this section. The purpose of the section is to identify in advance any issues that will delay the implementation and if so, corrective action is to be initiated by the concerned person/entity. The four areas, under which implementation issues, if any, for the ASBU Module to be identified, are as follows:

   - Ground System Implementation:
   - Avionics Implementation:
   - Procedures Availability:
   - Operational Approvals:

   Should be there no issues to be resolved for the implementation of ASBU Module, indicate as "NIL".

8. **Performance Monitoring and Measurement:** Performance monitoring and measurement is done through the collection of data for the supporting metrics. In other words, metrics are quantitative measure of system performance – how well the system is functioning. The metrics fulfil three functions. They form a basis for assessing and monitoring the provision of ATM services, they define what ATM services user value and they can provide common criteria for cost benefit analysis for air navigation systems development. The Metrics are of two types:

   A. Implementation Indicators/supporting metrics: This indicator supported by the data collected for the metric reflects the status of implementation of elements of the Module. For example- Percentage of international aerodromes with CDO implemented. This indicator requires data for the metric "number of international aerodromes with CDO".

   B. Benefit Metrics: This Metric allows to asses benefits accrued as a result of implementation of the module. The benefits or expectations, also known as Key Performance Areas (KPAs), are interrelated and cannot be considered in isolation since all are necessary for the achievement of the objectives established for the system as a whole. It should be noted that while safety is the highest priority, the eleven KPAs shown below are in alphabetical order as they would appear in English. They are access/equity; capacity; cost effectiveness; efficiency; environment; flexibility; global interoperability; participation of ATM community; predictability; safety; and security. However, out of these eleven KPAs, for the present, only five have been selected for reporting through ANRF, which are Access & Equity, Capacity, Efficiency, Environment and Safety. It is not necessary that every module contributes to all of the five KPAs. Consequently, a limited number of metrics per type of KPA, serving to measure the module(s)' implementation benefits, without trying to apportion these benefits between module, have been identified at the end of this table. This approach would facilitate States in collecting data for the chosen metrics.

On the basis of examples of Performance Indicators/supporting Metrics detailed in this document, PIRGs/States to reflect under this section the appropriate metrics that represents the monitoring of respective ASBU Module both in terms of implementation as well as benefits to five KPAs.

The impact on KPAs could be extended to more than five KPAs mentioned above if maturity of the system allows and the process is available within the State to collect the data.

AIR NAVIGATION REPORT FORM (ANRF)
APAC Regional Planning for ASBU Modules

REGIONAL/NATIONAL PERFORMANCE OBJECTIVE – B0-SURF: Safety and Efficiency of Surface Operations (A-SMGCS Level 1-2)

Performance Improvement Area 1: Airport Operations

ASBU B0-SURF: Impact on Main Key Performance Areas (KPA)

	Access & Equity	Capacity	Efficiency	Environment	Safety
Applicable	Y	Y	Y	Y	Y

ASBU B0-SURF: Planning Targets and Implementation Progress

Elements	Targets and Implementation Progress (Ground and Air)
Safety and Efficiency of Surface Operations	November 2015 (Seamless ATM Phase I): All high density international aerodromes (100,000 scheduled movements per annum or more) should have provided electronic surface movement guidance and control.

ASBU B0-SURF: Implementation Challenges

Elements	Implementation Area			
	Ground system Implementation	Avionics Implementation	Procedures Availability	Operational Approvals
Safety and Efficiency of Surface Operations	A-SMGCS system integrating sensors. Vehicles properly equipped (cooperative transponder systems)	Nil	Nil	Nil

ASBU B0-SURF: Performance Monitoring and Measurement (Implementation)	
Elements	**Performance Indicators/Supporting Metrics**
Surveillance system for ground surface movement(PSR,SSR, ADS-B or Multilateration (aircraft vehicles)	Percentage of applicable international aerodromes having implemented A-SMGCS Level 2

ASBU B0-SURF: Performance Monitoring and Measurement (Benefits)	
Key Performance Areas	**Performance Metrics**
Access & Equity	Improves portions of the Manoeuving area obscured from view of the control tower for vehicles and aircraft. Ensures equity in ATC handling of surface traffic regardless of the traffic's position on the international aerodrome
Capacity	Sustained level of aerodrome capacity during periods of reduced visibility
Efficiency	Reduced taxi times through diminished requirements for intermediate holdings based on reliance on visual surveillance only. Reduced fuel burn
Environment	Reduced emissions due to reduced fuel burn
Safety	Reduced runway incursions. Improved response to unsafe situations. Improved situational awareness leading to reduced ATC workload

AIR NAVIGATION REPORT FORM (ANRF)
APAC Regional Planning for ASBU Modules

REGIONAL/NATIONAL PERFORMANCE OBJECTIVE – B0-ACDM:
Improved Airport Operations through Airport-CDM

Performance Improvement Area 1:
Airport Operations

ASBU B0-ACDM: Impact on Main Key Performance Areas (KPA)

	Access & Equity	Capacity	Efficiency	Environment	Safety
Applicable	Y	Y	Y	Y	Y

ASBU B0-ACDM: Implementation Progress

Elements	Target and Implementation Status (Ground and Air)
Airport CDM at all high density aerodromes	November 2015 (Seamless ATM Phase I): - Airport CDM at all high density aerodromes.
Apron Management	November 2015- (Seamless ATM Phase I) All high density international aerodromes (100,000 scheduled movements per annum or more) should provide an appropriate apron management service in order to regulate entry of aircraft into and coordinate exit of aircraft from the apron;
ATM- Aerodrome coordination	November 2015- (Seamless ATM Phase I) All high density international aerodromes (100,000 scheduled movements per annum or more) should have appropriate ATM coordination on airport development and maintenance planning; coordination with local authorities regarding environmental, noise abatement, and obstacles; and ATM/PBN procedures for the aerodrome
Aerodrome Capacity - assessment of passenger, airport gate, apron, taxiway and runway capacity;	November 2015- (Seamless ATM Phase I) All high density international aerodromes (100,000 scheduled movements per annum or more) should have a declared airport terminal and runway capacity November 2018- (Seamless ATM Phase II) All high density aerodromes should have a declared airport terminal and runway capacity

ASBU B0-ACDM: Implementation Challenges				
Elements	**Implementation Area**			
	Ground system Implementation	**Avionics Implementation**	**Procedures Availability**	**Operational Approvals**
Airport CDM at all high density aerodromes	Inter connection of ground systems of all stakeholders	Nil	Lack of guidance material and Coordination procedures	Lack of Agreements (MOU) among stake holders, and procedures
Apron Management	communication facilities	Nil	Lack of Coordination procedures between a provider of ATS Services and the aerodrome operator.	Lac k of Agreements, (MOU) and procedures
ATM coordination	Nil	Nil	Lack of Coordination procedures	Lack of Agreements (MOU),and procedures
Aerodrome Capacity	Availability of space	Nil	Lack of guidance material to assess airport capacity	Nil

ASBU B0-ACDM: Performance Monitoring and Measurement (Implementation)	
Elements	**Performance Indicators/Supporting Metrics**
Airport CDM at all high density aerodromes.	% of applicable international aerodromes having implemented improved airport operations through airport-CDM (applicable=high density)
Apron Management	% of high density international aerodromes (100,000 scheduled movements per annum or more) providing an appropriate apron management service
ATM – Aerodrome coordination	% of high density international aerodromes having appropriate ATM coordination in accordance with the Seamless ATM Plan
Aerodrome Capacity –Phase 1	% of high density international aerodromes having declared capacity in accordance with the Seamless ATM Plan Phase 1
Aerodrome Capacity- Phase 2	% of high density aerodromes having declared capacity in accordance with the Seamless ATM Plan Phase 2

ASBU B0-ACDM: Performance Monitoring and Measurement (Benefits)	
Key Performance Areas	**Performance Metrics**
Access & Equity	Enhanced equity on the use of aerodrome facilities.
Capacity	Enhanced use of existing of gate and stands (unlock latent capacity). Reduced workload, better organization of the activities to manage flights. Enhanced aerodrome capacity
Efficiency	Improved operational efficiency (fleet management); and reduced delay. Reduced fuel burn due to reduced taxi time and lower aircraft engine run time. Improved aerodrome expansion in accordance with Master Plan
Environment	Reduced emissions due to reduced fuel burn
Safety	Not applicable

– END –

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA/PACIFIC SEAMLESS ATM PLAN

Version 1.0, June 2013

This Plan was developed by the Asia/Pacific Seamless ATM Planning Group (APSAPG)

Approved by APANPIRG/24 and published by the
ICAO Asia and Pacific Office, Bangkok

CONTENTS

SCOPE OF THE PLAN

Plan Structure

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

- Asia/Pacific Regional Air Navigation Plan (RANP, Doc 9673) objectives;
- the Seamless ATM performance framework, with a focus on technological and human performance within Aviation System Block Upgrade (ASBU) Block 0 elements, non-ASBU elements (mainly emanating from the Concept of Operations – CONOPS, which is regional guidance material endorsed by APANPIRG/22), and civil/military cooperation elements;
- a deployment plan with specific operational improvements, transition arrangements, expected timelines and implementation examples; and
- an overview of financial outcomes and objectives, cross-industry business and performance/risk management planning.

1.2 The Plan incorporates and builds upon the Asia/Pacific Air Traffic Flow Management (ATFM) Concept of Operations and the Asia/Pacific Air Navigation Concept of Operations (both hereinafter referred to as 'CONOPS'), and the Asia/Pacific PBN Plan, superseding these documents.

1.3 The RANP is expected to incorporate key components of this Plan and information on the mechanisms that enable these objectives to be met. High-level support may be necessary from regional bodies that can effectively support the Plan's implementation, such as the:

- Association of Southeast Asian Nations (ASEAN);
- Asia Pacific Economic Cooperation (APEC); and
- South Asian Association for Regional Cooperation (SAARC).

1.4 The Plan does not use 'continental', 'remote' and 'oceanic' areas to refer to an assumed geographical application area, as many Asia/Pacific States have islands or archipelagos that can support a higher density of Communications, Navigation, Surveillance (CNS) systems than in a purely 'oceanic' environment. In accordance with the CONOPS that air navigation services should be provided commensurate with the capability of the CNS equipment, it is important to categorise airspace in this manner, and simplify the numerous references to this capability throughout the Plan. Thus the Plan categorises airspace by reference to its CNS (Communications, Navigation and Surveillance) capability as:

a) Category R: remote en-route airspace within Air Traffic Services (ATS) communications and surveillance coverage dependent on a third-party Communication Service Provider (CSP); or

b) Category S: serviced (or potentially serviced) en-route airspace – by direct (not dependent on a CSP) ATS communications and surveillance; or

c) Category T: terminal operations serviced by direct ATS communications and surveillance.

1.5 The word 'States' in the Plan includes Special Administrative Regions and territories.

1.6 The Seamless ATM Plan is expected to be implemented in two phases. Neither phase, nor any element is binding on any State, but should be considered as a planning framework. The Seamless ATM Plan itself is therefore guidance material.

1.7 It was important to note that the Plan's Phase commencement dates are planning targets, and should not be treated like a 'hard' date such as the implementation of Reduced Vertical Separation Minimum (RVSM). In this case, there was a potential major regional problem if all States did not implement at the same time by the specific agreed date, which was clearly not the case for the start of the Plan's Phase I or II.

1.8 In that regard, although it would be ideal if all States achieved capability on day one of Phase I, this was probably not realistic. However States should consider the impact on stakeholders and improving capacity of the ATM system overall by not achieving target implementation dates. The draft Phase dates were chosen as being an achievable target for the majority of States. However the dates were not designed to accommodate the least capable State, otherwise the region as a whole would fall behind the necessary urgent ATM improvements required by the Director's General of Civil Aviation and APANPIRG.

1.9 **Appendix E** provides an example of a Seamless ATM planning framework, **Appendix H** provides a map of ASBU Elements to Plan references, and **Appendix I** provides a List of References.

Plan Review

1.10 The Plan needs to be updated to take into account ASBU Block 1, 2 and 3 modules, when these modules and their associated technology become mature.

1.11 Periodic updates to the Plan are also required in respect of the economic information contained therein.

1.12 As an iterative process, the Plan requires regular updating to keep current with aviation system changes. It is intended that APANPIRG and its contributory bodies conduct a complete review every three years (or a shorter period determined by APANPIRG) of the Plan to align with the review cycle of the GANP. The Plan and its subsequent revisions should be endorsed by APANPIRG.

PLAN OBJECTIVES AND DEVELOPMENT

Plan Objective

2.1 The objective of the Plan is to facilitate Asia/Pacific Seamless ATM operations, by developing and deploying ATM solutions capable of ensuring safety and efficiency of air transport throughout the Asia/Pacific region. The Plan provides a framework for a transition to a Seamless ATM environment, in order to meet future performance requirements.

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

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

Plan Development

2.4 The Plan was developed as part of a suite of Asia/Pacific air navigation plans, and thus, the Plan should not be considered in isolation.

2.5 This Plan addresses the full range of ATM stakeholders, including civil and military Air Navigation Services Providers (ANSPs), civil and military aerodrome operators as well as civil and military airspace users. The Plan has been developed in consultation with Asia/Pacific States, administrations and also with International Organizations (IO).

Note: civil airspace users include scheduled aviation, business aviation and general aviation.

2.6 States should consult with stakeholders and determine actions, in order to commit to achieving the objectives of Seamless ATM and the requisite performance objectives in the areas of safety, environment, capacity and cost-efficiency that flow from this Plan.

2.7 ASBU Block 0 modules contain technologies, systems and procedures which are expected to be available from 2013. However, the Plan also has references to ASBU Block 1, 2 and 3 modules, which are expected to be available from 2018, 2023 and 2028 respectively. Where such technology, systems, standards and procedures are available earlier than these dates and appropriate deliverables can be provided, the intention was to develop aggressive yet practical implementation schedules within this Plan in order to provide the earliest possible benefits.

2.8 The ICAO *Manual on Global Performance of the Air Navigation System* (ICAO Doc 9883) provides guidance on implementing a performance-oriented ATM System. The *Manual on ATM System Requirements* (ICAO Doc 9882) contains eleven Key Performance Area (KPA) system expectations, as well as a number of general performance-oriented requirements. In accordance with the expectations of these documents, the APSAPG developed the following performance objectives to facilitate Seamless ATM operations:

a) Preferred Aerodrome/Airspace and Route Specifications (PARS); and

b) Preferred ATM Service Levels (PASL).

2.9 The PARS/PASL introduced two Performance Objectives, which incorporate system expectations, such as general performance-oriented requirements. Each performance objective is composed of a list of expectations of different aspects of the aviation system.

2.10 In considering the planning necessary before the PARS/PASL Phase dates, it is important to ensure everyone in the planning process is aware that the necessary groundwork and capability building must take place as a priority, and that full operational capability by the Phase date commencement was a secondary consideration. It is recognised that it is possible a number of States would be working towards implementation during Phase I, in an effort to implement as soon as possible. Therefore it is considered that States in this position should not be identified as 'deficient' in regard to applicable elements.

2.11 Prior to implementation, each State should verify the applicability of PARS and PASL by analysis of safety, ATM capacity requirements to meet current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet the expectations of stakeholders. The PARS/PASL elements would be either:

a) not applicable; or

b) already implemented; or

c) not implemented.

2.12 The PARS and PASL are expected to be implemented in two phases, Phase I by 12 November 2015 and Phase II by 08 November 2018. Phase II was determined by referencing the charting AIRAC (Aeronautical Information Regulation and Control) cycle for the ASBU Block 1 commencement year. Recognising the economic and environmental costs associated with delay of system improvement using technologies available today, Phase I was considered to be the earliest date possible for ASBU elements and other non-ASBU elements, which mainly involved procedural changes and human training.

2.13 The PARS contain the expectations for airspace and ATS routes, including aircraft equipage to facilitate Seamless ATM operation, and is therefore a matter for the State regulator or the airspace authority, and is of primary interest to airspace planners, flight procedure designers and aircraft operators.

2.14 The PASL contain the expectations for Air Navigation Service Providers (ANSP), and is therefore a matter for the State regulator or the ATS authority. The PASL is of primary interest to ANSPs and aircraft operators. The PARS and PASL together form the foundation of Seamless ATM development, and as such should be enabled by national regulations, rules and policies wherever applicable to enable a harmonised effort by all stakeholders.

<u>Seamless ATM Definition</u>

2.15 The objectives of Seamless ATM was agreed by the Asia/Pacific Seamless ATM Planning Group (APSAPG) as follows:

> *The objective of Seamless ATM is the safe and interoperable provision of harmonized and consistent air traffic management service provided to a flight, appropriate to the airspace category and free of transitions due to a change in the air navigation service provider or Flight Information Region.*

2.16 The APSAPG noted the following description as the CANSO definition of Seamless ATM:

Seamless ATM operations is defined as ATM operations in contiguous airspace that is technically and procedurally interoperable, universally safe, and in which all categories of airspace users transition between Flight Information Regions, or other vertical or horizontal boundaries, without requiring a considered action to facilitate that transition and without any noticeable change in:

1) Type or quality of service received;

2) Air navigation and communications performance standards; and

3) Standard practices to be followed.

2.17 The ICAO Twelfth Air Navigation Conference (AN-Conf/12, Montreal, 19-30 November 2012) endorsed 10 High Level Air Navigation Policy Principles in the GANP, and the Asia/Pacific Seamless ATM Principles are aligned with these high level principles.

EXECUTIVE SUMMARY

<u>Seamless ATM</u>

3.1 ICAO data indicates that the Asia/Pacific Region in 2011 was the busiest in the world in terms of Passenger Kilometres Performed (PKP): 1,496 billion compared to 1,434 for North America and 1,385 for Europe, with growth rates of 8.0 - 8.8%, 2.3 - 3.5% and 4.2 - 4.8% over the 2012-2014 period respectively. In 2012, the Asia/Pacific region had the largest regional market share of total domestic and international Revenue Passenger Kilometres (RPK) at 30%, compared to 27% for both Europe and North America. **Figure 1 and Figure 2** indicating the projected air traffic growth which has necessitated the Seamless ATM approach.

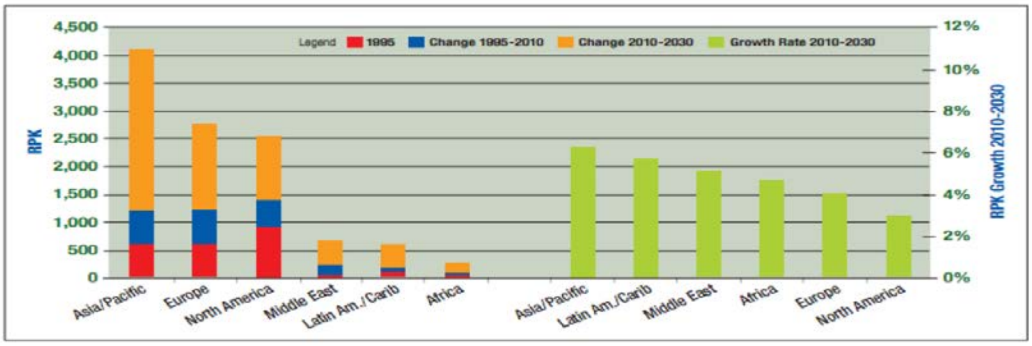

Figure 1: Passenger Traffic Forecasts – Top Traffic Flows in 2030 (ICAO 2010)

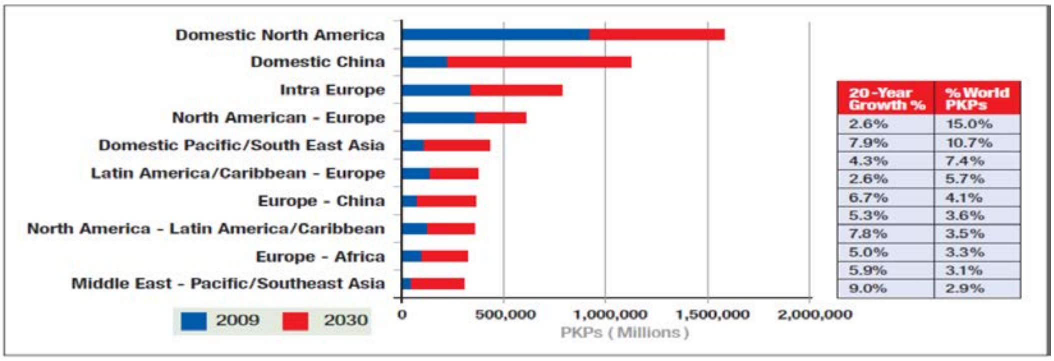

Figure 2: Top 10 Traffic Flows in 2030 (ICAO 2010)

3.2 The 46th Directors General Civil Aviation (DGCA) Conference (Osaka, October 2009) was the genesis of Asia/Pacific Seamless ATM discussion, endorsing the Kansai Statement (**Appendix A**). The DGCA Conference requested the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) to take a lead role in development of Seamless ATM in the Asia/Pacific region.

3.3 The ICAO Asia/Pacific (APAC) Seamless ATM Symposium and Ad Hoc Meeting (Bangkok, Thailand, 15 to 17 August 2011) developed:

a) proposed APSAPG objectives;

b) draft Seamless ATM principles;

c) civil/military cooperation Seamless ATM aspects;

d) the requirement for ASBUs to form a key part of Seamless ATM planning; and

e) the requirement for a capabilities matrix to provide a target and means of progressing to the Seamless ATM objectives.

3.4 APANPIRG/22 created the APSAPG in 2011 under Decision 22/56, with a primary goal to develop an Asia/Pacific Seamless ATM Plan.

3.5 The Global Air Navigation Industry Symposium (GANIS, Montréal, 20-23 September 2011) introduced the ASBU concept. This inferred an iterative improvement, from Block 0 (zero) to 3. Although the implementation of all ASBU elements is not mandatory, it is intended to achieve the highest level of conformance; thus supporting global interoperability and Seamless ATM.

3.6 Subject to several recommendations (**Appendix B**), the AN-Conf/12 endorsed the ASBU concept and the consequential changes to the GANP. The AN-Conf/12 stressed that ASBU Block 0 implementation and requirements needed to be coordinated at a regional level based on operational requirements, and that action plans to address identified impediments to ATM modernization should be developed. This Plan is part of the Asia/Pacific strategy to address the requirement for action plans, and to guide Asia/Pacific administrations in their ATM planning.

Air Navigation Service Provider Summary

3.7 The safety and efficiency of flights transcend national borders and airspace boundaries. Seamless ATM is therefore possible only if there is close regional collaboration among States, their ANSPs and all stakeholders. Cooperation is the key to success.

3.8 Given the size and diversity of the region, ATM harmonisation efforts will require the needs of the least developed ANSPs to be addressed especially in the areas of technical assistance such as funding, expertise and training. Differences in economic development may also mean that traffic demands are not uniform in the region, and therefore ATM solutions should be driven by performance requirements appropriate to the traffic demands.

Aerodrome Operator Summary

3.9 Aerodrome operations are a key component for Seamless ATM, especially in regard to infrastructure and operational efficiencies. The collaborative interaction of various stakeholders is important to ensure that aerodrome operations, facilities and equipment are suitable for all aircraft operators. Aerodrome operators require the airspace, ATM, aerodrome and aircraft operations to be cohesive and interoperable. This includes not only the aerodrome movement areas but the terminal and ancillary services, which may include border protection, fuel, baggage and passenger facilitation, which need to be aware of the interaction of their services with the aircraft operations.

3.10 Short, medium and long term aerodrome planning needs to take into account the seamless system so that capital investment is aligned to ATM operational efficiencies. Aerodrome development and airline changes are catalysts for changes driven by the aerodrome operator, but there is a need to ensure enroute and terminal ATS efficiencies are not impacted or lost, due to poor aerodrome infrastructure and operations. A saving in aircraft flight time can easily be eroded by lack of gates, poor taxiway-runway interface and inadequate terminal facilities. Stakeholder involvement and infrastructure changes needs to be coordinated to maximise the efficiencies from a systemic approach to aerodrome, airspace, air traffic management and aircraft operations.

ABBREVIATIONS AND ACRONYMS

AAR	Aerodrome Arrival Rate or Airport Acceptance Rate
ABI	Advanced Boundary Information (AIDC)
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ACP	Acceptance (AIDC)
ADOC	Aircraft Direct Operating Cost
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AIDC	ATS Inter-facility Data Communications
AIGD	ICAO ADS-B Implementation and Guidance Document
AIM	Aeronautical Information Management
AIRAC	Aeronautical Information Regulation and Control
AIRD	ATM Improvement Research and Development
AIS	Aeronautical Information Service
AIXM	Aeronautical Information Exchange Model
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
AN-Conf	Air Navigation Conference
AOC	Assumption of Control (AIDC)
AOM	Airspace Organization and Management
APAC	Asia/Pacific
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APCH	Approach
APEC	Asia Pacific Economic Cooperation
APSAPG	Asia/Pacific Seamless ATM Planning Group
APV	Approach with Vertical Guidance
APW	Area Proximity Warning
ASBU	Aviation System Block Upgrade
ASD	Aircraft Situation Display
ASEAN	Association of Southeast Asian Nations
ASMGCS	Advanced Surface Movements Guidance Control Systems
ATC	Air Traffic Control
ATCONF	Worldwide Air Transport Conference
ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Services
ATSA	Air Traffic Situational Awareness
ATM	Air Traffic Management
CANSO	Civil Air Navigation Services Organization
CARATS	Collaborative Actions for Renovation of Air Traffic Systems
CDM	Collaborative Decision-Making
CCO	Continuous Climb Operations
CDO	Continuous Descent Operations
CFIT	Controlled Flight into Terrain
CLAM	Cleared Level Adherence Monitoring
COM	Communication
CONOPS	Concept of Operations
CNS	Communications, Navigation, Surveillance
CPAR	Conflict Prediction and Resolution
CPDLC	Controller Pilot Data-link Communications
CPWG	Cross-Polar Working Group
CSP	Communication Service Provider

CTA	Control Area
CTR	Control Zone
DARP	Dynamic Airborne Re-route Planning
DGCA	Conference of Directors General of Civil Aviation
DMAN	Departure Manager
DME	Distance Measuring Equipment
EST	Coordinate Estimate
FAA	Federal Aviation Administration
FDPS	Flight Data Processing System
FIR	Flight Information Region
FIRB	Flight Information Region Boundary
FL	Flight Level
FLAS	Flight Level Allocation Scheme
FLOS	Flight Level Orientation Scheme
FRMS	Fatigue Risk Management System
FUA	Flexible Use Airspace
GANIS	Global Air Navigation Industry Symposium
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan
GBAS	Ground-based Augmentation System
GDP	Gross Domestic Product
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
GPI	Global Plan Initiative
HF	High Frequency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation Systems
IO	International Organizations
IPACG	Informal Pacific ATC Coordinating Group
ISPACG	Informal South Pacific ATS Coordinating Group
ITP	In-Trail Procedure
KPA	Key Performance Area
LNAV	Lateral Navigation
LVO	Low Visibility Operations
MET	Meteorological
METAR	Meteorological Aerodrome Report
MLAT	Multilateration
MSAW	Minimum Safe Altitude Warning
MTF	Major Traffic Flow
NextGen	Next Generation Air Transportation System
OPMET	Operational Meteorological
OLDI	On-Line Data Interchange
OTS	Organised Track System
PACOTS	Pacific Organized Track System
PARS	Preferred Aerodrome/Airspace and Route Specifications
PASL	Preferred ATM Service Levels
PBN	Performance-based Navigation
PIA	Performance Improvement Areas
PKP	Passenger Kilometres Performed
PVT	Passenger Value of Time
RAIM	Receiver Autonomous Integrity Monitoring
RAM	Route Adherence Monitoring

RANP	Regional Air Navigation Plan
RPK	Revenue Passenger Kilometres
RNAV	Area Navigation
RNP	Required Navigation Performance
RVSM	Reduced Vertical Separation Minimum
SAARC	South Asian Association for Regional Cooperation
SATVOICE	Satellite Voice Communications
SAR	Search and Rescue
SBAS	Space Based Augmentation System
SCS	South China Sea
SESAR	Single European Sky ATM Research
SHEL	Software, Hardware, Environment and Liveware
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Information
SPECI	Special Weather Report
STAR	Standard Terminal Arrival Route or Standard Instrument Arrival (Doc 4444)
STCA	Short Term Conflict Alert
STS	Special Handling Status
SUA	Special Use Airspace
SUR	Surveillance
SWIM	System-Wide Information Management
TAF	Terminal Area Forecast
TAWS	Terrain Awareness Warning Systems
TBO	Trajectory Based Operations
TCAC	Tropical Cyclone Advisory Centre
TCAS	Traffic Collision Avoidance System
TOC	Transfer of Control
UAS	Unmanned Aircraft Systems
UAT	Universal Access Transceiver
UPR	User Preferred Routes
VHF	Very High Frequency
VMC	Visual Meteorological Systems
VNAV	Vertical Navigation
VAAC	Volcanic Ash Advisory Centre
VMC	Visual Meteorological Conditions
VOLMET	Volume Meteorological
VOR	Very High Frequency Omni-directional Radio Range
VSAT	Very Small Aperture
WAFC	World Area Forecast Centre

BACKGROUND INFORMATION

Principles

5.1 There were considered to be three major areas of Seamless ATM Principles, involving People (human performance), Facilities (physical equipment), and Technology and Information. The 37 Principles agreed by APSAPG and endorsed by APANPIRG are included as **Appendix C**.

Aviation System Block Upgrade (ASBU)

5.2 At the Global level, ICAO started the ASBU initiative as a programme framework that developed a set of aviation system solutions or upgrades intended to exploit current aircraft equipage, establish a transition plan and enable global interoperability. ASBUs comprised a suite of modules organised into flexible and scalable building blocks, where each module represented a specific, well bounded improvement. The building blocks could be introduced and implemented in a State or a region depending on the need and level of readiness, while recognizing that all the modules were not required in all airspaces. ASBUs described a way to apply the concepts defined in the Doc 9854 with the goal of implementing regional performance improvements, and were used in the new edition of the GANP to guide implementation. AN-Conf/12 agreed that the ASBUs and the associated technology roadmaps were integral parts of the GANP and a valuable implementation tool kit.

5.3 ICAO estimated that US$120 billion would be spent on the transformation of air transportation systems in the next decade. While NextGen and SESAR accounted for a large share of this spending, parallel initiatives were underway in many areas including the Asia/Pacific region, North and Latin America, Russia, Japan and China. ATM modernization is a very complex but necessary task, given the benefit of these initiatives as traffic levels increased. It is clear that to safely and efficiently accommodate the increase in air traffic demand — as well as respond to the diverse needs of operators, the environment and other issues, it is necessary to renovate ATM systems, in order to provide the greatest operational and performance benefits.

5.4 ASBU are comprised of a suite of modules, each having the following qualities:

- a clearly-defined measurable operational improvement and success metric;
- necessary equipment and/or systems in the aircraft and on the ground along with an operational approval or certification plan;
- standards and procedures for both airborne and ground systems; and
- a positive business case over a clearly defined period of time.

5.5 ASBU are divided into four Performance Improvement Areas (PIA):

- PIA 1: Airport Operations;
- PIA 2: Globally Interoperable Systems and Data **–** *Through Globally Interoperable System Wide Information Management*;
- PIA3: Optimum Capacity and Flexible Flights **–** *Through Global Collaborative ATM*; and
- PIA 4: Efficient Flight Path **–** *Through Trajectory-based Operations.*

Asia/Pacific ASBU Implementation

5.6 ASBU Block 0 modules were incorporated into the Seamless ATM framework used to assess the uptake by Asia/Pacific States.

5.7 **Table 1** provides a summary of the Block 0 elements, and the expected priority for implementation within the Asia/Pacific region as discussed and agreed by APSAPG/2 (Tokyo, 6-10 August 2012). The allocation of priority was based on factors including its importance in promoting Seamless ATM (Priority 1 = critical upgrade, Priority 2 = recommended upgrade, Priority 3 = may not be universally implemented). A cost-benefit or economic analysis before implementation was identified as essential to determine whether to implement B0-SURF, B0-ASUR and B0-ACAS, but should not preclude an economic analysis of other elements as determined by the State.

PIA	Element	Economic Analysis	Priority
PIA 1	B0-APTA Optimization Of Approach Procedures Including Vertical Guidance	-	2
	B0-WAKE Increased Runway Throughput Through Optimized Wake Turbulence Separation	-	3
	B0-RSEQ Improve Traffic Flow Through Runway Sequencing (AMAN/DMAN)	-	2
	B0-SURF Safety and Efficiency Of Surface Operations (A-SMGCS)	Yes	3
	B0-ACDM Improved Airport Operations Through Airport-Collaborative Decision-Making (A-CDM)	-	2
PIA 2	B0-FICE Increased Interoperability, Efficiency And Capacity Through Ground-Ground Integration (AIDC)	-	1
	B0-DATM Service Improvement Through Digital Aeronautical Information Management	-	1
PIA 3	B0-FRTO Improved Operations Through Enhanced En-Route Trajectories (CDM, FUA)	-	1
	B0-NOPS Improved Flow Performance Through Planning Based On A Network-Wide View	-	1
	B0-ASUR Initial Capability For Ground Surveillance	Yes	1
	B0- ASEP Air Traffic Situational Awareness (ATSA)	-	2
	B0-OPFL Improved Access To Optimum Flight Levels Through Climb/Descent Procedures Using Automatic Dependent Surveillance – Broadcast (ADS-B)	-	3
	B0-ACAS ACAS Improvements	Yes	2
	B0-SNET Increased Effectiveness Of Ground-based Safety Nets	-	2
	B0-AMET Meteorological Information Supporting Enhanced Operational Efficiency and Safety	-	2
PIA 4	B0-TBO Improved Safety And Efficiency Through The Initial Application Of Data Link En-Route	-	1
	B0-CDO Improved Flexibility And Efficiency In Descent Profiles (Continuous Descent Operations - CDO)	-	2
	B0-CCO Improved Flexibility And Efficiency Departure Profiles - Continuous Climb Operations (CCO)	-	2

Table 1: Asia/Pacific ASBU Block 0 Priority

Critical ASBU Upgrades

5.8 The following ASBU Block 0 elements were considered by APSAPG and endorsed by APANPIRG as critical upgrades for Seamless ATM, and thus should be accorded the highest priority in terms of the earliest implementation and the resources required to support this.

Note: This did not suggest that 'critical' elements had a higher priority than safety critical improvements.

5.9 **B0-FRTO** *Enhanced En-route Trajectories*: Flexible Use Airspace (FUA), User Preferred Routes (UPR), Dynamic Airborne Re-route Planning (DARP) and CDM. These will allow the use of airspace which would otherwise be segregated, along with flexible routing adjusted for specific traffic patterns for greater routing possibilities, reducing flight time and fuel burn. The applicable Global Plan Initiatives related to this element are GPI-1 (FUA), GPI-7 Dynamic and Flexible ATS Route Management, and GPI-8 Collaborative Airspace Design and Management.

5.10 **B0-FICE** *Ground – Ground Integration and Interoperability*: ATS Inter-facility Data Communications (AIDC). AIDC application exchanges information between ATS units in support of critical ATC functions, including notification of flights approaching a Flight Information Region (FIR) boundary, coordination of boundary-crossing conditions, and transfer of control. AIDC application improves the overall safety of the ATM system, as well as increasing airspace capacity, as it permits the controller to simultaneously carry out other tasks. While there is no related GPI, this element has been considered to be a high priority to support GPI-7 Dynamic and Flexible ATS Route Management, and is also a key enabler to reduce Air Traffic Control (ATC) coordination errors as a result of human factors.

5.11 **B0-DATM** *Digital Aeronautical Information Management* (AIM). AIM is one of the foundation elements that supports other aspects of ASBU, and as such requires a high priority. A key strategy activity during Block 0 may include the development of the System-Wide Information Management (SWIM) concept of operations to support the next phase of AIM development and integration within the future SWIM framework.

5.12 **B0-NOPS** *Network Flow Management* ATFM: GPI-6 ATFM. The related GPI is GPI-10 Terminal Area Design and Management. ATFM is used to balance demand and capacity to manage the flow of traffic in a manner that minimises delay and maximises the use of the available airspace. ATFM is one of the solutions to ensure a sustainable air traffic growth for the future. Inter-linked and networked ATFM nodes between ANSPs should be developed to serve various sub-regions (refer Doc 9971 *Manual on Collaborative Air Traffic Flow Management*).

5.13 **B0-TBO** *En-route Data-link*: Automatic Dependent Surveillance-Contract (ADS-C), Controller Pilot Data-link Communications (CPDLC). Data-link application for ATC surveillance and communications supports flexible routing, reduced separation and improved safety. In areas where the provision of direct ATS surveillance is possible, ATC separation should be based on these surveillance systems (i.e. radar, multilateration and ADS-B), and that ADS-C and CPDLC with backup provided by High Frequency (HF) and/or Satellite Voice Communications (SATVOICE) were necessary elsewhere. Moreover, the Regional Surveillance Strategy states that ADS-C should be used where technical constraint or cost benefit analysis did not support the use of Automatic Dependent Surveillance-Broadcast (ADS-B), SSR or Multilateration (MLAT).

5.14 **B0-ASUR** *Ground-Based ATS Surveillance*: ADS-B, MLAT. The related GPI is GPI-17 Data-Link Applications. The Regional Surveillance Strategy stated that ADS-B should be used to support ATC separation service, while reducing dependence on Primary Radar for area surveillance and reliance on 4-digit SSR octal codes. ADS-B technology is an initial step in creating a more flexible air transportation system that will create seamless surveillance and shared situational awareness picture for both ground and air operations. Recommendation 1/7C adopted by the AN-Conf/12 urged States to share ADS-B data to enhance safety, increase efficiency, achieve seamless surveillance and work closely together to harmonize their ADS-B plans to optimize benefits. The provision of communication capability such as Very High Frequency (VHF) to support ATS surveillance is also necessary. Furthermore, APANPIRG/22 urged States to support provision of Very High Frequency (VHF) radio voice air/ground communication infrastructure for use by adjacent States to enable a reduction of ATS separation based on surveillance.

Recommended ASBU Upgrades

5.15 **B0-CDO**: *Improved Flexibility and Efficiency in Descent Profiles* CDO and Standard Instrument Arrival (STAR). These arrival procedures allow aircraft to fly their optimum profile, taking into account airspace and traffic complexity. The related GPI is GPI-11 Area Navigation (RNAV) and Required Navigation Performance (RNP) Standard Instrument Departures (SIDs) and STARs. This element has been accorded a high priority by ICAO HQ, due to the improvement in safety regarding Controlled Flight into Terrain (CFIT) and greater efficiency in terms of fuel usage and emissions.

Note: the terms 'Standard Terminal Arrivals' and 'Standard Instrument Arrival' from Doc 9750 and Doc 4444 respectively have the same meaning.

5.16 **B0-RSEQ** *Runway Sequencing*: Arrival Manager (AMAN), Departure Manager (DMAN). AMAN/DMAN procedures are designed to provide automation support for synchronisation of arrival sequencing, departure sequencing and surface information. Training on automation support, operational standards and procedures were necessary.

5.17 Point Merge PBN procedures (Section 6, **Appendix F**) are examples of procedures that may be used to assist sequencing until the following ASBU modules were implemented, to ensure more accurate Trajectory Based Operations (TBO):

- **B1-RSEQ** (*extended arrival metering, integration of surface management with departure sequencing*);
- **B1-NOPS** (*integrated ATFM including airspace management, user driven prioritisation and collaborative ATFM solutions*);
- **B1-TBO** (*synchronisation of traffic flows at merge points through controlled time of arrival capability and airport applications such as D-TAXI*); and
- **B1-AMET** (*weather information supporting automated decision support or aids*).

5.18 **B0-CCO** *Flexible and Efficient Departure Profiles* Continuous Climb Operations (CCO), SID. This element has been accorded a high priority by ICAO HQ, due to greater efficiency in terms of fuel usage and emissions. The related GPI is GPI-11 (RNP and RNAV SIDs, STARs).

5.19 **B0-APTA** *Airport Accessibility*: Performance-based Navigation (PBN) procedures with vertical guidance. The optimal use of appropriate PBN specification is a key enabler to progress Seamless ATM in the Asia/Pacific region. PBN lays the foundation for the airspace system for years to come as future navigation developments such as four-dimensional (4D) user prefer trajectories evolve. This element has been accorded a high priority by ICAO globally. Documents providing guidance on this subject were:

- *PBN Manual*, *GNSS Manual*, *Annex 10*, *PANS-OPS Volume 1 and 2*;
- *Manual on Testing of Radio Navigation Aids Volume 2* (Doc 8071);
- *Quality Assurance Manual for Flight Procedure Design Volume 5* (Doc 9906);
- and for avionics-
  - Basic IFR Avionics (TSO C129 with Receiver Autonomous Integrity Monitoring - RAIM);
  - Basic IFR Global Navigation Satellite System (GNSS) receivers with Baro-VNAV (Vertical Navigation), Space Based Augmentation System - SBAS avionics (TSO C145/146); and
  - GBAS receivers (TSO C161/162).

5.20 **B0-ACDM** *Airport CDM*: the relevant GPI is GPI-13 Airport Collaborative Decision-Making. The decision making process at the airport is enhanced by sharing up-to-date relevant information and by taking into account the preferences, available resources and the requirements of the stakeholders at the airport. Material from the ICAO CDM Manual is being incorporated into a global manual on collaborative ATFM (Doc 9971). .

5.21 **B0-ASEP** *Air Traffic Situational Awareness*: ADS-B OUT enabled for airborne surveillance. ATSA applications will enhance safety and efficiency by providing pilots with the means to achieve quicker visual acquisition of targets. These are cockpit based applications which do not require any support from ground, and hence can be used by any suitably equipped aircraft. The applicable GPI is (GPI-9) Situational Awareness.

5.22 **B0-ACAS** *Airborne Collision Avoidance System Improvements*: ACAS (Airborne Collision Avoidance System). Traffic Collision Avoidance System (TCAS) version 7.0 or 7.1 is the expected standard. The requirement for forward fit from 01 January 2014 and retrofit by 01 January 2017 of aircraft ACAS installations with an upgraded collision avoidance logic known as TCAS V7.1 was adopted in 2010 by the ICAO Council. This element is designed to increase the effectiveness of surveillance and collision avoidance systems through mandatory use of pressure altitude reporting transponders, in accordance with the Regional Surveillance Strategy.

5.23 **B0-SNET** *Ground-Based Safety Nets*: Short Term Conflict Alert (STCA), Area Proximity Warning (APW), Minimum Safe Altitude Warning (MSAW).

5.24 **B0-AMET**: *Meteorological Forecasts, Warnings and Alerts*: Aerodrome warnings, including windshear. World Area Forecast Centre (WAFC), Volcanic Ash Advisory Centre (VAAC), and Tropical Cyclone Advisory Centre (TCAC) forecasts. The relevant GPI is GPI-19: improving the availability of meteorological (MET) information in support of a seamless global ATM system.

5.25 The future, net-centric oriented ATM system requires the smart use of uncertainty characteristics often associated with MET information, enabling decision-makers to make choices according to their own objectively determined thresholds for action. This needs a transition of MET information, specifically in table-driven data representation supporting ATM collaborative, knowledge-based, and decision-making through free-flowing information exchange (ASBU B1-AMET).

5.26 The first evolutionary step in the improved provision of MET information includes the provisions in Amendment 76 to Annex 3 – Meteorological Service for International Air Navigation (applicable November 2013). This will facilitate the exchange of OPMET information (specifically METAR, SPECI, TAF and SIGMET) in a digital form (XML/GML), accompanied by the appropriate metadata, in accordance with the globally interoperable information exchange model. These developments were designed to foster the future SWIM environment, which would include meteorological, aeronautical and flight information, amongst others.

5.27 Amendment 77 to Annex 3 (intended applicability in November 2016) was expected to upgrade these particular provisions to a recommendation, while Amendment 78 to Annex 3 (intended applicability in November 2019) was expected to make it standard practice for States to exchange such OPMET information in digital form. During Amendments 77 and 78 of Annex 3, and beyond, a significant portion of current MET products would transition to supporting digital information exchange within SWIM. In addition, there would be an increased reliance on the automated relay of meteorological information to and from aircraft, including enhanced aircraft-based meteorological reporting capabilities (ASBU B3-AMET).

ASBU Elements Which May Not Be Universally Implemented

5.28 **B0-WAKE, B1-WAKE**: *Enhanced Wake Turbulence Separations*. As a function of local implementation plans, development of automation support (Decision Support Tools) is required to enable the display to ATC of the appropriate wake turbulence separation minima applicable between successive pairs of arriving and departing aircraft, to apply optimized wake turbulence standards. Such automation support is considered desirable for Block 0 (6 category system), and necessary for Block 1 (pair-wise system).

5.29 **B0-SURF**: *Improved Runway Safety*: Advanced Surface Movements Guidance Control Systems (ASMGCS), where weather conditions and capacity warranted. Implementation of ASMGCS may not be a high priority in the Asia/Pacific except at high density aerodromes where the cost benefits of mandating this were positive. The related GPI is GPI-9 (Situational Awareness: **o**perational implementation of data link-based surveillance), and GPI-15 (Match Instrument Meteorological Conditions - IMC and Visual Meteorological Conditions - VMC Operating Capacity: improve the ability of aircraft to manoeuvre on the aerodrome surface in adverse weather conditions).

5.30 **B0-OPFL**: *Climb/Descent Procedures using ADS-B In-trail Procedure* (ITP). This element is applicable only for those ANSPs that provide services within Category R airspace, and may be rarely used in airspace where 30/30NM separation is applied using RNP4 or other more efficient standards, as ITP required a number of steps to apply correctly. Thus, ITP is optional, primarily for higher density Category R airspace with Organised Track Systems (OTS).

Global and Regional Elements

5.31 **Aerodrome Certification**. GPI-13 *Aerodrome Design and Management* promoted, i*nter alia*, the implementation of management and design strategies to improve movement area utilization. ICAO Annex 14, Volume I required States to certify their aerodromes used for international operations in addition to aerodromes open for public use through an appropriate regulatory framework.

5.32 **Aerodrome Capacity Analysis**. GPI-14 *Runway Operations* establishes requirements to maximize runway capacity. In addition, there is a need to determine capacity and related constraints for runways, taxiways and gates, especially for Low Visibility Operations (LVO). Aircraft gate movement predictability affecting ATFM may be influenced by the efficiency of the embarkation and disembarkation of people and goods. In conducting aerodrome capacity analysis, it is important to include an assessment of the capacities of the airport passenger and cargo terminals and landside infrastructure to handle passengers, checked-in baggage, air freight and road traffic to ensure that the airfield, passenger/cargo terminals and landside capacities are balanced as much as possible.

5.33 Apron Management Services need to be integrated with ATC services using interoperable systems (including automated tools), shared data and harmonised procedures. Therefore clear procedures between a provider of aerodrome ATS services and the aerodrome operator are necessary in order to ensure that the planning, operation and review of aerodrome services are conducted collaboratively.

5.34 **Flight Information Regions** (FIRs). FIR boundaries should not limit the delivery of ATS surveillance-based separation services, and where possible the number of FIRs should be minimized, particularly along traffic flows.

Note: FIRs should not necessarily be based strictly on the boundaries of sovereign territories (Annex 11)

5.35 Recommendation 5/1 from the AN-Conf/12 (**Appendix B**) suggested that States fully assess the operational, safety, performance and cost implications of a harmonised transition altitude.

5.36 **Airspace Classification.** The applicable GPI is GPI-4 *Alignment of Upper Airspace Classifications*, which supports the harmonization of upper airspace and associated traffic handling through application of a common ICAO ATS Airspace Class above an agreed division level.

5.37 **Reduced Vertical Separation Minimum** (RVSM). The applicable GPI is GPI-2: the optimization of the utilization of airspace and enhanced aircraft altimetry systems. GPI-3 *Harmonization of Level Systems*: the adoption by all States of the ICAO Flight Level Orientation Scheme (FLOS) based on feet as contained in Appendix 3a to Annex 2. China is the only State that has adopted Appendix 3b to Annex 2, while some adjacent States continued to refer to the metre equivalent of feet (flight levels), as their domestic altimetry systems or regulations are commonly based on metres.

5.38 **Airspace Priority.** At the 6th Worldwide Air Transport Conference (ATCONF, Montréal, 18-22 March 2013) support was expressed for work to be undertaken on the schemes of economic incentives, ‘best equipped or capable, best served’ and ‘most capable, best served’ concepts. The CONOPS states that in each case where any aircraft that does not meet specified requirements, it should receive a lower priority, except where prescribed (such as for State aircraft).

5.39 Affording priority for flight levels or making specified levels unavailable for certain ATS routes under a Flight Level Allocation Scheme (FLAS) needs to be minimised, as this may penalise flights without consideration of actual capacity at the time and does not necessarily take advantage of the tactical capability of ATM systems. Thus FLAS should only be imposed to enhance safety and/or capacity, or where there were systemic operational limitations, such as the ability to deliver ATS surveillance-based separation services.

5.40 Establishing equipage mandates requiring operators to equip with a specific technology is an acceptable concept, provided the timeline for compliance is developed after due consultation and the [safety and economic] benefits in equipage were clearly identified and agreed (CONOPS).

5.41 **ATS routes**. The CONOPS establishes the expectation that in upper controlled airspace and within terminal controlled airspace (CTA and CTR) associated with major international aerodromes, ATS routes should be PBN based, with an appropriate specification determined by the Airspace Authority based on the GANP and the Regional Navigation Strategy as endorsed by APANPIRG. However, the RANP amendment of all conventional regional ATS routes to PBN routes would be very time consuming, so changes to PBN are being made on an opportunity basis, or when a new route is established, consistent with this Plan. A harmonised en-route PBN implementation is a key to achieving seamless ATM in order to cater to capacity growth. The applicable GPI is GPI-5: RNAV and RNP: the incorporation of advanced aircraft navigation capabilities into the air navigation system infrastructure.

5.42 The Plan advocates moving to take early advantage of GNSS so Asia/Pacific States do not need to undertake expensive ground-based navigation aid updates to support PBN ATS routes. For any move to a GNSS-based system, consideration must be made of the appropriate backup requirements. The following redundancy should be considered by States in their Safety Assessment with regard to reliance on GNSS:

- use of linked GNSS/Inertial Navigation Systems (INS) that provide a degree of accuracy commensurate with the navigation accuracy requirements until an alternative form of navigation is available;
- retention of terminal VOR/DME at major aerodromes only;
- retention of some radar or MLAT capability supporting terminal operations to provide a degree of navigation assistance if GNSS is not available; and
- the use of multi-modal receivers that can use different GNSS constellations.

5.43 **ATC Separation**. The CONOPS stated that in areas where the provision of direct ATS surveillance is possible, ATC separation should be based on these surveillance systems (i.e.: radar, multilateration and ADS-B). The Regional Surveillance Strategy reinforces this by encouraging the provision of communication, navigation, and data management capabilities necessary to make optimal use of surveillance systems. Moreover, States are expected to enhance ATM automation tools and safety nets through the use of aircraft-derived data such as flight identification, trajectories and intentions.

5.44 ATS surveillance-based separation may be provided with only one ATS surveillance system. Multiple ATS surveillance systems such as radar, ADS-B or MLAT should not be required, unless a single system does not demonstrate reliable performance in terms of availability, or overlapping coverage is required near an ATS sector boundary, or a safety case required enhanced redundancy or for any other economic reason.

5.45 There should be no requirement for radio reports at procedural waypoints when operating within ATS surveillance coverage, unless specifically requested by controllers on a tactical basis (Doc 4444, paragraph 4.11.1.3). When utilising ADS-C with waypoint event contract functionality, there should be no requirement for CPDLC waypoint reports, which should be stated in the State AIP.

5.46 **Civil Data-Sharing**. The provision of ATS surveillance data between civil ANSPs (suitably filtered as appropriate in terms of national security) is important for harmonised Transfer of Control (TOC) procedures between ATC units, unless surveillance coverage extended well into the adjacent unit's airspace. ADS-B system data should not require filtering, as it is publically broadcast information, lending itself to improving safety through the sharing of ATS surveillance data across FIR boundaries, in accordance with the Regional Surveillance Strategy.

Human Performance

5.47 The Global ATM Operational Concept (Doc 9854) states:

> *Humans will play an essential and, where necessary, central role in the global ATM system. Humans are responsible for managing the system, monitoring its performance and intervening, when necessary, to ensure the desired system outcome. Due consideration to human factors must be given in all aspects of the system.*

5.48 The AN-Conf/12 emphasised the importance of human performance considerations by endorsing Recommendation 6/4 (**Appendix B**), which called for the integration of human performance as an essential element for the implementation of ASBU modules and in the planning and design phase of new systems and technologies, as part of a safety management approach.

5.49 The role of the human is especially important in delivering high quality and consistent services supporting Seamless ATM. Therefore it is crucial to ensure that, training and licensing requirements are developed using a competency-based framework, fatigue-related risk is managed appropriately, and safety data, including the reporting of hazards, is collected, analysed and acted upon within ATM systems that support Seamless ATM

5.50 One of the more important human performance aspects in order to deliver a consistent, harmonised and efficient service is ATC training, to change from a procedural mind set to one that used the tactical delivery of services based on ATS surveillance and automated safety nets (airborne and ground).

5.51 Moving from reliance on paper-based flight progress strips to an electronic equivalent connected to the ATS surveillance Flight Data Processing System (FDPS) or direct data inputs to the Aircraft Situation Display (ASD) support this paradigm shift.

5.52 Controllers need to be trained on the application of tactical separation, including the use of positive control techniques, such as vectoring and speed control when conflict pairs approach minimum separation. In this regard, it is important that managers facilitate a modern operating environment in terms of air safety incidents and human factors, so personnel are confident using the full capability provided by the CNS facilities.

5.53 A critical human performance issue is the training of ANSP management and regulators in human performance issues. These decision-makers had an important influence on outcomes in terms of supporting the right environment for Seamless ATM activities, whether that is providing financial resources, or establishing high-level policies and procedures.

5.54 A key component of Seamless ATM is the ability of controllers to operate, and have confidence in, a new operating environment. The appropriate use of ATC simulators to enhance their learning experience is an essential part of the necessary training.

5.55 In planning to deliver Seamless ATM services, it is assumed that each State and aircraft operator will comply with the English language proficiency requirements in accordance with ICAO Standards and Recommended Practices.

Civil/Military Cooperation

5.56 One of the key enablers for improvement of ATM efficiencies supported by Doc 9854 (Global ATM Operational Concept) is the use of FUA. This is an airspace management concept based on the principle that airspace should not be designated as purely civil or military, but rather as a continuum in which all user requirements are accommodated to the greatest possible extent. FUA normally referred to the activation of Special Use Airspace (SUA), but could also include controlled airspace.

5.57 The establishment and operation of SUA required careful assessment, review and management, to ensure the most appropriate airspace designation is used, and the airspace is operated in a cooperative manner. This is ordinarily only possible through discussion between military and civil parties. Thus a key to the establishment of effective FUA is risk-based assessments, determining the risks or security issues involved through coordinated and cooperative methods if possible.

> *Note: Annex 2 Rules of the Air states that restricted areas were airspace of defined dimensions, above the land areas or territorial waters of a State, which means that restricted areas must not be designated over the high seas or in airspace of undetermined sovereignty*

5.58 Restricted areas designed to segregate civil aircraft from airborne military operations or ordnance firing would be expected when the risk of an accident for non-segregated operations is higher than acceptable. However, lower risk military operations (such as using small calibre weapons at an established firing range) may only require the establishment of a danger area or even no SUA. Thus the type, dimensions, activation notice and duration of SUA activity should be appropriate and commensurate with the type of activity affecting the airspace.

5.59 APANPIRG/9 (August 1998) developed the following guidelines for civil/military cooperation in the following areas: military procedures, aeronautical facilities and ground services, civil and military ATS unit personnel, airspace, research and development, common terminology, abbreviations rules and procedures, military exercises, and non-sensitive military data.

- If at all possible, military training should be conducted in locations and/or at times that do not adversely affect civilian operations, particularly those associated with major aerodromes. This requires strategic planning by formal civil/military coordination bodies.
- Consideration of the interoperability and operations of military systems is an integral part of a Seamless ATM environment. With increasingly complex aircraft equipage civil requirements, non-compliant military or other State aircraft may become more difficult to manage using Special Handling Status (STS). The limitations or requirements of military aircraft cockpits, avionics and airframes may even preclude some civil systems, and yet military aircraft still need to transit airspace used predominantly by civil operations.
- Military participation at civil ATM meetings and within ATS Centres will often lead to a better understanding of civil needs, as well as military requirements, including the operation of Unmanned Aircraft Systems (UAS). UAS have been predominately used by the military in segregated airspace, but now many forms of State missions including customs, immigration and police operations are being planned, as well as a myriad of potential civil uses.

- Responses to Search and Rescue (SAR), Civil Defence (normally natural disaster emergencies), and national security events will inevitably require civil/military coordination so this needs to be taken into account during the planning for such operations. As these occurrences could involve a number of States, regional civil/military planning is crucial in order to reduce the response time for emergency services to aid those in need. The response to an international aviation SAR event may well involve a location over the high seas, so all States should have SAR agreements with neighbouring nations to ensure that SAR services were unimpeded to the maximum possible extent.

5.60 The Asia/Pacific Civil/Military Cooperation Seminar/Workshop (Bangkok, 28 February to 1 March 2012) recommended that the following civil/military cooperation/coordination principles and practices should be elevated to the highest political level in the Asia/Pacific regions:

- civil/military working arrangements should be enacted where discussion of both civil and military needs were able to be negotiated in a balanced manner;
- the importance of the interoperability of civil air transport infrastructure and national security was recognized;
- the interoperability of civil and military systems including data-sharing was emphasized; and
- regular review of controlled airspace and special use airspace was encouraged to be undertaken by States to ensure its establishment, size, activation and operation was appropriate in terms of optimal civil/military operations.

5.61 The Asia/Pacific Civil/Military Cooperation Seminar/Workshop requested ICAO to update existing provisions related to civil/military cooperation/coordination and further develop guidance material related to airspace planning and management, including FUA.

5.62 Data sharing arrangements (including aircraft surveillance), are a key part of civil/military cooperation for tactical operational responses, and to increase trust between civil and military units. Data sharing between the civil and military could facilitate CDM, a vital component of ATFM. The Regional Surveillance Strategy espouses civil/military cooperation and system interoperability.

5.63 Aircraft operating ADS-B technology transmit their position, altitude and identity to all listeners, conveying information from co-operative aircraft that have chosen to equip and publicly broadcast ADS-B messages. Thus there should be no defence or national security issues with the use and sharing of such data.

Note: Some military transponders may support ADS-B using encrypted messages, but this data is not normally decoded or used at all by civil systems. In many cases, tactical military aircraft are not ADS-B equipped or could choose to disable transmissions. In future, increasing numbers of military aircraft would be ADS-B capable, with the ability to disable these transmissions. ADS-B data sharing should not influence the decision by defence agencies to equip or not equip with ADS-B. Moreover, it is possible for States to install ADS-B filters that prevent data from sensitive flights being shared. These filters can be based on a number of criteria and typically use geographical parameters to only provide ADS-B data to an external party if aircraft were near the boundary.

5.64 Ten civil/military elements were incorporated into the Seamless ATM framework after analysis of discussion of the APANPIRG/9 principles, and discussion from the Seamless ATM Symposium and Ad Hoc Meeting, APSAPG/1 and the Asia/Pacific Civil/Military Seminar/Workshop.

a) **Strategic Liaison**. This element emphasised the creation of a permanent body and procedures such as participation at appropriate civil ATM meetings, to ensure long and medium-term planning for optimal civil and military operations.

b) **Tactical Liaison**. The daily, safe and efficient tactical management of operations, including airspace scheduling through interaction and communications between civil and military units, which should include military representation within civil ATC Centres where necessary.

c) **Military SUA**. The minimisation of airspace exclusively assigned for civil or military use in accordance with FUA principles, assessed by the percentage of military SUA within an FIR.

d) **SUA Review**. The regular review of SUA, to ensure that the means and notice of activation provide adequate warning for other airspace users, and the airspace designations (SUA types) as well as the lateral and vertical limits are the minimum required to safely contain the activity therein. The review of airspace should be conducted by an airspace authority independent or a collaboration of civil and military airspace users.

e) **International SUA**. The minimisation of SUA that affected international civil ATS routes. Restricted and prohibited areas must not be designated in international airspace or airspace of undefined sovereignty.

f) **Integrated Civil/Military ATM Systems**. The integration of civil and military ATM systems where practicable, including joint procurement of systems where possible.

g) **Joint Civil/Military Aerodromes and Navigation Aids**: The operation of joint civil/military aerodromes if possible, and the provision of navigation aids that could be utilised by both civil and military aircraft where practical.

h) **Shared Civil/Military Data**: The provision of ATS surveillance data from civil surveillance systems to military units to improve monitoring (thereby reducing the need for individual defence identification authorisation), trust and confidence. The provision of surveillance data from military surveillance systems where this would enhance ATS surveillance coverage and redundancy; suitably filtered as appropriate.

i) **Common Civil/Military Training**. The familiarisation of civil and military ATM personnel in each other’s systems and procedures where national security allows. Training and licensing of civil and military air traffic controllers to equivalent standards.

j) **Common Civil/Military Procedures**. The implementation of the same or equivalent standards, procedures and policies for the provision of ATS and the management of air traffic.

CURRENT SITUATION

Aerodrome Analysis

6.1 In the 1990s and the first decade of the new millennium, aerodrome operators in Asia-Pacific invested billions of dollars to enhance capacity of existing aerodromes and to build new ones to meet increasing air traffic demand. Notable examples are the opening of Bangalore, Hong Kong, Incheon, Kuala Lumpur International, Shanghai Pudong and Suvarnabhumi airports and the expansion of New Delhi and Beijing Capital airports. The automation and the adoption of self-service technology for passenger handling such as check-in and automated border control has enabled many airports to build up capacity without expanding passenger terminal footprint.

6.2 However new capacities are often taken up quickly by tremendous traffic growth experienced by the Asia-Pacific region in the same period. From year 2000 to 2011, world passenger traffic increased by 56% while the Asia-Pacific region saw an increase of 139%. Runways are typically the capacity bottleneck of aerodromes but aircraft parking stands, baggage sorting and transfer facilities, aprons and passenger security screening points operating close to or over capacity are becoming choke points as well, especially at hub airports. A-CDM promises to alleviate congestion but the close collaboration between airport management and other stakeholders such as its shareholder, ATM and airlines is essential to a coordinated development of the capacity of the regional air transport network in the long-term.

Airspace and FIR Analysis

6.3 The results of the Major Traffic Flow (MTF) and busy city pair route study are at **Appendix D**. As a result of the study, there were several features of the lack of seamless ATM facilities and practices evident in the Asia Pacific region.

a) Size of FIR – fragmented FIRs resulting in flights transiting multiple FIRs with multiple TOC points.

b) Traffic density – the capacity of ANSP infrastructure and airspace had not kept up with traffic growth.

c) Airspace and Route design and capacity –

- route structure based on historical requirements and not on current aircraft navigational capability;
- ground-based navigation aid routes, around which SUAs have grown;
- crossing tracks with and without ATS surveillance, whereby States mainly rely on the use of FLAS for procedural flight level separation;
- requirement for vertical transitions because of the two different FLOS (metric and imperial) in the region;
- routes with flight level, direction, and time restrictions making flight planning more complex;
- routes with restrictions that are un-coordinated with neighbouring FIRs; and
- restrictive route structures agreed to in a historical context which is inadequate for today's traffic requirements.

d) ATS surveillance and communications capability -

- Non- existent or unreliable surveillance or communications capability in critical locations;
- Capability not fully utilised to provide appropriate level of service; and
- Hand-off procedures not aligned to ATM facilities and capabilities.

e) Compatibility between FIRs –

- Infrastructure development based only on national requirements, resulting in duplicated and yet uncoordinated facilities; and
- Unnecessarily conservative separation requirements at TOC points (it was not clear if this is due to lack of confidence in adjacent FIRs capability to adhere to agreed procedures, or for other operational reasons).

f) ATC standards –

- Apparent reluctance in applying ICAO standard separation minima (it was not clear if this is due a lack of confidence in ATM competence or capability); and
- Although GNSS separation is available in Doc 4444, few ANSPs in the Asia/Pacific Region used this as an alternative means of providing longitudinal separation.

g) Focus groups

- Lack of effective focus groups to address airspace capacity and FIR issues, although there had been a recent increase in informal and bi-lateral ATM coordination;
- Lack of a requirement for regular review mechanisms of operational issues within an FIR, including feedback from aircraft operators.

h) Uncoordinated and limited use of AIDC.

6.4 Generally flights operating on MTFs between large FIRs (particularly where there were multiple FIRs being provided services by one State) in Category R airspace were already reasonably seamless, such as in the Pacific. However, apart from being largely oceanic in nature, these MTFs had the advantage of being usually in an east/west alignment between continents and not impacted by busy crossing routes.

6.5 In addition, lower traffic density MTF enabled flexible tracks such as UPR applications. It was notable that these MTFs tended to have dedicated focus groups like Informal South Pacific ATS Coordinating Group (ISPACG) and Informal Pacific ATC Coordinating Group (IPACG) conducting regular reviews of operational efficiency.

6.6 Where long and short haul routes crossed multiple smaller FIRs, particularly with busy regional flows, there was a greater likelihood of reduced efficiency caused by a combination of inconsistent application of ATM procedures and standards, non-harmonized infrastructure development, route structure, TOC and other legacy issues. However, there were also examples of partly seamless ATM between some busy city pairs (such as Singapore/Kuala Lumpur and the Kuala Lumpur/Bangkok) in the region, resulting from bilateral efforts between ANSPs.

6.7 The Pearl River Delta airspace containing very dense air traffic served by Hong Kong, Macau, Shenzhen, and Guangzhou aerodromes, and associated heliports had Airspace Organization and Management (AOM) and civil/military coordination issues that stemmed largely from the division of responsibility between FIRs. Segregated SIDs and STARs, application of FUA and holistic 'Metroplex' planning principles as well as more integrated ATS systems are needed to achieve greater optimisation of the limited airspace available.

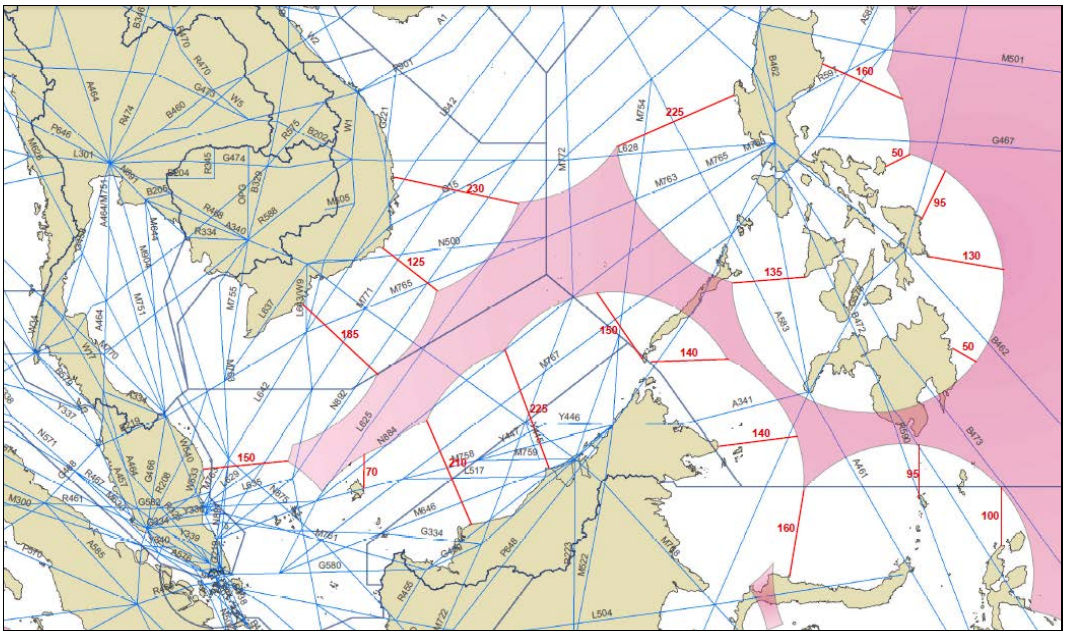

Figure 3: South China Sea ATS surveillance gaps (as at June 2013)

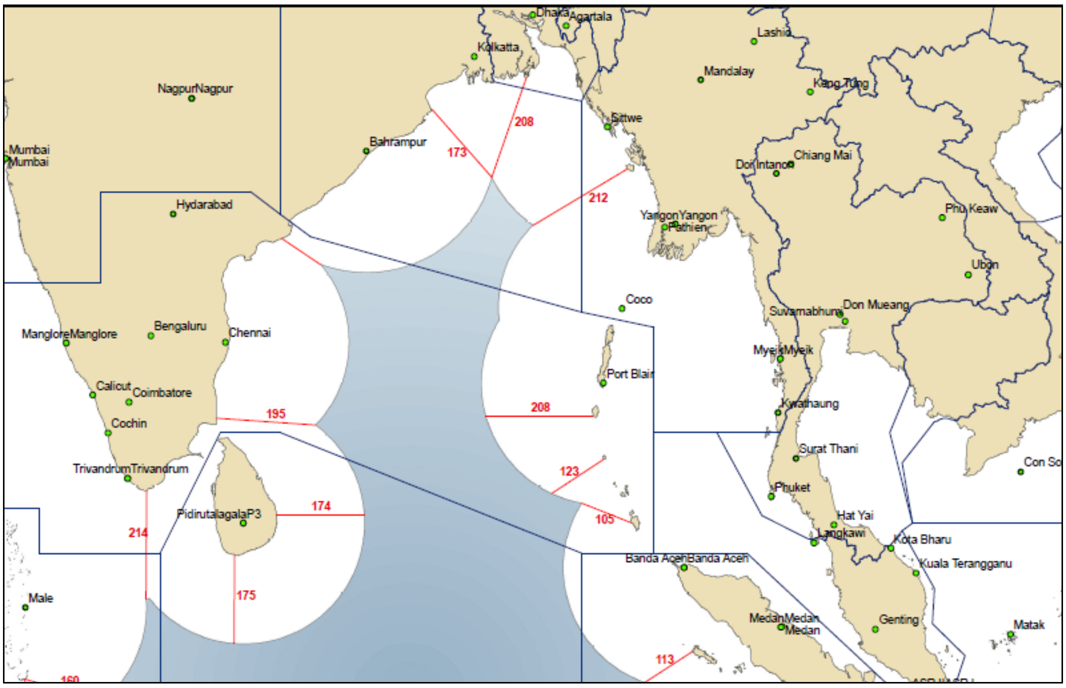

Figure 4: Bay of Bengal ATS surveillance gaps

6.8 The main areas of the Asia/Pacific region lacking ATS surveillance and communication coverage which need to be rectified due to traffic density, weather deviations and contingency responses are as follows:

a) highest priority: South China Sea airspace between Viet Nam, Brunei Darussalam and the Philippines (**Figure 3**);

b) high priority: Bay of Bengal airspace between the Indian subcontinent and the Andaman Islands (**Figure 4**);

c) medium priority:

- airspace between Indonesia and Australia (between Java and West Australia);
- airspace between the Philippines and Indonesia (**Figure 3**); and

d) lower priority: Coral Sea between Papua New Guinea and Australia.

Europe – Asia/Pacific Trans-Regional Issues

6.9 A number of ATS routes from the Russian Federation converged within Mongolian airspace because of the limited number of entry/exit points on the Mongolian/Chinese airspace boundary. Military restrictions had affected ATS route development to China/Mongolia/DPRK and Japanese airspace. An enhancement of civil/military cooperation and ATM coordination is necessary to address these trans-regional issues.

6.10 There is a long-standing problem with the incompatibility of the some elements of the European On-Line Data Interchange (OLDI) system with the more global AIDC messages from the Russian Federation to China and Mongolia. It is possible that a solution may be determined by the Inter-Regional APAC/NAT AIDC Task Force.

6.11 Russia utilised a 30 km (16NM) separation within its upper airspace, while Mongolia initially used 80NM when ATS surveillance was implemented in mid-2012, with an intention to reduce this to a surveillance-based separation after appropriate training.

6.12 Given the need to minimise safety issues such as Large Height Deviations and to improve confidence in order to minimise trans-regional separations, ATS surveillance data-sharing between the Russian Federation and China/Mongolia is necessary in accordance with PASL Phase I, even if only based on ADS-B.

North/South America – Asia/Pacific Trans-Regional Issues

6.13 There were no major trans-regional issues between Asia and North America via the Anchorage Oceanic, Fukuoka and Oakland Oceanic FIR due to the continuing work at the IPACG involving Japan and the United States. The Cross-Polar Working Group (CPWG) also discussed operations extending into the area between Asia and North America. The Fukuoka and Oakland Oceanic FIRs had high-density Category R airspace but is served by an OTS (PACOTS; Pacific Organized Track System). ADS-C, CPDLC and AIDC were fully deployed in the Anchorage Oceanic, Fukuoka and Oakland Oceanic FIRs, and common procedures, including 30NM separation standards based on RNP4, DARP, UPR were applied.

6.14 The Oakland Oceanic FIR and South Pacific utilised technologies consistent with Block 0 and with Conflict Prediction and Resolution (CPAR), AIDC, CPDLC and ADS-C, were able to provide a Seamless ATM service already between Asia/Pacific and North America. This included the provision of UPRs and DARP where operationally possible. These developments had been managed through the ISPACG, and were a model for other oceanic regions in the Asia/Pacific.

6.15 The airspace between the Pacific and South America had very low density traffic. South American States had not yet developed the same Seamless ATM services capability in the trans-regional airspace to support ATM and essential SAR services. However, Chile is an active member of ISPACG, and Ecuador is enhancing services in the airspace adjacent to the Tahiti FIR.

Middle East/Africa – Asia Trans-Regional Issues

6.16 The transition of traffic from the Muscat FIR to the Mumbai FIR is identified as a contributing factor to the congestion in the Bahrain FIR and causal factor for the delayed departures from airports, particularly in the United Arab Emirates. India had recently reduced horizontal separation on some routes to 50/50NM. In addition, a FLAS is also used by India and applied to low density traffic from/to African Regions, against the higher density Middle East (MTF AR-10) routes.

6.17 Oman require 10 minute longitudinal separation between eastbound aircraft from the United Arab Emirates regardless of the level the aircraft were climbing to, with plans to reduce this to seven minutes, consistent with the 50NM standard applied within the Mumbai FIR. However this is still very restrictive, given the ATS surveillance coverage within the Muscat FIR and the fact that the aircraft were climbing to a number of different flight levels.

6.18 Complicating trans-regional operations is the configuration of the Sana'a FIR (OYCS), which projected a triangle of airspace between the Muscat FIR (OOMM) and Mumbai FIR (**Figure 5**). This required aircraft that were operating between the Muscat and Mumbai FIRs to transit a short segment of the Sana'a FIR, which used procedural ATC standards.

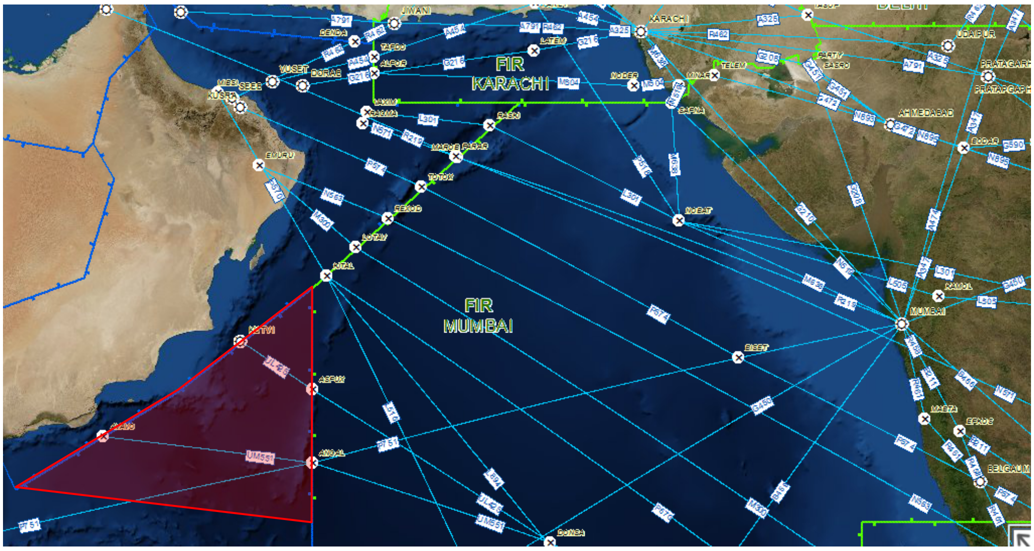

Figure 5: Middle East – Asia Trans-Regional Routes

6.19 One solution to improve Seamless ATM trans-regional operations between FIRs in this area would be to consider an amendment of the southern boundary of the Muscat Flight Information Region Boundary (FIRB) to a line joining N 15° 40', E 53 ° 24' and N 15°, E 60° 00'. This change would enlarge the Muscat FIR to include the area shown in red in **Figure 5**, and provide an opportunity for ATS surveillance and VHF communications (Category S airspace services) to be provided from Oman. In addition, this would reduce radiotelephone and TOCs, improving ATC workload.

6.20 The problem of OLDI conversions to AIDC between India and the Sultanate of Oman had prevented implementation of AIDC trans-regionally in this area thus far.

APSAPG Discussions on Economic Aspects

6.21 Action Item 48/2 from the DGCA/48 requested the APSAPG to study the ASBU elements and provide advice on the benefits, business case and implications to States and Administrations and explore formulating a regional position prior to the AN-Conf/12. APSAPG/1 discussed the economic aspects of ASBU and determined that the APSAPG itself would not provide detailed economic and business case data because each implementation situation would vary according to the operating environment; thus this is a matter for each State to analyse. However, the APSAPG agreed it is possible to provide high-level guidance such as guidance to States for the development of cost benefit analysis of implementation activity.

ADS-B South China Sea Cost-Benefit Study Summary

6.22 In 2008 CANSO and IATA agreed to conduct a cost-benefit study for the initial phase of the ADS-B project (**Figure 6**) over the South China Sea. The South China Sea (SCS) was identified for this purpose as it contained some of the highest traffic density routes that would benefit most from ADS-B. The initial phase involved ADS-B stations in Indonesia, Vietnam and Singapore. The aim was to enable radar-like separation for suitably equipped aircraft on selected routes in the area covered by the project scope.

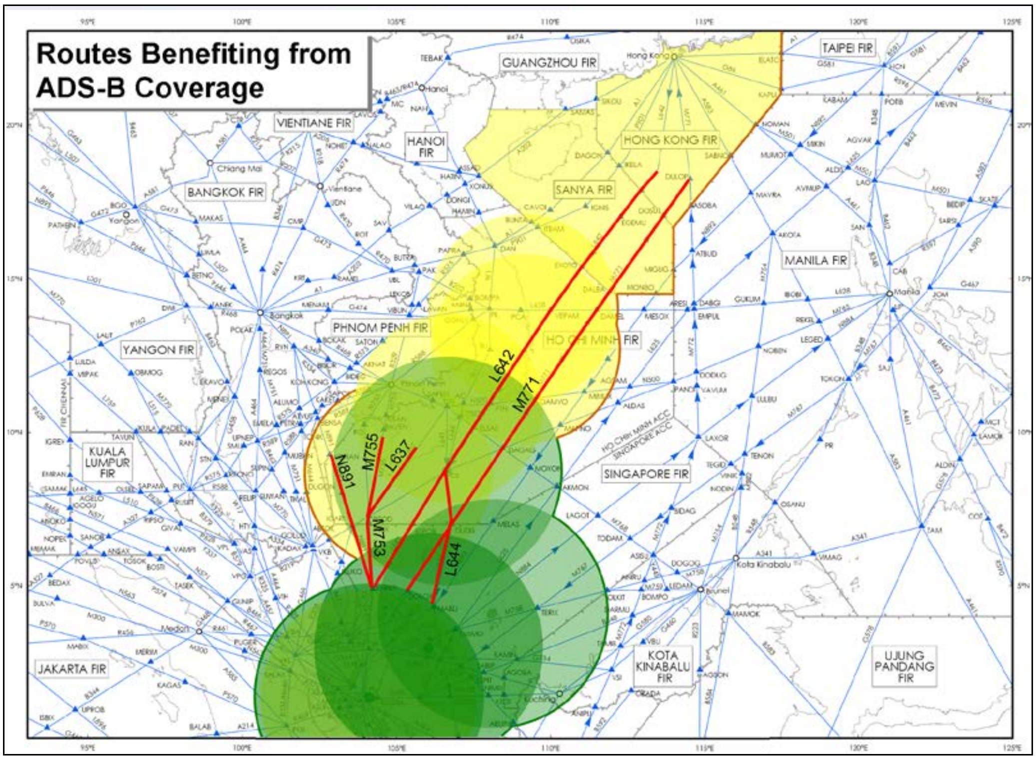

Figure 6: SCS ADS-B Study Area

6.23 The benefits that were monetized comprised the following:

a) Savings in aircraft fuel burn arising from availability of optimum flight levels and reduction in airborne and ground delays;

b) Reduction in carbon emissions; and

c) Reduction in flight delays leading to savings in Aircraft Direct Operating Cost (ADOC) and Passenger Value of Time (PVT).

6.24 The cost estimates were based on data provided by Singapore in consultation with the other ANSPs, while traffic estimates were based on an extrapolation of historical data provided by Singapore over three months in 2008. ADOC and PVT were based on FAA figures, with the latter discounted by about 40% based on the weighted GDP average for the region.

6.25 Based on data provided by Singapore from January 2008 to March 2008 for flights on airways that would benefit from the ADS-B deployment, potential savings from improved airborne efficiency and ground delay reductions were summarized in **Table 2** and **Table 3** respectively:

Airborne Efficiency – Potential Savings 2008	**3 months**	**12 months**
Fuel Burn Savings (kg)	276,585	1,106,342
Fuel Burn Savings (FY09 USD)	$177,097	$708,389
Flight time savings (hours)	117	468
Airborne ADOC w/o fuel savings (FY09 USD)	$346,283	$1,385,134
PVT savings (FY09 US $)	$292,493	$1,169,974
CO2 Emissions Savings (kg)	872,904	3,491,615
CO2 Savings (FY09 USD)	$21,777	$87,108
Total Economic Savings (FY09 USD)	$837, 651	$3,350,605

Table 2: ADS-B Airborne Efficiency

Ground Delay – Potential Savings 2008	
Fuel Burn Savings (kg)	213,531
Fuel Burn Savings (FY09 USD)	$136,724
Time savings (hours)	188
Ground ADOC w/o fuel savings (FY09 USD)	$206,132
PVT savings (FY09 US $)	$469,509
CO2 Emissions Savings (kg)	673,905
CO2 Savings (FY09 USD)	$16,812
Total Economic Savings (FY09 USD)	$829,177

Table 3: Ground Delay Savings

6.26 If it is assumed that ADS-B was 100% effective in overcoming the airborne inefficiencies and ground delays, the annual savings were nearly 1,400,000 kg of fuel burn and 4,500,000 kg of CO_2 emissions, for a relatively few number of airways.

6.27 Based on the estimated infrastructure costs, equipment life cycle of 20 years and an estimated ADS-B effectiveness of 90% and 75% in overcoming the airborne inefficiencies and the ground delays respectively, the cost benefits were calculated using three traffic growth scenarios. The results are shown in **Table 4**:

Factor	**Most Likely Estimate**		
Demand Growth	3%	5%	7%
Costs FY09 $M	$45.66	$45.66	$45.66
Benefits FY09 $M	$127.96	$200.47	$328.11
IRR	17%	22%	27%
Costs PV	$27.17	$27.17	$27.17
Benefits PV	$50.29	$73.60	$112.43
NPV	$23.12	$46.43	$85.26
B/C Ratio	1.9	2.7	4.1
Payback Year	2020	2018	2017

Table 4: Cost Benefit Estimates

6.28 The Cost Benefit Study for the initial phase of ADS-B implementation over the SCS showed clearly that there was a strong positive business case for the project.

United States NextGen Economic Benefits

6.29 The Federal Aviation Administration had conducted a business case study for the Next Generation Air Transportation System (NextGen). NextGen is a wide-ranging transformation of the air transportation system, including ATM technologies and procedures; airport infrastructure improvements; and environmental, safety and security-related enhancements. It is consistent with the GANP and the ASBU initiative.

6.30 The cost and benefit calculations underlying the business case for NextGen were developed based on the FAA's 2011 Mid-Term Concept of Operations and the 2012 NextGen Implementation Plan. Modelling of NextGen benefits and costs was based on various inputs. For basic inputs, the USA used traffic data from 2010, along with traffic and fleet forecasts released in early 2011. Recommended economic values, such as those for passenger value of time, etc., were used from early 2011. Based on these inputs, the FAA's analysis showed that NextGen mid-term improvements (until 2020) would generate more than two-and-a-half times in benefits as costs (**Figure 7**).

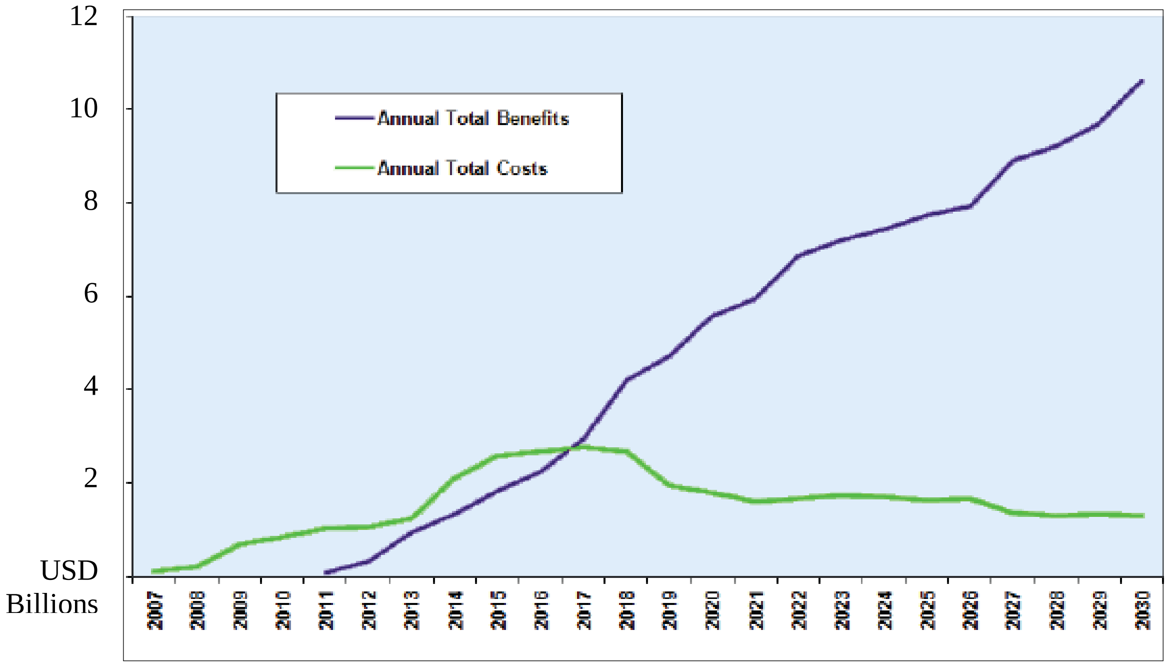

Figure 7: Annual Costs and Benefits

6.31 The NextGen business case focused on the direct benefits to aircraft operators, passengers, and taxpayers from the rollout of NextGen improvements. Benefits identified in the business case were:

- ADOC;
- PVT;
- Reduced FAA operating costs;
- Additional flights enabled by greater capacity;
- Reduced flight cancellations;
- Increased safety; and
- Environmental benefits from reduced aircraft emissions (CO_2 only).

6.32 Types of benefits that were **not** included in the business case were:

- New jobs and economic growth associated with major technology initiatives;
- environmental benefits of bio-fuels or improved engine/aircraft technologies; and
- Environmental benefits from reduced aircraft emissions (NO_X or SO_2).

6.33 The resulting benefit estimates are shown in **Figure 8**:

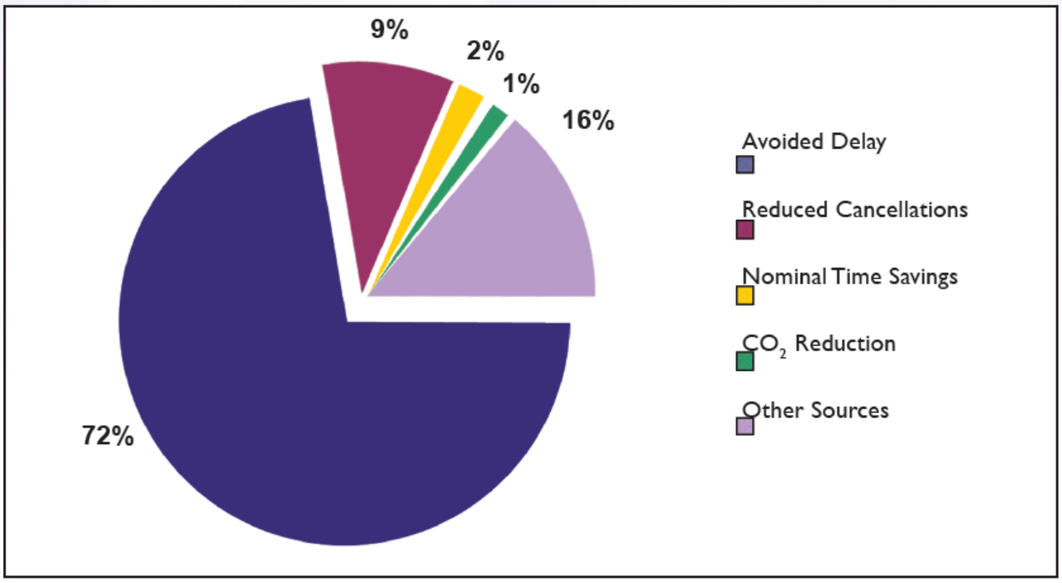

Figure 8: Types of NextGen Benefits until 2030

<u>IATA Seamless ATM Cost-Benefit Analysis</u>

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

6.35 A CBA of the transition to an Asia Pacific Seamless ATM environment will be developed when the Seamless ATM Plan has been accepted by APANPIRG on behalf of all Asia Pacific States. Although each State retains responsibility for their sovereign airspace, acceptance of the Seamless ATM Plan by APANPIRG, on behalf of all States, creates an obligation on each State to follow the agreed upgrade path. This agreed upgrade path will provide the basis for a Regional CBA.

6.36 Whilst the outcome of the CBA will be determined in future it was felt necessary to demonstrate, at a high level, the benefits of the proposed Seamless ATM Plan.

6.37 IATA conducted an initial economic analysis which was tabled at APSAPG/3 (Chennai, India, 21-25 January 2013).

6.38 Today, demand exceeds capacity at many locations and along some MTF. Many Asia Pacific airports have implemented slot management schemes for part of the day when demand exceeds supply. The consequence of this demand-supply gap is that many MTF are subjected to lengthy delays (e.g. Bay of Bengal) due to capacity limitations.

6.39 Any system delay causes the costs to increase exponentially. When the demand approaches the capacity limits, aircraft must wait to use the system, or various parts of it, until they can be accommodated. These delays impose costs both in terms of aircraft operating expenses and the value of wasted passengers' time.

6.40 In addition to the economic and cost benefits, the existing operational environment also causes longer flight trajectory, inefficient airport capacity usage, flight inefficiencies, higher CO2 emission impacting environment and lower predictability of flight operations.

6.41 IATA's initial economic analysis indicated that if the States in Asia Pacific do not implement the critical ICAO Aviation System Block Upgrade (ASBU) elements of the Seamless ATM Draft Plan, aviation's contribution to the Regional GDP will fall from today's **2.2%** to **0.81%** by 2030.

6.42 Although a "worst case" scenario this would represent a Regional potential economic benefit **loss** of **US$16.63 billion per annum** (based on 2012 data), which will reach an accumulated loss of **US$ 502 billion by 2030**. Upgrading the existing operational environment of ATM is essential in order to enhance the region's economic growth.

6.43 It can be argued that lack of investment in aviation infrastructure will result in this investment being diverted to sectors. However investment in aviation infrastructure, given the reliance in Asia Pacific on aviation, will yield a greater benefit than any other transport modality investment.

6.44 The IATA Economic Study is provided at **Attachment 1**.

<u>Point Merge Procedure Efficiency Analysis (Republic of Korea)</u>

6.45 An analysis of the efficiency and effectiveness of terminal airspace using the Point Merge method based on PBN is at **Appendix F**.

PERFORMANCE IMPROVEMENT PLAN

Preferred Aerodrome/Airspace and Route Specifications (PARS)

Note: prior to implementation, the applicability of PARS should be verified by analysis of safety, current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet expectations of stakeholders.

PARS Phase I (expected implementation by 12 November 2015)

Aerodrome Operations

7.1 All high density international aerodromes (100,000 scheduled movements per annum or more) should:

a) provide an appropriate apron management service in order to regulate entry of aircraft into and coordinate exit of aircraft from the apron;

b) have appropriate ATM coordination (including meetings and agreements) related to:

- airport development and maintenance planning;
- coordination with local authorities regarding environmental, noise abatement, and obstacles;
- ATM/PBN procedures for the aerodrome;

c) conduct regular airport capacity analysis, which included a detailed assessment of passenger, airport gate, apron, taxiway and runway capacity; and

d) provide electronic surface movement guidance and control.

Note 1: the 100,000 movement benchmark must not be viewed as lessening more stringent existing requirements and criteria established by the State, or superseding ICAO Annex 14 Volume I requirements, especially with regard to aerodrome certification.

Note 2: the provision of A-SMGCS should be subject to economic analysis (ASBU Priority 3).

7.2 All high density aerodromes should operate an A-CDM system serving the MTF and busiest city pairs, with priority implementation for the busiest Asia/Pacific aerodromes (ASBU Priority 2)[1].

[1] Based on 2012 ICAO data, the 21 busiest Asia/Pacific aerodromes were:

- Australia (Sydney, Melbourne);
- China (Beijing, Shanghai Pudong and Hong Jiao, Guangzhou, Hong Kong, Xi'an, Shenzhen, Chengdu, Kunming);
- India (New Delhi, Mumbai);
- Indonesia (Jakarta);
- Japan (Haneda, Narita);
- Malaysia (Kuala Lumpur);
- Philippines (Manila);
- Republic of Korea (Incheon);
- Singapore (Changi); and
- Thailand (Suvarnabhumi).

Terminal Operations (Category T airspace)

7.3 CCO and CDO operations should be considered for implementation at all high density international aerodromes after analysis, based on a performance-based approach (ASBU Priority 2).

Note: this does not preclude a State considering implementation of CCO/CDO at other aerodromes as appropriate.

7.4 All international high density aerodromes should have **RNAV 1** (ATS surveillance environment) or **RNP 1** (ATS surveillance and non-ATS surveillance environments) SID/STAR.

7.5 Where practicable, all high density aerodromes with instrument runways serving aeroplanes should have (ASBU Priority 2):

a) precision approaches; or

b) Approaches with Vertical Guidance (APV), either RNP APCH with Barometric Vertical Navigation (Baro–VNAV) or augmented GNSS (SBAS or GBAS); or

c) if an APV is not practical, straight-in RNP APCH with Lateral Navigation (LNAV).

En-route Operations

7.6 All Category S upper controlled airspace and Category T airspace supporting high density aerodromes should be designated as non-exclusive or exclusive as appropriate ADS-B airspace requiring operation of ADS-B using 1090ES with DO-260/260A and 260B capability, with priority implementation for the following high density FIRs (**Figure 9**) supporting the busiest Asia/Pacific traffic flows (APANPIRG Conclusion 22/8 and 23/5 refer):

a) South Asia: Delhi, Mumbai;

b) Southeast Asia: Bangkok, Hanoi, Ho Chi Minh, Jakarta, Kota Kinabalu, Manila, Sanya, Singapore, Vientiane; and

c) East Asia: Beijing, Fukuoka, Guangzhou, Hong Kong, Kunming, Incheon, Shanghai, Shenyang, Taibei, Wuhan.

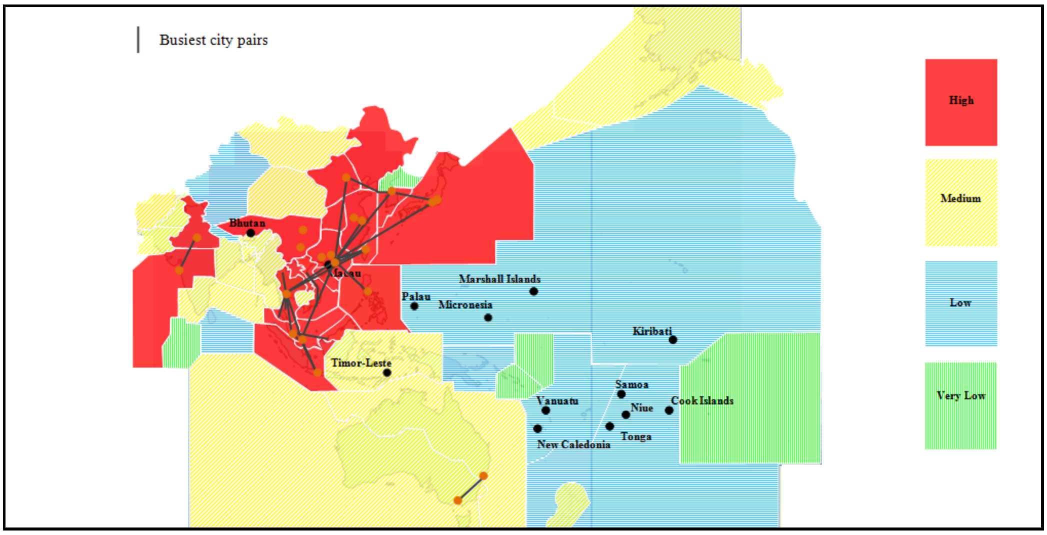

Figure 9: High Density FIRs

Note 1: in areas where ADS-B based separation service was provided, the carriage of ADS-B OUT using 1090ES with DO260/60A and 260B is recommended.

Note 2: States should refer to the ADS-B implementation in the ICAO ADS-B Implementation and Guidance Document (AIGD).

7.7 All Category R and S upper controlled airspace, and Category T airspace supporting high density aerodromes should require the carriage of an operable mode S transponder within airspace where Mode S radar services are provided; and ACAS and Terrain Awareness Warning Systems (TAWS), unless approved by ATC (ASBU Priority 2).

7.8 All Category R and S upper controlled airspace, and Category T airspace supporting high density aerodromes should be designated as non-exclusive or exclusive PBN airspace as appropriate. This is to allow operational priority for PBN approved aircraft, harmonised specifications and to take into account off-track events such as weather deviations, with priority implementation for high density FIRs.

Note: Non-exclusive means that non-PBN aircraft may enter the airspace, but may be accorded a lower priority than PBN aircraft, except for State aircraft.

7.9 All ATS routes should be designated with a navigation performance specification to define the CNS/ATM operational environment. The ATS route navigation performance specification selected should be harmonised and utilise the least stringent requirement needed to support the intended operation. When obstacle clearance or ATC separation requirements demand, a more stringent navigation specification may be selected. ATS routes should be established in accordance with the following PBN specifications:

- Category R airspace – **RNP 4**, **RNP 10** (RNAV 10) (other acceptable navigation specifications – RNP 2 oceanic); and
- Category S airspace –**RNAV 2** or **RNP 2** (other acceptable navigation specifications – RNAV 5).

Note 1: RNP 2 is expected to be utilised before Phase 2, when the RNP 2 instrument procedure design, ATC separation standards and operational approval are in place.

Note 2: within Category R airspace, transition to RNP 4 or RNP 2 oceanic specifications is recommended at the earliest opportunity. RNP 2 oceanic requires dual independent installations, plus CPDLC and ADS-C.

7.10 The ICAO Table of Cruising Levels based on feet as contained in Appendix 3a to Annex 2 should be used.

Civil/Military Cooperation

7.11 Civil/Military Airspace expectations are as follows:

a) SUA should only be established after due consideration of its effect on civil air traffic by the appropriate Airspace Authority to ensure it will be:
   - used for the purpose that it is established;
   - used regularly;
   - as small as possible, including any internal buffers, required to contain the activity therein;
   - if applicable, operated in accordance with FUA principles (ASBU Priority 1); and
   - activated only when it is being utilised; and

b) SUA should be regularly reviewed to ensure the activities that affect the airspace, and size and timing of such activity are accurately reflected by the SUA type, dimensions, activation notice and duration of activation.

PARS Phase II (expected implementation by 08 November 2018)

Aerodrome Operations

7.12 Where practicable, all high density aerodromes should provide the following infrastructure and facilities to optimise runway capacity:

a) additional runway(s) with adequate separation between runway centrelines for parallel independent operations;

b) parallel taxiways, rapid exit taxiways at optimal locations to minimize runway occupancy times and entry/exit taxiways;

c) rapid exit taxiway indicator lights (distance to go information to the nearest rapid exit taxiway on the runway);

d) twin parallel taxiways to separate arrivals and departures;

e) perimeter taxiways to avoid runway crossings;

f) taxiway centreline lighting systems;

g) adequate manoeuvring area signage (to expedite aircraft movement);

h) holding bays;

i) additional apron space in contact stands for quick turnarounds;

j) short length or tailored runways to segregate low speed aircraft;

k) taxi bots or towing systems, preferably controlled by pilots, to ensure efficiency and the optimal fuel loading for departure; and

l) advanced visual docking guidance systems.

7.13 All high density aerodromes should have a declared airport terminal and runway capacity based on a capacity and efficiency analysis, to ensure the maximum possible efficiency of aircraft and passenger movement. Sample runway capacity figures are provided from several States in **Appendix G**.

Terminal Operations (Category T airspace)

7.14 **RNP 0.3** arrival/departure, approach and/or en-route transiting procedures should be considered at high density aerodromes with rotary wing operations.

7.15 All international aerodromes should have **RNAV 1** (ATS surveillance environment) or **RNP 1** (ATS surveillance and non-ATS surveillance environments) SID/STAR.

Note: the Asia/Pacific PBN Plan Version 3 required RNAV 1 SID/STAR for 50% of international airports by 2010 and 75% by 2012 (priority should be given to airports with RNP Approach); and RNAV 1 or RNP 1 SID/STAR for 100% of international airports and 70% of busy domestic airports where there are operational benefits by 2016.

7.16 Where practicable, all aerodromes with instrument runways serving aeroplanes should have (ASBU Priority 2):

a) precision approaches; or

b) APV, either RNP APCH with Barometric Vertical Navigation (Baro–VNAV) or augmented GNSS (SBAS or GBAS); or

c) when an APV is not practical, straight-in RNP APCH with LNAV.

Note: the Asia/Pacific PBN Plan Version 3 required RNP APCH (with Baro-VNAV) for 30% of instrument runways by 2010 and 50% by 2012 (priority should be given to airports with operational benefits); and RNP APCH with Baro-VNAV or APV in 100% of instrument runways by 2016.

7.17 When establishing the implementation of PBN approach procedures in accordance with Assembly Resolution A37-11, States should first conduct an analysis of the instrument runway eligibility for APV approaches. This analysis should include the feasibility of the APV at a particular location, the presence of regular commercial operations and the current or projected user fleet capability for APV. The introduction of landing capability using GNSS and its augmentations such as GNSS Landing System (GLS) is recommended where these systems were economically beneficial. Locations where APV approach were either not feasible or where regular operators could not realise the benefit of APV should implement RNP APCH with LNAV minima instead of APV, to provide the safety benefits of straight-in approach procedures.

7.18 Where a short length or tailored runway designed to segregate low speed aircraft is established, the runway should be served by PBN procedures including SID and STAR that provided segregation from the procedures serving other aerodrome runways as far as practicable.

7.19 PBN procedures that overlay visual arrival and departure procedures should be established where this provided an operational advantage.

7.20 Airspace and instrument flight procedures associated with high density international aerodromes should not be constrained by international borders and political barriers as far as practicable. Airspace and procedures should be established only after appropriate consideration of:

a) environmental efficiencies;

b) noise abatement and local authority regulations;

c) adjacent aerodromes;

d) conflicting instrument flight procedures; and

e) affected ATC units or ATM procedures.

<u>En-route Airspace</u>

7.21 All <u>Category R and S</u> upper controlled airspace, and <u>Category T</u> airspace should, unless approved by the State, require the carriage of an operable:

a) mode S transponder within airspace where Mode S radar services are provided; and

b) ACAS and TAWS (ASBU Priority 2).

7.22 All en-route controlled airspace should be designated as being exclusive PBN airspace with mandatory carriage of GNSS utilising RNP navigation specifications, except for State aircraft. Such implementation mandates should be harmonised with adjacent airspace. ATS routes should be established in accordance with the following PBN specification:

- <u>Category R and S</u> airspace – **RNP 2**.

7.23 All <u>Category S</u> upper controlled airspace and <u>Category T</u> airspace should be designated as non-exclusive or exclusive as appropriate ADS-B airspace requiring operation of ADS-B using 1090ES with DO-260/260A and 260B capability.

7.24 In areas where ADS-B based separation service is provided, the mandatory carriage of ADS-B OUT using 1090ES with DO260/60A and 260B should be prescribed (ASBU Priority 2).

Preferred ATM Service Levels (PASL)

Note: prior to the implementation, the applicability of PASL should be verified by analysis of safety, current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet expectations of stakeholders.

PASL Phase I (expected implementation by 12 November 2015)

Aerodrome Operations

7.25 All high density aerodromes should have AMAN/DMAN facilities (ASBU priority 2).

Terminal Operations

7.26 All high density aerodromes should provide meteorological forecasts, aerodrome warnings and alerts that support efficient terminal operations (ASBU Priority 2).

En-route Operations

7.27 High density FIRs (refer **Figure 9**) supporting the busiest Asia/Pacific traffic flows and high density aerodromes should implement ATFM incorporating CDM to enhance capacity, using bi-lateral and multi-lateral agreements (ASBU Priority 1).

7.28 Harmonization of upper airspace classification should be as follows:

a) Category R controlled airspace– **Class A**; and

b) Category S controlled airspace– **Class A**, or if there are high level general aviation or military VFR operations: **Class B** or **C**.

7.29 Where practicable, all ATC Sectors within the same ATC unit with ATS surveillance capability should have automated hand-off procedures that allow the TOC of aircraft without the necessity for voice communications, unless an aircraft requires special handling.

ATM Systems

7.30 The delivery of CNS/ATM services should be based primarily on the CNS/ATM capability. All ATC units should authorise the use of the horizontal separation minima stated in ICAO Doc 4444 (PANS ATM), or as close to the separation minima as practicable, taking into account such factors as:

a) the automation of the ATM system;

b) the capability of the ATC communications system;

c) the performance of the ATS surveillance system, including data-sharing or overlapping coverage at TOC points; and

d) ensuring the competency of air traffic controllers to apply the full tactical capability of ATS surveillance systems.

7.31 The efficacy, continuity and availability of ATM services should be supported by adherence with regional planning and guidance material regarding ATM automation and ATM contingency systems.

7.32 ADS-B (using 1090ES) or MLAT or radar surveillance systems should be used to provide coverage of all Category S-capable airspace as far as practicable (ASBU Priority 1). Data from ATS surveillance systems should be integrated into operational ATC aircraft situation displays (standalone displays of ATS surveillance data should not be used operationally).

7.33 Within Category R airspace, ADS-C surveillance and CPDLC should be enabled to support PBN-based separations, as well as UPR and DARP (ASBU Priority 1).

7.34 Subject to appropriate filtering, ATS surveillance data, particularly from ADS-B, should be shared with neighbouring ATC units within high density FIRs (refer **Figure 5**). Direct speech circuits and appropriate handoff procedures should be implemented between controllers providing ATS surveillance in adjacent airspace.

7.35 ATM systems should enable AIDC (version 3 or later) between ATC units where transfers of control are conducted unless alternate means of automated communication of ATM system track and flight plan data are employed (ASBU Priority 1). As far as practicable, the following AIDC messages types should be implemented:

- Advanced Boundary Information (ABI);
- Coordinate Estimate (EST);
- Acceptance (ACP);
- TOC; and
- Assumption of Control (AOC).

Note: the 18th Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/18) determined that the following interface areas required AIDC priority implementation in order to reduce Large Height Deviations:

a) Indonesia: between Jakarta and Chennai/Ujung Pandang/Brisbane/Melbourne FIRs;

b) India: between Chennai and Kuala Lumpur FIRs;

c) Philippines: between Manila and Fukuoka/Taibei/Hong Kong/Ho Chi Minh/Singapore/Kota Kinabalu/ Ujung Pandang FIRs; and

d) China: between –

i. Urumqi and Lahore FIRs; and

ii. Beijing and Ulaan Baatar FIRs.

7.36 Priority for FLAS level allocations should be given to higher density ATS routes over lower density ATS routes. FLAS should comply with Annex 2, Appendix 3a unless part of an OTS. FLAS other than OTS should only be utilised for safety and efficiency reasons within:

a) Category R airspace with the agreement of all ANSPs that provide services:
   - within the airspace concerned; and
   - within adjacent airspace which is affected by the FLAS; or

b) Category S airspace with the agreement of all ANSPs that provide services:
   - where crossing track conflictions occur within 50NM of the FIRB; and
   - ATS surveillance coverage does not overlap the FIRB concerned, or ATS surveillance data is not exchanged between the ATC units concerned.

7.37 ATM systems, including communication and ATS surveillance systems and the performance of those systems, should support the capabilities of PBN navigation specifications and ATC separation standards applicable within the airspace concerned.

Note: guidance on the performance of ATS communication and surveillance systems is available in the Global Operational Data-link Document.

7.38 ATM systems should be supported by digitally-based AIM systems (using Aeronautical Information Exchange Model version 5.1 or later) through implementation of Phase 1 and 2 of the AIS-AIM Roadmap in adherence with ICAO and regional AIM planning and guidance material (ASBU Priority 1).

7.39 ATM systems should be supported by implementation of appropriate meteorological information reporting systems, providing, *inter-alia,* observations, forecasts, warnings and alerts, and also provide for information to meteorological authorities or offices where required.

Priority

7.40 Where a minimum aircraft equipage is specified, any aircraft that does not meet specified equipage requirements should receive a lower priority, except as prescribed (such as for State aircraft). States should require State aircraft to comply with equipage requirements as far as practicable.

Human Performance

7.41 The following should be established to support human performance in the delivery of a Seamless ATM service. The systems should consider all the elements of the SHEL Model (Software, Hardware, Environment and Liveware – humans), in accordance with the ICAO Human Factors Digest No. 1 and related reference material:

a) human performance training for all ANSP managers, including:
   - assessment and management of risks related to human capabilities and limitations;
   - effective participation in a team and team management
   - effective safety reporting systems;
   - human factors in air safety investigation;
   - fatigue management approaches;

b) enhancement and improved application of ATC simulators;

c) safety teams comprising multidisciplinary operational staff and managers which review safety performance and assess significant proposals for change to ATM systems;

d) human performance-based training and procedures for staff providing ATS, including:
   - the application of tactical, surveillance-based ATC separation;
   - control techniques near minimum ATC separation;
   - responses to ATM contingency operations and safety net alerts; and
   - the importance of an effective safety reporting culture.

Civil/Military Cooperation

7.42 Civil/Military ATM expectations are as follows:

a) a national civil/military body should be formed to coordinate strategic civil-military activities(military training should be conducted in locations and/or at times that do not adversely affect civilian operations, particularly those associated with major aerodromes);

b) formal civil-military liaison should take place for tactical responses by encouraging military participation at civil ATM meetings and within ATC Centres;

c) integration of civil and military ATM systems using joint procurement, and sharing of ATS surveillance data (especially from ADS-B systems) should be provided as far as practicable;

d) joint provision of civil/military navigation aids should be encouraged;

e) common training should be conducted between civil and military ATM units in areas of common interest; and

f) civil and military ATM units should utilize common procedures as far as practicable.

PASL Phase II (expected implementation by 08 November 2018)

Aerodrome Operations

7.43 ATM system design (including ATS surveillance, ATS communication systems, ATC separation minimum, aircraft speed control and ATC training) should be planned and implemented to support optimal aerodrome capacity expectations for the runway(s) concerned.

Terminal Operations

7.44 All terminal ATC Sectors should have a nominal aircraft capacity figure based on a scientific capacity study and safety assessment, to ensure safe and efficient aircraft operations.

Note: A study of the terminal ATC Sector airspace capacity every 15 minutes is provided in ***Appendix G****.*

7.45 All AMAN systems should take into account airport gates for runway selection and other aircraft departures from adjacent gates that may affect arriving aircraft.

En-route Operations

7.46 Where practicable, all ATC Sectors with adjacent ATC Centres using ATS surveillance capability should have automated hand-off procedures that allow the TOC of aircraft without the necessity for voice communications, unless an aircraft requires special handling.

7.47 All FIRs supporting Major Traffic Flows should implement ATFM incorporating CDM to enhance capacity, using bi-lateral and multi-lateral agreements (ASBU Priority 1).

7.48 Subject to appropriate filtering, ATS surveillance data, particularly from ADS-B, should be shared with all neighbouring ATC units.

7.49 ATM systems should enable AIDC, or an alternative process that achieves at least the same level of performance as AIDC, between en-route ATC units and terminal ATC units where transfers of control are conducted (ASBU Priority 1).

7.50 To ensure the safety and efficiency of aircraft operations, a nominal aircraft capacity figure based on a scientific capacity study and safety assessment should be available for all enroute ATC sectors.

Note: a study of the en-route ATC Sector airspace capacity every 15 minutes is provided in ***Appendix G****.*

ATM Systems

7.51 ATM systems should be supported by complete implementation of AIM Phase 3.

7.52 ATM systems providing services within Category R airspace should enable appropriate ATC capabilities including CPAR, which is a key enabler for UPR and DARP operations.

7.53 Electronic flight progress strips should be utilised wherever practicable.

Safety Nets

7.54 ATS surveillance systems should enable STCA, APW and MSAW (ASBU Priority 2). Route Adherence Monitoring (RAM) should be utilised when monitoring PBN route separations. Cleared Level Adherence Monitoring (CLAM) should be utilised to monitor RVSM airspace.

Human Performance

7.55 Prevention of fatigue systems should be established to support human performance in the delivery of a Seamless ATM service. The systems should be consistent with guidance within ICAO Doc 9966 *FRMS – Fatigue Risk Management System*.

RESEARCH AND FUTURE DEVELOPMENT POSSIBILITIES

Research and Development

8.1 To develop the tools and systems required to meet foreseeable long-term requirements, there is a need for States to undertake and co-operate on ATM Improvement. This includes major efforts to define concepts, to extend knowledge and invent new solutions to future ATM challenges so these new concepts are selected and applied in an appropriate timely manner. Such efforts could be forged through collaborative partnerships between, States, ANSPs, International Organizations, institutes of higher learning and specialised technical agencies. This concept is consistent with Seamless ATM Principle 36 (*Inter-regional cooperation ('clustering') for the research, development and implementation of ATM projects*).

8.2 The need for concepts beyond current technology and systems had been reinforced at APANPIRG/23. With the end goal of a globally interoperable ATM system in mind, the region will have to consider planning for a long term supporting concept and infrastructure. States should not overlook the need to include the development of future ATM concepts that will ensure the safety and fluidity of air transportation over the next few decades. The following are possible areas that should be considered for future development, in order to continue pursuance of seamless ATM beyond ASBU Block 0 implementations and global interoperability:

a. Space-Based ATS Surveillance - The AN-Conf/12 endorsed Recommendation 1/9 regarding space-based ADS-B systems being included in the GANP (**Appendix 2**);

b. Sub-Regional ATFM - Inter-linked (data-sharing) ATFM units (which may be virtual offices) should be developed to serve various sub-regions. This concept is consistent with Seamless ATM Principle 8 (*Sub-regional ATFM based on system-wide CDM serving the busiest terminal airspace and MTF*). The Global ATM Operational Concept paragraph 2.4.3 states: *Demand and capacity balancing will be integrated within the ATM system*;

c. Collaborative Air Navigation Services - This concept is consistent with the following Seamless ATM Principles: 9 (*Cross-border/FIR cooperation for use of aeronautical facilities and airspace, collaborative data sharing, airspace safety assessment and ATM Contingency plannin*g) and 15 (*Collaboration by ANSPs for evaluation and planning of ATM facilities*). The AN-Conf/12 endorsed Recommendation 5/1, regarding collaboration in airspace organization and routing, which emphasised, *inter alia*, the need to take advantage of improved models for inter-regional coordination and collaboration to achieve seamless air traffic management and more optimum routes through airspace (**Appendix 2**);

d. Airspace Optimisation - the CONOPS states: *Where possible the number of FIRs should be minimized particularly along traffic flows. FIRs should not necessarily be based strictly on the boundaries of sovereign territories*. This concept is consistent with and the following Seamless ATM Principles: 12 (*The optimisation of airspace structure through amalgamation and use of technology*) and 16 (*Optimization of ATM facilities through amalgamation and the use of technology, including automation, satellite-based systems and remote facilities*). The Global ATM Operational Concept paragraph 2.2.2 states: *While acknowledging sovereignty, airspace will be organized globally. Homogeneous ATM areas and/or routing areas will be kept to a minimum, and consideration will be given to consolidating adjacent areas*;

e. Consistent Operating Practices and Procedures - this is aligned with Seamless ATM Principle 3 (*Harmonised regional or sub-regional rules and guidelines*) and 4 (*Shared ATM operational standards, procedures, guidance materials through common manuals and templates*); and

f. Transition Altitude/Layer Harmonisation – this is consistent with AN-Conf/-12 Recommendation 5/1 b).

MILESTONES, TIMELINES, PRIORITIES AND ACTIONS

Milestones

9.1 Section 7 (Performance Improvement Plan) provides milestones and timelines for a number of elements in the PARS and PASL Phase I and II, being effective 12 November 2015 and 09 November 2018 respectively.

9.2 It should be noted that States should commence planning for the various elements, such as PBN specifications detailed in the PARS to cover overall ATM operations, taking into account the whole phase of flight. This should be planned from the approval of this Plan, to ensure a smooth transition by the onset of Phase I, and should include consideration of issues such as:

- aircraft equipage and certification;
- safety/operational analysis and assessment;
- cost-effectiveness;
- budgetary issues;
- development of operational procedures; and
- training.

9.3 States should commence planning for PBN specifications detailed in the PARS and other initiatives which have been globally documented, to facilitate a smooth transition by the onset of Phase I. The Regional PBN Plan is expected to transition to a general guideline for implementation during this period, with the prescriptive PBN specifications being incorporated into this Plan.

9.4 Section 8 (Research and Future Development Possibilities) provides, subject to future agreement by concerned parties, possible Seamless ATM improvements beyond 2018 until 2028.

Priorities

9.5 It is a matter for each State to determine priorities in accordance with its own economic, environmental, safety and administrative drivers. The ASBU Block 0 priorities determined by APSAPG/2 in Section 5 (Background Information) were used to determine the ASBU elements that should be contained within which PARS and PASL Phase.

Actions

9.6 This Plan necessitated a number of implementation actions. It was expected that Implementation Guidance would be further developed by the ICAO Regional Office. It is expected that each Asia/Pacific State and administration develop Seamless ATM Implementation Planning based on applicable parts of the Implementation Guidance Material, and implementation progress be reported to APANPIRG.

9.7 APANPIRG and its contributory bodies such as the ATM Sub-group and the CNS Sub-group are responsible for the oversight of air navigation issues within the Asia/Pacific, so these bodies needed to be made aware of State implementation progress of Seamless ATM initiatives. APANPIRG and its contributory bodies need to manage the implementation of Seamless ATM through the ASBU framework and this Plan.

9.8 Section 6 (Current Situation) provides detailed analysis and major concerns in the region. Some of the non-ICAO sub-regional collaborative frameworks or actions have successfully achieved ATM operational improvements in the past. These forums will continue to be important in Seamless ATM implementation in the future.

9.9 The ICAO Asia and Pacific Regional Office is responsible for taking actions that assisted the implementation of Seamless ATM within its accredited States. In addition, the Asia and Pacific Regional Office coordinated with adjacent ICAO regional offices on an ad hoc basis or at relevant trans-regional meetings.

Appendix A: KANSAI Statement

The Directors General of Civil Aviation (DGCA) of the Asia and Pacific Regions met for the 46th DGCA Conference in Japan, 12-16 October, 2009. Recalling that the 45th Conference had endorsed the Theme Topic for the 46th DGCA Conference as "Seamless Sky: Bringing Together the Asia/Pacific Regions," Directors General of the Region held a productive discussion focusing on three aspects of the "Seamless Sky," namely Air Traffic Management (ATM), Air Cargo Security, and Aviation Safety, and agreed to issue this Kansai Statement.

KANSAI STATEMENT

1. We recognized that as civil aviation develops and globalization progresses, harmonization in civil aviation systems is becoming critically important in the Asia and Pacific Region, which has been characterized by the diversities of the member States. What people expect from harmonization in civil aviation is that aircraft operators will become capable of seamlessly flying between regions, that the whole of the network will be secured at the agreed level, and that transparent and interoperable standards will be set among States and regions. In this regard, "Seamless Sky" is particularly important in the areas of air traffic management, aviation security and aviation safety.

2. Regarding Air Traffic Management (ATM), we recognized that the ICAO has been leading the development and implementation of the Global Air Traffic Management system with the implementation target of 2025. The Global Air Traffic Management system will be based on the components described in the Global ATM Operational Concept. We also recognized that the United States and Europe have been developing their future air traffic modernization programmes. Taking such global trends of future ATM system into consideration, we recognized the necessity of planning the future ATM system for the Asia and Pacific Region by the active collaboration and participation of the whole of the Region. In this regard, we agreed that APANPIRG be the starting platform to discuss and plan the future ATM system of the Asia and Pacific Region including targets and a time schedule.

3. Regarding aviation security, we recognized the significance of enhancing air cargo security. Such efforts will enable member States to protect the flow of air cargo, raise security standards and facilitate international trade in the Asia and Pacific Region. To achieve these desired outcomes effectively, member States are encouraged to collaborate with one another and with ICAO towards developing internationally harmonized measures and processes in air cargo security. We agreed that the further sharing of information and best practices should be promoted, and to consider including provisions on air cargo security into Annex 17, taking into account the need to protect the entire cargo supply chain.

4. Regarding the aviation safety, we acknowledged the ICAO's leadership in the improvement of aviation safety. We recognized the importance of the member States' role in ensuring that their air operators establish and maintain the highest standards in safety through the proper implementation of Safety Management System as envisaged under the State Safety Programme. In addition, we recognized the importance of the safety monitoring activities regarding foreign aircraft by the member States in the Region. We agreed to further enhance the cooperation in these efforts and activities in the Region in a harmonized manner.

5. We are determined to realize the Seamless Sky in the Asia and Pacific Region from this conference onwards. We agreed to make efforts to move forward toward the harmonized aviation in the Asia Pacific Region in cooperation with all the member States and the ICAO Asia Pacific Regional Office.

Appendix B: Relevant 12th Air Navigation Conference Recommendations

1 Recommendation 1/7 – Automatic dependent surveillance — broadcast

That States:

a) recognize the effective use of automatic dependent surveillance — broadcast (ADS-B) and associated communication technologies in bridging surveillance gaps and its role in supporting future trajectory-based air traffic management operating concepts, noting that the full potential of ADS-B has yet to be fully realized;

b) recognize that cooperation between States is key towards improving flight efficiency and enhancing safety involving the use of automatic dependent surveillance — broadcast technology.

That ICAO:

c) urge States to share automatic dependent surveillance — broadcast (ADS-B) data to enhance safety, increase efficiency and achieve seamless surveillance and to work closely together to harmonize their ADS-B plans to optimize benefits.

2 Recommendation 1/9 – Space-based automatic dependent surveillance — broadcast

That ICAO:

a) support, subject to validation, the inclusion in the GANP, development and adoption of space-based automatic dependent surveillance — broadcast surveillance as a surveillance enabler;

b) develop Standards and Recommended Practices and guidance material to support space-based automatic dependent surveillance — broadcast as appropriate; and

c) facilitate needed interactions among stakeholders, if necessary, to support this technology.

3 Recommendation 2/1 – ICAO aviation system block upgrades relating to airport capacity

That States:

a) according to their operational needs, implement the aviation system block upgrade modules relating to airport capacity included in Block 0;

b) endorse the aviation system block upgrade modules relating to airport capacity included in Block 1 and recommended that ICAO use them as the basis of its standards work programme on the subject;

c) agree in principle to the aviation system block upgrade modules relating to airport capacity included in Blocks 2 and 3 as the strategic direction for this subject.

4 **Recommendation 3/1 – ICAO aviation system block upgrades relating to Interoperability and data – through globally interoperable system-wide information management**

That States:

a) endorse the aviation system block upgrade module relating to interoperability and data – through globally interoperable system-wide information management included in Block 1, and recommend that ICAO use it as the basis of its work programme on the subject;

b) agree in principle with the aviation system block upgrade module relating to interoperability and data – through globally interoperable system-wide information management included in Block 2, as the strategic direction for this subject; and

That ICAO:

c) include, following further development and editorial review, the aviation system block upgrade modules relating to interoperability and data – through globally interoperable system-wide information management for inclusion in the draft Fourth Edition of the *Global Air Navigation Plan* (Doc 9750, GANP).

5 **Recommendation 4/2 – ICAO ASBU relating to ground surveillance using ADS-B/MLAT, air traffic situational awareness, interval management and airborne separation**

That States:

a) according to their operational needs, to implement the aviation system block upgrade modules relating to ground surveillance, improved air traffic situational awareness and improved access to optimum flight levels included in Block 0;

b) endorse the aviation system block upgrade modules relating to interval management included in Block 1 and recommend that ICAO use them as the basis of its work programme on the subject;

c) endorse the aviation system block upgrade modules relating to airborne separation included in Blocks 2 and 3 as the strategic direction for this subject;

That ICAO:

d) include, following further development and editorial review, the aviation system block upgrade modules relating to airborne separation in the draft Fourth Edition of the *Global Air Navigation Plan*;

e) adopt “airborne separation” concepts involving controllers assigning tasks to flight crews, with controllers able to apply different, risk-based separation minima for properly equipped ADS-B IN aircraft;

f) in the development of provisions, acknowledge the relationship between airborne separation and airborne collision avoidance system;

g) modify aviation system block upgrade (ASBU) Module B2-85 to reflect e) and f), modify ASBU Module B2-101 to reflect f); and

h) review the concept and terminology supporting B2-25 “airborne separation” and amend the module accordingly.

6 Recommendation 5/1 - Improved operations through enhanced airspace organization and routing

Considering that performance-based navigation (PBN) is one of ICAO's highest air navigation priorities and the potential benefits achievable through creation of additional capacity with PBN:

That States:

a) implement performance-based navigation in the en-route environment;

b) fully assess the operational, safety, performance and cost implications of a harmonization of transition altitude and, if the benefits are proven to be appropriate, undertake further action on a national and (sub) regional basis;

c) take advantage of improved models for inter-regional coordination and collaboration to achieve seamless air traffic management and more optimum routes through the airspace;

d) through the planning and implementation regional groups improve their methods of coordination to increase implementation of en-route performance-based navigation in order to achieve more optimum routes through the airspace;

That ICAO:

e) encourage the planning and implementation regional groups to support the early deployment of performance-based navigation.

7 Recommendation 6/1 – Regional performance framework – planning methodologies and tools

That States and PIRGs:

a) develop and maintain regional air navigation plans consistent with the Global Air Navigation Plan;

b) finalize the alignment of regional air navigation plans with the Fourth Edition of the *Global Air Navigation Plan* by May 2014;

c) focus on implementing aviation system block upgrade Block 0 Modules on the basis of operational requirements, recognizing that these modules are ready for deployment;

d) use the electronic regional air navigation plans as the primary tool to assist in the implementation of the agreed regional planning framework for air navigation services and facilities;

e) consider how the continuous monitoring approach to safety oversight maps to the evaluation of Member States' safety oversight capabilities concerning aviation system block upgrades;

f) involve regulatory and industry personnel during all stages of planning and implementation of aviation system block upgrade modules;

g) develop action plans to address the identified impediments to air traffic management modernization as part of aviation system block upgrade planning and implementation activities.

8 **Recommendation 6/4 – Human performance**

That ICAO:

a) integrate human performance as an essential element for the implementation of ASBU modules for considerations in the planning and design phase of new systems and technologies, as well as at the implementation phase, as part of a safety management approach. This includes a strategy for change management and the clarification of the roles, responsibilities and accountabilities of the aviation professionals involved;

b) develop guidance principles, guidance material and provisions, including SARPs as necessary, on ATM personnel training and licensing including instructors and assessors, and on the use of synthetic training devices, with a view to promoting harmonization, and consider leading this effort with the support of States and industry;

c) develop guidance material on using field experience and scientific knowledge in human performance approaches through the identification of human-centred operational and regulatory processes to address both current safety priorities and the challenges of future systems and technologies;

d) assess the impact of new technologies on competencies of existing aviation personnel, and prioritize and develop competency-based provisions for training and licensing to attain global harmonization;

e) establish provisions for fatigue risk management for safety within air traffic services operations;

f) develop guidance material on different categories of synthetic training devices and their respective usage;

provide human performance data, information and examples of operational and regulatory developments to ICAO for the benefit of the global aviation community;

h) support all ICAO activities in the human performance field through the contribution of human performance expertise and resources;

i) adopt airspace procedures, aircraft systems, and space-based/ground-based systems that take into account human capabilities and limitations and that identify when human intervention is required to maintain optimum safety and efficiency; and

j) investigate methods to encourage adequate numbers of high quality aviation professionals of the future and ensure training programmes are in line with the skills and knowledge necessary to undertake their roles within a changing industry.

9

Recommendation 6/12 – Prioritization and categorization of block upgrade modules

That States and PIRGs:

a) continue to take a coordinated approach among air traffic management stakeholders to achieve effective investment into airborne equipment and ground facilities;

b) take a considerate approach when mandating avionics equipage in its own jurisdiction of air navigation systems provision, taking into account of burdens on operators including foreign registry and the need for consequential regional/global harmonization;

That ICAO:

a) continue to work on guidance material for the categorization of block upgrade modules for implementation priority and provide guidance as necessary to planning and implementation regional groups and States;

b) modify the block upgrade module naming and numbering system using, as a basis, the intuitive samples agreed by the Conference; and

c) identify modules in Block 1 considered to be essential for implementation at a global level in terms of the minimum path to global interoperability and safety with due regard to regional diversity.

Appendix C: Seamless ATM Principles

People: Cultural and Political Background

1. High-level political support (including development of educational information for decision-makers) to support Seamless ATM initiatives, including military cooperation and AIM.
2. Education and implementation of non-punitive reporting and continuous SMS improvement systems.

Aviation Regulations, Standards and Procedures

3. Harmonised regional or sub-regional rules and guidelines, modelled on the regional application of common regulations incorporated by reference into local legislation.
4. Shared ATM operational standards, procedures, guidance materials through common manuals and templates.
5. The promotion of mutual recognition of ATM qualifications between States.
6. An emphasis on delivery of ATM services based on CNS capability, resulting in flexible, dynamic systems.
7. The use of high-fidelity simulators to train controllers on the optimal application of ATC separations and procedures that support Seamless ATM applications, emergency and contingency responses, testing of software releases, and may serve as a backup ATM platform.

ATM Coordination

8. Sub-regional ATFM based on system-wide CDM serving the busiest terminal airspace and MTF.
9. Cross-border/FIR cooperation for use of aeronautical facilities and airspace, collaborative data sharing, airspace safety assessment and ATM Contingency planning.
10. Encouragement of military participation in civil ATM meetings and in ATS Centres where necessary.

Airspace Organisation

11. Promoting flexible use airspace arrangements and regular review of airspace to ensure it is appropriate in terms of purpose, size, activation and designation.
12. The optimisation of airspace structure through amalgamation and use of technology.

Facilities: Aerodromes

13. To encourage aerodrome operators to actively participate in ATM coordination in respect of Airport CDM development and operational planning, including aerodrome complexity and capacity.
14. Planning and coordination with local authorities and government agencies to take into account environmental issues, obstacles, aerodrome and PBN development.

ATS Units

15. Collaboration by ANSPs for evaluation and planning of ATM facilities.
16. Optimization of ATM facilities through amalgamation and the use of technology, including automation, satellite-based systems and remote facilities.

Navigation Aids

17. The continued rationalisation of terrestrial navigation aids to satellite-based procedures, while retaining a minimum network necessary to maintain safety of aircraft operations.
18. Support for a GNSS-based global PBN approval standard.
19. Regional cooperation for augmentation systems in terms of interoperability and increased service areas, and a GNSS ionospheric monitoring network.

Telecommunication

20. Encouragement of the use of ground-ground ATN/AMHS and diverse satellite communication systems.
21. Enhancement of data-link capabilities (VHF including VDL M2, SATCOM).
22. Where cost beneficial and appropriate, the implementation of:
    - SATVOICE technologies and standards;
    - HF data-link;
    - VSAT networks in support of COM and SUR.
23. The prioritisation of AIDC systems to alleviate ATC coordination issues.

ATS Surveillance

24. The encouragement of ADS-B and/or MLAT implementation to improve ATS surveillance coverage, redundancy and multiple tracking capability.
25. Establishment of ADS-C where radar, ADS-B (including satellite –based ADS-B) and/or MLAT is not possible.
26. Expansion of ATS surveillance data-sharing initiatives.

Technology and Information: Flight Operations

27. Implementation of UPR and DARP where practicable.
28. Implementation of CDO and CCO where possible.
29. The encouragement of appropriate technologies that support Trajectory-Based Operations.

Aeronautical Data

30. Early implementation of AIM, including cooperative development of aeronautical databases and SWIM to support interoperable operations.

ATM Systems and Safety Nets

31. Application of ground-based safety nets, which includes tactical and strategic conflict probing (such as APW, STCA) and MSAW.
32. Support for Inter-facility Flight Data Processing System capability.
33. Collaborative development of CDM, ATFM, A/MAN and D/MAN support tools.
34. Encouragement of Digital ATIS and VOLMET information systems.
35. Encourage sharing of air traffic data between military ATM systems and civil ATM systems.

ATM Modernisation Projects

36. Inter-regional cooperation (‘clustering’) for the research, development and implementation of ATM projects.
37. A focus on technologies for earliest deployment and best cost benefits.

Appendix D: Asia/Pacific Performance Analysis

1 The following tables provide an assessment of the delta between current capabilities and practices of administrations that serve FIRs and Phase 1 of the PARS/PASL (12 November 2015), within Category R, S and T airspace. An 'X' indicates that there is a requirement to upgrade to meet the PASL, while a tick indicates current compliance.

South Asia

Afghanistan	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		? (in progress)	√	
Horizontal Separation		X	X	
TOC separation		X		
AIDC		X		
FLAS		X		

Table D1: Kabul FIR Assessment

Bangladesh	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	X	
ATS surveillance		X	X	No en-route service above FL150
Horizontal Separation		NA	X	
TOC separation		X		
AIDC		X		
FLAS		NA		

Table D2: Dhaka FIR Assessment

India	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	X	X	√	
ATS surveillance	√	X	√	
Horizontal Separation	X	√	√	
TOC separation	X	X		
AIDC	X	X		
FLAS	X	X		Indian Ocean FLAS

Table D3: **Chennai**, Delhi, Kolkata, Mumbai FIR Assessment

Maldives	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	X	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	X	√	√	
TOC separation	X	X		
AIDC	X	X		
FLAS	√	NA		

Table D4: Male FIR Assessment

Nepal	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		√	√	
Horizontal Separation		X	√	
TOC separation		X		
AIDC		X		
FLAS		√		

Table D5: Kathmandu FIR Assessment

Pakistan	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		√	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		X		

Table D6: Karachi, Lahore FIR Assessment

Sri Lanka	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	CPDLC Unreliable
Navigation	X	X	X	
ATS surveillance	X	√	√	ADSC Unreliable
Horizontal Separation	X	√	X	
TOC separation	X	X		
AIDC	X	X		
FLAS	X	X		

Table D7: Colombo FIR Assessment

Southeast Asia

2 Southeast Asian airspace had a number of features that worked counter to Seamless ATM:

- fragmented FIRS not aligned with the direction of the main traffic flows;
- wide differences in the level of development in ATM infrastructure and capability;
- infrastructure development at national level with little consultation among neighbouring FIRs, resulting in limited or no integration with each other;
- inadequate ATS surveillance cover in some busy traffic junctions, resulting in greater reliance on vertical restrictions as a means of ensuring a safe traffic flow;
- obstacles to the development of ADS-B and data sharing, although regional efforts were underway (a concerted effort is required to accelerate these programs);
- conservative application of horizontal separation standards at TOC points with surveillance, which should be addressed by focus groups; and
- un-coordinated and limited use of AIDC.

Cambodia	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	X	
ATS surveillance		√	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		X		

Table D8: Phnom Penh FIR Assessment

Indonesia	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	X	X	X	
ATS surveillance	√	√	√	
Horizontal Separation	X	√	√	
TOC separation	X	X		
AIDC	X	X		
FLAS	X	X		

Table D9: Jakarta, Ujung Pandang FIRs Assessment

Lao PDR	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	X	
ATS surveillance		√	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		X		

Table D10: Vientiane FIR Assessment

Malaysia	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		X	√	Requires ADS-B
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		√		

Table D11: Kuala Lumpur, Kota Kinabalu FIR Assessment

Myanmar	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		X	√	
Navigation		X	X	
ATS surveillance		X	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		X		

Table D12: Yangon FIR Assessment

Philippines	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	X	√	√	Unreliable HF
Navigation	X	X	X	
ATS surveillance	X	X	√	ATM automation upgrade required
Horizontal Separation	X	√	√	
TOC separation	X	X		
AIDC	X	X		
FLAS	√	√		

Table D13: Manila FIR Assessment

Singapore	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		X	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		√		

Table D14: Singapore FIR Assessment

Thailand	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		√	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		√		

Table D15: Bangkok FIR Assessment

Viet Nam	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	Waypoint reports not required with ATS surveillance
Navigation	X	X	X	
ATS surveillance	√	√	√	
Horizontal Separation	X	√	√	
TOC separation	X	X		
AIDC	X	X		
FLAS	X	X		Domestic v. A1

Table D16: Hanoi, Ho Chi Minh FIR Assessment

East Asia

China	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS Surveillance		√	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		√		AIDC HKG
FLAS		√		Appendix 3b FLOS

Table D17: Beijing, Guangzhou, Kunming, Lanzhou, Sanya, Shanghai, Shenyang, Urumqi, Wuhan FIRs Assessment

Hong Kong, China	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS Surveillance		√	√	
Horizontal Separation		√	√	
TOC separation		X		
AIDC		√		AIDC Sanya
FLAS		√		

Table D18: Hong Kong FIR Assessment

DPR Korea	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	X	
ATS surveillance		√	√	
Horizontal separation		√	X	
TOC separation		X		
AIDC		X		
FLAS		X		Metre FLOS ≤FL290

Table D19: Pyongyang FIR Assessment

Japan	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	√	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	√	√	√	
TOC separation	X	X		
AIDC	√	X		
FLAS	√	X		

Table D20: Fukuoka FIR Assessment

Mongolia	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	X	
ATS surveillance		X	√	Partial coverage
Horizontal separation		√	√	
TOC separation		X		
AIDC		X		
FLAS		√		

Table D21: Ulaan Baatar FIR Assessment

Republic of Korea	**Category R**	**Category S**	**Category T**	**Remarks**
Communication		√	√	
Navigation		X	√	
ATS surveillance		√	√	
Horizontal Separation		√	√	B467, B332, L512 FLAS. AKARA Corridor procedures require review
TOC separation		X		
AIDC		X		
FLAS		X		

Table D22: Incheon FIR Assessment

Note: the Taibei FIR was not assessed.

Pacific

Australia, Nauru, Solomon Islands	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	√	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	√	√	√	
TOC separation	√	√		
AIDC	√	√		
FLAS	√	√		

Table D23: Brisbane, Honiara, Melbourne, Nauru FIRs Assessment

Fiji	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	√	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	√	√	√	
TOC separation	√	√		
AIDC	X	NA		
FLAS	√	√		

Table D24: Nadi FIR Assessment

French Polynesia	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	√	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	√	√	√	
TOC separation	√	X		
AIDC	X	√		
FLAS	√	√		

Table D25: Tahiti FIR Assessment

New Zealand	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	
Navigation	√	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	√	√	√	
TOC separation	√	√		
AIDC	√	√		
FLAS	√	√		

Table D26: Auckland Oceanic, New Zealand FIRs Assessment

Papua New Guinea	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	X	√	√	
Navigation	X	X	X	
ATS surveillance	X	X	√	
Horizontal Separation	X	X	X	
TOC separation	X	X		
AIDC	X	X		
FLAS	√	√		

Table D27: Port Moresby FIR Assessment

United States	**Category R**	**Category S**	**Category T**	**Remarks**
Communication	√	√	√	Cat S/T for islands
Navigation	√	X	√	
ATS surveillance	√	√	√	
Horizontal Separation	√	√	√	
TOC separation	√	√		
AIDC	√	√		
FLAS	√	√		

Table D28: Oakland, Anchorage Oceanic FIRs Assessment

Appendix E: New Zealand Seamless ATM Planning Framework

Background

1 A performance-based planning framework, derived from ICAO planning frameworks, has been adopted for the New Zealand project. The Plan brings together airspace, CNS, ATM, aerodromes, AIM, and meteorology work streams. The Plan also considers over-arching issues, such as regulatory requirements (including rules, operational approvals, etc.), aircraft requirements, licensing and training requirements, security and environmental matters.

2 The following factors are drivers for change from equipment-based to performance-based system:

- many airline and modern general aviation aircraft have been equipped for GNSS navigation;
- RNP approaches have been established;
- the establishment of enhanced ATS surveillance such as MLAT to assist in the situational awareness of air traffic; and
- a single aeronautical database that allows the Aeronautical Information Publication and aeronautical charts to be produced from one database, thereby reducing errors.

3 Considerable effort has been undertaken in recent years on improving individual elements of the New Zealand national airspace and air navigation system, including:

- Airspace Policy;
- a PBN Implementation Plan;
- Aeronautical Information Service (AIS) to AIM Roadmap which includes development of the AIXM database for AIM;
- plans for improved ATM and ATS surveillance.

4 However, a much greater degree of coordination is needed between government and the industry in order to manage change in the airspace and air navigation system effectively, efficiently and safely. In particular, changes are needed to reduce the risk of inappropriate and wasted investment in technologies and equipage, and to reduce any risk of disruption due to lack of coordination between industry, the air navigation services provider (ANSP), the regulator, and government. Five key policy areas that would need to be addressed to enable these changes were identified:

a) implementation of a suitable planning approach to facilitate the changes in the airspace and air navigation system;

b) effective management by phasing the system changes;

c) establishment of principles for the designation of airspace in the future system;

d) better integration of decision-making on airspace and land use management (which involves coordination with local authorities and increasing awareness of aviation requirements); and

e) streamlining of changes to regulatory requirements wherever possible.

5 As part of the Plan development, New Zealand will coordinate with neighbouring States in accordance with the concept of Seamless ATM.

Appendix F: Point Merge Procedure Efficiency Analysis (Republic of Korea)

1 Existing STARs, usually designed to provide the shortest transition, provide information on the expected arrival track to the pilot, allowing planning for the approach to include CDO. However, it was not applicable if the traffic volume exceeded the maximum capacity of the STAR. In this situation, radar vectors were used to accommodate the increased traffic. However, radar vectors increased air traffic controller workload and reduced pilot situational awareness, even when following ATC instructions.

2 To overcome the disadvantages of radar vectors and to improve efficiency and effectiveness of terminal airspace, the Point Merge method based on PBN was implemented at Incheon International Airport on 3 May 2012 (**Figure F1**). The Point Merge method allowed improved:

- safety (due to the reduction of controller-pilot radio communication and enhanced surveillance capability);
- fuel efficiency (mainly through use of CDO); and
- capacity management (with better information on aircraft position supporting 4D Trajectory-Based Operations and enhanced wake turbulence management).

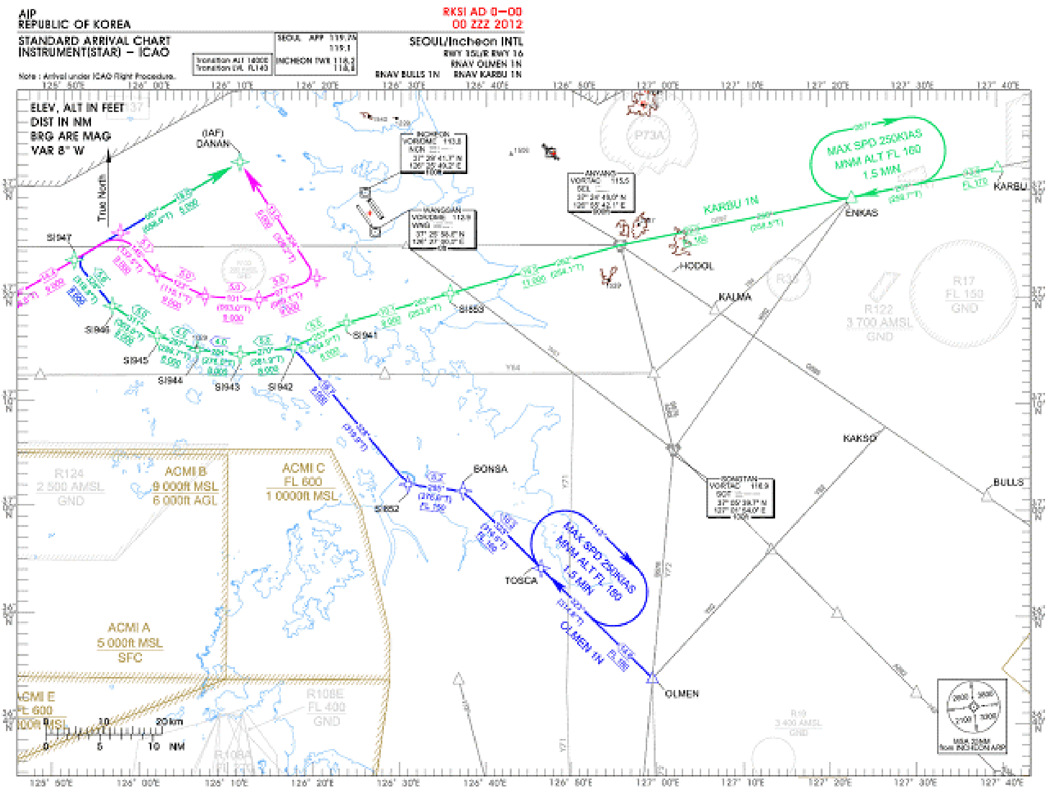

Figure F1: Incheon Airport Point Merge Procedure

3 STARs with Point Merge method were implemented at Incheon International Airport on 3 May 2012. According to the analysis of the initial phase of implementation of point merge method, the average flight distance was decreased by 2.3%, while average flying time was increased by 1.1% (due to speed control for spacing). However, variance related to flight distance and flying time decreased by 35.6% and 42.4% respectively, increasing the predictability of aircraft operations.

4 As for the vertical profiles of aircraft, analysis indicated that the aircraft following STARs with the point merge method descended from it significantly higher altitude comparing to conventional procedures including radar vectors (**Figure F2**). This meant that the Point Merge procedures were enabled to descend continuously. Based on the observed results, the new Point Merge procedures saved fuel consumption by 16%, compared to the replaced procedures.

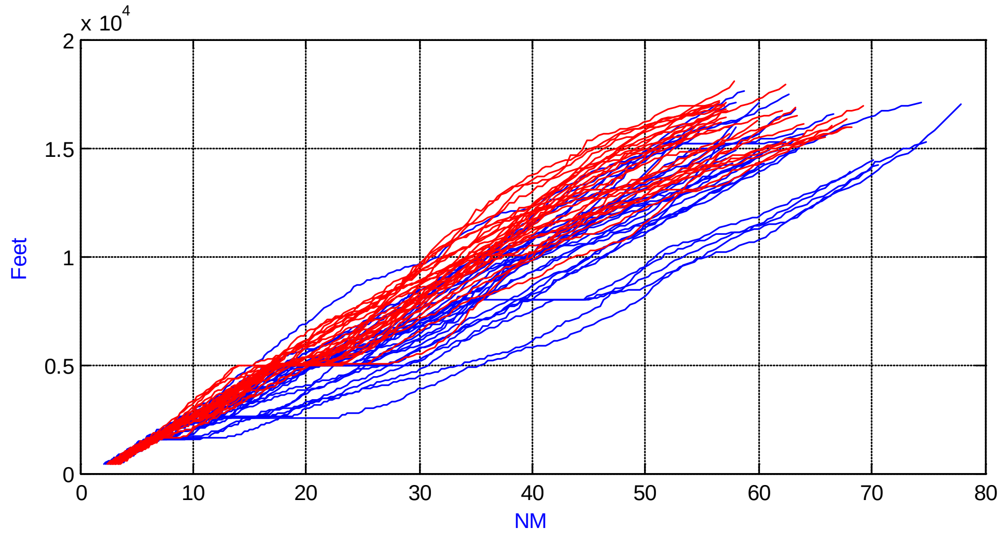

Figure F2: Vertical Profile Comparison – Blue Tracks: Radar Vectors, Red: Point Merge

5 In terms of the workloads of air traffic controllers, the Point Merge procedures reduced average communication time per aircraft and average communication frequency per aircraft by 36.6%, 10.0% respectively. This meant air traffic controllers could concentrate on traffic monitoring, and provide pilot with more information useful for situational awareness.

6 The study showed that there was no significant difference between radar vectors and Point Merge method regarding airspace capacity. However, greater capacity was expected overall due to the improvement in controller workload, and if the arrival management tool was also used, this would further increase capacity (**Figure F3**). Therefore, implementation of the Point Merge method enabled terminal airspace operations to be safer and more efficient (in terms of cost savings, less carbon dioxide, and increased airspace capacity), provided that CDO and arrival management tools were also implemented with the point merge method.

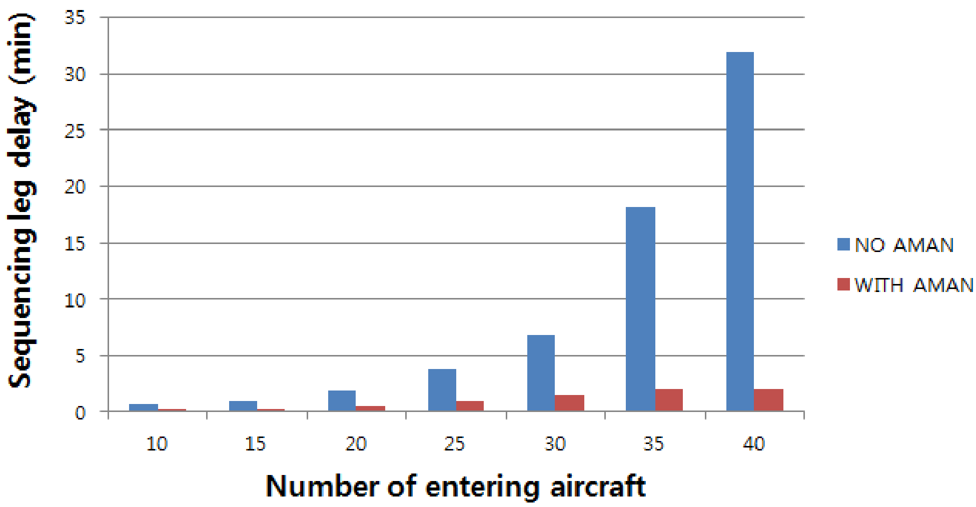

Figure F3: Point Merge Sequence Leg Delay Time

Appendix G: Capacity Expectations

1 Capacity metrics will vary considerably, depending upon many factors such as the COM and SUR capabilities, the presence of terrain, physical attributes of aerodromes and weather. Thus the expectations outlined for the following States need to be treated with caution, however they form a useful guide as to the sort of capability being achieved with modern systems and appropriately trained controllers.

2 **Table G1** provides an indication of potential Aerodrome Arrival Rate (AAR) for a single runway, given aircraft ground speeds and aircraft spacing near the runway threshold (source: *Guide for the Application of a Common Methodology to Estimate Airport and ATC Sector Capacity for the SAM Region, Attachment 7: Calculation of the Aerodrome Acceptance Rate used by the FAA*).

Speed	3NM	3.5NM	4NM	4.5NM	5NM	6NM	7NM	8NM	9NM	10NM
140kt	46	40	35	31	28	23	20	17	15	14
130kt	43	37	32	28	26	21	18	16	14	13
120kt	40	34	30	26	24	20	17	15	13	12

Table G1: Potential Runway Arrival Rate

3 ATC capacity calculations needed to take into account the volume of airspace of each sector, which varied considerably by State, and factors such as automation, density of traffic and complexity of routes/airspace. The ICAO *Manual on Collaborative Air Traffic Flow Management* (Doc 9971) contained guidelines for ATC sector capacity assessment. **Table G2** provides simplified ATC sector calculation guidance from Doc 9971.

Average sector flight time (minutes)	Optimum sector capacity value (aircraft)
3 minutes	5 aircraft
4	7
5	8
6	10
7	12
8	13
9	15
10	17
11	18
12 minutes or more	18

Table G2: Simplified ATC Sector Capacity Table (no complexity/automation allowance)

4 Australia, Japan, New Zealand, Singapore, Thailand and the United States provided runway and airspace (ATC Sector) capacity data, to indicate potential capacity figures in varying Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC) circumstances.

<u>Australia</u>

5 Brisbane and Melbourne aerodrome capacity expectations:

- single runway: **48** (24 arrivals - 150 seconds between arrivals, 24 departures, VMC);
- single runway: **40** (20 arrivals - 180 seconds, 20 departures, IMC).

Japan

6 Aerodrome capacity expectations:

- Narita (dual runways): 56-64;
- Haneda (4 runways): 74.

New Zealand

7 Auckland aerodrome capacity expectations:

- single runway: **40** (VMC);
- single runway: **39** (IMC circling);
- single runway: **37** IMC below circling with missed approach protection for jets);
- single runway: **32** (IMC below circling with missed approach protection)

8 ATC Sector capacity expectations:

- terminal/low level Category T airspace: **12** aircraft; and
- en-route Category S airspace: **15** aircraft;
- en-route Category R airspace: **15** aircraft.

Singapore

9 Changi aerodrome capacity expectations:

- single runway: **30** (IMC); and
- two parallel/near parallel runways: **72** (IMC);
- three parallel/near parallel runways: to be confirmed, possibly 100+ (IMC).

10 ATC Sector capacity expectations:

- terminal/low level Category T airspace: **14** aircraft; and
- en-route Category S airspace (sector dimension of 150NM x 100NM): 7 aircraft (extrapolated √6.66 x airspace volume = 2.58 x 7 = **18**).

Thailand

11 Suvarnabhumi aerodrome capacity expectations:

- single runway: **34** (VMC/IMC).

United States of America

12 **Table G3** provides an indication of optimal aerodrome parallel or near parallel arrival rate runway arrival capacity at selected USA aerodromes. It should be noted that multiple runway combinations or whether runways were used for arrivals, departures, or both yielded a number of permutations from the data.

Aerodrome	Runways	IMC	VMC
ATL	5	104	126
ORD	5	84	112
DFW	5	90	96

ATL	4	92	112
DEN	4	-	114
LAX	4	64	80
ORD	4	-	92
ATL	3	76	96
DEN	3	-	96
IAD	3	72	100
ATL	2	68	82
JFK	2	-	58
SDF	2	40	52
ATL	1	34	42
SDF	1	20	26
SFO	1	25	27

Table G3: Capacity at selected US airports

13 Average aerodrome arrival capacity expectations (range):

- single runway: IMC average **26** (25-34), VMC average **32** (26-42);
- two parallel/near parallel runways: IMC **55** (40-68), VMC **64** (52-82);
- three parallel/near parallel runways: IMC **74** (72-76), VMC **97** (96-100);
- four parallel/near parallel runways: IMC **78** (64-92), VMC **100** (80-112);
- five parallel/near parallel runways: IMC **92** (84-104), VMC **111** (96-126).

14 ATC Sector capacity expectations:

- terminal/low level Category T airspace: **12-18** aircraft; and
- en-route Category S airspace: **16-20** aircraft; and
- en-route Category R airspace: **17-24** aircraft.

Summary

15 **Table G4** summarises runway and airspace capacity expectations from States, with the greatest capacity achieved in optimum conditions highlighted in bold.

	Parallel or Near Parallel Runway Capacity					ATC Sector Capacity		
	1	2	3	4	5	T	S	R
Australia	40-48							
Japan		56-64		74				
NZ	32-40					12	15	15
Singapore	30	72				14	18	
Thailand	34							
USA	**61**	**95**	**150**	**177**	**211**	12-**18**	16-**20**	17-**24**
Doc 9971 Simplified Table Comparison						15	18	18

Table G4: Capacity Expectations Summary

Note: Given the unique operation environment and constraints of individual States, these figures are indicative only and do not represent the same expectation across different States in the region

Appendix H: Elements Map

ASBU Element	Global/Regional Element	Civil/Military Element	Plan	Reference/ Principle
B0-CDO: CDO, STAR			PARS I/II	28
B0-FRTO: FUA, UPR, DARP			PARS I	27, 11
B0-RSEQ: AMAN/DMAN			PARS I/II	8, 33
B0-CCO: CCO, SID			PARS I/II	28
B0-FICE: AIDC, ATN			PASL I	20, 23, 26
B0-DATM: AIM			PASL I/II	30
B0-NOPS: ATFM			PASL I	8
B0-TBO: ADS-C, CPDLC			PARS I PASL I	25, 29
B0-APTA: AIRPORT PBN			PARS I/II	17
B0-WAKE: WAKE TURB			-	3, 4
B0-SURF: ASMGCS, CMM			-	24
B0-ACDM AIRPORT CDM			PARS I/II	13
B0-ASUR: ATS SUR			PARS I PASL I	24, 29
B0-85: ATSA			PARS I	-
B0-OPFL ITP			-	-
B0-ACAS: ACAS			PARS I	Annex 6
B0-SNET: SAFETY NETS			PASL I/II	31
B0-AMET MET WARN			PASL I	34
	AIRPORT CERT.		PARS I	Annex 14
	AIRPORT CAPACITY		PARS I/II	GPI 14
	AIRSPACE: FIRS		PASL 1	CONOPS
	AIRSPACE: CLASS		PASL I	GPI 4
	AIRSPACE: RVSM		PARS I	GPI 2
	AIRSPACE: PRIORITY		PASL I	CONOPS
	NAV: PBN ROUTES		PARS I/II	17, 18
	SUR: ATC STDS		PASL I	CONOPS, 2, 6
	SUR: DATA SHARING		PASL I	26
		STRATEGIC LIAISON	PASL I	10
		TACTICAL LIAISON	PASL I	10
		MILITARY SUA %	PARS I	11
		SUA REVIEW	PARS I/II	11
		INT. SUA	PARS I	11
		ATM INTEGRATION	PASL I	35
		JOINT AD/NAV AIDS	PASL I	-
		SHARED DATA	PASL I	35
		COMMON TRAINING	PASL I	4
		COMMON PROC.	PASL I	4

Appendix I: List of References

Global and Regional Framework

Doc 9673 *Asia/Pacific Regional Air Navigation Plan*
Doc 9750 *Global Air Navigation Plan*
Doc 9854 *Global Air Traffic Management Operational Concept*
Global Aviation Safety Plan

Air Navigation Services

Annex 10 *Aeronautical Telecommunications*
Annex 11 *Air Traffic Services* (particularly Chapter 2 [2.1 and 2.30], and Attachment C)
ASBU Document
ASEAN *Master Plan on ASEAN Connectivity*
Asia/Pacific Air Traffic Flow Management Concept of Operations
Asia/Pacific Air Navigation Concept of Operations
Asia/Pacific Regional Performance-Based Navigation Implementation Plan (V4.0)
Circular 330 *Civil-Military Cooperation in Air Traffic Management*
Doc 4444 *Procedures for Air Navigation Services Air Traffic Management (PANS ATM)*
Doc 8071 Manual on Testing of Radio Navigation Aids Volume 2
Doc 9613 *Performance-based Navigation Manual*
Doc 9882 *Manual on ATM System Requirements*
Doc 9883 *Manual on Global Performance of the Air Navigation System*
Doc 9906 *Quality Assurance Manual for flight Procedure Design Volume 5*
Doc 9971 *Manual on Collaborative Air Traffic Flow Management*
Global Operational Data-link Document
ICAO AN-Conf/12 Yellow Cover Report on Agenda Item 1
Roadmap for the Transition from AIS to AIM

Flight Operations

Annex 6 *Operation of Aircraft*
Doc 8168 *Procedure for Air Navigation Service Aircraft Operations Volume I Flight Procedures*
Doc 8168 *Procedure for Air Navigation Service Aircraft Operations Volume II Flight Procedures*
Doc 9931 Continuous Descent Operations (CDO) Manual
Doc 9993 Continuous Climb Operations (CCO) Manual

Human Factors

Annex 1 *Personnel Licensing*
Circular 214 *Fundamentals on Human Factors*
Circular 227 *Training of Operational Personnel on Human Factors*
Circular 241 *Human Factors in ATC*
Circular 249 *Human Factors in CNS and ATM Systems*
Circular 318 *Language Testing Criteria for Global Harmonization*
Circular 323 *Guidelines for Aviation English Training Programmes*
Doc 9835 *Manual on the Implementation of ICAO Language Proficiency Requirements*
Doc 9966 *Fatigue Risk Management Systems*
Human Factors Digest No. 1

Seamless Asian Skies:
Initial Economic Analysis of Benefits

International Air Transport Association (IATA),

Asia Pacific Office

Seamless Asian Skies: Initial Economic Analysis of Benefits

Executive Summary

This report is the first stage of IATA's commitment to work with States and other agencies to quantify the Seamless Asian Skies (SAS) initiative's likely benefits.

SAS will improve the efficiency of Asia Pacific's air traffic management and deliver the system capacity to meet the projected future demand.

This initial analysis suggests that if Asian Nations implement the critical ICAO Aviation System Block Upgrade (ASBU) elements of the Seamless ATM Draft Plan, aviation's contribution to Regional GDP will increase from 2.2% in 2011 to 4% in 2030. This would represent an Overall Aviation contribution of USD 2358.76 billion to the regional GDP for the year 2030.

However if Asian Nations do not implement ICAO Aviation System Block Upgrade (ASBU), aviation's contribution to the Regional GDP will fall to 0.8% in the year 2030.

Clearly, the figures indicate a demand for a sustainable and mutual development of aviation infrastructure in the Asia Pacific Region.

The next stage of IATA's commitment to SAS is to quantify the investment required to implement 'Block 0' upgrades across Asia Pacific.

Today, most airport and air traffic management upgrades are funded by airport or by the State (whether by airline revenue or consolidated funds) and implemented within that State.

Future air traffic management upgrades, as recommended in ASBU, will require a Regional solution implemented across a number of States and managed cooperatively between the participating Nations.

> If aviation is to continue to drive global economic prosperity and social development to the extent our community and the world have grown accustomed, especially in the face of dramatic regional traffic growth projections and the pressing need for more determined and effective climate related stewardship, States must fully embrace the new Block Upgrade process and follow a unified path to the future global Air Navigation system.
>
> ICAO Global Air Navigation Capacity & Efficiency Plan, 2013-2028, p24

Introduction

A finding of the second meeting of the ICAO Asia/Pacific Seamless ATM Planning Group (APSAPG/2) held in Tokyo 6-10 August 2012 was the need to develop a method to assess the economic implications of operational performance as a result of the implementation of the seamless operational concept (such as how to set the value of time to quantify passenger time savings) within a framework of business cases and cost-benefit analysis (CBA).

In accordance with APSAPG/2 agenda Item 3: 'Drivers for a seamless ATM Environment', IATA made a commitment to work with States and other organizations to define and quantify the likely benefits of Seamless ATM across the Asia Pacific region.

This report provides updated information from the first report which defined and quantified the economic benefits/costs of seamless skies in the Asia Pacific region. This is a "high level" study defining the overall costs and benefits of implementing ICAO's ASBUs as a framework for the harmonization of ATM.

This updated report illustrates extended economic benefits of upgrading current aviation infrastructure in the Asia Pacific region.

It is also a scoping study because it recognizes from the outset that the required information to conduct a detailed, step-by-step, analysis of the costs and benefits of the ASBU program is not readily available in this region. However, with the continued support of Asia Pacific leaders, airlines and ANSPs, it will be possible to collect the data needed to complete a detailed CBA of the seamless skies program from the perspective of individual airlines, ANSP's and Airports in the near future.

> As CANSO (2012)[1] commented, "At the economic and financial level, we may understand the costs but do not fully understand the benefits of ATM modernisation. Yet, billions are expected to be invested. ATM modernisation needs to be supported by a solid business case. ……. "

The study's methodology has been developed in accordance with the principles described in ICAO Doc 9161; ICAO Circular 257-AT/106; Eurocontrol (2000) Guidelines for the economic appraisal of EATMP projects; FAA (1998) Economic Analysis of Investment and Regulatory Decisions; SESAR (2006) Cost Benefit Modeling, and; Boeing C/ATF's (2000) Economic Evaluation of CNS/ATM Transition.

A detailed analysis of seamless skies should utilize the taxonomy of phase-offlight efficiency indicators which have been jointly developed over many years by Eurocontrol and the FAA[2] and which are now being recommended to ICAO's 12th Air Navigation Conference to become the common air navigation services (ANS) performance metrics and indicators[3]. The benefits and costs, such as increased capacity, notional cost of delay

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[1] AN-Conf/12-WP/ /12, Addressing the Impediments to ATM Modernisation.

[2] US/Europe Comparison of ATM-related Operational Performance (2009, updated in 2012).
See http://www.eurocontrol.int/documents/useurope-comparison-atm-related-operationalperformance-2010

[3] AN-Conf/12-WP/35

per passenger are subsequently monetized to enable financial analysis. This methodology provides greater transparency and helps users align the cost of services with the benefits provided.

Limitations of the Study

As this initial study has been carried out over a relatively short time frame it therefore uses information that is readily available. Where there is an absence of data, the study makes assumptions, which are stated in the text. Any assumptions are conservative by design and the main results robust.

The first part of the study represents an aggregation of aviation activity across all the Asia Pacific countries. It should be noted there are wide variations in service levels and capacity between the States and often even within a single States.

The second section of the report represents an analysis of ASBU Block 0 Implementation into Manila, which is the gateway to the Philippines and a major traffic constraint point. To obtain more detailed and widespread CBA analysis requires the submission of historical flight data, schedules and demand forecasts from airlines, and projections of project costing for ASBU module implementation by ANSPs throughout the region.

Economic Analysis

When air navigation services projects are publicly funded, a methodology that reflects both the public and private benefits and costs of the project should be considered. Accordingly, this analysis identifies the benefits of aviation activity to the broader national economies. The analysis forecasts the overall contribution of aviation to the regions GDP by 2030 based on the expected growth in passenger and cargo movement.

There are also potential productivity gains for the providers of services, which must be taken into consideration. For example, an investment in modern ATS technology may reduce the number of air traffic controllers required in the future thereby reducing future operating costs. Transportation efficiency benefits may also accrue to operators (e.g. airlines) and would include savings arising from the more efficient operation of aircraft, and greater service reliability and predictability.

At a project level, once the benefits and costs have been identified and forecast, in order to determine if a project is cost-beneficial, or to assess which option yields the greatest net benefits; the net cash stream of benefits and costs is discounted to today’s value to produce a single net present value (NPV)[4]. The preferred option, from an economic perspective, would be the one with the highest NPV.

The need for discounting stems from the fact that the value placed on income and expenditures depends on when they occur. One unit of currency to be received a year from now is worth less than the value of one unit of currency in one’s pocket today, because of opportunities foregone during the year.

Steps in Cost and Benefit Methodology

[4] The discounted value of benefits from the investment less the discounted value of expected costs. A positive NPV indicates that an investment is worthwhile.

Step 1 - Define the objective
Step 2 - Specify assumptions
Step 3 - Identify alternatives
Step 4 Estimate benefits and costs
Step 5 - Compare the alternatives
Step 6 - Evaluate the outcome

STEP 1 – Define the objective

The purpose of a cost benefit analysis is to identify, measure and aggregate the incremental costs and benefits associated with the replacement of existing technologies and procedures with ASBU Block upgrades to implement Seamless Asian Skies and how to use this information to draw conclusions about the expected economic impact on governments, ANSPs and users. The objective here is to compare the implementation of relevant Block 0 upgrades with a base case[5].

STEP 2 – Specify assumptions

Access to the full potential operational benefits of Block 0 upgrades is conditional on a broad range of aviation, economic and social policies, primarily national but also, in many cases, regional.

The overall model is generated based on the assumption that all benefits are accumulated based on the implementation of all relevant ASBU modules.

Certain assumption must be made in the calculation of projected benefits such as national and regional growth expectations, traffic forecasts, airline fleet configurations, discount rate for net present value calculations, etc.

To compare the implementation of relevant Block 0 upgrades, the base model assumes that there will not be any investment made in the region to upgrade current infrastructure, and overall aviation contribution will remain constant till the year 2030.

STEP 3 – Identify Alternatives

The alternatives available to governments, ANSPs and airlines with regard to the improvement of ATM performance through the implementation of ASBU modules as a framework for Seamless Asian Skies are:

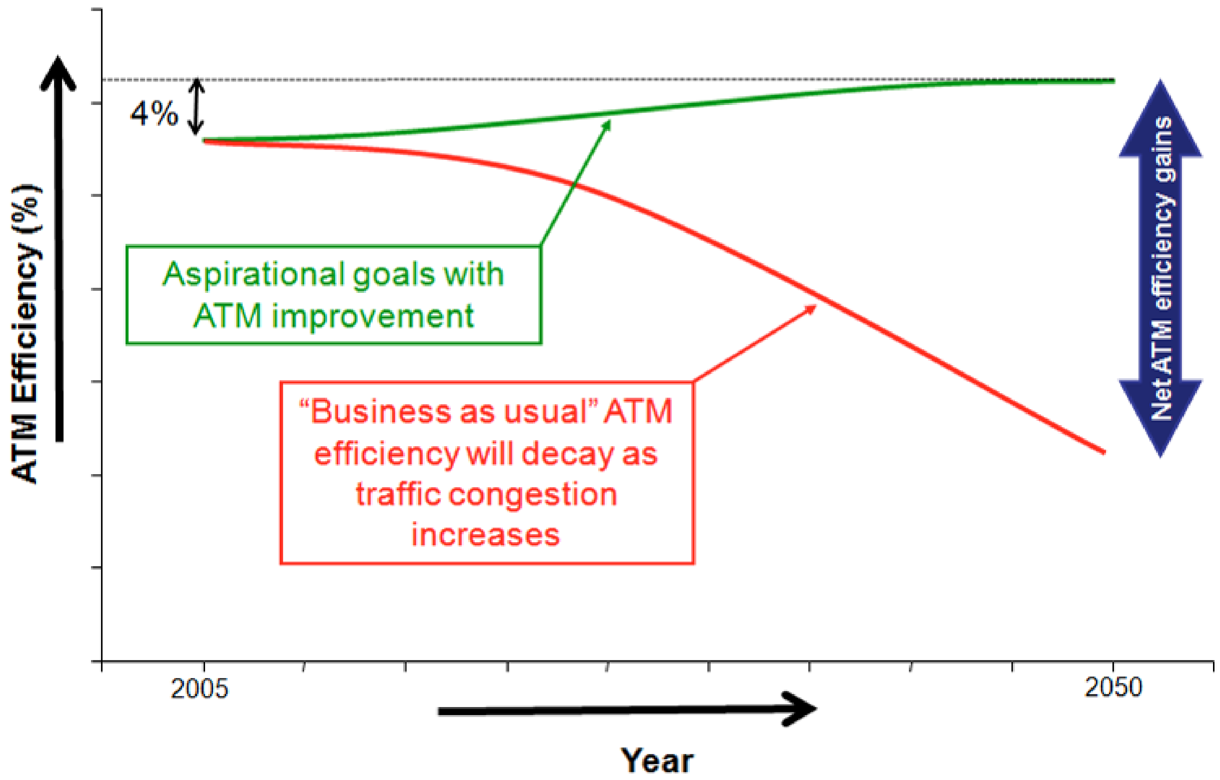
1. **Do nothing (base case)**

In this scenario, the state in the Asia Pacific region maintains the status quo in the face of increasing demand on the system. The current infrastructure, which is already insufficient to accommodate existing demand, is assumed to remain the same.

> CANSO (2008, p. 7) reported that if the industry was to continue with the existing operational environment (business as usual) then the level of global ATM efficiency will decrease as additional traffic increases congestion.

[5] Base Case: Maintaining the level of service available in the base year, with no change to equipment other than direct replacement at the end of service life.

Furthermore, in addition to the increased costs attributable to delays brought about by increased congestion, there will also be a negative impact on the nation's economy from lost aviation activity (refer table page 19). These lost aviation activities will reduce catalytic affect (tourism).



Effect of increases congestion on ATM efficiency, Stollery (2008, p. 4)

2. Implement Aviation System Block Upgrades

This scenario considers the implementation of modules of the ICAO ASBUs in accordance with regional plans to enhance the performance of the ATM System. The preferential basis for the development of the modules relies on the applications being adjustable to fit many regional needs as an alternative to being made mandated as one-size fits- all application.

The ASBUs describe a way to apply the concepts defined in the ICAO Global Air Navigation Plan (Doc 9750) with the goal of implementing regional performance improvements. They include the development of technology roadmaps, to ensure that standards are mature and to facilitate synchronized implementation between air and ground systems and between regions. The ultimate goal is to achieve global interoperability. Safety demands this level of interoperability and harmonization. Safety must be achieved at a reasonable cost with commensurate benefits.

Each block and its underlying components are intended to interoperate seamlessly and independently of how they are implemented in neighboring States.

The modules in each block are grouped to provide operational and performance objectives in relation to the environment in which they apply.

The four performance improvement areas are (refer Appendix D),

1. Greener airports

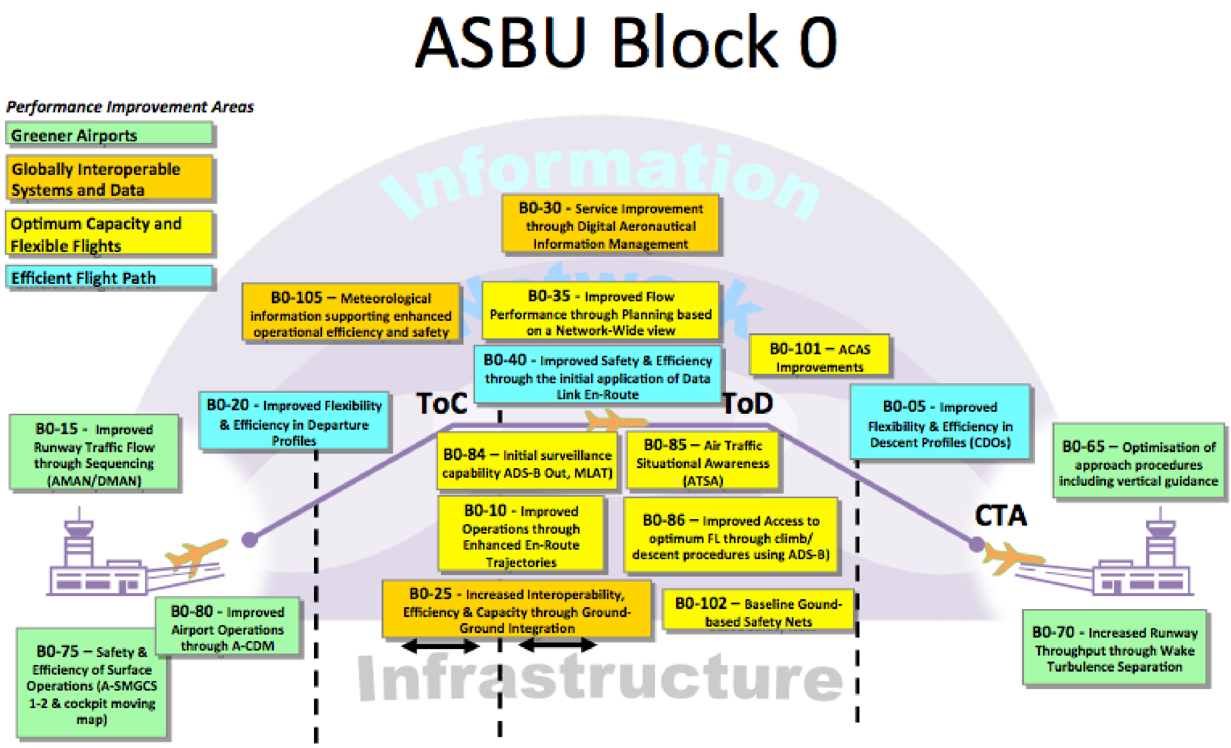
2. Globally Interoperable Systems and Data – through Globally Interoperable System-Wide Information Management
3. Optimum Capacity and Flexible Flights – through Global Collaborative ATM
4. Efficient Flight Path – through Trajectory Based Operations

The Aviation System Global Block Upgrade initiative constitutes the framework for a regional agenda towards ATM system modernization. Offering a structure based on expected operational benefits, it should support investment and implementation processes, making a clear relation between the needed technology and operational improvement.

Implement ASBU Block 0 (available now) – Note: IATA is seeking the region wide implementation of ASBU Block 0 by 2018.

For Block 0, no new airborne technologies are required, although modules may imply the deployment of existing technologies to a larger aircraft population depending on chosen modules respectively paired with tied benefits. It is therefore critical for all stakeholders to:

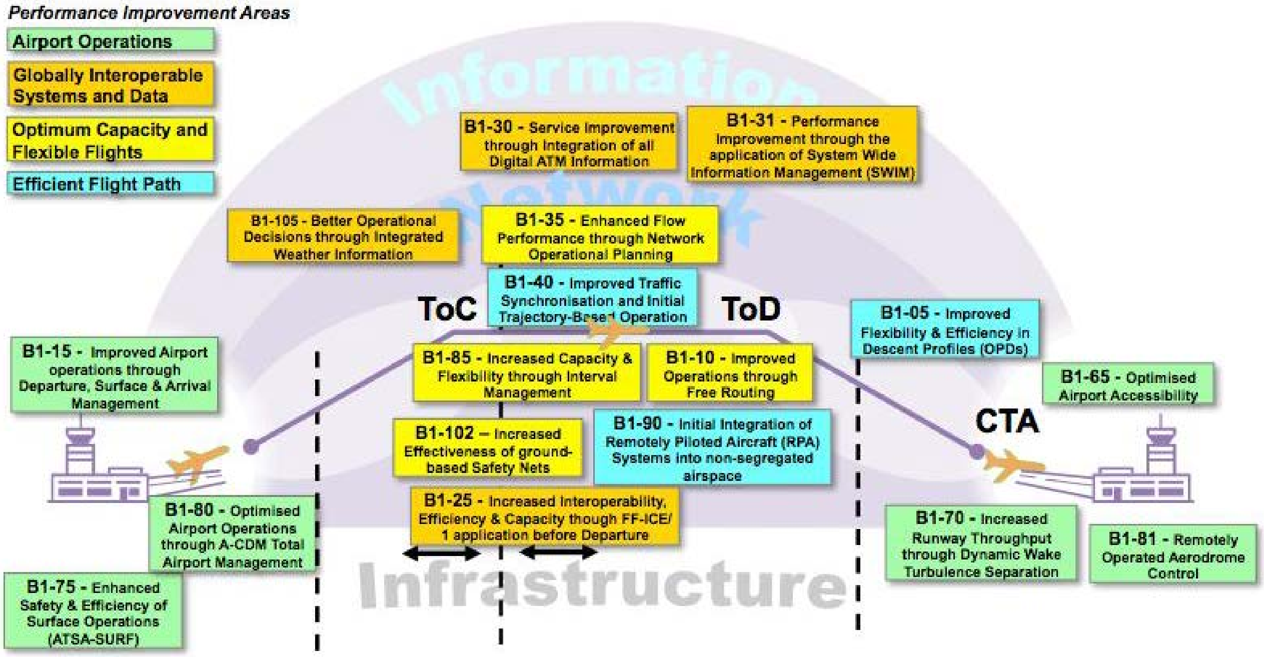
- Fully realizes the benefits and experience of current technology
- Determine and define future requirements (Blocks 1 and above) based on this experience.



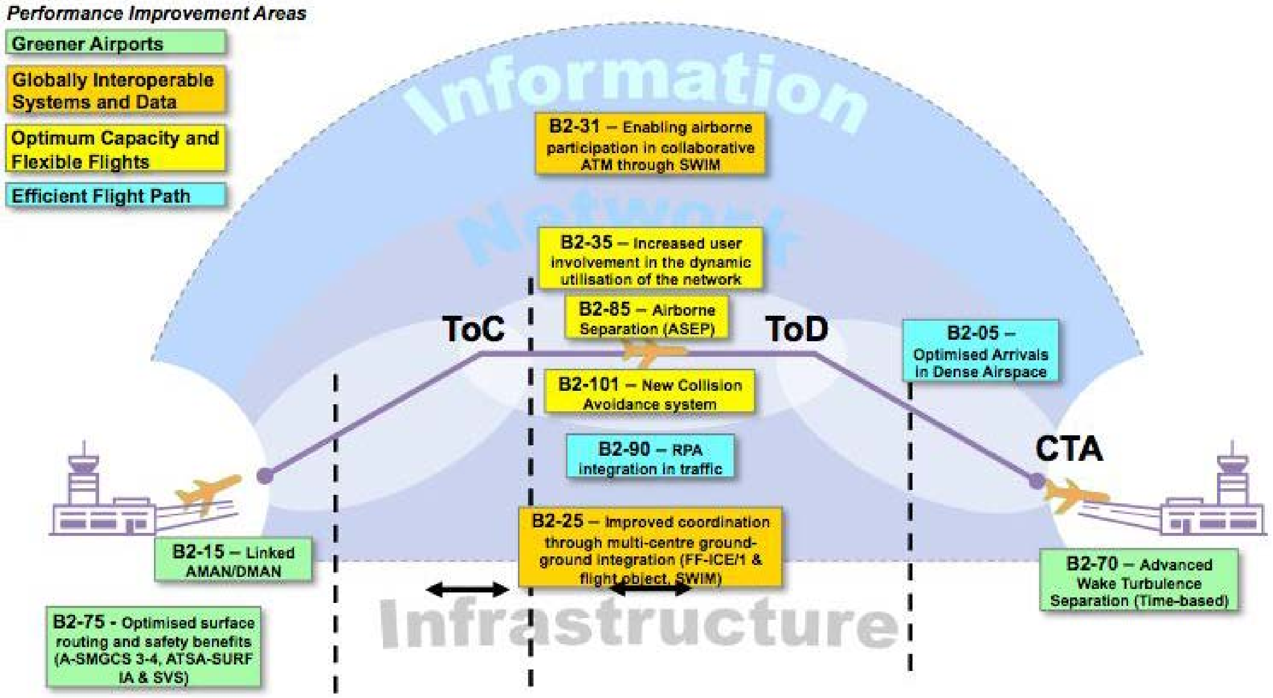
It must be recognized by stakeholders that if Block 0 is not implemented as a foundation, there is a risk certain functionalities may not be available as enablers for future blocks.

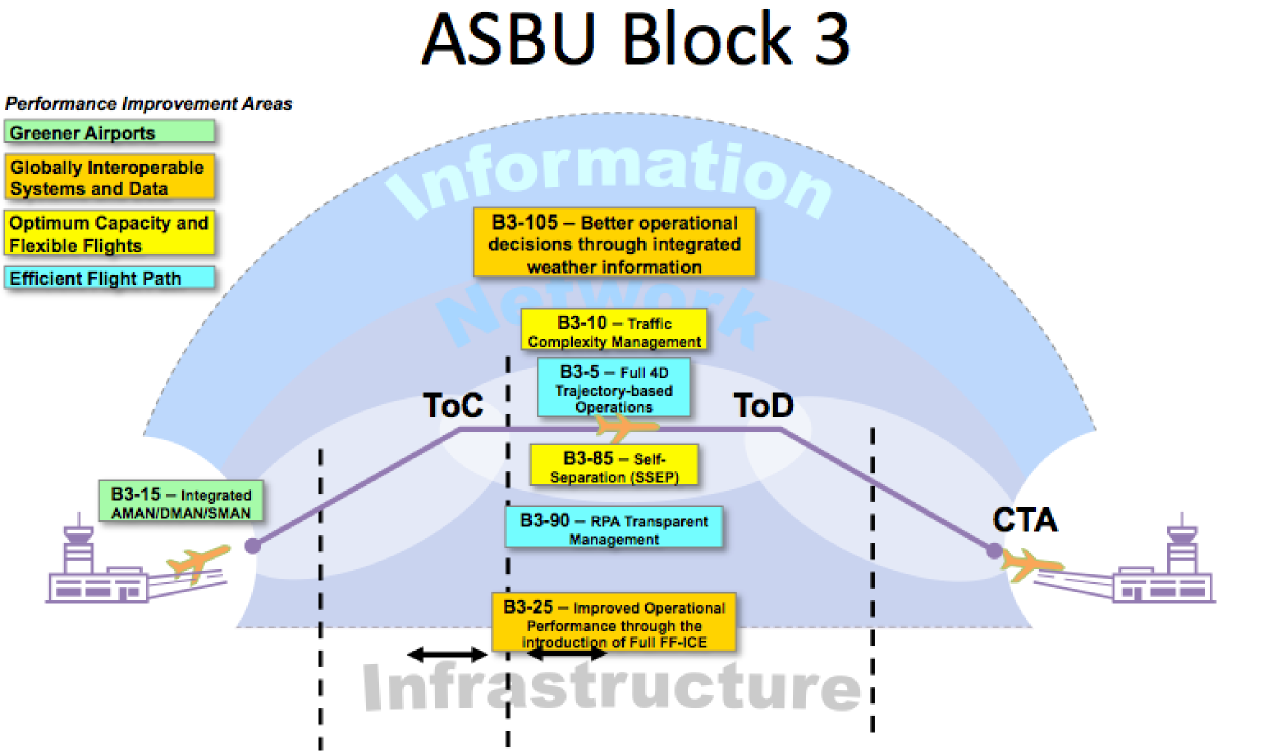
Implement ASBU Stage 1 (from 2018)

ASBU Block 1



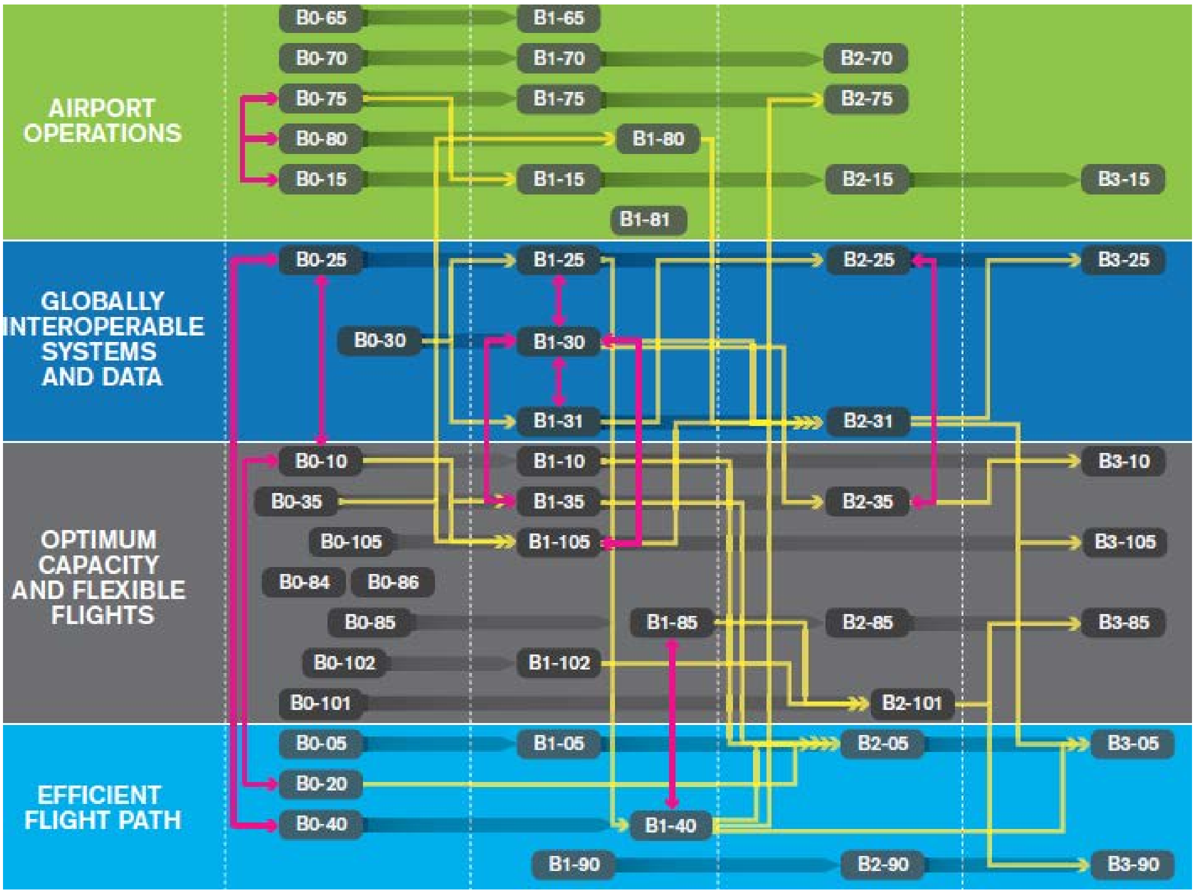
ASBU Block 2





In addition, ICAO's Global Air Navigation Capacity & Efficiency Plan 2013-2028 (in draft) reinforce the dependencies between modules stating that they are:

- Essentially Dependent, and
- The benefits of each module are mutually reinforcing, i.e. implementation of one module enhances the benefits achievable with the other modules.



Module Dependencies

Source: ICAO (2012) Global Air Navigation Capacity & Efficiency Plan 2013-2028, p 129 (in draft).

As the implementation of Blocks 1, 2 & 3 are dependent on the successful implementation of Block 0 modules this analysis will focus on a comparison between the costs and benefits of implementing the Block 0 modules up until 2018 to achieve seamless skies, with their non-implementation or the businesses-as-usual case.

STEP 4 - Estimate of Benefits and Costs

Air Transportation growth drivers

Growing delays threaten the competitiveness of national economies, by limiting the ability of the air transport system to serve the needs of the nation's economy. The growth in gross domestic product (GDP) and air travel demand are closely linked (Oxford Economics, 2009). A recent study that examined the interdependency of air transportation and economic activity in 139 countries (Ishutkina, 2009) revealed a correlation coefficient of 0.99 between air transportation passengers and GDP using world aggregate time-series data during the 1970-2005 time period.

However underpinning this strong correlation are many factors that can either stimulate or suppress the development of a nation's air transportation system in the shorter term. These factors are categorized as either Supply Side or Demand Side.

Air transport Supply Side Factors	Air transport Supply Side Factors
Regulatory Framework • Ownership Restrictions • Safety and Environmental Restrictions • Geopolitical and Security Restrictions Infrastructure Capability • Airport infrastructure Capacity • Air Navigation Services Capability • ATM Shortage of personnel Airlines • Airline Business Factors • Perceived airline/fleet safety • Insufficient fleet capacity (due to lack of finance, external factors)	Direct Factors • Exogenous Demand Shocks • Economic downturn (domestic or non-domestic) • Political/Economic sanctions • Competition of other transportation modes • Civil Unrest or War Indirect Factors • Political or Macroeconomic factors • Exchange rate Fluctuations

Air Transport System Change Factors. Adapted from (Ishutkina, 2009)

While each (or a combination) of the above factors, will at various times, effect the growth of a nation's aviation activity, from a long-term perspective Air Transportation growth is closely aligned to GDP growth.

However, the scope of this study is to evaluate the costs and benefits of the seamless skies initiative through ASBUs to improve Airport Capacity & Air Navigation Services Capability

Infrastructure Capability

Estimate of Benefits and Costs of Seamless Skies

Introduction

Increasing the overall capacity and efficiency of the aviation system in order to accommodate forecast growth in traffic is the principle driver of the Seamless Asian Sky (SAS) initiative. SAS is helping to define the way forward by harmonizing procedures and interoperable technology between states, bearing in mind it needs to be cost efficient at the same time.

"Aviation is a vital part of Asia's economy, supporting 24 million jobs and nearly half-a-trillion dollars of GDP. Connectivity, facilitated by aviation, is a critical link to markets and a generator of wealth—both material and of the human spirit. Ensuring the timely development of sufficient and cost-efficient infrastructure capacity is a priority for the continued successful growth of air transport in Asia- Pacific…We must not repeat the mistakes made in Europe where efforts to implement a Single European Sky are stalled because states are not delivering…. Asia –Pacific is not immune to air traffic congestion issues and these will continue to grow if they are not well managed with a regional perspective." said Tony Tyler, IATA's Director General and CEO.

In an endeavor not to repeat the mistakes of Single European Skies, which continues to suffer from fragmentation of airspace that caused 17.9 million minutes of delays in air traffic flow management in 2011[6], an analysis to identify the primary areas of capacity constraint and inefficiency in the system is required.

In 1999 the Intergovernmental Panel on Climate Change (IPCC) estimated global ATM inefficiency to be between 6-12%, with large variations by region and by airport. Since then efficiency has improved by 4% with the introduction of procedures such as RVSM. CANSO (2012) estimate worldwide ATM system fuel inefficiencies are currently between 6 and 8%.

There continues to be intense pressures on governments to further improve ATM systems around the world and recover the remaining inefficiencies.
Pressure on ATM system performance comes from:

- Airlines need for increased efficiency and capacity in the system;
- Some ATM systems that are becoming antiquated and costly to maintain;
- Multiple parties actively advocating individual technology 'solutions'

To increase ATM performance CANSO (2012, p10) believes stakeholder collaboration is required to plan a phased approach to implement,

- ANSP enhancements that safely increase ATM efficiency and global interoperability
- ANSPs to provide enhanced services to 'better equipped' aircraft as a means of capacity and efficiency improvement
- Better management of fuel efficient delay absorption into congested terminal areas
- Fuel efficient flight tracks while maintaining noise consequences near airports
- Regional solutions across major traffic flows (MTF)

ICAO's ASBU initiative is such a programme framework that develops a set of ATM solutions or upgrades that exploits current equipage, establishes a transition plan and

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[6] CAPA, http://centreforaviation.com/analysis/europe-to-take-a-third-attempt-at-sorting-outthe-single-european-sky-86383

enables global interoperability. The ASBUs comprise a suite of modules organised into flexible and scalable building blocks, where each module represents specific, well bounded improvements that enable capacity related and/or efficiency related benefits.

Benefits

The quantification of economic benefits is based on capacity and efficiency considerations. Examples of benefits are,

- Capacity Related
  - Capacity of en-route airspace and airports
  - Reduction in Separation Standards
  - Decision Aids
- Efficiency Related
  - Direct Routing
  - Optimum trajectory

Implementing ASBU will bring in aforementioned benefits to the region's aviation capacity and efficiency.

The Cost Benefit Study shows that upgrading the current aviation infrastructure to raise system's capacity to meet the future demand will increase overall aviation contribution to regional GDP from USD 470 billion in 2010 to USD 2358.76 billion by the year 2030.

> ***Implementing ASBU will increase overall aviation contribution to regional GDP at USD 2358.76 billion by the year 2030.***

Furthermore, increasing system capacity to accommodate future demand will also increase overall aviation contribution to the regions GDP from present 2.2% to 4% by the year 2030.

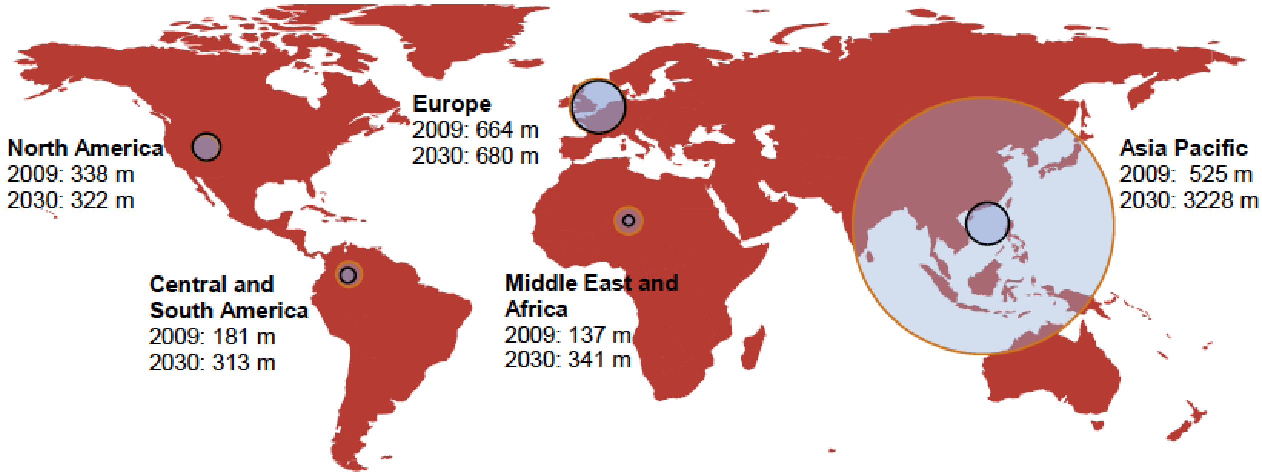
> ***Successful investment in ASBU will raise overall aviation contribution to 4% of the regional GDP by the year 2030.***

Capacity

Capacity is defined as the maximum number of aircraft that can be accommodated in a given time period by the system or one of its components (throughput). The term capacity can be used to refer to a number of factors, any of which could be the limiting factor that might place a constraint on the amount of air traffic that can be handled, e.g. airspace capacity, airport capacity, controller capacity or equipment capacity.

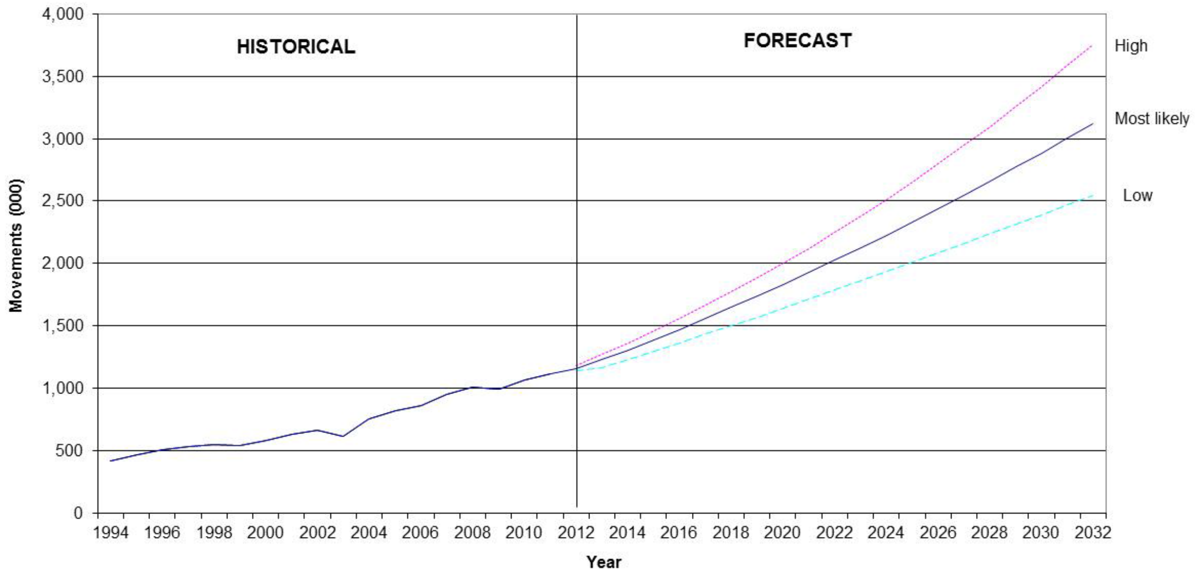
Demand

The Asia Pacific region is expected to be the fastest growing region in the world for air transport over the next 20 years with demand increasing by over 6% per annum. The number of passengers per inhabitant is expected to increase by 170%, from 0.16 to 0.44 (trips/person/year), in the next 15 years (Oxford Economics, 2008:46). The magnitude of the shift towards the region can be seen in the growth of middle-class consumers. An expanding middle class can use its increasing purchasing power to buy high-value products and services, be increasingly mobile, and help drive growth.



Growth of the 'Middle Class'[7] in Asia Pacific region

According to ICAO's Asia Pacific Area Traffic Forecasting Group (APA TFG) Report (Sept, 2012:27), Intra-Asia/Pacific passenger aircraft movements are expected to increase from some 1,114.9 thousand in 2011 to about 3,119.7 thousand movements by the year 2032, at an average annual growth rate of 5.0 per cent. The growth rates for the intermediate periods of 2011-2022 and 2022- 2032 are 5.6 and 4.4 per cent, respectively.



Intra-Asia Pacific aircraft movement forecast, Source: ICAO

However, it is unlikely these forecasts will eventuate due to the "bottlenecks" or constrained demand that already exist throughout the region.

Eurocontrol (1996:40) define three types of constrained demand as,

- **demand generally less than capacity, but exceeding it during peak periods:** Excess demand may be accommodated by allowing delays to build up during the peak period then recovering during the subsequent "quiet" period;
- **demand approaching/exceeding capacity:** If capacity is, on a regular basis, insufficient to meet demand at certain times of the day, airlines may be forced to

[7] 'Middle class' is defined as those households with daily expenditures of between US$10 and US$100 per person. The black border circles and orange border circles depict the size of the middle-class population in 2009 and 2030 respectively. Source: Kharas & Gertz (2010).

operate services at less busy times (demand spreading) or to fly non-optimum routings;

- **unaccommodated demand:** Demand may exceed capacity to the extent that there are simply no available slots for further traffic, and therefore demand spreading and re-routing are not possible. In this case airlines would be unable to satisfy any additional demand from passengers for further services.

Constrained Demand

Un-accommodated demand across the Asia Pacific region can be seen in an examination of the busiest city-pairs. As an example, the top 50 city-pairs that transited the Hong Kong FIR during a sample week 1-7 July 2012 (as per Table 15 of the aforementioned APA TFG report) show that every airport on the list is classified as an IATA Level III airport[8], with the exceptions of Macao, Osaka & Kaohsiung Level II, and Ching Chuan Kang (Military), Anchorage and Busan. A similar picture is painted in the report for aircraft transiting Bangkok, Fukuoka and Kolkata FIRs.

Without airport capacity enhancement through the construction of additional runways or the implementation of ICAO ASBU upgrades such Airport Collaborative Decision Making (A-CDM) and Arrivals Management (AMAN/DMAN), increases to one operator's schedules can only be made at the expense of another's.

Traffic Growth is possible only if there is sufficient aviation infrastructure present in the form of:

- Airport capacity
- Air Navigation System Capability

Many airports in the Asia Pacific Region are currently operating at nearly full capacity due to a long history of traffic growth, while land availability and environmental constraints have hindered expansion. IATA lists 42 Level III and 20 Level II airports in the region[9]. The infrastructure at these airports is not able to accommodate all of the demand and slot availability is subject to coordination and allocation.

The region also suffers from a high degree of variance in Air Navigation Services capability. The lack of sufficient communications, navigation and surveillance and air traffic management (CNS/ATM) capability at various locations affects the system's throughput, thus causing increased delays and adds to airline costs. Inadequate aviation infrastructure is also detrimental to the overall air transport system safety and its perception by the flying public. In particular air travel advisories are typically based on the country's total level of safety.

As Ball et al (2010:1) noted, "It is widely recognized that delay increases nonlinearly as demand approaches the capacity in the system (figure below). If current demand in the

[8] A Level 3 airport is one where:

a) Demand for airport infrastructure significantly exceeds the airport's capacity during the relevant period;
b) Expansion of airport infrastructure to meet demand is not possible in the short term;
c) Attempts to resolve the problem through voluntary schedule adjustments have failed or are ineffective; and
d) As a result, a process of slot allocation is required whereby it is necessary for all airlines and other aircraft operators to have a slot allocated by a coordinator in order to arrive or depart at the airport during the periods when slot allocation occurs.

[9] refer to http://www.wwacg.org/FTableList.aspx?list=62 for list of Airports

system is D1 with delay at delay1 level, it is likely that, without substantial upgrades to aviation infrastructure, such growth (for example, to D2) would result in flight delays far in excess of any we have hitherto experienced (delay2)".

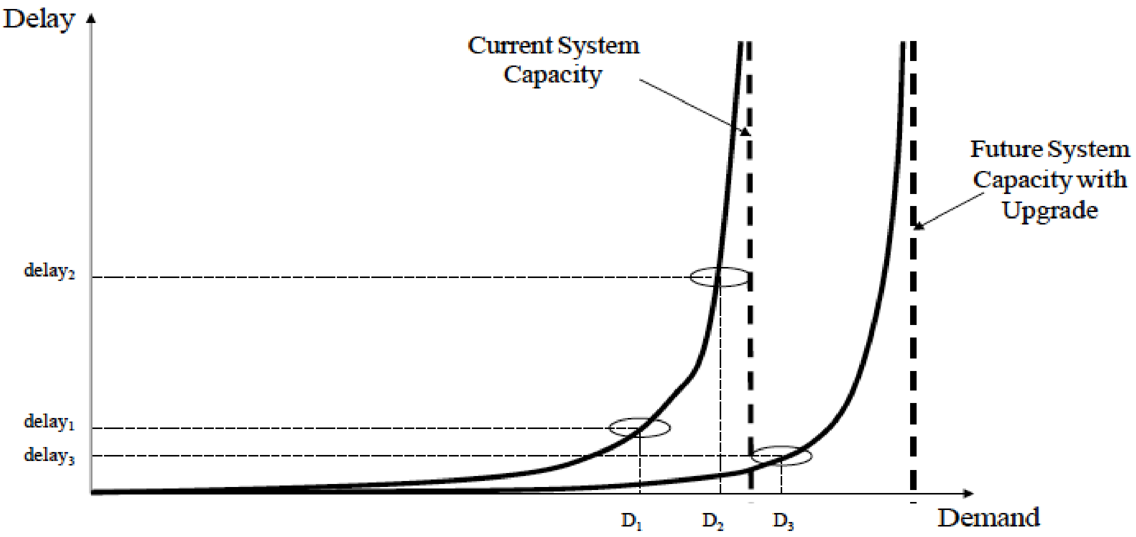


Illustration of the relationship between Demand, Delay and System Capacity Source: Ball et al 2010

The figure above could also be illustrative of a major traffic flow route who's capacity has been increased from point D2 to D3 through a reduction in enroute separation standards associated with the implementation of full surveillance coverage e.g. ADS-B, or RNP routes with ADS-C & CPDLC capability. Airlines then have the ability to increase existing schedules with a commensurate reduction in delay until the future system's capacity is reached.

It is this exponentially increasing delay that leads to a serious concern among users that system capacity must keep up with demand. Thus, capacity constraints in the system take on a level of urgency considerably higher than efficiency constraints, which grow linearly with traffic demands. (Allen, Haraldsdottir, Lawler, Pirotte, & Schwab, 1997) p. 7.

> *It is important to distinguish between operating costs caused by lack of capacity from cost due to procedural inefficiencies. Allen, et al (1997) p5.*

To accommodate capacity limitations at an airport or through airspace, aircraft may be required to wait (hold) on the ground prior to departure (at gate or on taxiways); deviate en route, or complete holding procedures prior to arrival. When traffic demand approaches available capacity, there is some necessary increase in congestion and fuel inefficient delays to maximize use of available capacity. This congestion reduces efficiency and increases CO_2 emissions.

Cost of Constrained Demand

As the number of flights increases per year, a number of capacity constraints are affecting the efficiency of the air transportation system, as well as its ability to expand further. The two main constraints are airport runway capacity (the number of takeoffs and landings that can be performed per hour), as well as terminal area and enroute capacity. Research into the identification of these capacity constraints, as well as potential ways of removing bottlenecks from the air transportation system, require the improvement of infrastructure and technology, and/or the adoption of new procedures.

As mentioned earlier, the Asia Pacific region boasts 62 level III or II airports, which indicated demand is beyond capacity in many countries. In addition many major traffic flows (MTF) are subjected to lengthy delays (e.g. Bay of Bengal) due to capacity limitations. Unless capacity constraints are identified and their performance elevated, national economies will suffer significant losses due to aviation activity stagnation.

Prudently and in accordance with Ishutkina's (2009) long-term findings, conservative national GDP growth rates have been used as opposed to aviation industry forecasts of aviation growth (e.g. Boeing & Airbus). In addition Oxford Economics' average Aviation Contributions to GDP have been used as proxies, where none exist.

The net overall opportunity loss caused by stagnated aviation infrastructure facility to the economic benefits to Asia Pacific countries is valued at USD 1888.76 billion for the year 2030.

If no action is taken, the lack of aviation capacity will cost Asia Pacific economies an opportunity loss of USD 1888.76 billion.

Aviation's overall contribution to Asia Pacific regional GDP will reduce from current 2.2% to 0.8% by 2030 if investment to increase aviation capacity and efficiency in infrastructure is not made.

Failure to invest in aviation capacity will reduce overall aviation contribution to 0.8% of regional GDP by the year 2030.

A consequence of reduced GDP growth is that the emerging economies of the last two decades risk becoming ensnared in 'the middle-income trap', in which middle-income[10] countries don't quite push through to high-income status.

Unfortunately many middle-income countries[11] have seen infrastructure gaps develop and widen. While the existing aviation infrastructure of many countries is inadequate to accommodate the increased passenger and freight transportation, the middle-income trap is avoidable[12] if governments act early and decisively to improve access to infrastructure. The 'trap' can be mitigated to some degree with continued investment in infrastructure to improve regional connectivity (Agénor, et al, 2012).

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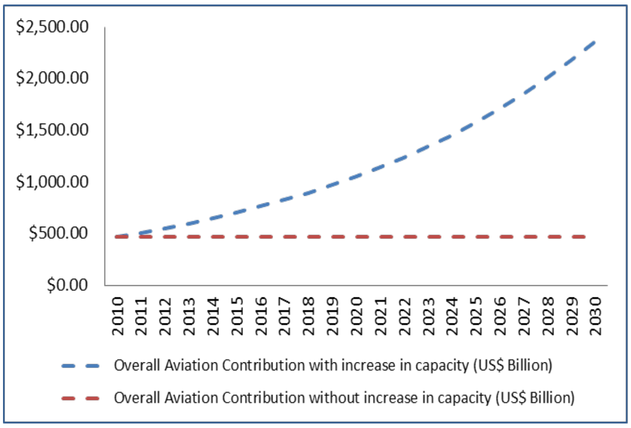
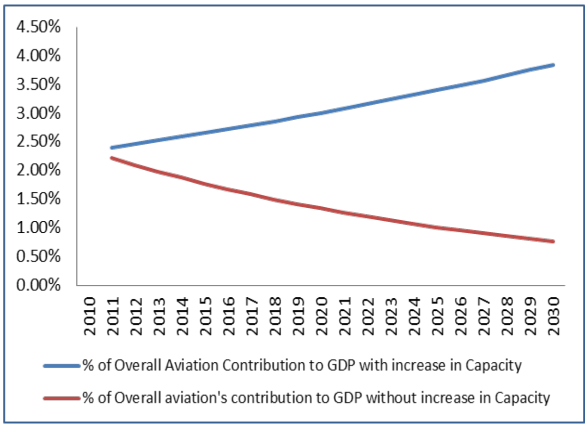
[10] Income Thresholds (GNI per capita) used by the World Bank in 2011 USD. The thresholds are; low income, $1025 or below; lower middle income, $1026-$4035; upper middle income, $4036- $12475; and high income, $12476 or above.

[11] Asia is different from the other developing regions, for some economies (four plus Japan) are already high-income, and five have been low-income since 1950. In Asia there are three (the Philippines and Sri Lanka in the lower middle-income trap, although the latter should get out of it soon; Malaysia in the upper middle-income trap, although it should also get out of it soon; and Indonesia and Pakistan will most likely fall into the lower middle-income trap soon).

[12] Avoiding the middle-income trap is a question of how to grow fast enough so as to cross the lower middle-income segment in at most 28 years (which requires a growth rate of at least 4.7% per annum); and the upper middle-income segment in at most 14 years (which requires a growth rate of at least 3.5% per annum). Only 13 countries were able to transition from middle to high-income status since the 1960s. Of these countries, five were from East Asia – Hong Kong SAR (China), Japan, Korea, Taiwan, China, and Singapore.





Comparison of overall aviation contribution with and without investing in ICAO ASBU

Efficiency

While simply increasing public investment in infrastructure has often been advocated as a strategy for development, research shows that the effect of such investment critically depends on the efficiency of the existing infrastructure network (Riojas, 2003). The seamless skies initiative is designed to improve the efficiency of air navigation services through increased harmonization and interoperability and flight path optimization.

A cornerstone of seamless skies is that ATM service delivery management will operate seamlessly from gate-to-gate for all phases of flight and across all service providers (ICAO, 2008). In order to measure the success of seamless skies ANSPs and Airlines need to have quantifiable targets for efficiency and costs in order to develop a sound cost benefit analysis.

The Single European Sky (SES) program for example has set aspirational targets for efficiency as a threefold increase in capacity and significant reduction in delays, while the USA's NextGen program is expecting a 35% reduction in delays by 2018 whilst increasing capacity. SES and NextGen also expect to cut costs through delay reduction by EUR 250 Million and USD 23 Billion respectively.

From the perspective of a cost-benefit analysis, ATM Efficiency (Economic, Operational, Technical and Airspace) is of prime importance in order to:

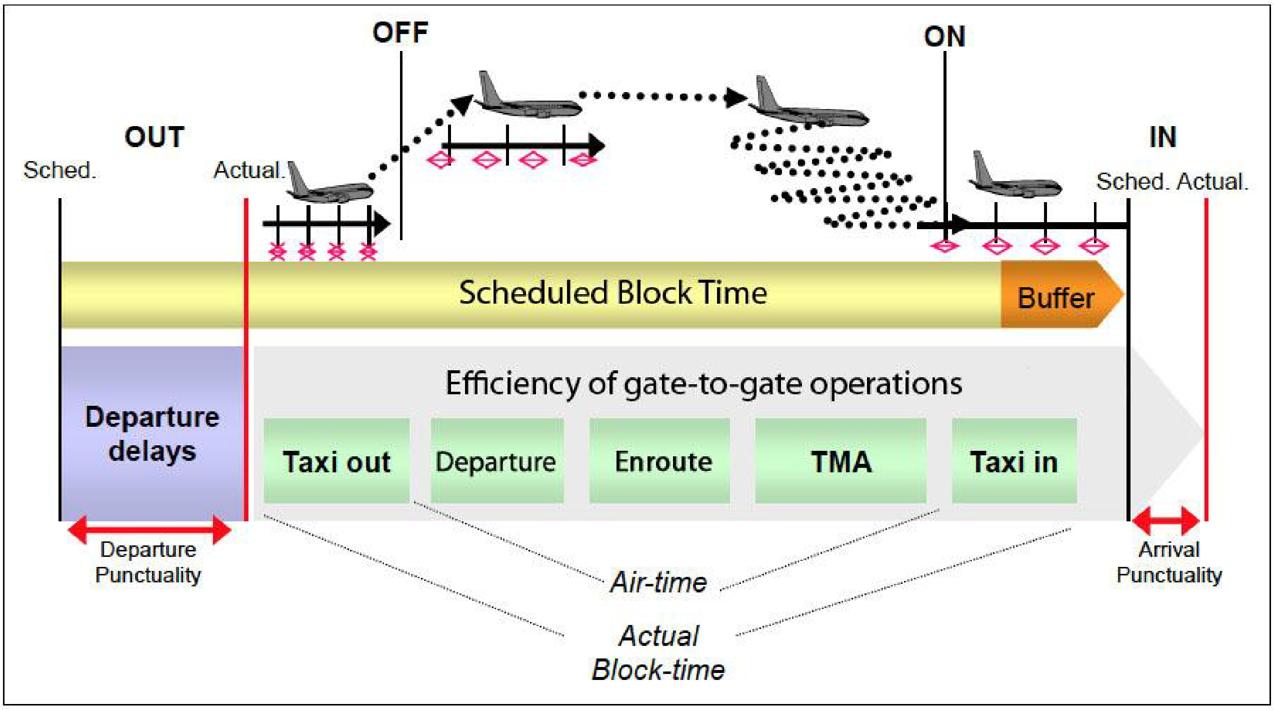
- Improve cost-effectiveness;
- Optimize capacity & minimize delays;
- Reduce flight inefficiency and minimize environmental impact;
- Improve predictability of operations;

The quantification of ATM efficiency is most readily addressed through the single-flight perspective. Its value rests in reducing direct operating costs (DOC) by optimizing flight path trajectory and by eliminating excess flight time, route distance, and fuel usage at non-optimum speeds and altitudes. Because airlines fly millions of single operations per year, small incremental DOC savings on every flight can add up to significantly improved financial performance (C/AFT, 1999).

Therefore the unit of measure used to define ATM efficiency from gate-to-gate, is a single 'optimal' or 'ideal' flight that is not subjected to any delays and allowed to fly via the most direct path with continuous climb and descent profiles.

ATM efficiency is defined as the ratio between actual flight time and an 'ideal[13]' or 'optimum' flight time. The 'ideal' flight can then be disaggregated into different phases of flight, which follows the work of Boeing's CNS/ATM Focused Team (C/ATF) in the late nineties, Eurocontrol & FAA (2012), and Boeing & CANSO (2012)

Phases of Flight



Conceptual framework to measure ATM performance (Adapted from Eurocontrol & FAA (2012, p. 24), p.24

ATM system inefficiencies can be analysed gate-to-gate within the following phases of flight,

1. Planning, pre-flight and gate departure
2. Taxi-out
3. Departure
4. Enroute (including Oceanic)
5. TMA (descent and arrival)
6. Taxi in

According to Boeing & CANSO (2012) p12, the inefficiencies for each phase of flight are defined as the difference between actual travel time, travel distance, or fuel use against an unimpeded or benchmark travel time, travel distance, or fuel use. The difference between actual travel time and benchmark travel time is delay.[14]

Inefficiencies in the different flight phases have different impacts on aircraft operators and the environment. Whereas ATFM related holdings result in departure delays mainly

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[13] Ideal flight - Minimum cost travel between origin and destination, assuming still air conditions and no traffic or procedural constraints.

[14] Refer to Boeing & CANSO (2012) p 15-25, and Eurocontrol & FAA (2012) Chapter 6 for extensive discussion of Air Traffic Management efficiencies according to flight phase.

experienced at the stands, inefficiencies in the gate-togate phases generate additional fuel burn, which also has an environmental impact through gaseous emissions (mainly CO_2),

Gate Departure Delays (1)
Reducing gate/surface delays (by releasing too many aircraft) at the origin airport when the destination airport's capacity is constrained potentially increases airborne delay (i.e. holding or extended final approaches). On the other hand, applying excessive gate/surface delays risks under utilization of capacity and thus, increases overall delay. The aim is to keep aircraft at the gate in order to minimise fuel burn due to departure holdings at the runway.

Taxi out phase (2)
The impact of ANSPs on taxi times is marginal when runway capacities are constraining departures. However, data on taxi delays is useful in developing policies and procedures geared towards keeping aircraft at the gate longer, in readiness for the implementation of Airport Collaborative Decision Making (ACDM). A-CDM initiatives try to optimise the departure queue while minimizing costs to aircraft operators.

Departure (3) & Taxi In (5) phases
The results of the combined Eurocontrol & FAA (2012) study on ATM performance found the taxi-in and the TMA departure phases (40 NM ring around departure airport) generally not considered to be large contributors to ATM related inefficiencies.

Vertical Flight Inefficiencies in phases 3,4&5
In addition to time delays and horizontal inefficiencies are vertical inefficiencies, which comprise of two components.

1. Flight level capping: the flight can't reach its optimum cruising level during the flight
2. Interrupted climb/descent: during the climb or descent phase, the flight is kept at a suboptimal flight level (Intra-flight vertical inefficiencies)

A Eurocontrol, PRC (2008) study found vertical flight inefficiencies increased fuel burn by less than 0.6% (Average 23kg/flight). However it should be noted that study was conducted in airspace with full surveillance and VHF communication coverage –a similar study conducted across Asia Pacific airspace with limited surveillance and communication coverage would be expected to result in much higher fuel burn figures. Nevertheless, while vertical flight inefficiencies do generate some negative impacts they remain relatively small when compared to other types of inefficiencies (horizontal, taxi time, airborne delays).

While vertical flight inefficiencies will not be analyzed in this study, there is scope for improvement, and more work on vertical flight inefficiencies and the potential benefits of implementing Continuous Climb Operations (CCO)[15] and Continuous Descent Operations (CDO), as per ASBU B0-20 and B0-05 respectively, would form a more complete picture.

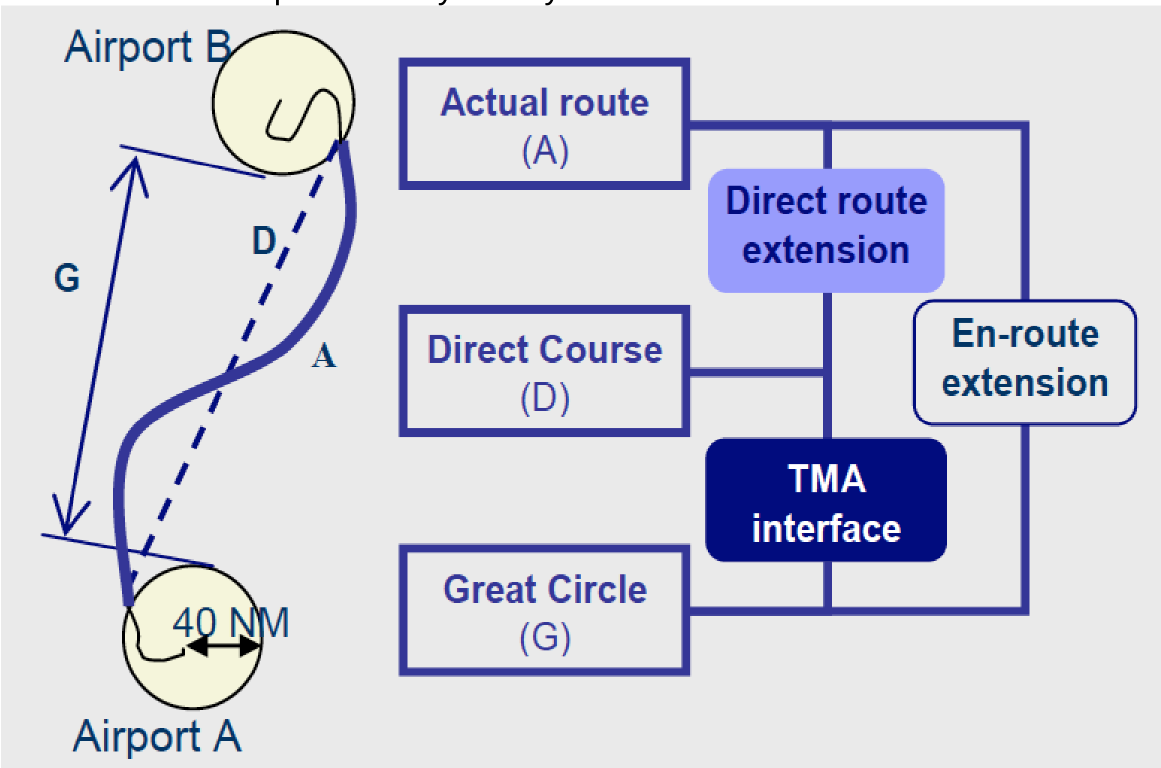
Enroute Inefficiency (Horizontal) phase 4
The objective of analyzing Enroute flight inefficiency is to:

- Calculate performance indicators that measure flight inefficiency,

[15] It is important to consider that CCO and CDO benefits are heavily dependent on each specific ATM environment. Nevertheless, if implemented within the ICAO CCO / CDO manual framework,
it is envisaged that the benefit/cost ratio (BCR) will be positive

- Identify areas in the Asia Pacific region where ATM system performance
- could be improved,
- Assess economic impact of flight extension on airlines and environment.

Optimum trajectories
The horizontal component of optimum trajectories has been defined by previous studies (E.g. Kettunen, et al. 2005; Boeing & CANSO, 2012; Eurocontrol & FAA, 2012) as the great circle distance. In a simplified view of aircraft flight management, this direct route is considered as the cheapest option, as it minimizes fuel costs. In reality, aircraft often do not follow this direct route since airlines have to make tradeoffs between several factors, such as meteorological conditions, which may lead to definitions of optimum, which differ, from great circle distance. However, great circle distance provides the advantage of being a constant benchmark (independent of individual strategies) against which actual trajectories can be compared from year to year.



The KPI used for horizontal en route flight efficiency is enroute extension. Enroute extension is defined as the difference between the length of the actual trajectory (A) and the Great Circle Distance (G) between the departure and arrival terminal areas (radius of 40 NM around airports) (Eurocontrol & FAA, 2012:47).

Fragmentation of airspace and military restricted airspace play significant roles in increasing enroute inefficiencies and limits the ability of the enroute facilities to support airport throughput.

TMA (descent and arrival) phase 5.
TMA inefficiencies are defined by the average “additional” time beyond the unimpeded transit time for each airport within the last 100Nm of flight.

The additional time is used as a proxy to measure the tactical management initiatives (TMI) used at an airport irrespective of local ATM strategies (sequencing, flow integration, speed control, mile-in-trail, holding) (refer Annex IV, Eurocontrol & FAA, 2012 for detailed EU methodology). The fragmentation of Asia Pacific airspace is expected to be a significant contributor to TMA inefficiencies as the support of the en route function is limited and rarely extends beyond the national boundaries. Hence, most of the sequencing is done at lower altitudes around the airport.

Conclusion
This conceptual framework enables operational performance to be measured in a consistent way and ATM best practices to be better understood.

While the estimated total ATM inefficiency pool and associated fuel burn in more developed aviation systems such as the US and Europe are similar (estimated to be 6-8% of the total fuel burn), it is expected to be higher across the Asia Pacific region due to the diverse levels of CNS/ATM infrastructure and institutional fragmentation.

The analysis of aircraft operations, broken down by phase of flight (i.e. pre-departure delay, taxi-out, en route, terminal arrival, taxi-in, and arrival delay), will reveal the strengths and weaknesses or bottlenecks of the ATM system at various locations in the Asia Pacific region.

The subsequent implementation of associated ASBU Block 0 modules, which utilize today’s best practices, existing technology and operational concepts, should elevate the performance of ATM across Asia Pacific in the relative short term in a standardized, harmonized manner to achieve seamless operations.

Costs

As previously mentioned, delays and their subsequent costs increase exponentially as demand approaches the capacity limits of the system. As these levels are approached, aircraft must wait to use the system, or various parts of it, until they can be accommodated. These delays impose costs both in terms of aircraft operating expenses and the value of wasted passengers' time.

Estimation of the delay benefits of new infrastructure projects or procedures requires measurement of the aggregate annual aircraft operating time and passenger time which the new proposal will save.

The saving is the difference between the delays currently experienced and those, which would be experienced with the proposed new project or procedures. Once determined, the value of this saved time can be valued in dollars using standardized values (FAA, 1998).

Airline Costs

Cost of Delay to airline
A recent study by the University of Westminster (2011)[16] evaluated the costs of delay by four flight phases: at gate, taxi, Enroute extension, and TMA.
These costs are dominated primarily by passenger costs, and then fuel burn differences. Only tactical costs (marginal costs) incurred on the day of operations are considered in this study – network effects and strategic effects have been omitted.

Fuel
Fuel Cost

[16] European airline delay cost reference values. Final Report March 2011(Version 3.2)

As of 2 Nov 2012 (IATA & Platts)

- USD $124.7/ barrel or
- USD $0.9827/kg

Rate of fuel burn

The cost of fuel burned per minute is calculated for the three off-gate phases. The at-gate calculations assume the engines and APU are off. As a proxy for fuel burn rates for individual aircraft types at varying weights and altitudes this analysis will use average fuel burn rates representing a 'standard' aircraft in the system as established by Eurocontrol & FAA (2012), p52.

Standard aircraft fuel burn

- Taxi = 15kg/min
- Enroute = 46 kg/min
- TMA holding = 41kg/min

Direct Aircraft Operating Costs (DOC)

Flight and ground cost per block hour[17] that are linked to the operation of an aircraft, such as fuel, aircraft parking, air bridges and maintenance costs (refer Appendix B for more detail)

Cost of Distance Flown

Marginal Cost (Tactical) USD $11.8 /Nm (for track extension calculation)

Passenger Value of Time

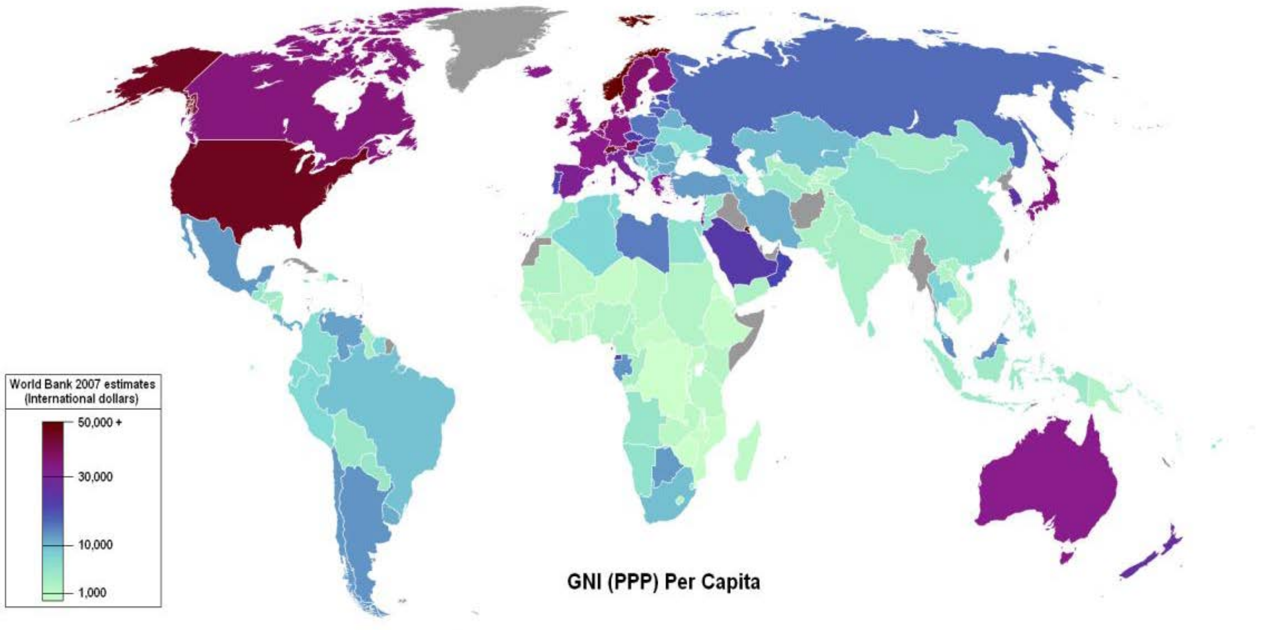
The passenger value of time is an opportunity cost, which corresponds to the monetary value associated with a traveler during a journey. This value of time is approximately equal to 70 per cent of the wage rate (Peterson, et al, 2013)

According to the Air Transport Association of America, the passenger value of time is USD$ 33[18]/ passenger /hour. Eurocontrol value the opportunity cost of passengers similarly at €24.20 (USD$ 32/passenger/hour) baseline case, and €3.90 (USD $5.13) low scenario.

The diagram below provides an overview of Gross National Income (PPP) per capita. A valid argument could be raised for more similar average incomes for airline passengers across all regions, however due to a lack of research on air passenger incomes outside of the USA and EU, Eurocontrol's low scenario amount USD $ 5.13/passenger/hour will be used for prudence (Note this figure is expected to produce a result on the extreme low side – a more appropriate figure is being sought).

[17] A block hour is the time an aircraft is utilised from the moment the aircraft door closes at departure of a revenue flight until the moment the aircraft door opens at the arrival gate following its landing.

[18] The time values are derived from the Air Travel Survey last conducted by the Air Transport Association of America in 1998 and adjusted to 2011 prices.



Average Aircraft Capacity

	1989	1999	2009
Passenger Load Factor	68%	69%	76%
Aircraft Utilization (hours/aircraft/year)	2,193	2,770	3,502
Average aircraft Capacity	181	171	166

Source ICAO: 2009

Load Factors

- Passenger - Average approx. 77% (International and Domestic)
- Cargo - approx. 61% Available Freight Tonne kilometers (ATFK)

Source: IATA, Asia Pacific 2011-2012

Therefore the average passenger cost per aircraft with an average of 166 passengers, a load factor of 77% and USD $ 5.13 per hour = (166*0.77*5.13)=USD $655 per hour = USD$ 10.93/aircraft/minute.

ANSP Costs

The implementation of ABSU Block upgrades will require investment decision to be made by ANSPs. Cost categorisations include,

- R&D Costs
- Implementation Costs (refer Appendix C for indicative list of CNS/ATM costs)
- Operational Costs
- Overheads

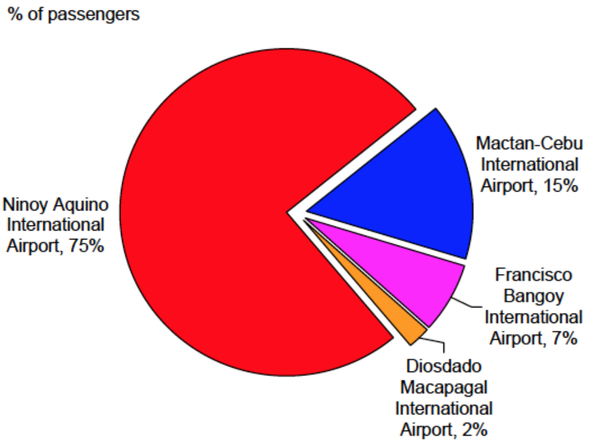
As these costs are context and environmental specific, an accurate CBA requires detailed data from each country.

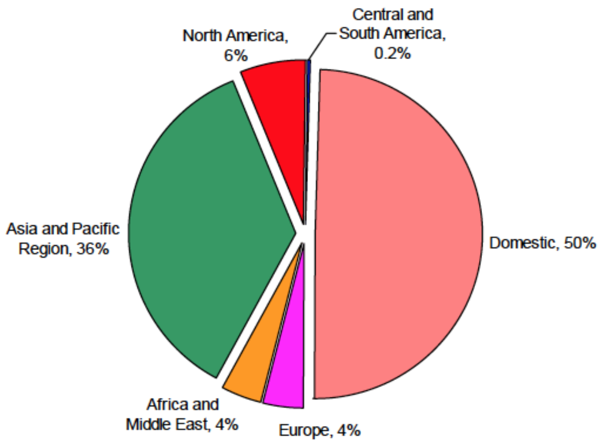
STEP 5 - Compare the Alternatives

Philippines FIR Business Case

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

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, with 50% of the total domestic passengers.





Source: IATA

Accordingly, the continued growth of aviation activity at these airports is vital to the Philippines economy. As indicated in Oxford Economics' (2011) report, the aviation sector contributes PHP 35.5 billion (0.4%) to Philippine GDP, and with the addition of 'catalytic' benefits through tourism the overall contribution is raised to PHP 195.2 billion or 2.4% of GDP.
This analysis has been completed but has yet to be shared with relevant stakeholders to verify the assumptions and accuracy of the output.

STEP 6 - Evaluate the Outcome

Benefit of ASBU Block 0 to NAIA
Fuel savings achieved by implementing ASBU Block 0 into NAIA airport are:

	Taxi out Phase SBU	TMA Phase
Without implementing A	26,017,000 kg	59,261,400 kg
With implementing ASBU	6,504,300 kg	17,778,420 kg
Fuel Savings	19,512,700 kg	41,482,980 kg

Total Fuel savings: 609,956,680kg

Fuel Cost: USD $0.9827/kg

Total savings on Fuel: $ 59,940,454

CO_2 emission: 3.149 kg per kg of fuel

Total CO_2 reduced: 192,075 Tonne

Opportunity cost of delay to passengers (based on low scenario)

- Taxi Out phase: 18 Aircraft per hour * (24-6) min * $10.93/aircraft /min = $3,541/hour *11 Hours = 38,954 per day = USD $14,218,210 per year
- TMA Arrival: 18 Aircraft per hour* (20-6) min* $10.93/aircraft/min = $2,754/hour *11 Hours = $30,298 per day = USD $11,058,755 per year

Annual Passenger Opportunity Costs: USD $ 25,276,965 per annum.

Total Benefit of Implementing ASBU Block 0 to the users of NAIA is USD$ 85,217,419 per annum.

The cost of not implementing ASBU Block 0 to the users of NAIA is USD$ 85.2 million per year

Appendix A
Air Traffic Statistics

IFR Flights 2010 (Source ICAO GIS, 2012)				
Member State	FIR	Number of Flights	Total flight time in FIR (Hours)	Average Fight Time in FIR (Hours)
Afghanistan	Kabul	154684	67096	2.31
Australia	Brisbane	449152	495925	1.01
	Melbourne	594383	539255	
Bangladesh	Dhaka	160779	35157	4.57
Bhutan				
Brunei Darussalam				
Cambodia	Phnom Penh	154618	38940	3.97
China	Hong Kong,	558493	99448	1.96
	Sanya,	294,754	94628	
	Guangzhou,	1348761	592660	
	Kunming	691992	364751	
	Shanghai	1689318	1150795	
	Wuhan,	591438	280118	
	Lanzhou	368355	229129	
	Beijing	760757	356517	
	Shenyang	441305	227406	
	Urumqui	153821	127650	
Cook Islands				
Democratic People's Republic of Korea	Pyonngyang	178087	56101	3.17
Fiji	Nadi	62085	51569	1.20
India	Mumbai,	521208	503565	1.29
	Chennai,	449267	311038	
	Delhi	395665	240904	
Indonesia	Jakarta	502768	336942	1.54
	Ujung Panang	373258	300173	
	Kota Kinabalu	202562	63784	
Japan	Fukuoka	1084469	1027206	1.06
Kiribati				
Lao People's Democratic Republic	Vientiane	187894	37705	4.98
Malaysia	Kuala Lumpur	586760	183955	3.19
Maldives	Male	36240	21493	1.69
Marshall Islands				
Micronesia				
Mongolia	Ulan Bator	116635	95518	1.22
Myanmar	Yangon	220439	131179	1.68
Nauru	Nauru	1005	1214	0.83
Nepal	Kathmanu	170031	38050	4.47
New Zealand	New Zealand,	246958	19672	3.33
	Auckland Oceanic	266598	134446	
Pakistan	Karachi,	226444	132528	2.01
	Lahore,	150385	54942	
Palau				
Papua New Guinea	Port Morseby	48592	29021	1.67
Philippines	Manila	315681	258290	1.22
Republic of Korea (Sth)	Incheon	533119	213352	2.50
Samoa				
Singapore	Singapore	359938	174680	2.06
Solomon Islands	Honiara	7520	4928	1.53
Sri Lanka	Colombo	61234	44389	1.38
Thailand	Bangkok	459813	217153	2.12
Timor Leste				
Tonga				
Vanuatu				
Viet Nam	Ho Chi Minh,	332981	164826	2.39
	Hanoi	194592	55634	
(Taipei)	Taipei	303731	94583	3.21
TOTAL	45	17008569	9698315	1.75

Appendix B

Direct Aircraft Operating Costs (DOC)

Flight and ground cost per block hour[19] that are linked to the operation of an aircraft, such as fuel, aircraft parking, air bridges and maintenance costs.

Value:

Aircraft	Fuel con-sumption	Other costs	Cost of Fuel	Total operating costs
A300-600	7,071	1,853	5,671	7,524
A319	3,108	1,349	2,492	3,842
A320	3,354	1,407	2,690	4,096
A321	3,505	1,607	2,811	4,418
A330-200	6,670	2,039	5,349	7,388
A330-300	7,083	2,048	5,680	7,728
A340-300	8,230	2,059	6,600	8,659
A340-600	9,782	2,456	7,844	10,301
A380-800	n/a	n/a	n/a	n/a
ATR-42	757	931	607	1,538
ATR-72	810	1,252	650	1,902
B-727-200	4,028	1,734	3,230	4,964
B-737-200	3,013	1,323	2,416	3,740
B-737-200C	4,300	1,833	3,449	5,282
B-737-300/700	2,612	1,397	2,095	3,492
B-737-400	3,051	1,560	2,447	4,007
B-737-500	3,044	1,400	2,441	3,841
B-737-800	2,135	1,099	1,712	2,812
B747-100	15,176	4,581	12,170	16,751
B-747-200	15,229	5,190	12,213	17,403
B-747-400	14,169	3,832	11,363	15,195
B-757-200	3,407	1,902	2,732	4,634
B-767-200	4,607	2,189	3,695	5,883
B-767-300	4,910	2,304	3,937	6,242
B-777-200	7,301	2,590	5,855	8,446
BAE 146-300	3,240	1,838	2,599	4,437
CRJ-100	1,832	1,027	1,469	2,497
CRJ-200	2,018	701	1,618	2,320
DC-9-10	3,153	1,331	2,529	3,860
DC-9-30	3,422	1,410	2,744	4,155
DC-9-40	3,661	888	2,936	3,824
DC-9-50	2,930	1,117	2,350	3,467
DC-10-10	6,787	3,675	5,443	9,118
DC-10-30	9,467	3,902	7,592	11,494
DC-10-40	8,464	3,576	6,788	10,364
DHC 8-100	931	839	747	1,586
EMB-120	591	868	474	1,342

Aircraft	Fuel con-sumption	Other costs	Cost of Fuel	Total OPS costs
ERJ-135	1,287	607	1,032	1,639
ERJ-145	1,321	710	1,059	1,769
MD-11	8,237	2,862	6,606	9,467
MD-80	3,025	1,597	2,426	4,023
MD-87	2,805	1,204	2,250	3,454
MD-90	2,351	2,129	1,885	4,015
L-1011-500	0	2,846	0	2,846
A300-600	7,071	1,853	5,671	7,524

(Adjusted from 2000 US $ values with 2011 jet fuel prices)

Source: ICAO Base-line Aircraft Operating Costs, Summer 2000
http://legacy.icao.int/icao/en/ro/allpirg/allpirg4/wp28app.pdf

[19] A block hour is the time an aircraft is utilised from the moment the aircraft door closes at departure of a revenue flight until the moment the aircraft door opens at the arrival gate following its landing.

Appendix C

CNS/ATM Base-line costs (USD)

Systems	Costs				
	Purchase	Upgrade/ retrofit Kit	Installation (same site)	Maintenance	Inspection/ commissioning
Communications aircraft					
AMSS Package (See notes)	$650,000				
HF data upgrade		$20,000			
FMS Retrofit (See Note)		$300,000			
FANS-1 retrofit (see note)		$134,000			
Communications ground					
VHF	$170,000	$51,000	$20,000	$17,000	
HF	$160,000	$48,000	$20,000	$16,000	
AMSS ground Station	$15,000,000		(included)	$1,500,000	
ATN Router	$120,000		(included)	$12,000	
ATN gateway	$100,000		(included)	$10,000	
Navigation aircraft					
GPS for FANS-1 PACKAGE (DUAL)	$58,000				
FMS retrofit (MD-11)	$300,000				
FMS retrofit (b-747-400)	$100,000				
MMR for GBAS (DIGITAL)	$30,000				
MMR for GBAS (ANALOG)	$40,000				
Navigation Ground					
VOR	$135,000	$45,000	$50,000	$9,700	$5000/$50000
DME	$125,000	$38,000	$50,000	$8,000	$5000/$50000
VOR/DME	$17,429	$80,000	$90,000	$12,200	$125000/$50000
DVOR/DME	$525,000	$160,000	$100,000		
NDB (100 WATTS)	$30,000	$10,000	$15,000	$3,000	$5,000
TACAN	$525,000	$240,000			
GNSS Master Station	$8,000,000				
GNSS Uplink	22,000,000/year				
GNSS reference Station	$1,000,000				
GBAS	$850,000				
Landing Aids					
ILS Cat I	$500,000	$290,000	$200,000	$17,100	$50,000
ILS Cat II	$1,100,000	$540,000	$225,000	$17,100	$50,000
ILS Cat III	$1,250,000	$540,000	$225,000	$17,100	$50,000
Control Center					
Work Station (CPDLC)	$350,000		(included)		$35,000.00
FANS-1 Work Station (see Note)	$540,000		(included)		$54,000.00
ATM FDPS	$950,000		(included)		$95,000.00
CNS/ATM Syst. (2 seats)	$2,000,000		(included)		$200,000.00
Additional seats	$650,000		(included)		$65,000.00

Note: 2000 figures require updating to 2012 (Source: ALLPIRG/4-WP/28)

Appendix D
ICAO Aviation System Block 0 & 1 Upgrades by Performance Improvement Area (PIA)

PIA 1. Greener Airports

Block 0	Block 1
B0-65 **Improved Airport Accessibility** This is the first step toward universal implementation of GNSS-based approaches	B1-65 **Optimized Airport Accessibility** This is the next step in the universal implementation of GNSS-based approaches
B0-70 **Increased Runway Throughput through Wake Turbulence Separation** Improved throughput on departure and arrival runways through the revision of current ICAO wake turbulence separation minima and procedures .	B1-70 **Increased Runway Throughput through Dynamic Wake Turbulence Separation** Improved throughput on departure and arrival runways through the dynamic management of wake turbulence separation minima based on the real-time identification of wake turbulence hazards
B0-15 **Improved RunwayTraffic Flow through Sequencing (AMAN/DMAN)** Time-based metering to sequence departing and arriving flights	B1-15 **Improved Airport operations through Departure, Surface and Arrival Management** Extended arrival metering, Integration of surface management with departure sequencing bring robustness to runways management and increase airport performances and flight efficiency
B0-75 **Improved Runway Safety (A-SMGCS Level 1-2)** Airport surface surveillance for ANSP	B1-75 **Enhanced Safety and Efficiency of Surface Operations (A-SMGCS/SURF IA) and EVS** Airport surface surveillance for ANSP and flight crews with safety logic, cockpit moving map displays and visual systems for taxi operations
B0-80 **Improved Airport Operations through Airport-CDM** Airport operational improvements through the way operational partners at airports work together	B1-80 **Optimized Airport Operations through Airport-CDM** Airport operational improvements through the way operational partners at airports work together
	B1-81 **Remote Operated Aerodrome Control Tower** Remotely operated Aerodrome Control Tower contingency and remote provision of ATS to aerodromes through visualisation systems and tools

PIA 2. Globally Interoperable Systems and Data – Through Globally Interoperable, SWIM

Block 0	Block 1
B0-25 **Increased Interoperability, Efficiency and Capacity through Ground-Ground Integration** Supports the coordination of ground-ground data communication between ATSU based on ATS Inter-facility Data Communication (AIDC) defined by ICAO Document 9694	**B1-25** **Increased Interoperability, Efficiency and Capacity though FF-ICE/1 application before Departure** Introduction of FF-ICE step 1, to implement ground-ground exchanges using common flight information reference model, FIXM, XML and the flight object used before departure
B0-30 **Service Improvement through Digital Aeronautical Information Management** Initial introduction of digital processing and management of information, by the implementation of AIS/AIM making use of AIXM, moving to electronic AIP and better quality and availability of data	**B1-30** **Service Improvement through Integration of all Digital ATM Information** Implementation of the ATM information reference model integrating all ATM information using UML and enabling XML data representations and data exchange based on internet protocols with WXXM for meteorological information
	B1-31 **Performance Improvement through the application of System Wide Information Management (SWIM)** Implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximize interoperability
B0-105 **Meteorological Forecasts, Warnings and Alerts**. Global, regional and local meteorological information: • Aerodrome warnings to give concise information of meteorological conditions that could adversely affect all aircraft at an aerodrome including windshear. • Forecasts provided by world area forecast centres (WAFC), volcanic ash advisory centres (VAAC) and tropical cyclone advisory centres (TCAC) This information will support flexible airspace management, improved situational awareness and collaborative decision making, and dynamically-optimized flight trajectory planning.	**B1-105** **Better Operational Decisions through Integrated Weather Information (Strategic >40 Minutes)** Weather information supporting automated decision process or aids involving: weather information, weather translation, ATM impact conversion and ATM decision support

PIA 3. Optimum Capacity and Flexible Flights – Through Global Collaborative ATM

Block 0	Block 1
B0-10 **Improved Operations through Enhanced En-Route Trajectories** To allow the use of airspace which would otherwise be segregated (i.e. military airspace) along with flexible routing adjusted for specific traffic patterns. This will allow greater routing possibilities, reducing potential congestion on trunk routes and busy crossing points, resulting in reduced flight length and fuel burn.	**B1-10** **Operations through Free Routing** Introduction of free routing in defined airspace, where the flight plan is not defined as segments of a published route network or track system to facilitate adherence to the user-preferred profile
B0-35 **Improved Flow Performance through Planning based on a Network-Wide view** Collaborative ATFM measure to regulate peak flows involving departure slots, managed rate of entry into a given piece of airspace for traffic along a certain axis, requested time at a way-point or an FIR/sector boundary along the flight, use of miles-in-trail to smooth flows along a certain traffic axis and re-routing of traffic to avoid saturated areas	**B1-35** **Enhanced Flow Performance through Network Operational Planning** ATFM techniques that integrate the management of airspace, traffic flows including initial user driven prioritisation processes for collaboratively defining ATFM solutions based on commercial/operational priorities

B0-84 Initial Capability for Ground-Based Cooperative Surveillance Ground surveillance supported by ADS-B OUT and/or wide area multilateration systems will improve safety, especially search and rescue and capacity through separation reductions. This capability will be expressed in various ATM services, e.g. traffic information, search and rescue and separation provision.	
B0-85 **Air Traffic Situational Awareness (ATSA)** Two *ATSA (Air Traffic Situational Awareness)* applications which will enhance safety and efficiency by providing pilots with the means to achieve quicker visual acquisition of targets: • AIRB (Enhanced Traffic Situational Awareness during Flight Operations). • VSA (Enhanced Visual Separation on Approach).	B1-85 **Increased Capacity and Flexibility through Interval Management** Interval Management (IM) improves the management of traffic flows and aircraft spacing. Precise management of intervals between aircraft with common or merging trajectories maximizes airspace throughput while reducing ATC workload along with more efficient aircraft fuel burn..
B0-86 **Improved access to Optimum Flight Levels through Climb/Descent Procedures using ADS-B** This prevents an aircraft being trapped at an unsatisfactory altitude and thus incurring non-optimal fuel burn for prolonged periods. The main benefit of ITP is significant fuel savings and the uplift of greater payloads	
B0-101 **ACAS Improvements** To provide short term improvements to existing airborne collision avoidance systems (ACAS) to reduce nuisance alerts while maintaining existing levels of safety. This will reduce trajectory perturbation and increase safety in cases where there is a breakdown of separation.	
B0-102: Increased Effectiveness of Ground-based Safety Nets This module provides improvements to the effectiveness of the ground-based safety nets assisting the Air Traffic Controller and generating, in a timely manner, alerts of an increased risk to flight safety (such as short terms conflict alert, area proximity warning and minimum safe altitude warning).	**B1-102: Ground-based Safety Nets on Approach** This module enhances the safety provide by the previous module by reducing the risk of controlled flight into terrain accidents on final approach through the use of Approach Path Monitor (APM).

PIA 4. Efficient Flight Path – Through Trajectory-based Operations

Block 0	Block 1
B0-05 **Improved Flexibility and Efficiency in Descent Profiles (CDOs)** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with continuous descent operations (CDOs)	B1-05 **Improved Flexibility and Efficiency in Descent Profiles (OPDs)** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Optimized Profile Descents (OPDs)
B0-40 **Improved Safety and Efficiency through the initial application of Data Link En-Route** Implementation of an initial set of data link applications for surveillance and communications in ATC	B1-40 **Improved Traffic Synchronization and Initial Trajectory-Based Operation.** Improve the synchronization of traffic flows at en-route merging points and to optimize the approach sequence through the use of 4DTRAD capability and airport applications, e.g.; D-TAXI, via the air ground exchange of aircraft derived data related to a single controlled time of arrival (CTA).
B0-20 **Improved Flexibility and Efficiency in Departure Profiles** Deployment of departure procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with continuous climb operations (CCOs)	
	B1-90 **Initial Integration of Remotely Piloted Aircraft (RPA) Systems into non-segregated airspace** Implementation of basic procedures for operating RPAs in non-segregated airspace including detect and avoid

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