



ICAO

**The Second Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (APAC ATMAS TF/2)**

Video Tele-Conference, 14 - 16 September 2021

**Agenda Item 5:** Review the Development of Guidance Material of Implementation of ATM Automation System in Asia/Pacific Region (APAC ATMAS IGD)

**AIR TRAFFIC MANAGEMENT AUTOMATION SYSTEM  
IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT**

(Presented by China, Hong Kong China and Singapore)

**SUMMARY**

This paper presents the draft of the Air Traffic Management Automation System Implementation and Operations Guidance Document (ATMAS IGD) which has been developed based on the framework adopted in ATMAS/TF1 for consideration and endorsement by the meeting.

**1. INTRODUCTION**

1.1 Following the conclusion of ATMAS/TF 1, the framework of Recommended Functions and Performances of ATM Automation System (RFAP ATM AS) edition 0.0, which was led by China, Hong Kong China and Singapore in preparing, had been adopted. The meeting also agreed to develop the guidance document on the basis of edition 0.0 by a specialized ad-hoc group of volunteered experts from Member States/Administrations.

1.2 The guidance document has been mainly input by China, Hong Kong China and Philippines based on the agreed framework. The completed draft guidance document was sent to Member States/Administrations on 6th August for review and comment. According to the comments, China revised the draft guidance document and uploaded for this meeting.

**2. DISCUSSION**

2.1 Hong Kong China, Singapore and Philippines provided comments on the draft. The guidance document were revised according to the comments, and major of them were adopted.

2.2 Document name: the original document name is Recommended Functions and Performances of ATM Automation System (RFAP ATM AS). In order to align with the naming convention of other IGDs for APAC, Hong Kong China suggested to adopt "Air Traffic Management Automation System Implementation and Operations Guidance Document (ATMAS IGD)" as the official name.

**Agenda Item 5**

14-16/09/21

2.3 Adjustment of framework: base on the initial document framework, Philippines suggested to do some adjustments as follow:

- (1) ATMAS IGD Request for Change Form is recommended to be included in the **Appendix A** for an entire page view of the form.
- (2) Amendment Record is recommended to appear in the before the Table of Contents, that is after the Title/Cover Page.
- (3) Acronyms and abbreviations is recommended to be moved before the Introduction and after the Table of Contents.
- (4) The adjusted framework is outlined as follow:

## Acronyms and Abbreviations

## Section 1 Introduction

- Purpose
- Background

## Section 2 Reference Documents

## Section 3 System Functional Baseline

- System essential functions
- System optional functions

## Section 4 System Design

- System architecture
- Position roles and types
- Main and fallback system configuration
- System operation mode
- Capacity and performance
- External interfaces
- Systems Interoperability
- Cyber threats and mitigation

## Section 5 System Software Management

- System Requirement Management
- System Fault Management
- Software Version & Patch Management

## Section 6 System Transition

- Phases of system transition
- Transition preparation
- System Rehearsal/Pre-Transition Verification
- System Transition
- Post-Transition Operation

## Section 7 System Maintenance

- System Maintenance Participants
- Resources Requirement
- Maintenance Content

Appendix A  
Appendix B

**3. ACTION BY THE MEETING**

3.1 The meeting is invited to:

- a) Review the proposed draft of the **ATMAS IGD**;
- b) Share experiences and knowledge for incorporating into the **ATMAS IGD**; and
- c) Discuss any relevant matter as appropriate.

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ATM AS TF/2  
Appendix A to the WP/11



**INTERNATIONAL CIVIL AVIATION ORGANIZATION  
ASIA AND PACIFIC OFFICE**

**AIR TRAFFIC MANAGEMENT AUTOMATION SYSTEM  
IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT**

**Edition 0.1-September 2021**



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## **ACRONYMS AND ABBREVIATIONS**

ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
ADEXP	ATS Data Exchange Presentation
AFTN	Aeronautical Fixed Telecommunications Network
AIDC	ATS Inter-facility Data Communication
AGDL	Air Ground Data Link
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
APP	Approach Center
APM	Approach Path Monitoring
APW	Area Proximity Warning
A-SMGCS	Advanced Surface Movement Guide Control System
AST	Approach Spacing Tool
ASTERIX	All-purpose Structured EUROCONTROL Radar Information Exchange Protocol
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMAS	Air Traffic Management Automation System
ATO	Actual Time Over
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
AWOS	Automatic Weather Observation System
BSDP	Bypass Surveillance Data Processing
CA	Conflict Alert
CFL	Cleared Flight Level
CLAM	Cleared Level Adherence Monitoring
CPDLC	Controller-Pilot Data Link Communications
CRC	Cyclic Redundancy Check
CWP	Controller Working Position
DAP	Downlink Aircraft Parameter
DBS	Distance-based Spacing
DCL	Data Link Departure Clearance
DPM	Departure Path Monitoring
ELDT	Estimated Landing Time
ETO	Estimated Time Over
ETO	Expected Time Over
EUROCONTROL	European Organization for the Safety of Air Navigation
eWTS	enhanced Wake Turbulence Separation
FAA	Federal Aviation Administration
FDP	Flight Data Processing
FIR	Flight Information Region
GNSS	Global Navigation Satellite System
GRIB	Processed Meteorological Data in the Form of Grid Point Values Expressed in Binary Form

HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
LAN	Local Area Network
METAR	Aerodrome Routine Meteorological Report(in Meteorological Code)
MSAW	Minimum Safe Altitude Warning
MSP	Maintenance Service Provider
MTCDD	Medium Term Conflict Detection
NTP	Network Time Protocol
NTZ	No Transgression Zone
PBN	Performance Based Navigation
PCA	Predicted Conflict Alert
PDC	Predeparture Clearance
PMON	Position Report Monitoring
PSR	Primary Surveillance Radar
QNH	Altimeter Sub-scale Setting to Obtain Elevation When on the Ground
RAM	Route Adherence Monitoring
RVSM	Reduced Vertical Separation Minimum
SCA	Similar Callsign Advisory
SDP	Surveillance Data Processing
SID	Standard Instrument of Departure
SMD	Software Management Department
SP	System Supplier
SPI	Special Position Identification
SSR	Secondary Surveillance Radar
STAR	Standard instrument Arrival
STCA	Short Term Conflict Alert
TBS	Time-based Spacing
TLDT	Target Landing Time
UTC	Universal Time Coordinated
VSP	Variable System Parameter
WAM	Wide Area Multilateration

## **1. INTRODUCTION**

### **1.1 Purpose**

Since the Air Navigation Conference held in 2012, ICAO has been exploiting a global roadmap in the aviation system block upgrades (ASBU) under its Global Air Navigation Plan (GANP), with a focus on harmonization and interoperability leading to a global air traffic management (ATM) system.

Following the framework of GANP and the timeline of ASBU, the Asia/Pacific Seamless ATM Plan, was adopted by the 24th Meeting of the Asia/Pacific Planning and Implementation Regional Group (APANPIRG/25) in 2013. It defines goals and the means of meeting State planning objectives for a Regional seamless ATM performance framework, with a focus on technological and human performance.

To facilitate and harmonize the provision of robust, safe, efficient and orderly ATM services in the region, it is considered necessary to develop regional guidance materials with recommendations on the development and implementation of Air Traffic Management Automation System (ATMAS).

This Air Traffic Management Automation System Implementation and Operations Guidance Document (ATMAS IGD) provides guidance for the planning, design, testing and implementation of the ATMAS in the Asia and Pacific Regions, with the purpose of ensuring continuous and coherent development of the ATMAS that is harmonized with adjacent regions.

The system requirements and operational procedures for the ATMAS are detailed in the relevant States' projects and AIP. This ATMAS IGD is intended to provide guidelines on basic and the most important functional as well as performance requirements of the ATMAS, based on the operations and maintenance practices.

### **1.2 Background**

#### **1.2.1 ATM Operational Concept**

The global air traffic management (ATM) operational concept presents the ICAO vision of an integrated, harmonized and globally interoperable ATM system. The planning horizon is up to and beyond 2025. The baseline against which the significance of the changes proposed in the operational concept may be measured is the global ATM environment in 2000.

**Vision Statement**

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

While the operational concept is visionary and even challenging, many of the current practices and processes will continue to exist through the planning horizon. In this sense, this operational concept document should be seen as evolutionary.

A key point to note is that the operational concept, to the greatest extent possible, is independent of technology; that is, it recognizes that within a planning horizon of more than twenty years, much of the technology that exists or is in development today may change or cease to exist. This operational concept has therefore been developed to stand the test of time.

**Air Traffic Management**  
Air traffic management is the dynamic, integrated management of air traffic and airspace — safely, economically and efficiently — through the provision of facilities and seamless services in collaboration with all parties.

### **1.2.2 ATM System and Its Sub-system**

The mission of ATM is to effectively maintain and promote the safety, order and smooth of air traffic. ATM includes Air Traffic Service (ATS), Air Traffic Flow Management (ATFM) and Airspace Management (ASM), as shown in Figure 1.2.2-1.

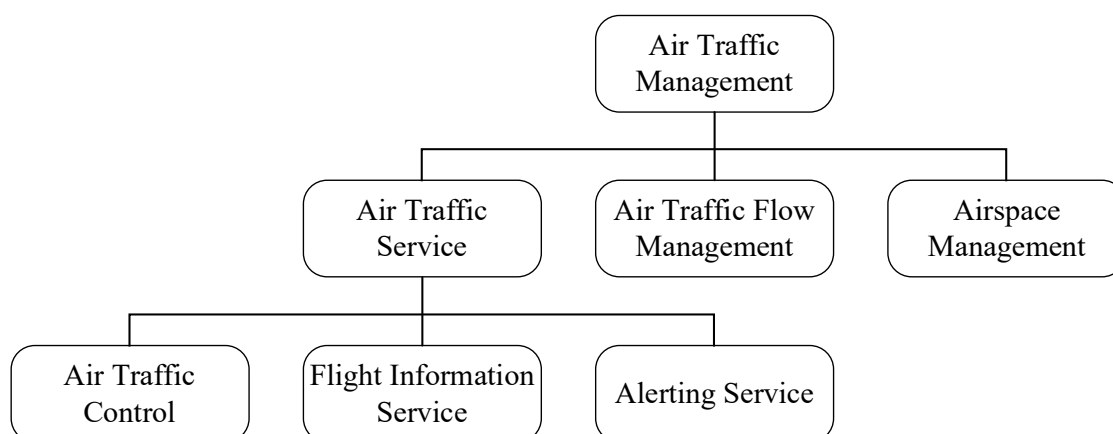


Figure 1.2.2-1 Composition of air traffic management

ATS is the main part of ATM, which includes air traffic control (ATC), flight information service (FIS) and alerting service (ALS).

ATC is to prevent collision between aircraft and aircraft, and collision between aircraft and obstacle in maneuvering area. The object of FIS is to provide advice and intelligence helpful for flight safety and effectiveness to the aircraft in flying. ALS is to issue notices of searching for and rescuing aircraft to relevant organizations, and to assist these organizations or coordinate this work if necessary.

### **1.2.3 Concept of ATMAS**

The ATMAS mentioned in this document is mainly applied in ATC service, as well as offering assistance for ALS and ATFM. It comprises a group of processing sub-systems dedicated to specific functions, which are integrated as one air traffic management system to provide functional capabilities to air traffic controllers in the Area Control Centers (ACC), Approach

Control Unit and Aerodrome Control towers. The ATMAS helps controllers keeping conformance monitoring, hazard monitoring, and assuring safety separation to air traffic flow.

Normally, the ATMAS has a modular design and distributed architecture to ensure robustness under adverse operating conditions. The modularity enables modifications to the baseline product to be made with relative ease. The principle of distributed processing ensures the safe, uninterrupted provision of air traffic services by controllers.

All processing and display sub-systems are interconnected via high-capacity redundant LANs. Computers providing common services (e.g., Flight Data Processing) may be duplicated with each individual computer connected to each LAN providing a high degree of redundancy. Fail soft operation of the dual computer groups is achieved by multiple computation redundancy, (parallel operation of the computer), or hot stand-by redundancy, to provide an uninterrupted service to the controllers.

Typically, considering the safety and redundancy requirements, the ATMAS has two individual LANs which are called working LANs, where the redundancy computers are connected. The working LANs keep sharing information all the time and function as main and fallback modes. Air traffic control airspace with high density traffic is recommended to use a third LAN which is called service LAN. The latter's main function is system trace collection, handling of recording and playback, etc.

#### **1.2.4 Challenges and Solutions**

Considering the framework for global ATM roadmap requirements and the current world situation, ATMAS is facing the following challenges:

As the system functions and features continue to develop, the system is getting more and more complex. These cause long software/application development and practically, in most often cases, these functions/features are seldom used. Consequently the system is getting hard to maintain and costly to deploy.

The public health emergencies have a devastating impact on the economy and the aviation industry worldwide. It will not be surprising that the ICAO member states, including those in the APAC Region, must reappraise both their capital and operational expenses (CAPEX and OPEX) in the coming years, including the expenditure in the ATMAS.

The seamless ATM Plan requires the individual ATMAS sharing a common set of accurate information in a timely manner, which needs to interface each other seamlessly, and work interoperability.

To overcome the above challenges, it is important to come up with the ATMAS IGD that will provide the main functions and performances which is aimed at facilitating the implementation or provision of the robust, safe, efficient ATM automation systems. This will help the APAC region member states/CAAs/ANSPs to have an ATM automation system that shares common/core functions/performances while achieving seamless interoperability rather than investing more on CAPEX/OPEX to cope with future increase in air traffic. It is relatively more important to put focus on (a) application of new/innovative technologies that would help make good business cases, (b) incorporating baseline/key optional features into their system design at early stage, and (c) preparing for system completion effecting changes during low air traffic periods before full traffic recovery.

### **1.2.5 Outcomes and Endorsements**

To ensure continuous and coherent development of the ATM automation systems that are harmonized with adjacent regions to enhance systems interoperability, and to keep abreast of the latest developments in ASBU and ATM automation systems, topics pertaining to ATMAS have been focusing and fruiting in APAC Region since 2018.

The ICAO Asia Pacific Regional ATMAS Symposium (APAC RATMS) held in Nanjing, China, from 22 to 23 November 2018 successfully addressed Action Item 54/13 of 54th DGCA Conference on ATMAS where it also suggested for States/Administrations to consider establishment of a regional working group/task force under the ICAO CNS Sub-group of APANPIRG to deal with matters arisen from this symposium concerning ATM automation systems. The symposium agreed to formulate an action item for the 23rd meeting of CNS Sub-group in 2019 to review and consider whether such regional working group/task force is needed.

The SURICG/4 was held in Nanjing, China from 9 to 12 April 2019. The meeting reviewed and further discussed the outcome of the ICAO APAC Regional ATMAS Symposium (APAC RATMS) and other SURICG/4 papers relevant to ATMAS and endorsed the draft Decision of **“Draft Decision SURICG/4/5-Establishment of ATM Automation System Working Group (ATMAS/WG)”** for consideration by CNS SG.

The Twenty Third Meeting of the Communications, Navigation and Surveillance Sub-group (CNS SG/23) of Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) held at the ICAO Regional Office, Bangkok, Thailand, from 2 to 6 September 2019 considered the report of SURICG/4 with some other CNS SG/23 working papers and noted that a briefing on the proposal on establishing a working group to deal with ATMAS issue was also provided to ATM SG/7 meeting. Several States/Administration expressed their willingness to support the work of the Task Force including China, Hong Kong-China, India, Indonesia, Nepal, Singapore, Thailand and USA. Hence, the meeting adopted the **“Decision CNS SG/23/13 (SURICG/4/5) - Establishment of ATM Automation System Task Force (ATMAS/TF)”**.

APANPIRG/30 meeting that was held from 4-6 November 2019 at ICAO APAC Office, Bangkok, Thailand, The APANPIRG/30 meeting noted with appreciation the work done and achievements by the CNS SG and the contributory bodies reporting to APANPIRG through the SG pertaining to ATMAS. The meeting noted that CNS SG/23 meeting had adopted 9 Conclusions and 4 Decisions on technical and operational matters, including the **“Decision CNS SG/23/13 (SURICG/4/5) Establishment of the Asia/Pacific ATM Automation System Task Force (ATMAS/TF)”**.

### **1.3 Arrangement of ATMAS IGD**

This ATMAS IGD consists of the following parts:

Section 1	Introduction
Section 2	Reference Documents
Section 3	System Functional Baseline
Section 4	System Design
Section 5	System Software Management
Section 6	System Transition
Section 7	System Maintenance

### **1.4 Document History and Management**

The framework of this document was first introduced in the first Working Group Meeting of ATMAS Task Force (ATMAS TF/1) of video conference, which is held in October 2020. The Meeting agreed to further develop based on the proposed framework to a complete document for approval as regional guidance document. A working team, consisting of volunteers from China, Hong Kong-China, India, Japan, Malaysia, Philippines, Singapore, Thailand, and Vietnam was established by the Meeting to contribute to the content of the document. In August 2021, the completed draft of this document was ready for circulation among States for review and comment.

The aim of this document is to supplement SARPs, PANS and relevant provisions contained in ICAO documentation, and it will be regularly updated to reflect evolving provisions. To support the ICAO in making specific recommendations and developing guidance materials, such as minimum functional/performance requirements and additional/local requirements, which aim at facilitating the implementation or provision of robust, safe, efficient, and orderly ATM services by the use of existing and/or new procedures, facilities and technologies in relation to ATMAS.

### **1.5 Copies**

Paper copies of this ATMAS IGD are not distributed. Controlled and endorsed copies can be found at the following web site: <http://www.icao.int/APAC/Pages/edocs.aspx>

Copy may be freely downloaded from the web site or by sending an email of request to APANPIRG through the ICAO Asia and Pacific Regional Office.

### **1.6 Changes to ATMAS IGD**

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (refer to Appendix A) should be completed and submitted to the ICAO Asia and Pacific Regional Office. This form may be photocopied as required, emailed, faxed or e-mailed to ICAO Asia and Pacific Regional Office +66 (2) 537-8199 or [APAC@icao.int](mailto:APAC@icao.int). The Regional Office will collate RFCs for consideration by the ICAO Communications, Navigation, Surveillance (CNS) Sub-group of APANPIRG.

When an amendment has been agreed by a meeting of the ICAO CNS Sub-group of PANPIRG, then a new version of the ATMAS IGD will be prepared, with the changes marked by an “|” in the margin, and an endnote indicating the relevant RFC for the traceability of the change. If the

change is in a table cell, the outside edges of the table will be highlighted, for example, as follows.

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Final approval for publication of an amendment to the ATMAS IGD will be the responsibility of APANPIRG.

## **1.7 Editing Conventions**

(Intentionally blank)

## 2. REFERENCE DOCUMENTS

Id	Name of the document	Edition	Date	Origin	Domain
1	Annex 2 - Rules of the Air	10th Edition	2005	ICAO	
2	Annex 12 - Search and Rescue	8th Edition,	July 2004	ICAO	
3	Annex 11 — Air Traffic Services	15th Edition	2018	ICAO	
4	Annex 17 - Security	10th Edition	2017	ICAO	
	11th Edition	March 2020	ICAO		
5	“PANS-ATM, or Procedures for Navigation Services – Air Traffic Management (DOC 4444)	16th Edition (Amendment 9 dated 5/11/20)	2020	ICAO	
6	Global Air Navigation Plan (GANP) (Doc 9750)	6th Edition	2020	ICAO	
7	Global Air Traffic Management Operational Concept (Doc 9854)	First Edition	2005	ICAO	
8	Manual on Air Traffic Management System Requirements (Doc 9882)	First Edition	2008	ICAO	
9	Manual on Global Performance of the Air Navigation System (ICAO Doc 9883)	First edition	2009	ICAO	
10	Doc 10031 Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes	First edition	2014	ICAO	
11	Restricted—Air Traffic Management Security Manual(Doc 9985)	First edition	2013	ICAO	
12	Air Traffic Services Planning Manual (Doc 9426)	4th Edition	2007	ICAO	
13	Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive (Doc 9574)	4th Edition	2013	ICAO	

*Air Traffic Management Automation System*

*Implementation and Guidance Document*

14	Performance Based Navigation (PBN) Manual (Doc 9613)	4th Edition,	2013	ICAO	
15	Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)	2nd Edition	2007	ICAO	
16	Manual of Air Traffic Services Data Link Applications (Doc 9694)	5th Edition	2010	ICAO	
17	Manual on Flight and Flow — Information for a Collaborative Environment (FF-ICE) (Doc 9965)	First edition	2012	ICAO	
18	Manual on Simultaneous Operations or Parallel or Near-Parallel Instrument Runways (SOIR) (Doc 9643)	2nd Edition	2020	ICAO	
19	Asia/Pacific Regional Interface Control Document (ICD) for ATS Interfacility Data Communications (AIDC)	Version 3.0	2007	ICAO APAC	
20	The Revised ADS-B Implementation and Operations Guidance Document (AIGD) Adopted by CNS SG/23 September	Version 12.0	2019	ICAO APAC	
21	The Mode S DAPs Implementation and Operation Guidance Document Adopted by CNS SG/23 September 2019	Edition 1.0	2019	ICAO APAC	

### **3. SYSTEM FUNCTIONAL BASELINE**

The functional baseline, forming the core of the ATMAS, are broadly described as those which are involved with the processing and display of operational information that will be used in providing an alerting, flight information and separation service to aircraft.

#### **3.1 System Essential Functions**

In order to provide controllers with the display of air situation, the ATMAS is suggested with the following essential functions.

- a. Surveillance Data Processing Function. Chapter 3.1.1 introduces the essential surveillance data processing function. For the processing of enhanced surveillance data such as ADS-B, please refer to chapter 3.2.1.
- b. Flight Data Processing Function.
- c. Bypass Surveillance Data Processing Function.
- d. Coupling of Surveillance and Flight Data function. Chapter 3.1.4 introduces the essential coupling function with mode 3/A code. The processing of using 24-bit address code etc. as the condition for coupling, please refer to chapter 3.2.2.
- e. Safety Net Function. Chapter 3.1.5 introduces the essential Safety Net function. For extended Safety Net function such as Medium Term Conflict Detection Warning (MTCD), please refer to chapter 3.2.3.
- f. Meteorological Information Processing Function.
- g. Air Ground Data Link Function (AGDL).
- h. Variable System Parameter (VSP) Management Function.
- i. ATS Inter-facility Data Communication Function.
- j. Human Machine Interface Function (HMI).
- k. Recording and Playback Function. Chapter 3.1.11 introduces the essential data recording and playback function. For video recording and playback function, please refer to chapter 3.2.7.
- l. System Monitoring and Controlling Function.
- m. Software Version Management Function.
- n. GNSS Time Synchronization.

### **3.1.1 Surveillance Data Processing Function**

SDP is one core function of ATMAS. SDP should be able to integrate multiple radars and process the received surveillance data to generate a unique system track. System tracks containing accurate real time positioning information, are used to couple with flight plans and displayed on HMI with specific track symbols.

Normally, SDP includes the following functions:

- a. Access and process data from primary radar, secondary radar, primary and secondary combined radar and weather data from PSR radars.
- b. Pre-process the surveillance data to monitor the data quality.
- c. Process mono-sensor surveillance data and generate mono-sensor track.
- d. Process multi-sensor surveillance data and generate continuous and smooth system tracks adopting advanced tracking filtering algorithms.
- e. Manage the altitude tracking and perform conversion of Mode C derived data according to QNH value.
- f. Provide prompts in case of overload, filter received data and discard extra data.
- g. Process the special position identification pulse (SPI) and display using a unique indication.
- h. Allow special area definition to improve system track accuracy.

#### **3.1.1.1 Surveillance Data Pre-processing**

The system is recommended to process standard radar formats including ASTERIX format and other related standards. It should automatically identify the format of surveillance data, decompose and extract the data items according to the corresponding format specifications.

The system is encouraged to be able to monitor the received data quality and filter out the abnormal data to ensure the data fusion quality.

The surveillance data quality check is suggested taking following factors into consideration:

- a. CRC error.
- b. Data frame error.
- c. North messages lost.
- d. Radar sector crossing messages lost.
- e. Track lost.

- f. Time stamp check.

### **3.1.1.2 Mono-radar Data Processing**

The system is recommended to perform syntactic and semantic checks on the received data against specifications, including the attributes of target, identifier (SSR code, track number, address code, etc.), position, altitude, speed, time stamp, SIC/SAC, etc.

The system is suggested with time drift management to handle abnormal time stamping, correct the timestamp by adding a time shift in received data. It should perform coordination conversion and projection, as well as providing mono-radar tracking function.

The system handles target correlation for the purpose of generating a new track, or updating the existing, or deleting the dated, and then form a stable mono-radar track in the end.

### **3.1.1.3 Multi-radar Data Processing**

The system should generate stable system tracks by multi-radars data fusion, which includes correlation and tracking, and takes into account of radar bias settings.

After receiving data from multi-radars, the system handles target correlation process, which is taken into account of target characteristics, such as position, SSR, altitude and speed.

The system is suggested to further conduct target correlation with existing system track for updating, or with establishing new system track on the other hand so as to ensure accuracy, continuity and smoothing. Abnormal data derived from some radar should not impact system track quality.

In track fusion process, the system records the quality of every surveillance sensor, so as to estimate the quality of this sensor based on the historical and the real-time data.

The system tracks is normally used as the basic data of the entire system to support modules such as alarm calculation, plan-couple processing, and human-machine interface.

During the period of fusion process, the system gathers statistics of each radar data quality. As a reference, system track updates.

As a result of fusion process, the system track is provided to alert calculation, coupling process and HMI display.

### **3.1.1.4 Target Altitude Tracking and Processing**

The system is suggested to support QNH area definition and correct Mode C values into barometric altitudes for all aircrafts in specific QNH area.

The system provides altitude tracking, extrapolating the flight level according to current mode C value and altitude change rate.

The system discards abnormal altitude reported by the surveillance source.

### **3.1.1.5 Surveillance Data Overload Processing**

The system is recommended to cope with surveillance data overloading processing as follows:

- a. When the total number of targets processed by SDP reaches a certain threshold, the system generates a warning prompt automatically.
- b. When the total number of targets exceeds the load threshold, the system gives prompts to users and considers filtering or discarding the extra data.

### **3.1.1.6 Special Pulse Identification Processing**

When receiving SPI from radar track, the system is suggested to display a prompt on track identifier automatically.

### **3.1.1.7 Automatic Test Target Monitoring**

The system is advised to be capable of monitoring the quality of radar via automatic Test Target Monitoring with fixed SSR Test Transponders.

### **3.1.1.8 Special Area Setting and Processing**

The system is proposed to be capable of:

- a. Defining areas of interest (AOI) for each sensor, and discard reports outside the AOIs.
- b. Defining inhibition areas for each sensor, and stop track initialization in the inhibition areas.
- c. Defining blanking areas for each sensor, and discard reports in the blanking areas.

## **3.1.2 Flight Data Processing Function**

Flight data processing (FDP) is one core function of the ATMAS. Data which is relevant with flight plan are received, stored, processed and updated by FDP. FDP can also exchange data with other software modules.

Normally, FDP includes the following functions:

- a. ATS messages processing, which processes ICAO, AIDC, OLDI and other format messages.
- b. Flight plan life cycle management to flight plan.
- c. 4D profile trajectory computation, including route analysis, profile

calculation and time estimation, SID /STAR /runway automatic allocation.

- d. SSR code management, including SSR code automatic assignment for inbound and outbound flights, and manual SSR codes assignment by controllers;
- e. Sector management and posting computation, post flight plans based on conditions, and provide electronic strip display and paper strip printing at designated position;
- f. Flight plan data exchange with other external systems (such as Main/Fallback ATM automation systems, tower ATM automation systems, flow management systems, etc.). This part will be described in detail in section 4.7 of this document.

### **3.1.2.1 Flight Message Processing**

The system should be capable of processing flight message following ICAO PANS-ATM (Doc 4444) and AIDC and other related regulations, including FPL, CHG, CNL, DEP, ARR, DLA, CPL, EST, CDN, ACP, LAM.

The system is advised to perform semantic and syntactic checks on the received messages and create or update associated flight plans with correction. Messages failed in semantic or syntactic checks are categorized and sent to the designated position for manual processing. Manually corrected messages are processed again by the system.

The system is suggested to be designed with messages manual transmission function, and provide a default template for each type of messages to be modified and confirmed by users.

The system is recommended to automatically transmit messages according to the pre-defined conditions and addresses. At least the following messages can be sent: FPL, DEP, ARR, CHG, DLA, CPL, and EST.

### **3.1.2.2 Life Cycle Management**

The system is recommended to be able to manage the life cycle of flight plans. Flight plan states could be generally defined as INACTIVE, PREAMBLE, COORDINATED, ACTIVE, FINISHED, etc. User is encouraged to adjust the above states according to the operation requirement.

The evolution of the flight plan states could be triggered automatically based on time, message, coupling, etc., or by manual input.

Example of the main state transition conditions and processing are as follows:

- a. INACTIVE

At creation, the flight plan state is INACTIVE.

Normally, all flight plans in INACTIVE state support manually modification or via messages.

b. PREACTIVE

When the flight is approaching its execution and control airspace, the flight plan state will change to the PREACTIVE state.

At pre-activation, the system is suggested to perform 4D trajectory and posting computation, and send strips to relevant positions. The system could allocate SSR codes, departure runways and SIDs for departure flights.

c. COORDINATED

When the flight is ready for control, the plan state will change to COORDINATED. This coordination is triggered by manual operations or system events.

The flight plan in COORDINATED state is qualified for coupling with system tracks.

d. ACTIVE

When the flight is in jurisdiction, the flight plan state becomes ACTIVE.

Generally, the system calculates and updates 4D trajectory based on surveillance data, air-ground data and manual commands. The flight plan in ACTIVE state is qualified for coupling with system tracks.

e. FINISHED

When the flight plan is no longer used to assist in controlling the actual flight, the plan state becomes FINISHED.

At finishing, the system is suggested to:

- Release the SSR code.
- Stop the 4D trajectory calculation.
- Delete posting events and remove the electronic strip.
- Save the records for further analysis and statistics.

f. Other states

In addition to the above states, users can also define SUSPENDED, INHIBITED and other states according to operation requirements, which are used for flight plan suspension or inhibition. Under these states, FDP will stop updating the flight profile and suppress related alarms.

### **3.1.2.3 4D Profile Trajectory Calculation**

It is recommended the system support 4D flight profile trajectory calculation. The profile calculation is continuous and generally divided into three stages: take-off, level flight and descent. The profile may start from the departure airport or the fixes before the FDRG entry, containing height and time information for each waypoint, and ends at the destination airport.

The profile calculation could refer to waypoint information, DEP/ARR airport, runway, requested altitude, cruise speed, aircraft performance parameter, GRIB, target position, and real-time data input by controllers, etc.

The profile update could be done at the change of flight attitude or passing waypoints, sector boundary points, or on system events or controller inputs.

The system is proposed to automatically allocate departure runways and SIDs for departure flight plans as well as arrival runways and STARs for arrival flight plans. The system would provide function of manual assignment, modification and deletion to SID/STAR/runway.

### **3.1.2.4 SSR Code Management**

Normally, the system is capable of manually and automatically assigning SSR codes.

The system is recommended to adopt specific SSR code group and allocation rules according to the type of flights (inbound and outbound).

The system is suggested to perform SSR code retention check and use the SSR code in received messages (e.g. DEP message) if the code is available. If not free, the system will allocate a new code from free code list. In case of no free codes, the system could assign a SSR code from the allocated code list, and the earliest allocated code should have priority.

Generally, the system is not supporting special codes (such as 7700, 7600, 7500, etc.) assignment.

The SSR code will be released, when the flight plan is finished.

The system is proposed to support manually modify the SSR of the flight plan. If the input code is already occupied, a prompt is suggested to be produced.

It is recommended that the system uses A1000 as Mode S conspicuity code. The flight plan with that code will use 24-bit address or ACID for the coupling with system tracks, and warning/alerts should not be generated when SSR duplication due to Mode S conspicuity code

### **3.1.2.5 Sector Management and Posting Computation**

Normally, the system is capable of pre-configure the airspace into different sectors and enables the controllers to group or ungroup these sectors online.

The system is recommended to post the relevant electronic strip to designated sector according to offline defined conditions. The electronic strip is suggested to display on the controlling sector and posted sector in specific colors.

The system is proposed to compute and insert posting events based on the way points or sectors in the flight plan. Posting conditions are tightly linked with the operational concept and control procedures, including: way points, altitude range, ACID, airport, runway, flight rule, flight type, etc.

The system is advised to support manual and automatic transfer of jurisdiction. The automatic transfer could be computed based on offline rules to get the timing and the target sector. The automatic transfer conditions are similar to posting conditions.

### **3.1.3 Bypass Surveillance Data Processing Function**

To further enhance resilience, bypass surveillance data processing (BSDP) could be implemented according to the operational need. BSDP is a redundancy module of SDP, which can independently receive, process and distribute surveillance data independently to SDP. When the SDP fails, the system will switch to BSDP automatically.

The system is suggested to configure BSDP module according to operation requirement. BSDP is recommended to be capable of directly accessing various surveillance sources, using a different tracking algorithm with SDP.

BSDP should at least provide mono-sensor tracking function. Multiple-sensor data tracking function and alarm functions, such as Special Codes alert, Short Term Conflict Alert (STCA), Minimum Safe Altitude Warning (MSAW), Area Proximity Warning (APW), etc, could be considered as part of BSDP.

Human-Machine interface (HMI) is proposed to support displaying effective alert in bypass mode.

### **3.1.4 Coupling of Surveillance and Flight Data**

The objective of surveillance and flight plan coupling function is to establish an association between a surveillance track and a flight plan, based on identifying codes and position check. The way to establish association includes automatic and manual coupling.

#### **3.1.4.1 Automatic Coupling**

Normally, the system performs automatic coupling between the flight plan and the system track, when pre-defined conditions are met, for examples:

- a. Specific flight plan status.
- b. Identical SSR code.
- c. Passing position and altitude check.

The flight plan in the system has two kinds of SSR code:

- a. ASSR (Assigned SSR code): currently assigned to the flight plan within the FIR.
- b. PSSR (Previous SSR code): used for inbound flight, which was used in the previous FIR or the previous code used in the case of a code change within the FIR.

The position check is suggested to include:

- a. Whether the track position is in the route model. The route model is composed of airports, way points and route corridors in the flight plan.
- b. Whether the difference between the estimated flight plan position and the track position is within a certain range.
- c. For take-off and landing system tracks, the altitude check is recommended to be performed.

#### **3.1.4.2 Manual Coupling**

The system is recommended to support manual coupling of a flight plan to a track by controllers, for example using mode 3/A code as a criteria.

A warning message is suggested to be provided if manual coupling is failed.

#### **3.1.4.3 Decoupling**

The system is suggested to cancel the coupling if the coupling conditions are not met.

Under emergency settings, the system is advised to maintain the coupling when the SSR code is changed to 7500, 7600, 7700.

#### **3.1.4.4 Coupling Data Distribution**

At the time of coupling, the system is recommended to distribute coupling information to other modules and display coupled system tracks on the controller positions.

Normally, the system updates the flight profile according to the position and altitude information of the coupled surveillance track.

### **3.1.5 Safety Net Function**

Safety Net Function serves to alert controllers of potential, imminent or actual infringement of safety margins to prevent hazardous situations from developing into major incidents or even accidents. The aviation safety areas covered by Safety Net Function generally include:

- a. Aircraft Separation.
- b. Airspace Operation Requirement.
- c. Conformance of Clearance.
- d. Terrain Clearance.
- e. Approach/Departure Path Conformance.

Alerts/warnings from Safety Net Function are generated based on different levels of severity of infringement and imminency with distinguishable visual and/or aural alarms with their prominence corresponding to the severity and imminency of the infringement.

During the planning stage, States/Administrations are encouraged to conduct comprehensive study on the applicability of safety net features in ATMAS to their local environment with consideration of system behavior, Human Machine Interface (HMI) design and operational procedures. By design, the Safety Net Function in the ATMAS should be configurable with various parameters on activation/deactivation/acknowledgement of alarm adjustable by the user. Where applicable, references, especially on test strategy and system parameters, to successful cases of Safety Net implementation by other States/Administrations are suggested.

For actual implementation of Safety Net Function, a progressive approach is suggested with potential advantages as below:

- a. Reducing risks in implementation and operation of one safety feature at a time as compared to deployment of all planned safety features in one go;
- b. Reducing demand of resources and staff workload involved in evaluation of the safety features; and
- c. More time for air traffic controllers to evaluate the safety features and fine-tune the parameters before embarking on further implementation.

A post-implementation review is recommended including collection of feedback and suggestions from frontline air traffic controllers, effectiveness and performance of the safety features (such as user-friendliness, alert timeliness, nuisance alerts), data analysis to gauge improvement in safety figures with a view to continuously fine-tuning of safety net parameters to reduce nuisance alerts.

### **3.1.5.1 Types and Priority**

The system is recommended to provide serious alerts and warnings to controllers with visual and aural indication, integrating surveillance data, flight plan data and other operational data, by means of different algorithms and rules.

The alerts and warnings are normally classified into emergency, alerts and warnings, the presentation is advised to consider indicators, display position, colors and audios etc.

The emergency should have the highest priority, including hijack (7500), radio failure (7600), general emergency (7700), etc.

Examples of alerts include STCA, MSAW, APW, APMW, etc.

Examples of warnings include SSR Code Duplication warnings, AIDC coordination prompt, SPI indication, etc.

It is recommended that the system is capable to set the priority of alerts, the priority of warning is higher than its corresponding pre-warning. Multiple warning indicators could be displayed on the label simultaneously according to the warning priority.

### **3.1.5.2 Emergency**

At reception of emergency codes, the system is suggested to process it, and display the emergency on the concerned positions.

The emergency codes include:

- a. 7500 (hijack).
- b. 7600 (radio failure).
- c. 7700 (general emergency).

Normally, the emergency is displayed until the received Mode 3/A code is different from the emergency code.

### **3.1.5.3 Short Term Conflict Alert**

Short Term Conflict Alert (STCA) is an important safety net feature of ATMAS for alerting controllers of potential or actual infringement of separation minima between aircraft to avoid collision.

The STCA function in ATMAS generates visual and/or aural alerts to controllers in air situation display if any pair of aircraft is violating, or is predicted to, within a look-ahead time, which is a pre-defined separation minima in the STCA settings of the ATMAS. Controller would need to resolve the conflict immediately once the alert has been generated.

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Surveillance, flight plan and environmental data are required for generating STCA in ATMAS. The following list of information could be considered to include in the STCA processing:

- a. Aircraft position
- b. Pressure altitude
- c. Cleared flight level
- d. Flight rule
- e. RVSM status
- f. Concerned controller jurisdiction
- g. Separation standards of STCA areas
- h. Look-ahead time

Flight plan data, i.e. cleared flight level, flight rule and RVSM status of the aircraft, could help improve relevancy of alert generation so as to reduce cases of nuisance alerts. In addition, the implementation of STCA inhibition could be considered based on a definition of inhibition zones, SSR code groups, callsign or other conditions applicable to the local operational environment and needs.

The STCA processing cycle is recommended to be at a frequency not less than once per track update of ATMAS. States/Administrations could also consider implementing STCA with two stages of alerts based on situation of predicted and actual infringements, i.e. Predicted Conflict Alert (PCA) and Conflict Alert (CA).

For complex airspaces with different separation standards for different sectors, the design of ATMAS is recommended to allow the configuration of multiple STCA volumes in which specific STCA parameters could be applied for a given STCA volume according to the operational needs.

The performance of STCA is highly dependent on the optimization of conflict detection algorithm and adapted parameters for the local environment. States/Administrations are suggested to work closely with system manufacturers to adapt the STCA detection according to the local environment. For successful implementation, regular review with controllers on the performance is necessary for fine-tuning of the STCA to local operational needs.

#### **3.1.5.4 Minimum Safe Altitude Warning**

Minimum Safe Altitude Warning (MSAW) is intended for assisting controllers with alerts of potential risk of an aircraft infringing a defined minimum safe altitude over a concerned region.

The MSAW function monitors the position and altitude of an aircraft against defined MSAW regions and minimum safe altitudes. When the altitude of an aircraft is found or predicted to be lower than the applicable minimum safe altitude within

defined the MSAW region, visual and/or aural warning would be generated to alert controllers to take necessary actions on resolving the infringement.

For reference, examples of surveillance, flight plan and environmental data are required for the MSAW functional module to generate alerts are:

- a. Aircraft position.
- b. Pressure altitude.
- c. Cleared flight level.
- d. Flight rule.
- e. Concerned controller jurisdiction.
- f. Terrain and obstacle model.
- g. Look-ahead time.

To minimize nuisance alerts, flight rule and cleared flight level in flight plan data can help improve the relevancy of MSAW alert generation. In addition, States/Administrations could consider implementing MSAW alert inhibition which suppresses MSAW alerts based on defined inhibition zones (such as final approach zones), SSR code groups, callsign or other conditions applicable to the local operational environment.

The accuracy of MSAW alert is related to MSAW terrain/obstacle definition, look-ahead time setting and inhibition strategy adopted for flights intentionally flying close to terrains/obstacles. Appropriate settings of the above are necessary for providing a reliable MSAW detection that controllers can rely on. Any unoptimized parameters would likely result in nuisance alerts or insufficient time for controllers to respond to the alert. It is important to perform tuning of MSAW parameters based on controllers' feedback for successful MSAW implementation.

### **3.1.5.5 Area Proximity Warning**

Area Proximity Warning (APW) is a safety net for alerting controllers of any potential or actual unauthorized penetration of aircraft into Special Use Airspaces (SUA) including:

- a. Danger airspace.
- b. Prohibited airspace.
- c. Restricted airspace.
- d. Temporarily restricted airspace.

Each SUA volume could be defined in ATMAS as an area (e.g. circle, polygon, etc.) with upper and lower bound on altitudes. The defined volumes would be assigned with unique names to facilitate identification by controllers. The activation/deactivation of warning in a SUA volume could be triggered automatically according to a defined schedule or by manual action of controllers. A pre-active stage

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of SUA volume with a configurable lead time before the scheduled activation could be further introduced to provide controllers with an early awareness of a planned airspace restriction.

To minimize nuisance warnings, States/Administrations could consider implementing APW inhibition in ATMAS to exclude the checking of certain aircraft flying into the SUA volumes. The inhibition could be implemented based on flight rules, SSR code groups, callsign and other conditions applicable to the local environment and operational needs.

### **3.1.5.6 Approach Path Monitoring**

Approach Path Monitoring (APM) is a safety net to alert controllers of a predicted or actual unsafe descending final approach profile (e.g. flying into terrains and obstacles) adopted by an aircraft to avoid accidents during final approach.

The APM function monitors the aircraft's final approach profile for any vertical and lateral deviation from the optimal one. Visual and/or aural alerts would be generated when an aircraft exceeds or is predicted to exceed the defined tolerance of deviation. In such a case, controllers would need to respond to the situation and resolve the deviation.

In general, an APM zone would be defined in ATMAS for performing APM processing on flights. Examples of parameters on the definition of APM zone are:

- a. Runway name and direction.
- b. Touchdown point on the runway.
- c. Horizontal angular extend from touchdown point.
- d. Vertical angular extend from touchdown point.
- e. Distance from touchdown point.
- f. Glide slope elevation.
- g. APM inhibition zone.

Surveillance, flight plan and environmental data are required for generating APM warning. The following list of information could be considered to include in the APM processing:

- a. Aircraft position.
- b. Pressure altitude.
- c. Flight rule.
- d. Concerned controller jurisdiction.
- e. APM zone definition.
- f. Look-ahead time.

To minimize nuisance alerts, the checking of flight rule could help improve the relevancy of warning generation. In addition, an aircraft flying close to terrains/obstacles during final approach which could easily trigger MSAW alert due to nearby terrains/obstacles. States/Administrations could consider to suppress MSAW alert generation in ATMAS within APM zone or via the definition of inhibition zones if an aircraft's descent profile is already under the monitoring by APM.

The performance of APM is highly related to adapted APM parameters for local environment, look-ahead time setting and inhibition strategy adopted for flights intentionally deviated from optimal final approach path. Regular review of the performance is crucial for the tuning of APM parameters based on controllers' feedback for increasing its effectiveness.

#### **3.1.5.7 SSR Code Duplication Warning**

When detecting multiple aircrafts with the same SSR code in the certain area, the system is suggested to provide SSR Code Duplication warning to the controller.

#### **3.1.5.8 AIDC Coordination Failure Warning**

On failure of AIDC coordination, the system is advised to provide visual indications to controllers on track labels and electronic strips.

#### **3.1.5.9 SPI Indication**

At reception of SPI information transmitted by the aircraft, the system normally provides visual indications to controllers.

### **3.1.6 Meteorological Information Processing Function**

Generally, the system is capable of receiving, processing and displaying meteorological information including GRIB, QNH and mono-radar derived weather information. The meteorological information should be applied in surveillance data and flight data processing.

The system could process GRIB messages from the meteorological information system, which contain upper wind and temperature for accurate calculation and estimation of flight plan profiles.

The system is recommended to automatically extract and process QNH data from METAR and SPECI messages, as well as accept manual input.

Considering about the weather situation awareness to controller, the system is recommended to be capable to receive and process mono-radar derived weather information, and display on the controller positions. From the experience, the categorization of weather echo display could be classified no less than three levels. The parameters of display level and priority could be defined as required.

### **3.1.7 Air Ground Data Link Function**

The AGDL function mainly processes the information based on the data link communication, including: ADS-C (Automatic Dependent Surveillance-Contract), CPDLC (Controller-Pilot Data Link Communication) and DCL (Departure Clearance), etc. States/Administrations could implement the Air Ground Data Link Function according to the operational needs.

#### **3.1.7.1 ADS-C Data Processing**

The ADS-C data processing is recommended as follows:

- a. The system automatically determines whether the aircraft enters the ADS-C area according to route information.
- b. The ADS-C connection could be initiated by pilots or controllers.
- c. The system receives and processes ADS-C messages, including periodic contract, event contract, emergency, current location, etc.
- d. The system updates and manages ADS-C tracks with received ADS-C messages.

#### **3.1.7.2 CPDLC Data Processing**

From experience, the system is suggested to provide following functions for CPDLC data processing:

- a. Display CPDLC position report and flight data.
- b. Display a CPDLC dialogue window.
- c. Determine whether the aircraft enters the CPDLC area according to route information.
- d. Allow to initiate a CPDLC connection automatically or manually by the pilot or the controller.
- e. Receive and process CPDLC downlink messages, send CPDLC uplink messages, and manage the message status.
- f. Allow to search CPDLC historical messages and display the messages in chronological order.
- g. Provide prompts to controllers in the following cases: correct message transmission and reception, manual operation and successful logon.

#### **3.1.7.3 DCL Processing**

The system is recommended to provide following DCL functions:

- a. Receive, process and send DCL messages (ARINC 623, EUROCAE ED-85A, etc.).
- b. Identify and process the RCD message, and automatically send error messages to controllers suggesting voice-clearance in case of invalid RCD message.
- c. Correlate the RCD message with a certain flight plan according to the callsign, departure airport, landing airport, and automatically reply with an FSM message.
- d. Automatically send CLD messages according to the correlated FDR and manual input data and perform synthetic and semantic checks.
- e. Check the compliance between the CDA and CLD message.
- f. Be capable to display RCD information, including the callsign, SSR code, CLD processing identification, and enable the edition and transmission of CLD messages.

### **3.1.8 System Parameter Management Function**

For the convenience to system maintenance, the system is proposed to be capable of managing the variable system parameters through dedicated positions.

#### **3.1.8.1 Types of System Parameters**

Generally, the types of system parameters include the following:

- a. Basic parameters: airspace, sectors, positions, routes, QNH areas, etc.
- b. Surveillance data parameters: surveillance source parameters, fusion parameters, etc.
- c. Flight data parameters: message processing and transmission rules, SSR code allocation rules, FDR parameters, etc.
- d. System interface parameters: interface configuration parameters.
- e. HMI parameters: sectorization parameters, electronic and paper strips formats, CFL popup values, system maps, etc.
- f. Alert parameters: warning and inhibition area definition, warning condition parameters, etc.
- g. Other maintenance parameters: recording parameters, warning messages, error messages, etc.

### **3.1.8.2 System Parameter Validations**

By experience, the system is suggested to support the following two validation modes:

- a. Online validation: for parameters allowed to be configured, selected and validated online, without restarting the system.
- b. Offline validation: for parameters to be validated after restarting the entire system or specific system modules.

### **3.1.8.3 System Parameter Management**

For the friendly to system user, the system is recommended to provide graphical user interface to establish, delete, modify, display, release and validate the online/offline system parameters.

At same time, the system is proposed to be capable of performing syntactic and semantic check, and providing error messages (such as the parameter function, format requirements, restrictions, etc.) to help data operator correction.

### **3.1.9 ATS Inter-facility Data Communication Function**

The system should incorporate an AIDC application that supports the following ATS-related information exchanges with similar application within the ATMAS of adjacent Control Units and Flight Information Regions adopted in the Asia-Pacific region.

The AIDC function of the system should conform to the standards in the prevailing version of the following documents:

- a. Asia/Pacific Regional Interface Control Document (ICD) for ATS Inter-facility Ground/Ground Data Communications; and
- b. Procedure for Air Navigation Services-Air Traffic Management (PANS-ATM) (ICAO Doc4444).

#### **3.1.9.1 AIDC message transmission and processing**

The system should support the core AIDC messages recommended in Asia/Pacific Regional ICD, such as ABI, CPL, EST, MAC, CDN, ACP, REJ, TOC, AOC, EMG, MIS, LAM and LRM.

The system should be configurable in supporting variations in AIDC processing and messages that are dependent on the mutual agreements with each adjacent Control Unit or FIR.

Normally, the system is recommended to be able to transmit AIDC messages automatically and manually, and be capable to process received AIDC messages automatically.

The system is suggested to transmit ABI, EST, PAC and other messages automatically according to the AIDC handover conditions and the status of the flight plan.

The system is proposed to transmit AOC, TOC, and EST messages manually through the HMI. The flight data operation position (FDOP) is capable to process erroneous and irrelevant messages manually.

For received messages that failed syntactic and semantic checks, the system should send such messages to a message queue to process by controllers manually.

The system is expected to alert controllers of any unsuccessful transmission of AIDC messages due to communication fault, or rejection by the receiving adjacent Control Units or FIRs, or failure to receive an expected application response from the receiving Control Unit within a time threshold.

### **3.1.9.2 AIDC Handover**

The system should be able to trigger AIDC handover automatically, depending on configured AIDC handover parameters, which may include handover points, height, time, adjacent Control Unit, etc.

The system could allow controllers to initiate AIDC hand over manually.

### **3.1.9.3 AIDC Coordination Process**

Generally, the AIDC handover is mainly fulfilled by the exchange of a variety of messages. The AIDC procedure is composed of three phases forming a standard AIDC process:

- a. Notification Phase;
- b. Coordination Phase; and
- c. Transfer of Control Phase.

The standard AIDC procedure could be simplified according to the handover agreement between adjacent Control Units. For example, taking advantage of five indispensable messages, regarding EST, ACP, TOC, AOC and LAM, the handover could be simplified into two phases of coordination and handover. The procedure is shown in the figure as below:

AIDC phase	ATS Control Unit A	Direction	ATS Control Unit B
Coordination	Send EST N minutes before the handover point	➡	
		←	Automatically Reply with LAM
		←	Automatically Reply with ACP
	Automatically Reply with LAM	➡	
Transfer of Control	Send TOC automatically/manully before the handover point	➡	
		←	Automatically Reply with LAM
		←	Automatically/manually reply with AOC
	Automatically Reply with LAM	➡	

Figure 3.1.9-1 Simplified AIDC procedure

The system could update the flight state of a flight as it transits through the AIDC coordination phases.

After successful completion of a coordination process, the system could automatically update the concerned flight plan with the cleared flight profile.

The system is expected to alert controllers when coordination with an adjacent Control Unit or FIR is not completed by certain time thresholds before Estimated Time over Boundary RP, Estimated Time of Departure, etc.

### 3.1.10 Human Machine Interface Function

HMI (Human Machine Interface) as an important part of the ATMAS is the medium for interaction and information exchange between the system and controllers. Operational users can monitor air traffic situation and modify flight plan and other relevant information through the use of physical peripherals and/or onscreen control interfaces. Technicians can monitor the status of the ATMAS and perform technical maintenance operations as well. HMI design of ATMAS should consider the day-to-day operation of air traffic controllers to provide a user-friendly interface for controllers to perform their duties effectively and efficiently. In general, the design should facilitate safe, efficient and sustainable control of air traffic based on the following principles:

- a. Accurate presentation of air traffic data
- b. Timely presentation of air traffic data
- c. Automatic data validity checking including operator input
- d. Input options automatically limited to valid data selections
- e. Allow a variety of user-friendly input methods (e.g. keyboard, number pads, mouse, etc.) for data entry by controllers

Considering about the user-friendly, The HMI function is recommended to include at least as follows:

- a. Providing graphical interfaces and functions for different positions, such as: supervisor position, controller position, flight data operator position, etc.
- b. Providing multiple position modes (e.g. Normal, Degraded, Bypass, and Mono) if required.
- c. Providing variable user modes (e.g. Operational, Free, Shadow, and Replay) if required.
- d. Providing a complete set of HMI configuration, including track display, HMI layout, menu setting, color management, mouse/keyboard functional definitions, map management, etc.
- e. Providing the operation interfaces for flight plan modification and control/management of onscreen information.

#### **3.1.10.1 Controller Position**

The controller position provides controllers with relevant information required for air traffic control, helping the controller be fully aware of the situation and manage the aircrafts in the responsible area. The specific functions are suggested as follows:

- a. Display system tracks, multi-radar tracks, multi-ADSB tracks, multi-WAM tracks, flight plan tracks and bypass tracks.
- b. Enable flight interactive operations such as handover and accept of aircraft, manual coupling, level assignment and coordination status.
- c. Allow screen operations such as zoom in, zoom out, off-center, measurement, window movement, label rotation, etc.
- d. Manage map display.
- e. Display and edit Flight plans.
- f. Post and display electronic strips/flight data list.
- g. Display system information.
- h. Personalize position parameters and display.
- i. Other relevant information required for operations.

#### **3.1.10.2 Supervisor Position**

The supervisor position normally has the same display and operation interface as the controller position. In addition, the system is advised to provide other functions on the supervisor position, such as: online operation parameters settings and management, SSR code management, sector management, QNH setting; automatic handover setting, position alert management, ATFM function; dangerous/restricted/inhibition

area management, temporary/global map setting, etc. are usually provided on the supervisor position.

### **3.1.10.3 Flight Data Operator Position**

The flight data operator position is capable to display relevant flight plans in a flight list containing all the flight information fields, in addition to enable the online flight plan editing function and AFTN message display, query, error correction and sending function.

### **3.1.10.4 Technical Management Position**

The technical management position provides graphic interface enabling efficient system maintenance and software management. The specific functions of the position are generally as follows:

- a. Technical parameters management.
- b. Operational parameters management.
- c. Software configuration and management.
- d. User Management.
- e. Map generator.

### **3.1.10.5 Position Mode Switch**

The system could be designed to provide controller position with various user modes to cater for different operational needs. Below gives an example of different user modes. States/Administrations could define their own set of position mode according to the operational need.

- a. Operational mode

The position in operational mode is allocated with sector and providing ATC service.

- b. Free mode

The position in free mode is sector-free and functionally limited, such as read-only access to flight data.

- c. Shadow mode

The position in shadow mode provides real-time monitoring of operational position of specific sectors and functionally limited, such as read-only access to flight data.

- d. Replay mode

The system only provides playback function in replay mode, and cannot be used for ATC service.

### **3.1.10.6 Track Display**

The graphical representation of a track normally includes a track symbol located at the current position of the aircraft, a label, a label leader, a selectable velocity vector and a selectable number of track history dots, etc.

The system should be able to display the accurate position of track, generated and updated according to surveillance source.

From experience, the system is capable of customization of the display of information in different layout types to show information on the label in different levels of detail depending of the operational needs.

The system is suggested to support label action such as CFL modification, handover request and acceptance, runway modification, STAR allocation, etc.

### **3.1.10.7 Map Display**

The system is recommended to be capable of the offline definition of the system maps, the online creation of the Local Maps by individual controller position, and the online creation of the Global Map, Temporary Restricted/Danger Area Maps etc. by the supervisor position.

The online created Local Map, Global Map and Temporary Restricted/Danger Area Maps could be saved and restored automatically during system restart.

### **3.1.10.8 Flight Plan Window**

The flight plan window is suggested to support the display and modification of the flight plan information data fields such as SSR code, ACID, flight rule, aircraft type, wake category, departure airport, destination airport, requested flight level, route, field 18 data.

The flight plan window is recommended to enable at least the following flight plan functions: creation, deletion, modification, coordination, handover, query, message sending, strip printing, etc.

### **3.1.10.9 Electronic Strip Function (if applicable)**

Electronic Strip Function could be implemented as apart of HMI function, from which controllers can access to do handover, acceptance, filtering, and sorting function. The electronic strips can be sorted and displayed by flight plan state, route fixes, time information etc.

### **3.1.10.10 System Information Display**

It is recommended to provide in the HMI system information, including device failure, operational information, feedback of operation, system status information etc. for controllers' awareness of system status.

### **3.1.10.11 Tracks Quick Search**

It is recommended that the system has a quick search function to search a track with complete or partial search criteria of callsign, SSR code, departure/destination airport, or other information. Matching track will be highlighted to the controllers.

### **3.1.10.12 Track Filtering**

It is recommended that the system provides track filtering function.

The system could filter tracks based on upper/lower limitation of level or SSR code.

Enabling and disabling flight plan track display could also be achieved via the HMI.

### **3.1.10.13 Personalized Position Parameters Setting**

The system is recommended to provide flexible configurations including label layout, HMI colors, mouse and keyboard functions, color configurations of all elements, menus and windows according to operational demand.

## **3.1.11 Recording and Playback Function**

The Recording and Playback function enables the recording of operational data in ATMAS and allows synchronized playback of air traffic situation, controller-pilot communication and controller actions in the air situation display for incident analysis and investigation. The design of recording and playback function in ATMAS should aim at reconstructing the actual scenario as accurately as possible.

### **3.1.11.1 Recording Function**

The Recording Function of ATMAS should maintain a continuous recording on all controller working positions. The following data and display could be considered to be recorded by the System:

- a. Screen data of controller working positions, including identical picture of windows, temporary maps, and any alert and warning, etc.
- b. Surveillance data including SDP track output, radar data, ADS-B data, etc.
- c. Controller input actions on keyboard or mouse.
- d. Messages of external interfaces such as AIDC messages, meteorological messages such as GRIB, AFTN, ICAO messages (including flight plan data), ADEXP messages, data link such as PDC, CPDLC, ADS-C.
- e. System data such as system event data, system performance data, system log, etc.

The recording of data and display is suggested to be synchronized with a deviation of less than 1 second or an acceptable tolerance according to the local operational needs.

The deviation is suggested to be as minimal as possible to allow the best reconstruction of the recorded scenario during playback.

The Recording Function should ensure no loss of data at all time during the operation of ATMAS and the recording process should not render any degradation to the performance of other functions of ATMAS. Recorded data should be retained for at least 31 days or a duration which satisfies local regulatory requirements. Appropriate warnings are needed for notifying maintenance personnel when storage capacity drops below certain threshold so that appropriate action could be taken to resolve the situation.

### **3.1.11.2 Playback Function**

The ATMAS should allow the replay of recorded and archived data onto designated or idle controller working positions. In general, a playback session should be able to start up within a short period of time and allow continuous replay of recorded data for considerable duration according to operational needs. The system shall support synchronized playback of voice data.

The following two modes of playback is suggested to implement in ATMAS to cater for different investigation scenarios:

a. Passive Playback

The system replays what was on the screen of controller position with recorded and archived data at the period of recording without interaction

b. Interactive Playback

The system replays the air situation display of the controller working position at the period of recording. Controller tools, such as change of display range, range and bearing line, separation probe, quick look, altitude filtering, map selection, etc., are allowed to be used interactively during playback.

For both of the above playback modes, the system should allow synchronized playback of voice data in order to provide a complete picture of events for investigation purpose. To facilitate the playback, the following controls are recommended to be included in the playback function of ATMAS:

- a. Start / Pause (Resume) / Stop of a playback session.
- b. Selection of different playback speeds at least real time speed and a range of playback speeds faster than normal recording speed.
- c. Allow to select a start time for playback in terms of minute.
- d. Selection of playback mode.

The system is suggested to be capable of performing multiple playback sessions simultaneously to allow the playback of the same or different scenario using different controller working positions. For the same playback session, synchronized replay of recording of multiple controller working positions could be considered as part of the

playback function to facilitate investigation of events involving multiple control sectors.

Screen dump function is recommended for capturing the screens during playback and storing them as files for subsequent printing and exporting. Facility should be provided for exporting the screen dump file to external media using common image format which could be viewed in computers using non-proprietary software readily available in the market.

### **3.1.11.3 Data Archiving**

Data Archiving function is recommended to be included in ATMAS for transferring recording data onto removable media for backup or impounding purpose. The archiving process could be initiated in the system via manual action or configured automatic process based on criteria, e.g. periodic archiving process at defined time interval or when remaining storage dropped below certain threshold.

In general, the archiving process should not interfere with normal recording and playback processes in the system as well as other system functions. Appropriate warnings should be given whenever there is an error or the archiving media is full during the archiving process.

### **3.1.12 System Monitoring and Control Function**

The system is recommended to provide monitoring and controlling function, and the failure of the monitoring and controlling function should not affect the operation of other modules.

#### **3.1.12.1 Monitoring Function**

The system is suggested to monitor in real time the operational status of each module and display the major events. Alerts could be raised in levels according to severity, and log files are generated accordingly. The system should be able to search, print and export logs by time. Normally, the system monitoring function mainly includes:

- a. Interface status monitoring.
- b. Hardware operation status monitoring.
- c. Software operation status monitoring.
- d. Network equipment operation status monitoring.
- e. Database operation status monitoring.
- f. System capacity and resource usage monitoring.
- g. Important system events monitoring.

### **3.1.12.2 Control Function**

In general, the system controlling function mainly includes the operations of start, stop, restart, and switch as follow:

- a. Start and stop the entire system.
- b. Start and stop single surveillance source.
- c. Start and stop a single server.
- d. Start and stop network.
- e. Switch between redundant equipment and networks.
- f. Start and stop software modules.

### **3.1.13 Software Management Function**

Thinking about friendly to system maintenance, the system is recommended to provide software management tool, for installation, roll back and backup operation to the software patch and version.

### **3.1.14 GNSS Time Synchronization**

The system is suggested to be able to access to an accurate time source, synchronize external GNSS signals, and calibrate internal system time based on the NTP (Network Time Protocol), so that the system time is consistent with the UTC.

The system is capable of receiving multiple external clock sources and switching among them automatically or manually.

On the condition of all the external clock signals interrupted or lost, the system is proposed to correspondingly synchronize with internal time.

Unified time within the system is recommended to be shown on the HMI and provided for surveillance data processing, flight data processing, monitoring and controlling, recording and playback, etc.

## **3.2 System Optional Functions**

### **3.2.1 Extended Surveillance Data Processing**

Except from PSR and mode A/C radar data, the extended surveillance data include Mode S radar data, ADS-B data, WAM and other surveillance data, containing more target information, for instance DAP parameters and accuracy etc.

The system is encouraged to be able to process the extended surveillance data to provide higher quality tracks and supplementary data.

### **3.2.1.1 Extended Surveillance Data Interface**

The system could extend the capability to receive and process following extended surveillance data:

- a. Mode S radar data: Data from a single Mode S radar, in ASTERIX CAT 034/048 or other standard formats.
- b. ADS-B data: Data from ADS-B ground station or ADS-B data center, in ASTERIX CAT 021 format.
- c. WAM data: Data from WAM system, in ASTERIX CAT 020 format.
- d. Other ATMAS track data: Surveillance track data from other ATMAS, in ASTERIX CAT 062/065 or other standard format.

### **3.2.1.2 Extended Surveillance Data Processing**

The system could extend the capability to receive and process multi-sensor extended surveillance data to generate a unique system track. The quality of multi-sensor tracks should not be lower than mono-sensor tracks.

Online selection of mono-sensor (multi radar tracks, multi ADS-B tracks or multi WAM tracks) or multi-sensor tracks is recommended.

### **3.2.1.3 Extended Surveillance Data Display**

The system is suggested to have the capability to display:

- a. Single sensor track: generated by a single source data, for instance a single radar.
- b. Mono-sensor track: generated by one sensor type data.
- c. Multi-sensor track: track fused by data from several types of surveillance input specified.

The system could determine the type of a surveillance track and display with a specified track symbol according to the different sensor type components (radar, WAM, ADS-B) identified for the generation of this surveillance track.

ADS-B tracks are recommended to displayed with high-quality and low-quality track symbols.

The system is proposed to display extended surveillance data on the track labels, for instance target aircraft identification, target aircraft address and selected altitude etc.

Normally, the system should be able to define target aircraft address filter to suppress the display of all surveillance tracks whose target aircraft address corresponds to one target aircraft address in the filter.

The system will inhibit track display if ground bit is set in the position reports.

The system is suggested to generate emergency alarm if a report is received with emergency identification.

#### **3.2.1.4 Extended Surveillance Data Output**

The system could extend the capability to output system track data in a specified format, such as ASTERIX CAT062. Extended surveillance data will be present in the output data when available.

#### **3.2.1.5 Quality Monitoring For Surveillance Data**

The system is recommended to enable monitor the quality of extended surveillance data, for example:

- a. Via ASTERIX CAT034 messages for Mode S radar data.
- b. Via Automatic Test Target Monitoring with the fixed SSR Test Transponders of ADS-B and WAM data, in detail to check the link status.
- c. Via corresponding quality indicators according to ADS-B MOPS versions and ASTERIX CAT021 editions for ADS-B data.

### **3.2.2 Extended Coupling**

On the basis of the original automatic coupling conditions, the system could further perform coupling for a surveillance track and a flight plan based on the aircraft 24-bit address or Aircraft Identification (ACID) provided by the aircraft downlink parameters.

The system is recommended to give prompts on the coupled track label when SSR codes, aircraft 24-bit address or ACID of the flight plan mismatch the ones of the surveillance track.

### **3.2.3 Extended Alert, Warning and Advisory Function**

In addition to the Safety Net Functions stated in paragraph 3.1.5, States/Administrations could consider implementing the following extended set of alert, warning and advisory functions in ATMAS according to local environment and operational needs. These optional functions aim at enhancing the operational efficiency and possibly reduce controller workload.

#### **3.2.3.1 Departure Path Monitoring**

Departure Path Monitoring (DPM) is used for alerting controllers of predicted or actual deviation from planned departure path (e.g. flying too close terrains and obstacles) of an aircraft to avoid accidents during initial departure phase of the flight.

The DPM function monitors the departure flight's trajectory for any vertical and lateral deviation from the planned path. Visual and/or aural alerts would be generated

when the flight exceeds, or is predicted to exceed the defined tolerance of deviation. Then controllers would need respond to the situation and resolve the case.

Departure path for monitoring would be defined in ATMAS for performing DPM processing on flights. Examples of parameters on the definition of departure path are:

- a. Runway name and direction.
- b. Take-off point on the runway.
- c. SID definition.
- d. Climb gradient.
- e. End detection point.
- f. DPM inhibition zone.

Surveillance, flight plan and environmental data are required for generating DPM warning. The following list of information could be considered for inclusion into the DPM processing:

- a. Aircraft position.
- b. Pressure altitude.
- c. SID.
- d. Flight rule.
- e. Concerned controller jurisdiction.
- f. Departure path definition.
- g. Look-ahead time.

To minimize nuisance alerts in DPM, the checking of flight rule (e.g. to exclude VFR flight from DPM) could help improve the relevancy of alert generation. In addition, aircraft could be close to terrains/obstacles during initial climbing after takeoff. This could lead to inappropriate MSAW alert triggered and cause nuisance to controllers. States/Administrations could consider to suppress MSAW alert generation along the defined departure path for DPM or via the definition of inhibition zones.

Similar to other safety net function, a successful DPM implementation would require careful tuning of the parameters according to the local environment. Adequate warning time is important to allow enough time for controllers to respond and resolve the alert. Regular review of the DPM performance with controllers is encouraged to assist the tuning of DPM to increase its effectiveness.

### **3.2.3.2 No Transgression Zone Alert**

In the context of parallel approaches, No Transgression Zone (NTZ) is normally defined as the corridor of airspace between two extended runway center lines which aircraft is not allowed to penetrate. The purpose of NTZ alert is to warn controllers of

a predicted or actual unauthorized penetration of NTZ by aircraft during final approach. An appropriate look-ahead of predicted NTZ alert is important to allow enough time for controllers to respond to the situation.

When a track is predicted to infringe an NTZ area within a predefined time interval, or has already infringed an NTZ area, the system shall provide NTZ warning.

- a. The NTZ warning function includes two parts: NTZ pre-warning and NTZ warning.
- b. The system shall generate pre-NTZ warning for a track predicted to infringe an active NTZ area within a predefined time interval.
- c. The system shall generate NTZ warning for a track having infringed an active NTZ area.
- d. Visual and aural signals shall be provided on concerned controller positions on which pre-NTZ or NTZ warning is raised. The system shall enable operators to acknowledge the raised warning to cancel the aural alarm.
- e. The system shall be allowed to define multiple NTZ areas and activate or deactivate online.

### **3.2.3.3 Medium Term Conflict Detection Warning**

Medium Term Conflict Detection (MTCD) is designed as an extension of STCA concept which provide warnings to controllers for potential conflict for "aircraft-to-aircraft" or "aircraft-to-airspace" encounters up to 20 minutes ahead. The aim of MTCD is to proactively resolve possible conflict in advance during sector planning so as to reduce tactical workload.

States/Administration should consider the following factors to determine the applicability of MTCD to their local environment:

- a. Suitability of local airspace structure to cater for long look-ahead time.
- b. Local air traffic control procedures.
- c. Whether an airspace is under Free Route Operation.

MTCD advisory could be considered to implement in the following situations:

- a. Potential Conflict: Conflict detected based on current track trajectory and clearance.
- b. Risk of Conflict: Conflict detected based on current track trajectory and trial clearance/probe. When a controller inputs a clearance, the MTCD will be calculated and conflict information, if any, will be provided to the controller and prompt for a confirmation to proceed or abort. If a confirmation to proceed is received, an MTCD warning would be generated to concerned

controllers with the jurisdiction where conflict may occur.

If more than one type of conflict is implemented, different visual presentations is recommended for each type of conflict to avoid confusion of alerts. In addition, MTCO inhibition could also be implemented based on airspace, flight rule, SSR code groups, ACID or other conditions applicable to the local environment and operational needs.

#### **3.2.3.4 Route Adherence Monitoring**

Route Adherence Monitoring (RAM) monitors the conformance of an aircraft to its flight route in the flight plan. When an aircraft is detected to have deviated from the cleared route by more than a defined tolerance, a visual/or aural warning is suggested to generate to alert controllers to take actions on the situation. The RAM warning could be acknowledged manually.

The RAM route model could be defined by the width of the corridor, and the radius of the waypoint. It is recommended that the system is designed to allow the definition of different route model parameters for specific route segments.

#### **3.2.3.5 Cleared Level Adherence Monitoring**

Cleared Level Adherence Monitoring (CLAM) monitors the conformance of the Actual Flight Level (AFL) of an aircraft to the Cleared Flight Level (CFL) issued by air traffic controller and provides warnings if deviation between the two levels (i.e. Level Bust) was found after the aircraft has been level-off. To reduce nuisance alerts, the system could allow an adaptable tolerance on the deviation of AFL from CFL.

States/Administrations is recommended to consider including the use of Mode S DAPs, Selected Altitude, in the CLAM detection logic. Selected Altitude is the altitude inputted by pilot at the aircraft cockpit based on the clearance from controllers. The checking of Selected Altitude with CFL in the CLAM logic could allow early detection of potential Level Bust and alert controller in advance.

#### **3.2.3.6 Similar Callsign Advisory**

Similar Callsign Advisory (SCA) provides advisory to alert controllers when an aircraft carries a similar callsign with another one in the same jurisdiction controlled by a controller. SCA checking rules could be pre-defined or pre-programmed at the design stage of ATMAS implementation according to the operational environment and local needs. Adaptable SCA checking rules or look-up tables are preferred to allow modification of similar callsign checking process based on the latest requirement and feedback from controllers.

#### **3.2.3.7 Reduce Vertical Separation Minimum Warning**

Reduce Vertical Separation Minimum (RVSM) Warning provides alerts to controllers when a non-RVSM approved/compliant aircraft is within, or is predicted to enter RVSM airspace.

To provide the warning to controllers, the volume of RVSM airspace would need to be defined in the ATMAS and the Field 10 of ICAO flight plan would be checked to see if the aircraft is RVSM-approved. Visual indication would be generated if the aircraft did not match with the airspace requirement on RVSM.

### **3.2.3.8 Position Report Monitoring**

Position Report Monitoring (PMON) monitors ATO/ETO inconsistency in position report and provides warnings to controllers when:

- a. Actual Time Over (ATO) and/or Estimated Time Over (ETO) of next report point differ from that calculated by the flight trajectory by more than a defined time interval
- b. The ETO of the respective waypoint differs by more than a defined time interval
- c. No position report is received for a defined time interval after the ETO missed position report

### **3.2.3.9 Last Known Position Display**

Last Known Position Display occurs when coupled tracks, uncoupled or ADS-C tracks with critical alerts are lost.

The last known position of the track is suggested to display with a special track symbol to the dedicated position.

### **3.2.3.10 SSR Inconsistency Warning**

For coupled flight plan tracks, when the Mode 3/A code in the surveillance data is inconsistent with the SSR code in the flight plan, the system is suggested to raise ASSR Inconsistency Warning.

### **3.2.3.11 Corrected Level Information Display prompt**

The system is recommended to be capable to display the Mode C level or QNH corrected barometric altitude on track labels with distinction.

When an aircraft is within a designated QNH area, in order to ensure safe operation, the system could perform altitude correction based on the QNH value.

### **3.2.3.12 PBN Capability Indication**

When the PBN indicator is presented in the flight plan message, the system is suggested to determine the PBN capability of the aircraft and inform controllers of the PBN capability.

It is proposed that the system could define different priorities of PBN capability display for each logical position.

### **3.2.3.13 Downlink Aircraft Parameters Related Warnings**

Please refer to section 3.2.4.2 for Downlink Aircraft Parameters related warnings.

### **3.2.4 Downlink Aircraft Parameter Processing and Display**

It is recommended that the system have the capability to process and display aircraft downlink aircraft parameters (DAPs) from Mode S radars and/or ADS-B to help controllers have a more integrated view of the aircraft's flight status in the air.

The system is recommended to be able to use the processed DAPs in the computation of safety nets like STCA and MTCDD etc.

#### **3.2.4.1 DAPs in Track Fusion**

The system is recommended to be capable of making use of DAPs for report consistency check, altitude and position tracking. DAPs used in track fusion include magnetic heading, true airspeed, selected altitude, barometric vertical rate, geometric vertical rate, roll angle, track angle rate, track angle and ground speed, etc.

#### **3.2.4.2 DAPs Related Warnings**

DAPs Related Warnings generally include:

a. 24-Bit Code Mismatch Warning

The system is recommended to create an ICAO 24-bit code mismatch warning and present to the responsible controller when the downlink 24-bit code of the coupled track does not match the CODE in field 18 of the FPL message.

b. Callsign Mismatch Warning

The system is suggested to create a callsign mismatch warning and present to the responsible controller when the downlink callsign of the coupled track does not match the callsign in field 7a of the FPL message.

c. Predicted Level Mismatch Warning

It is recommended that the system is able to continuously monitor the consistency of Selected Altitude from the airborne equipment and the Cleared Flight Level from controller, and create a predicted level mismatch warning and present to the responsible controller if the difference is greater than the pre-defined threshold. This warning could be displayed to controllers immediately in the event of a change in Selected Altitude without any change in Cleared Flight Level by the controller.

d. Resolution Advisory (RA) alert indication

The system is proposed to process and create a RA alert indication and present on the track label of the responsible controller when a RA report is

received via DAPs. The system is suggested to make available the detail of the resolution advisory.

### **3.2.4.3 DAPs Display**

The system is encouraged to be able to provide a downlink data window, which is used to display the downlink aircraft information. The information to be included (if applicable): SSR code, Target aircraft address, Target aircraft identification, Magnetic heading, True airspeed, Selected altitude, Final state selected altitude, Barometric vertical rate, Geometric vertical rate, Roll angle, Geometric vertical rate, Track angle rate, Track angle, Ground speed, Velocity uncertainty, Position uncertainty, Indicated airspeed, Mach number, Barometric pressure setting, etc. The information should be presented in a Downlink Data Window and/or accessed through the onscreen aircraft track label.

The information in the Downlink Data Window/track label is suggested to be configured through online and/or offline selection. The DAPs configuration could be offline assignable by logical positions and logical systems.

The system is recommended to define the units in which DAPs data are displayed in the downlink data window.

### **3.2.5 Arrival Manager Function**

The purpose of Arrival Manager (AMAN) is to optimize the flight landing sequence by providing validated and conflict free sequence, reduce flight holding time in the air, thus minimizing delay and providing control actions and advisories. These are achieved by considering factors such as airport runway configuration, runway rate, weather conditions, and stand arrangements, etc.

It is normal that the basic functions of AMAN include four-dimensional trajectory prediction, flight sequencing, arrival route allocation, runway allocation, and delay advice etc.

a. Four-dimensional trajectory prediction function

AMAN system takes in calculates the Estimated Time Over (ETO) at various points, such as handover points, merge points, etc. and the estimated landing time at the runway threshold (ELDT) based on flight plan data, surveillance data, aircraft performance models, meteorological data, and calculated path data.

b. Flight sequencing function

According to the calculated four-dimensional trajectory, AMAN calculates takes into account the relevant constraints and performs a sorting calculation to obtain the target landing time (TLDT) and the arrival sequence.

c. Arrival route allocation function

According to the set restrictions, AMAN assigns a specific approach to the aircraft. The factors considered include runway aircraft constraints, airline

stopping rules, parking spaces, runway load balancing, traffic distribution in different approach direction, etc.

d. Runway allocation function

In multi-runway airports, AMAN allocates runways for arrival flights based on actual conditions such as the local operating environment and runway configuration. The factors to be considered may include runway-aircraft type restrictions, airline parking rules, aircraft stand, runway load balance, and flow distribution in different directions of arrival.

e. Delay advice function

The delay advices generated by AMAN include re-route, holding pattern, point merge system (PMS), and delay time indication. The system gives different delay advices according to the time of the delay.

### **3.2.6 System Log Management**

For the convenience of anomalies investigation, the system is recommended to be able to collect and manage operational logs and error messages. The operational logs include personnel commands, hardware logs, software logs and external interface logs, etc. The error messages consist of software and hardware error messages, etc.

The system is suggested to be capable to:

- a. Record operational logs and error messages.
- b. Display necessary logs on the dedicated positions.
- c. Store logs on the disk and classify by dependency. The user is allowed to sort logs by given conditions.
- d. Backup logs automatically or manually, and the backup logs are readable.
- e. Store logs on the disk for at least 31 days.

### **3.2.7 Enhancement Recording and Playback Function**

Considering about the convenience to user, the system is recommended to extend the capability to integrally record the screenage of the HMI by the way of frames and replay the recording onto designated position and mobile devices in the form of video as well.

#### **3.2.7.1 Video Recording Function**

The video record refers to the continuous footage derived from controllers screen as exactly same as shown. The video recording data is recommended to output as common video formats as well.

The system is suggested to support the storage of video recording data as a period of time, such as 31 days. By reducing disk occupancy and transferring the data for method, the system should not be impacted by storage overload.

### **3.2.7.2 Video Playback Function**

It is recommended that the replay of the video record data could be performed on any designated controller position, and the video replay should be synchronized with the Audio.

The system is expected to be able to control the replay, including selection of replay mode, retrieval replay, change replay speed, start, pause, forward, stop, etc.

### **3.2.8 Enhanced Wake Turbulence Separation and Approach Spacing Tool**

The Amendment 9 of the PANS-ATM (Doc 4444) introduces a new “enhanced Wake Turbulence Separation” (eWTS) scheme with an alternative set of wake turbulence groups and associated wake turbulence separation minima for approach and departure phases of flights. The new eWTS scheme is based on the studies performed by Federal Aviation Administration (FAA) and European Organization for the Safety of Air Navigation (EUROCONTROL) on the wake generation and wake resistance characteristics of different aircraft types, which allows a reduction in wake turbulence separation between some aircraft pairs depending on the leading and the following aircraft type, as well as increases in wake turbulence separation for the smaller and more vulnerable aircraft type.

The ICAO Flight Plan is not required to be updated with the new wake turbulence groups while air traffic controllers will have to consider seven wake turbulence groups instead of four categories when applying the new wake turbulence separation minima. States/Administrations are recommended to implement Approach Spacing Tool (AST) function in ATMAS to assist air traffic controllers in the delivery of intended aircraft separation under the new eWTS scheme without memorizing all the separation pairs.

#### **3.2.8.1 eWTS Scheme and Airspace**

The harmonized ICAO eWTS scheme categorizes aircraft into the 7 wake turbulence groups based on maximum certified take-off mass and wing span:

- GROUP A - aircraft types of 136 000 kg or more, and a wing span less than or equal to 80 m but greater than 74.68 m;
- GROUP B - aircraft types of 136 000 kg or more, and a wing span less than or equal to 74.68 m but greater than 53.34 m;
- GROUP C - aircraft types of 136 000 kg or more, and a wing span less than or equal to 53.34 m but greater than 38.1 m;
- GROUP D - aircraft types less than 136 000 kg but more than 18 600 kg, and a wing span greater than 32 m;
- GROUP E - aircraft types less than 136 000 kg but more than 18 600 kg, and a wing span less than or equal to 32 m but greater than 27.43 m;

- GROUP F - aircraft types less than 136 000 kg but more than 18 600 kg, and a wing span less than or equal to 27.43 m;
- GROUP G - aircraft types of 18 600 kg or less (without wing span criterion).

For the implementation of eWTS scheme, States/Administrations have the flexibility to determine the scope of applicability of the new eWTS minima. Also, States/Administrations can consider introducing the reduced minima in total, or in part as the first step, or a combination of these with fewer groups, or updating the local minima based on a partial set of eWTS minima, whichever will provide the most benefit given the local traffic mixture.

To facilitate the transition from legacy to eWTS scheme by air traffic controllers, the design of ATMAS should allow the flexibility to adapt the mapping of eWTS wake turbulence group (A-G) to a custom set of abbreviations according to the local operational environment to minimize the impact to air traffic controllers in handling extra wake turbulence groups under the new scheme.

States/Administrations would need to define the specific volume of airspace that operates using eWTS scheme, whilst other airspaces should continue to operate using legacy ICAO wake turbulence categories. For the implementation of eWTS, the design of ATMAS should allow the use of both wake turbulence schemes in the system so that the appropriate wake turbulence categories/groups could be applied based on airspaces, controlling sectors or controller's roles in accordance to operational needs.

### **3.2.8.2 Human Machine Interface of Wake Turbulence Groups**

The abbreviation of wake turbulence categories/groups are normally displayed in the track labels of an aircraft in the HMI of ATMAS. Since eWTS would only be implemented in designated volume of airspace, the ATMAS should be configurable to display the appropriate wake turbulence categories/groups to air traffic controllers in accordance with applied wake turbulence scheme of that airspace. The ATMAS could determine the appropriate scheme by referring to the location of aircraft and/or roles of the controllers.

In addition, States/Administrations can consider to implement electronic cue cards on the pair-wise aircraft separation under eWTS scheme in ATMAS to assist controllers identifying the required separation for aircraft pairs during operation.

### **3.2.8.3 AMAN Optimization**

With implementation of eWTS scheme, runway capacity is expected to increase in most cases due to a general reduction of wake turbulence separation in popular aircraft pairs of traffic mix. To benefit from the increase in runway capacity due to eWTS scheme, the AMAN would need to be optimized to provide plans with arrival rate matching with the runway capacity. The optimization could involve a change in the AMAN logic on handling extra wake turbulence groups or fine-tuning of system parameters to increase the arrival rate of landing sequence generated by AMAN in order to match with the theoretical runway capacity as far as possible.

### **3.2.8.4 Approach Spacing Tool**

To assist air traffic controllers in handling air traffic under enhanced wake turbulence separation and improve air traffic controllers' consistency in delivering the traffic according to the intended runway capacity, Approach Spacing Tool (AST) is recommended to be implemented. The AST could project and present graphically the required spacing between aircraft pairs along the approach sequence and provide advisories, in the form of graphical indicators on the Air Situation Display, to indicate the optimal positions of aircraft along the final approach path.

The AST could be operated in either Distance-based Separation (DBS) or Time-based Separation (TBS). Time-based Spacing could be helpful in safely managing the traffic without reduction in capacity when aircraft ground speed is generally reduced on final approach due to strong and consistent headwinds. States/Administrations should assess separation standards by considering performance/accuracy/reliability of local wind prediction, time-to-fly forecast and other relevant ATC support tools.

#### Projection of Spacing

During the computation of spacing guidance, the AST should consider all the required separation criteria for a given aircraft pair, including wake turbulence separation minima, minimum radar separation and dependent parallel approach separation. Then the tool would apply the most stringent criteria to ensure that none of the required separation is infringed.

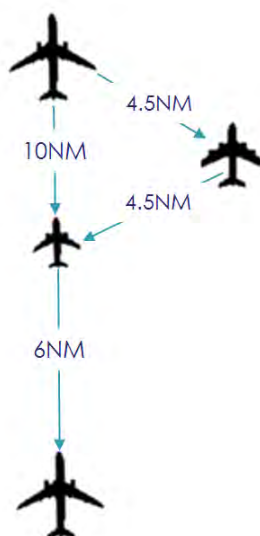


Figure 3.2.8-1 Minimum Separation

Apart from the required minimum separation, the AST would also consider other operational situations or parameters which could affect the optimal spacings between aircraft such as runway occupancy times, specific minimum separation defined for a runway, extra gap required between specific landing aircraft, etc. Together with the operational mode on the aircraft spacing and runway mode, the

AST would consider all the above factors and provide spacing guidance in form of graphical cues illustrated in the subsequent paragraphs.

### AST Guidance Cues

Provision of visual guidance on the computed spacing, in the form of graphical indicators on the Air Situation Display, is recommended as part of the AST function. The purpose of visual guidance is to support air traffic controllers in delivering the traffic according to intended capacity as far as practicable. Two guidance cues are recommended to be implemented by the AST:

- a. Final Target Distance (FTD).
- b. Initial/Intermediate Target Distance (ITD).

Final Target Distance (FTD) is the appropriate position for the following aircraft behind a leading aircraft at the required minimum spacing applied at the runway threshold. The follower shall always be behind its respective FTD indicator along the final approach path.

Initial Target Distance (ITD) is the optimal distance for the following aircraft to be positioned behind a leading aircraft with the consideration of the required minimum spacing and the deceleration compression buffer. The ITD should be calculated based on the estimated 3D trajectory, the estimated speed profile, environment data (including wind, temperature, etc.) and the target FTD.

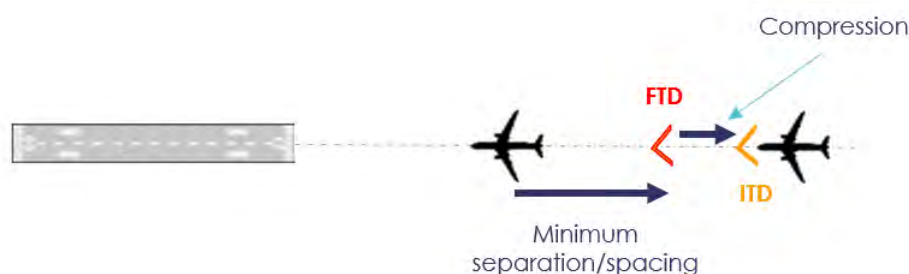


Figure 3.2.8-2 FTD and ITD Guidance

FTD and ITD guidance should be updated at every track updates of ATMAS. Depending on actual operational environment, the position of the FTD and ITD guidance cues could be chosen to implement in AST along:

- a. Planned trajectory of the flight.
- b. Predefined common path.

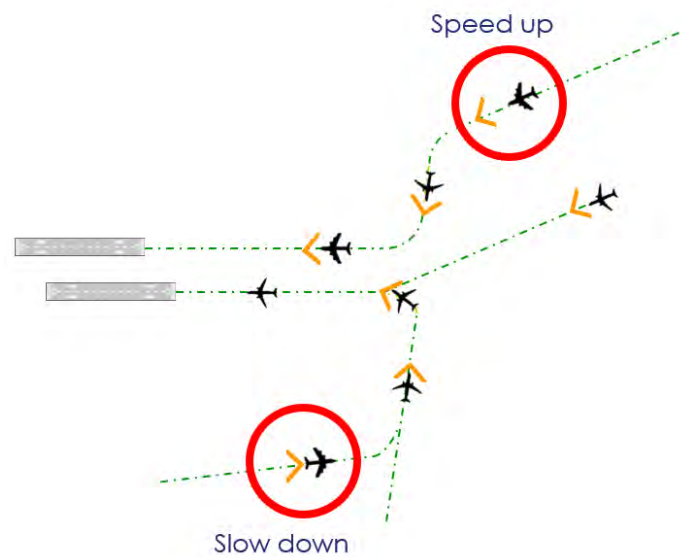


Figure 3.2.8-3: Guidance on the planned trajectory

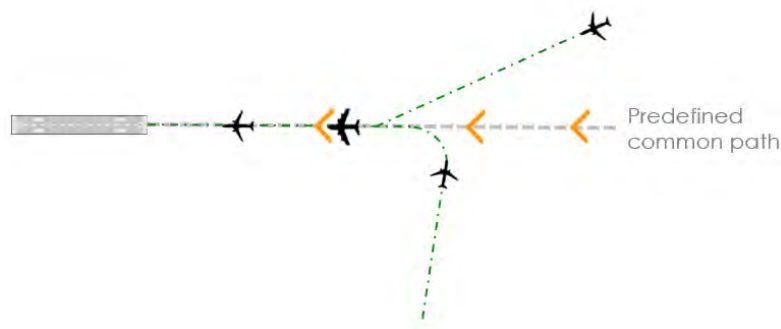


Figure 3.8.2-4: Guidance Cues on a predefined common path

Flexibility is recommended to allow each user to toggle online the on/off of FTD or ITD guidance according to the operational needs.

### Final Approach Sequence Management

The planned Final Approach sequence is crucial in the generation of AST Guidance Cues by providing necessary information to the AST in determining the required wake turbulence separation between aircraft. Therefore, an accurate planned sequence is important for smooth AST operation. If State/Administration has implemented Arrival Manager (AMAN) in its operation, its arrival sequence data would be the best candidate for processing by the AST. If AMAN is not available, an arrival sequence based on the flight trajectories from ATMAS would be an alternate option for AST processing.

To present controllers with the sequence of arrival flights, the AST should provide a sequence management list with flights listed in sequential order of arrivals for management by controllers. Depending on the runway modes (i.e. independent or dependent runway mode), controllers should be allowed to choose

one or multiple sequence management lists to be displayed on the air situation display of AST.

Arrival flights in the sequence management list should be automatically sorted according to the Scheduled Time of Arrival (STA) from AMAN or the Estimated Time of Arrival (ETA) if AMAN data is not available. In case of sequence mismatch between the planned sequence and actual traffic pattern, the AST should allow controllers to alter the sequence by dragging the flights via the Human Machine Interface for sequence management. In addition, to prevent the manual actions by controllers from being overwritten by AMAN updates, AST should prevent changes to a flight's sequence when the STA/ETA falls within the frozen window based on current time.

VHHH: 25R/25L ARRIVAL					
ACID	TYPE	W	RWY	STA	ΔITD
CPA551	B744	B	25R	01:35	
CPA998	B788	B	25R	01:32	
MCU323	B773	B	25R	01:29	5.5
CAL923	A333	B	25R	01:27	4.0
SIA111	A320	D	25L	01:24	4.3
ETH3618	A359	B	25R	01:20	3.8
QFA068	A388	A	25R	01:17	3.0

} Flights within  
STA frozen

Figure 3.8.2-.5: Sequence Management List

### Monitoring Aids in Approach Spacing Tool

To ensure the appropriate spacing between arriving aircraft can be delivered, the following monitoring aids could be implemented for aircraft under management by AST:

- a. FTD Catch-up Alert: when predicted trajectory of an aircraft infringe the FTD.
- b. FTD Catch-up Alert: when predicted trajectory of an aircraft infringe the FTD.
- c. FTD Infringement Alert (FTDA): when the FTD is infringed.
- d. ITD Infringement Alert (ITDA): when the ITD is infringed.
- e. Arrival Sequence Discrepancy Alert (ASDA): when the actual aircraft sequence differs from the planned arrival sequence, as computed by the Arrival Manager, or as manually sequenced by controllers.

- f. Arrival Speed Conformance Alert (ASCA): when the aircraft speed differs by an adapted tolerance from the speed requirement in the STAR and approach procedure assigned to the aircraft within a defined distance from the runway threshold.

The alerts of monitoring aids should be displayed to air traffic controllers based on the jurisdiction and roles/positions with the flexibility of selecting visual and/or aural alerts by controllers.

### **3.2.9 Operational Data Synchronization**

In order to provide continuous ATM service in case of the ATMAS in operational use suffering with technical problems, system failures or other critical anomalies, some ATM centers are configured with two types ATM automation systems, which works in main and backup mode.

The Operational Data Synchronization Function serves for both master and backup ATM automation systems deployed in the same ATM center. This function enables the system to synchronize operational data to backup system when in master mode. This function also synchronizes the system when in backup mode with operational data from other master system.

#### **3.2.9.1 System Main/Fallback Mode**

The system provided with operation data synchronization function is suggested to have two working modes at least: main and fallback mode. These two working modes could be switched manually.

In the main mode, all of functions of the system are operating normally, and output initiatively synchronous data in real time.

In the fallback mode, the system receives and processes the synchronous data in real time, and all functions of the system are running as usual and stops automatically transmitting messages to external system.

#### **3.2.9.2 Synchronous Data**

Synchronous data between the main and fallback systems is recommended to include basic flight data and operational setting data as follows, States/Administrations can adjust the data to be synchronized based on the operation needs:

- a. Basic flight data comprises flight plan information, allocated runway, SID/STAR etc.
- b. Operational setting data includes sector allocation, airport runway status, position settings, online area creation or modification, etc.

### **3.2.9.3 Synchronization Trigger**

Data synchronization is recommended to carry out periodically at a pre-defined time interval. In addition to the periodic data synchronization, the synchronization could be triggered by pre-defined events, for examples:

- a. Each item in the flight plan information changed.
- b. Each flight plan state changed
- c. Each operational setting changed.

### **3.2.10 Statistics and Analysis Function**

Statistics and analysis function could be implemented for generating reports on the surveillance data, flight plan, alarm information and traffic flow data.

Flight data that can be extracted from the ATMAS database at a minimum would have the following correlated data fields: aircraft ID<sup>1</sup>, number of aircraft movements in the airspace sector and controlled airspace<sup>2</sup>, flight rule<sup>3</sup>, flight type<sup>4</sup>, number of danger area infringements, number of rejected & accepted uplink messages, number of rejected & accepted downlink messages, number of uplink & downlink delivery timeouts, number of received and transmitted messages, number of AIDC messages<sup>5</sup> (transmitted, received, rejected, and accepted) and total number of flights.

Presentation of correlated data fields would be in the form as shown in Appendix B: **Table 3.2.10-1A for Flight Specific Flight Data and Table 3.2.10-1B for Collective Flight Data**, where these are organized according to the date and/or time (in hour resolution<sup>6</sup>) of interest. The date and/or time window selection will allow flexibility in the period of data of interest. Hence, the correlated data will not be limited on fixed time periods, e.g., daily, weekly, or monthly. Nonetheless, fixed time period can be the default setting and, in any case, the selected time period that defines the scope/coverage of the data that are being presented in the interface will always be visible to the user.

The data fields for **Collective Flight Data** will refer to the specified time periods. For example, data for the Total No. of Flights will be presented for the Day if the selected Time Period is set to Day; the Total No. of Flights will be shown in each sector for the Airspace Sector; and so on. Furthermore, the Total No. of Flights data need not to be equal to the Total No. of Flights in the Airspace Sector when the Total No. of Flights

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<sup>1</sup>ICAO 2012 strictly enforces that this figure should be letters and numbers only, devoid of dashes, spaces, or other punctuation.

<sup>2</sup>sorted into ARR, DEP, Overflight, and Domestic Flights

<sup>3</sup>“I” for IFR, “V” for VFR, “Y” for when the flight will be initially IFR followed by one or more subsequent flight rules changes, and “Z” for VFR first with any number of subsequent changes.

<sup>4</sup>“S” for Scheduled Air Service, “N” for Non-scheduled Air Transport Operation, “G” for General Aviation, “M” for Military, and “X” for everything else

<sup>5</sup> applicable to flights involving the exchange of AIDC messages with adjacent FIR/ATS Unit

<sup>6</sup> the selection of time period will allow up to values in hour, e.g., 19 March 2021 0900-1000 UTC

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in each Airspace Sector is summed together for the reason that the flight may have traverse more than one Airspace Sector. The same principle is applied in the presentation of other correlated data field.

Correctness and accuracy of information in the presented data should be verified prior to deployment of the ATMAS into live operation. This can be arranged as one of the test cases for each data field that the vendor must be able to comply to verify its performance.

Similarly, surveillance data coupled to flight data records can be retrieved from the ATMAS. These data are grouped into Flight Specific Surveillance Data.

Flight Specific Surveillance Data should be able to provide information on the type of surveillance track that is/are coupled to the flight. For instance, in a single flight data record, there is information if Secondary, Mode S, Multilateration and ADS-B tracks are coupled to the flight. This applies for an ATMAS interfaced to multiple surveillance technologies. For more than one source of the same type surveillance technology, information about the source of that coupled track data should be provided e.g., ADS-B Source: 2 (ADS-B track data taken from the second ADS-B sensor defined in the system). Furthermore, information about the surveillance track quality should also be provided if coasting, normal, low or high. This track information shall be based on the time stamped track at the time of track distribution. The time stamp shall be the reference of the ATMAS for generating the Flight Specific Surveillance Data after selecting the time period of interest. Appendix B **Table 3.2.10-2** illustrates the presentation of **Flight Specific Surveillance Data**.

Considering the number of surveillance tracks generated as system tracks for the ATMAS from a single source alone for one target, it will be quite irrelevant to gather **Collective Surveillance Data**. **Flight Specific Surveillance Data** would be more useful for the analysis of information generated by the ATMAS.

Data records should be retained for at least 30 days to allow for accident/incident investigation processes. These records should be made available on request to the relevant State safety authority. Where data is sought from an adjacent State, the usual State to State channels should be used. These recordings shall be in a form that permits a replay of the situation and identification of the messages that were received by the ATS system<sup>7</sup>.

The data can be used for pre- and post-analysis of Air Traffic Management situation. Peri-analysis process will allow the ATC Supervisor to make the necessary adjustment(s) in the operations while post-analysis can provide guidance in improving the operational processes and activities complementary to the technical aspect of the operations.

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<sup>7</sup> The excerpts from Chapter 7.7.1 of the ADS-B IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT, Edition 8.0 – September 2015 is hereby adopted for all surveillance data sources.

## **4. SYSTEM DESIGN**

### **4.1 System Architecture**

In general, ATMAS should be equipped with adequate redundancy to ensure full availability for all critical, essential and routine operational functions for air traffic control. Its system architecture should allow extra redundancy to be deployed whenever considered necessary. The architecture of ATMAS should follow the design and implementation principles below:

- a. The ATMAS software should adopt modular design and distributed architecture to ensure robustness under adverse operating conditions. For the key function modules, such as FDP and SDP, they should be at least deployed on dual redundant servers in hot standby configuration to ensure a safe and uninterrupted service of ATMAS.
- b. To minimize the number of single point failures due to hardware or software, multiple system redundancy and distributed system architecture are recommended.
- c. System elements running simultaneously on multiple servers/computers should communicate over redundant networks and the failure of any element should not affect the operation of other system elements.
- d. The network of ATMAS should be built on redundant network elements. Each main stream operational data should be transmitted over independent links and networks. Failure of any network element would not affect the delivery of main data stream within ATMAS.
- e. For large-scale ATMAS designed for handling large traffic volume, it is recommended to separate the transmission of different types of system data into dedicated networks. For example,
  - Operational Network: for handling the exchange of operational data, including surveillance data, flight plan, etc., between all controller working positions and operational servers.
  - Maintenance Network: for the transmission control & monitoring data, maintenance-related data, system log, replay data as well as distribution of new software and adaptation updates to system elements.
  - Direct Surveillance Access Network: for direct distribution of surveillance data from surveillance sources to controller working positions as the backup to the system track output of Surveillance Data Processor (SDP) of ATMAS.

- Data Synchronization Network: for synchronizing data between redundant systems of ATMAS.
- f. High reliability through redundancy such that at least two identical system elements of the same function operate concurrently and the failure of either one should not affect the satisfactory operation of its counterpart and the system service.
- g. Fault tolerant such that the system could continue its service, rather than failed completely, when some elements of the system failed.
- h. With fail over capability such that the system operation should switch over to the fallback system elements after failure or abnormal termination of operational system elements.
- i. Apart from having redundant elements within ATMAS, it is encouraged to implement separate set of ATMAS as fallback system to main operational system for maintaining air traffic services in case of catastrophic events happened in the main system.
- j. For ATMAS managing busy airspaces with high traffic volume, the main and fallback systems are recommended to be provided by different manufacturers for avoiding common software faults to both systems.
- k. The main and fallback systems are suggested to be physically located at different sites to prevent any single-site accident affecting the operation of ATMAS.
- l. External interfaces of the system (such as radar, AFTN, etc.) shall be redundantly configured and system support automatic/manual switch to the redundant interface channels in case of partial failure.

## **4.2 Position Roles and Types**

Based on functionalities, positions of ATMAS can be categorized into the different types, e.g.

- a. Controller Working Position.
- b. Flight Data Operator Position.
- c. Flow Management Position.
- d. Technical Maintenance Position.
- e. Data Management Position.
- f. Search and Rescue Position.

States/Administrations are suggested to review their operational needs during the design stage if ATMAS in order to adopt the suitable set of positions for their operational environment.

Working positions can be further categorized based on the user roles. For example, in ATC Center, controller working positions are categorized into roles of Supervisors, Executive Controller, Planning Controller and Assistants under Enroute, Terminal and Approach Control Streams. In ATC Tower, controller working positions are categorized into roles of Supervisor, Air/Ground Controls, Clearance Delivery and Assistants.

Access to different system functions by users would be controlled based on the assigned roles. Controllers would be assigned with controlling roles for flights under their jurisdiction while maintenance engineers would be granted with monitoring and control permission on system components of ATMAS. All the roles and permissions should be off-line adaptable in the system database by authorized personnel. Once a role has been assigned to an individual, that person can access the data and functions based on the assigned permission.

States/Administrations could consider to strategically deploy extra controller working positions as spare in ATC Center and Tower. If a controller working position failed for some reasons, controllers can quickly move to a spare controller working position and continue the ATC operation. The design of ATMAS should allow the restoration of air traffic situation display, flight data, electronic flight strips, display settings and preferences after controllers moved to another position to continue their works.

The type and number of positions shall be deployed on each site according to the operational requirement. For the functions of each position, please refer to section 3.1.10.

### **4.3 Main and Fallback System Configuration**

States/Administrations are encouraged to implement two sets of ATMAS (Main and Fallback) as the baseline in order to be capable of providing uninterrupted ATC service for their airspace. The Fallback system should possess comparable system scale, configuration and software functions with the Main system. In addition, the Main-Fallback data synchronization mechanism should be implemented to ensure the readiness of Fallback system for taking up the role as operational system for air traffic control in case of failures in Main system.

For ATMAS managing busy airspaces with high traffic volume, States/Administrations are encouraged to set up the Main and Fallback ATMAS with same functionalities, capabilities and capacities but in separated systems in order to enhance robustness and continuity in providing safe, efficient and orderly ATC services. In busy airspaces, ATMAS failure could be a catastrophic event and cause disruption to air traffic. The Main and Fallback systems with data synchronization mechanism should allow the switch over between Main and Fallback systems seamlessly when needed. In addition, since the system switch over due to unexpected failure could be a rare event, States/Administrations are suggested to perform the switch over between Main and Fallback systems regularly to get air traffic controllers and engineers familiar with the process.

To further enhance resilience and mitigate risks of complete ATMAS failure, Main and Fallback systems are recommended to be provided by different manufacturers to avoid common software faults encountered in both systems simultaneously. If Main and Fallback systems with same functionalities, capabilities and capacities were supplied by the same manufacturer, a full-fledged Ultimate Fallback system from a different manufacturer would need to be implemented such that the Ultimate Fallback system could take up the operation as last resort in case of common software faults in Main and Fallback systems. The Ultimate Fallback should be designed to have same level of functionalities, capabilities and handling capacity as Main and Fallback systems in order to sustain possible prolonged control of the airspace.

For the case of Main and Fallback systems from the same manufacturer but without the deployment of Ultimate Fallback system, States/Administrations should conduct safety risk assessment on the overall system architecture to ensure that the risks of having common software faults in both Main and Fallback systems simultaneously have been mitigated to an acceptable level.

Real-time data synchronization function shall be implemented between the main and fallback systems, to ensure the data consistency and smooth switch when technical failure. The operational data synchronization function can refer to section 3.2.9.

## **4.4 System Operation Mode**

### **4.4.1 Normal and Degraded Modes**

The ATMAS should be capable of operating in normal and degraded modes. Under normal mode of operation, all the system elements of ATMAS are running normally with full redundancy. Whenever there is any key system function (such as FDP or SDP) failed, the ATMAS should maintain its service and automatically change to a degraded mode of operation. The degraded mode should allow controllers to maintain the provision of air traffic control service using limited system functionalities for a short period of time while the system issues are being fixed by maintenance staff or switching over to Fallback system is still underway.

Under FDP failure, the ATMAS would be unable to process new incoming flight plans and existing flight data records in the system. Silent coordination across controller working positions may be unavailable as well. To mitigate the impact, controller working position should keep a local copy of system flight plan data at individual workstation so that flight plan association to the surveillance tracks could be maintained using local flight plan copy upon FDP failure. In this case, controllers could continue to identify tracks under their jurisdiction in their air situation display and maintain the control of traffic.

For SDP failure, the processed multi-surveillance track data from SDP would be unavailable in ATMAS. The system should maintain the display of air traffic situation to the controllers by automatically switching to direct surveillance access mode which individual sources of surveillance data are directly fed to the controller working positions without the need of a SDP. In this case, controllers can continue the air traffic control operation using directly fed surveillance data while the SDP issue are being investigated and fixed by the maintenance team.

In case of other failures, the system should display impacted functions and operate smoothly in absence of degraded functions. When the failed function recovers, controllers are allowed to manually upgrade to the normal mode on the position.

#### **4.4.2 Main and Fallback Modes**

For the case with Main and Fallback systems in place, the system should be capable of configuring between Main and Fallback modes. In the Main operation mode, the system would be responsible to process AFTN messages, assign SSR codes, respond to controllers' input, communicate with external systems and synchronize data to the Fallback system. In the Fallback operation mode, the system would not process carry out the above processing but receives synchronization data from the Main system and keep the system database up-to-date for operation switchover at any time. Since the Main-Fallback switchover involves the coordination across different controlling streams and technical maintenance team, it is suggested that the Main/Fallback modes should be manually switched by the user at the dedicated position of ATMAS for centralized coordination on the switchover.

Regarding the HMI design, the operational modes should be shown at the controller working positions and technical maintenance positions with prominent indications in case of any degradation of system functionalities. For cases with Main and Fallback systems in operation, the ATMAS should clearly indicate the current mode of operation, Main or Fallback, in its HMI to ensure that controllers are working at the correct system.

### **4.5 Capacity and Performance**

#### **4.5.1 System Capacity**

Normally, system capacity is used to describe the maximum processing capabilities, which is determined by the air traffic flow, operation requirements and system architecture, etc. It is suggested to include the following items at least:

- a. System area.
- b. Maximum number of sectors.
- c. Maximum number of positions.
- d. Maximum number of tracks displayed/coupled/under-controlled.
- e. Maximum number of flight plans existing in the system.
- f. Maximum number of flight plans activated simultaneously.
- g. Maximum number of surveillance sensor inputs.
- h. Maximum number of adjacent centers with AIDC protocol.

#### **4.5.2 Response Time**

Response time is used to measure the speed, stability and resource usage of hardware and software in the system, the following recommended criteria are listed by experience, States/Administrations are encouraged to consider during the system planning stage.

- a. The duration to start up a single node should be not more than 5 minutes.
- b. The duration to cold start up whole system should be not more than 30 minutes.
- c. The duration to start up a set of applications on single node should be not more than 1 minute.
- d. The duration to start up all the application of the whole system should be not more than 10 minutes.
- e. MTBF of surveillance data processing should be not less than 100,000 hours.
- f. MTBF of flight data processing should be not less than 100,000 hours.
- g. MTBF of a single workstation should be not less than 10,000 hours.
- h. Maximum CPU usage of servers and workstations should be not more than 40%.
- i. Maximum memory usage of servers and workstations should be not more than 50%.
- j. Maximum disk usage of servers and workstations for playback and recording should be not more than 80% and for others, not more than 50%.
- k. Maximum network load of servers and workstations should be not more than 60% of the total bandwidth.
- l. Maximum deviation of clock synchronization should be not more than 100 milliseconds.

#### **4.5.3 Performance of Surveillance Data Processing**

Performance of surveillance data processing is used to measure the accuracy and ability of the system surveillance data processing, the following suggested values would be considered for system planning.

Recommended performance requirements for 5 NM horizontal separation provided by ATCO:

- a. Measurement interval for probability of update should be less than or equal to 6 seconds.

- b. Probability of update of horizontal position should be greater than or equal to 97% for 100% of the flights.
- c. Horizontal position RMS error for cruising flights should be less than or equal to 350 m global and less than 385 m per flight.
- d. Probability of update of pressure altitude with correct value should be greater than or equal to 96 % global.
- e. Forwarded pressure altitude average data age should be less than or equal to 4 seconds.
- f. Pressure altitude unsigned error should be less than or equal to 200/300 ft in 99.9% of the cases for stable flights and less than or equal to 300 ft in 98.5% of the cases for climbing / descending flights.

Recommended performance requirements for 3 NM horizontal separation provided by ATCO:

- a. Measurement interval for probability of update should be less than or equal to 4 seconds.
- b. Probability of update of horizontal position should be greater than or equal to 97% for 100% of the flights.
- c. Horizontal position RMS error for cruising flights should be less than or equal to 210 m global and less than 230 m per flight.
- d. Probability of update of pressure altitude with correct value should be greater than or equal to 96 % global.
- e. Forwarded pressure altitude average data age should be less than or equal to 4 seconds.
- f. Pressure altitude unsigned error should be less than or equal to 200/300 ft in 99.9% of the cases for stable flights and less than or equal to 300 ft in 98.5% of the cases for climbing / descending flights.

#### **4.5.4 Capacity of Recording and Playback**

Generally, the capacity of recording and playback refers to the storage time of data in the system, the following proposed values would be used as information during system design.

- a. The minimum period for recording data archived in system should be not less than 31 days.
- b. The minimum period for system traces should be not less than 31 days.

- c. The minimum period for raw surveillance data archived in system should be not less than 7 days.

#### **4.6 External Interfaces**

External interfaces are used to communicate with other systems, including receiving and transmitting messages.

The selection, configuration and design of external interfaces can be determined by environment condition, operational requirements and long-term scheme.

States/Administrations can determinate the external interface to be interface with the ATMAS. In general, ATMAS includes the following external interfaces:

- a. Surveillance data interface
  - Radar interface  
The system is recommended to manage dual inputs from individual radar with synchronous serial interface and be able to receive and process the plots/tracks in a standard format, including ASTERIX.
  - ADS-B interface  
The system is suggested to manage dual inputs from individual ADS-B with serial interface or Ethernet and be able to receive and process ADS-B data in a standard ASTERIX CAT021 format.
  - WAM interface  
The system is proposed to be able to receive and process the WAM data in a standard format, including ASTERIX CAT020 from Ethernet.
- b. ICAO message interface  
The system should be able to receive and transmit the ICAO messages automatically in IA5 or ITA2 format with asynchronous serial interface.
- c. AIDC Interface  
The system should be able to exchange the AIDC messages compliant with the standard AIDC protocol on dedicated line and AFTN line
- d. Meteorological interface
  - QNH interface  
The system should be able to process the QNH data from AWOS system with asynchronous serial interface.
  - GRIB interface

The system should be able to receive and process the GRIB message from Ethernet.

e. Data synchronization and exchange interface

➤ System track interface

The system should be able to receive and transmit the system tracks with serial interface and Ethernet in ASTERIX CAT 062.

➤ Flight data exchange interface

The system should be able to receive and transmit flight data with serial interface and Ethernet in the message format agreed.

➤ Audio playback interface

The system is recommended to be able to provide the interface to synchronize the playback activities with the audio in an agreed data format through serial interface or Ethernet, which can keep the playback of audio and situation awareness synchronization in time.

f. GNSS time interface

The system should be able to receive the GNSS time from the time reference system with Ethernet NTP protocol or serial interface.

g. CPDLC interface

The system is suggested to enable communicate with external CPDLC equipment in compliance with the ARINC, FANS1/A, ATN B1 data formats through Ethernet or serial interface.

## **4.7 Systems Interoperability**

The system interoperability function enables ATMAS to exchange messages with other external systems to implement information sharing, it is recommended to include the followings:

a. Data synchronization with fallback ATMAS

Please refer to Chapter 3.2.9.

b. Messages exchange with Tower systems

The system is recommended to be able to exchange messages with the integrated tower system, A-SMGCS, and tower electronic strip system, the followings are the major exchanging messages:

➤ flight plan message

Providing synchronization information of flight plan messages between ATM system and tower system, including flight plans creation, modification, deletion, cancellation and flight plan life evolution, etc.

➤ SSR assignment message

Providing synchronization information of SSR allocation and release between ATM system and tower system.

➤ Runway operational state

Providing synchronization information of runway operational states between ATM system and tower system, including DEP/ARR CLOSE, and additional information such as inspection and construction temporarily, etc.

## **4.8 Cyber Threats and Mitigation**

### **4.8.1 General Description**

With the extensive deployment and closer interconnection of Commercial-Off-The-Shelf (COTS) Information and Communications Technology (ICT) Systems which is built on common standards rather than on the conventional proprietary equipment, Air Navigation Service Providers (ANSPs) have been facing increasing challenges to protect their critical infrastructure and manage potential risks arising from cyber security threats.

To address the growing concerns on cyber security threats, ICAO has extended its SARPs with Annex 17 on Security, with the supplement as in ICAO Doc 8973 “Aviation Security Manual” which set out the aviation security requirements, including cyber security in ATMAS. In addition, ICAO published Doc 9985 “ATM Security Manual” setting out the principles and guidelines for protecting ATC system infrastructure from cyber attacks. States/Administrations are encouraged to pursue appropriate level of compliance to the cyber security control requirements as stated in the ICAO documents and make collaborative efforts to effectively address cyber security threats. ICAO and other international organizations have been promoting the importance of cyber security in ATC systems via their web site, such as ICAO’s Thematic Website on Cyber security ([www.icao.int/cybersecurity](http://www.icao.int/cybersecurity)) and CANSO’s website on Standard of Excellence in Cyber security.

### **4.8.2 Cyber Security Management**

States/Administrations are encouraged to develop cyber security management, which adopts a proactive and systematic approach for protecting increasing digitisation of ATS against cyber threats, through the establishment of Cyber Security Manual, Cyber Security Handbook and User Account Management Policy. The above-mentioned documents should be developed in accordance with relevant provisions in ICAO Annex 17 and Doc 9985 to provide protection of the safety-critical ATMAS against cyber threats and interference. Key elements of enhanced controls on cyber security are as follows for reference:

a. Cyber Security Policy

States/Administrations should establish its own Cyber Security Policy to mitigate cyber threat. Dedicated committee or working group on cyber security with regular meetings is encouraged to set up for reviewing policies and steering the implementation of cyber security control measures throughout the whole life cycle of ATMAS.

b. Network Infrastructure Protection

Interoperation among ATMAS and other ATS systems for information exchange is inevitable. Proactive protection of backbone data network of ATMAS is essential to ensure its operation. Multi-tier defence-in-depth scheme for external TCP/IP unicast communication to other systems, comprising network equipment, firewalls, Network Intrusion Detection (NIDS) or Network Prevention System (NIPS), is suggested to strengthen the protection of the network ATMAS against cyber threats from external connections. To further strengthen the above-mentioned scheme, data diode gateway could be utilized to leverage on unidirectional communication for dissemination of data from ATMAS to other systems.

During the project implementation stage of ATMAS, Virtual Private Network (VPN) is often suggested by system manufacturer to allow their personnel assisting the installation and configuration of the system remotely. Since the system is not yet in operational use and is isolated from other operational ATC systems, external VPN connection to ATMAS is considered acceptable in general for facilitating the project implementation. States/Administration should assess the cyber security risks involved in remote VPN access during the integration of data interfaces to other ATC systems and ensure that all the security risks have been mitigated to an acceptable level.

After the ATMAS is put into operational use, external VPN access by system manufacturer is in general not recommended. If there are operational needs to keep the VPN access by system manufacturer, States/Administrations should assess the cyber security risks and safety risks involved and implemented all the necessary measures to mitigate the risks to an acceptable level.

c. User Account Management

To protect the ATMAS from the cyber security risk of access control, States/Administrations should establish a systematic and traceable process for administration of user accounts applicable to authorized access to ATMAS.

d. System Development Life Cycle

To achieve the viability and sustainability of cyber security protection, the protection from cyber threat in mind throughout the system life cycle of the development of ATMAS is indispensable. States/Administrations could formulate a project procedures handbook, which include cyber security requirements, to safeguard against cyber threats from an early concept and design stage of a project. Besides, Independent Network Security Risk

Assessment (INSA) for ATMAS is encouraged to conduct at different stage of project cycle to assess the adequacy of the cyber security measures applied to the system development.

e. Removable Media Control

Removable media provides a common route for importing malicious content to information system. To mitigate the potential risk posed by the use of removable device or media in ATMAS, States/Administrations should consider to refine its workflow to strengthen the security control, such that a removable media should be scanned for malicious content by the machine prior to uploading data to ATMAS.

f. Software Security Patch Management

Patching vulnerabilities for ATMAS is key challenge to maintain the balance between security and performance. States/Administrations could setup a scheme to work closely with system manufacturers to evaluate system patches when considered appropriate.

g. Physical Security Measures

While cyber security measures are in place for dealing with cyber threats, States/Administrations should implement physical security measures to physically protect the infrastructure of ATMAS from physical threats. The physical security provision includes facility management, security guards, CCTV surveillance, access control, physical lock, USB blocker, etc., from perimeter security down to console/rack level.

h. Response to Cyber Security Incidents

States/Administrations are encouraged to closely collaborate with relevant local authority responsible for investigation and prevention of cyber crime. Direct reporting mechanism is recommended to establish in order to seek swift assistance from the local authority for handling cyber security incident. States/Administration is encouraged to seek relevant authority for an independent assessment on cyber security measures implemented on ATMAS. Periodic drill exercises should be arranged to upkeep staff awareness and the robustness of the reporting mechanism

## **5. SYSTEM SOFTWARE MANAGEMENT**

The system software management is a primary discipline of managing how software is modified through standardized procedures all over the life cycle in order to enhance system robustness, reliability, stability and safety and contribute to keep it running healthily. It is highly recommended to establish designated Software Management Department (SMD) specialized in system software management.

By experience, software management is recommended to cover requirement management, fault management and version&patch management. States/Administrations are encouraged to conduct different management stages for the practical requirement.

### **5.1 System Requirement Management**

System requirement management is intended to properly control the impact of changes throughout the software architecture, tracing back to the originating source of needs. The objective is to ensure a complete and consistent representation of the software requirements baseline, to satisfy with development of civil aviation, and to lead to high-quality and effectiveness.

SMD is responsible, with accordance to issued policies, to developing requirements database, guiding system construction, upgrading and tracking requirements realization.

#### **5.1.1 Requirements proposal and application**

System software requirements generally originate from changes relevant to work procedures, new techniques application, etc. At the beginning, a preliminary requirement scheme needs to be drawn up, including the following contents:

- a. Necessity analysis.
- b. Feasibility analysis.
- c. Design specification.
- d. Implementation time expected.

After determined and confirmed, requirement scheme shall be applied and submitted for approval.

#### **5.1.2 Requirements assessment and approval**

SMD is accountable for analyzing and assessing the scheme, considering the following factors at least:

- a. Content integrity, reason sufficiency.
- b. Adherence to standards and regulations.

- c. Technical feasibility.
- d. Influence on the system.
- e. The scope of software baseline and corresponding impact (in case of multiple sets from different sites).
- f. Uniformity across systems (if equipped with a fallback system).

The department shall feedback assessment results and reviews, archive them into the requirement database and follow up the progress of software requirements implementation.

## **5.2 System Fault Management**

System fault management mainly includes fault record, fault investigation, solution evaluation and troubleshooting arrangement. It is necessary to track the entire process of faults from occurrence to resolution, ensuring various faults resolved in an efficient and orderly way.

### **5.2.1 Fault record**

The Maintenance Service Provider (MSP) is suggested to record all of faults happened on operation and handling processes, collect valuable logs and information for analysis, and register faults caused by defects. The content of fault registration includes basic system information (like manufacturer, operating site, and software version&patch number), the occurrence time, and detailed description of phenomenon. In addition, the severity and priority of the fault should be determined on the basis of the impact.

### **5.2.2 Fault investigation**

Fault investigation requires a comprehensive analysis of the cause in the light of system performance, logging records and other information. Participants in the fault investigation are suggested to involve SMD, System Supplier (SP), SMP, and controllers. The SMD is advised to carry on the number to faults, follow up and manage them, as well as double check the severity and priority. The SP is required to check software codes, locate defects and provide analysis report with root cause.

Given that one fault might have an influence on the systems deployed on different sites and sharing the same software baseline, SMD is suggested to analyze the scope of the affected and release risk notification in time to each MSP. Countermeasures shall be supplied for the best preparation.

### **5.2.3 Defect correct plan**

The defect repair plan is recommended to be discussed and formulated by the SMD, SP, SMP, and controllers. The content and consideration factors of the plan include:

- a. According to the severity and priority, determine the software version&patch for each recovery.

- b. According to the workload, formulate the schedule of software version&patch delivery.

SMD is suggested to follow up the progress of plan implementation and adjust as it stands.

### **5.3 Software Version& Patch Management**

Software version&patch management is a process of validating the software handed in by SP as expected and avoiding the appearance of new defects. The key of software version&patch management contains review and check, test and evaluation, and release. Based on the extent of the impact of changes on the system, the new release is divided into software version and patch.

#### **5.3.1 Software delivery**

The supplied software is suggested to include the compiled programs, software modification description and upgrading instruction. SP should provide check code for the programs to guarantee the correctness for fear of errors in the delivery process. Besides, for the benefit of software quality, SP is proposed to conduct factory test with specific cases and scenarios before delivery, and then submit test result and report.

#### **5.3.2 Software review**

From experience, it is recommended that the SMD register the software programs and review the factory test report. SMD verify the software programs with check code, install them on the test platform and validate the upgrading instruction. Moreover, SMD make sure that the integrity and accuracy of modification description contents requires are satisfied with expectation.

#### **5.3.3 Software test**

Based on the software modification, SMD is recommended to set up a test team, prepare a platform, and formulate a testing plan. Compared with patch test, software version test should consider broader testing scope, longer time, and more participants.

Controllers and MSP are suggested to deeply participate in the testing work and conduct a comprehensive test at aspect of functional improvements, main functional modules, regular operations on HMI and system stability. The test team is advised to write down test results in detail.

After the test is completed, test team is suggested to render a report that test process and result demands to be elaborated and analyzed, and then comes to conclusion.

#### **5.3.4 Test reports evaluation and software release**

The result of test is recommended to be evaluated by both SMD and MSP. Software which has passed the evaluation can be released for on-site installation, and otherwise returned to the manufacturer.

In addition, SMD and MSP are suggested to give full consideration to impact on operational environment, user experience and maintenance capability because of software evolution and changes.

## **6. System Transition**

There are several scenarios in which ATMAS transition normally happens, ranging from minor to major changes, including:

- a. Minor software corrections or patches for defects tracked under System Software Management (previous chapter) to enhance system robustness, reliability, stability and safety.
- b. Moderate or Major software and/or hardware upgrade, including operation system upgrade and important modules upgrade such as SDP or FDP to provide new or enhanced functionalities.
- c. Overall system upgrade with new software and hardware equipment.

For more complex transition that involves multiple stakeholders and equipment, change management, safety risk management, transition plan, rehearsal and post-transition support are the key elements to ensure smooth system transition.

### **6.1 Phases of System Transition**

There are mainly four transition phases: transition preparation, transition rehearsal, system transition and post-transition operation.

- a. Transition preparation: the necessary preparation for transition In this phase, transition scheme, safety assessment, equipment preparation, staff training, manual update shall be completed.
- b. System Rehearsal/Pre-Transition Verification: The main objective of this phase is to build confidence on the new changes and to flag out any possible issues before the actual transition. It can be achieved by running an on-line test of the new system during off-peak hours or in backup system in parallel with the operational system. During the on-line test, the new system could be connected with external interfaces and systems progressively. The operational users and engineering staff will test the main functions and interfaces, and record necessary optimization to the system as well as the rehearsal procedure. The frequency and duration of rehearsal shall be adjusted according to the complexity of system transition.
- c. System transition: In this phase the new system will be put into operation. If the transition is complex with software and hardware upgrade, shadow operation is suggested and shadow operational period could last 1 or 2 weeks or even longer where appropriate. And according to the result of shadow operation, the time point to start the transition shall be determined. If the transition failed, a decision whether to repeat or roll back needs to be made.
- d. Post-Transition operation: In this phase, the new system operates on line and

an observation period of one month or more is suggested, depending on the complexity of the changes.

## **6.2 Transition Preparation**

### **6.2.1 Transition Scheme**

The complete transition scheme is necessary for successful transition. Depending on the scale of the transition, the transition scheme is suggested to contain followings:

- a. The preliminary work to be finished, including:
  - Review of acceptance testing results and equipment preparation.
  - Review of adequacy of change management and safety risk management.
  - Review of training including competence of operational and engineering staff.
  - Review of the change in ATC Procedures and update the operation manual.
  - Other relevant work required.
- b. Transition plan, procedures and key points.
- c. Check list: used to check the system transition operation and verify system functions and performance during transition rehearsal and system transition.
- d. Decision mechanism: transition institution shall be established to determine on transitional key point.
- e. Contingency plan: used to cope with the emergency situations and include the decision-mechanism about roll back or transition delay, roll back plan and the emergency support team.

### **6.2.2 Scheme Evaluation**

The scheme evaluation is necessary and proposed to include scheme feasibility, scheme completeness, scheme presumption, equipment and staff preparation, the stability of the new system, and the solutions to bugs discovered during the on-site test. According to all these elements, some improved suggestions should be raised to make the scheme more perfect. After the evaluation, recheck should be made to ensure the implementation of the suggestions.

### **6.2.3 System Deployment**

To ensure the system rehearsal and smooth transition, the new software and hardware should be sufficiently deployed.

#### **6.2.4 Table Pre-rehearsal**

For major transition, table-top exercise is recommended to ensure the feasibility of system switch steps, the smoothness of cooperation, the completeness of checklist and the rationality of time arrangement.

#### **6.2.5 Other Preparations**

The operational and engineering manual should be updated, including system information, technical manual, notification process, emergency plan. Staff training is suggested to be completed to ensure familiarity of the new system.

### **6.3 System Rehearsal/Pre-Transition Verification**

The transition scheme including the detailed transition procedure and steps should be made familiar to the team through training activities prior to the system transition. Depending on the complexity, several system rehearsals are suggested to be performed during the off-peak hours. The purpose of the system rehearsal is to verify the transition procedure as well as to validate the functionality, reliability and stability of the new system in a real operational environment.

#### **6.3.1 System Switch Steps Validation**

The transition procedures are recommended to be validated according to the overall transition rehearsal scheme. The procedure to be validated includes at least the following: system switching steps, operating contents, transition team and reasonability allocation, notification and reporting process. A checklist is suggested to be developed and optimized according to the result of each rehearsal. The optimization should be verified at the next rehearsal.

During the rehearsal, the time spent on each step is advised to be verified, and to be used as reference to support the decision making during the formal transition.

#### **6.3.2 System Functions and External Interfaces Validation**

The system functions and external interfaces are suggested to be tested and to ensure that they are functional as intended during the rehearsal. To ensure a smooth transition, the problems identified during the transition should be recorded in details and corrected with the support of the SP.

### **6.4 System Transition**

At the end of the above preparation activities, the transition management organization is suggested to decide to approve the date and time of the formal transition, based on the transition scheme evaluation report, the transition preparation status, and the result of the transition rehearsals.

For major system replacement or overall system upgrade transition, a 1~2 weeks or longer shadow period is recommended to put the new system into operation during off-peak time, to verify the system performance in a real operational environment and

to allow staff to gain familiarity and confidence in operating the new system. Appropriate rostering of staff is required such that all staff will be given opportunity to gain the experience in operating the new system.

Finally, transition is recommended to be performed based on the pre-defined procedure at the pre-defined transition time. The new system should be put into operational use after the verification of the functioning of the system is confirmed, following its transition.

However, if there are blocking or critical issues, e.g. problem affecting safe operation occurring during the transition, decisions should be made according to the decision making strategy defined in the transition scheme, which may result in rollback or delay of the transition.

## **6.5 Post-Transition Operation**

The post-transition operation phase is suggested as the run-in period of the system, which preferably requiring additional staffing from the MSP as well as SP, to resolve teething issues. The issues identified during this phase should be timely analyzed, corrected and reviewed. In addition, the maintenance experience of the new changes will be accumulated.

The duration of the post-transition operation phase is recommended to be one month or longer. A formal assessment is suggested to be performed at the end of this phase. The assessment is proposed to include:

- a. Issues reported during the observation period.
- b. The cause analysis, and possibly the avoidance and corrective methods of the issues.
- c. Recommendations for future operation, matters-needs-attention etc.

The system will enter to the stable operation phase after the observation period.

## **7. System Maintenance**

The ATMAS goes to the system maintenance phase after put into operation. System maintenance is necessary for the entire service life of the system. Critical functions and equipment should work normally even as the environment changes by planned and organized maintenance. The purpose of system maintenance is to guarantee the stable and continuous operation, and to improve the performance of the system.

### **7.1 System Maintenance Participants**

To handle the maintenance of complex and safety-critical ATMAS, a robust and systematic maintenance management and practice should be set up with close cooperation among system supplier, Maintenance Service Provider (MSP) and the Air Navigation Service Provider (ANSP) to ensure the operation of the system.

Under the maintenance framework for ATMAS, the system supplier, MSP, and ANSP form a close coordination trio in operating and supporting the maintenance framework.

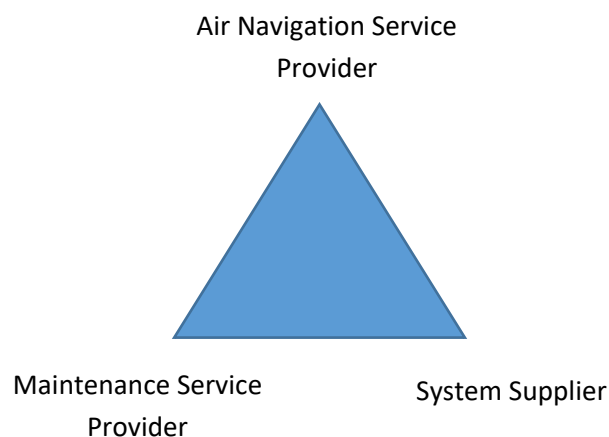


Figure7.1-1: Trio for Maintenance Framework

#### **7.1.1 System Supplier**

The design of system plays a critical role on the ease of maintenance during operation stage of the system. Before system commissioning, system supplier, as the entity with the most comprehensive know-how on the system, should provide sufficient maintenance documentation and training to ANSP and MSP including complete information for proper installation, set-up, use, operation, support and maintenance of the system.

System supplier should provide documentation to the ANSP and MSP for aiding the use, application and maintenance of the system and individual equipment which should include:

- a. Operation handbooks and user manuals for operating procedures and system functionalities for use by controllers, supervisors, assistants and support specialists.
- b. Technical literature for full technical description of configuration and operation in the system as well as full details of each system component, block diagrams with data flow, mechanic and wiring schematic diagrams, as-built drawings, etc.
- c. Service and maintenance manuals including system setup, optimization and parameterization, preventive maintenance procedures (system checking and rebooting, calibration, cleaning, housekeeping, etc.) with recommended frequencies, and troubleshooting procedures in hardware and software (recommended solution and flow chart to identified issues, handling of alarms and error messages, etc.).

All documentations should be reviewed and endorsed by relevant authority prior to use.

System supplier should prepare training plans and training course materials to ANSP and MSP for review with sufficient time prior to critical milestones, such as commencement of design review, factory/site acceptance tests, and ATC operational train-the-trainer course. ANSP, in coordination with MSP, should set out the required training topics, which should be specific to different user groups, in the system contract.

Subject to actual needs, after ANSP and MSP have built up their own training capability, on-site maintenance review and assessment on MSP should be conducted by system supplier after commissioning on regular basis, with more frequent trainings/assessments during the start-up and run-in period after commissioning.

As ATMAS is a complex system, it is unavoidable that unexpected technical issues might emerge, especially teething issues during the early stage of operation. As such, system supplier should be required to respond to requests from ANSP or MSP to provide timely assistance in dealing with and rectifying all faults or deficiencies in software and hardware within pre-defined response time according to the criticality of such faults or deficiencies as specified in the contract. Repeated faults should be handled and investigated with high priority by system supplier to identify the root cause and implement corrective measures.

Since technology is changing rapidly, some system components might become obsolete and become difficult to source in the market. System supplier should provide a list of obsolete equipment and its replacement models on regular basis, and the replacement model should be evaluated on-site for its compatibility prior to use as a spare for operation.

The performance of system supplier has to be regularly reviewed in suitable forum, such as performance review meetings in conjunction with ANSP and MSP representatives.

System supplier could consider to form user groups to allow sharing of users' experience and gather feedbacks. System supplier should facilitate regular hosting of user group meetings.

### **7.1.2 Maintenance Service Provider**

Engagement of a MSP to perform frontline maintenance under supervision of ANSP is a practical solution in leveraging skill sets and latest technology available in private sector in order to facilitate provision of reliable services with cost benefit.

Under the regime of compliance to all applicable ordinances and regulations, Safety Management System and Air Traffic Safety Electronics Personnel (ATSEP), the maintenance services provided by MSP should include, watch-keeping of equipment, preventive/corrective maintenance, system/equipment minor modification/replacement works, staff training, and procurement of spares and test equipment/ tools. Support services such as record-keeping on maintenance activities, preparation of statistics and reports and inventory control, etc. could be provided as part of the package from MSP.

MSP needs to perform maintenance according to system supplier's established procedures at recommended intervals, including health checks on system, servers, equipment and workstations, critical data backup and log capture/review for hardware, software, user management and other activities, system parameters and user preference checks and backup, regular clean-up and reboots of hardware including servers and workstations etc. Proactive system housekeeping procedures adopting industry best practice with recommendation from system supplier and expertise from MSP, together with close monitoring of system healthiness/system resources, and housekeeping of servers/workstations on regular basis to upkeep the system performance, should be in place.

There could be cases that due to local specific environment/operational status of the ATMAS, it would require extra steps or more frequent maintenance, e.g. more frequent clean-up/reboot of servers and workstations, on top of recommended maintenance procedures by system supplier. MSP, who looks after the system day-by-day and is familiar with local environment, would contribute their expertise for adapting the maintenance procedures to fit into the local needs after consulting the system supplier.

In addition, like any critical systems running on round-the-clock basis, ATMAS has no exception that it might encounter system fault where immediate attention from MSP is required. For example, a server breakdown after a software bug is hit with no or little pre-alerts. It is important that MSP has geared up with a full deck of operational instructions for their watch-keeping staff to handle all sorts of foreseeable system scenarios with proper initial and re-fresher trainings/drills on such scenarios. The build-up of know-how and experience for MSP in dealing with urgent scenarios is crucial to smooth operations of the ATMAS.

Similar to system supplier, the service level of performance of MSP has to be constantly monitored to meet with the target levels set out in the contract and regularly reviewed in suitable forum, such as operations & maintenance review

meetings in conjunction with ANSP representatives to ensure maintenance provisions could meet the service needs.

### **7.1.3 Air Navigation Service Provider**

As the party to govern maintenance service performance by MSP and system supplier through various means discussed above, ANSP has to ensure the necessary support and resources to be provided to MSP and system supplier for fulfilling, or even exceeding, the baseline maintenance requirements set out in the contracts with these parties. Payment deduction might be incorporated into the contract to handle cases where performance does not meet requirements but it might bear impacts on maintaining good relationship with MSP or system supplier.

ANSP has to ensure the services provided by MSP and system supplier are in compliance with ICAO standards and international best practice. ANSP is encouraged to share experience and best practice gained from ICAO and international meetings/symposia/seminars, as well as overseas facts-finding visits, with MSP and/or system supplier with a view to enhancing the maintenance regime.

To allow ATC professionals to perform their work safely and satisfactorily, it is highly desirable for ANSP's engineering professionals to understand the operational needs such that the ATMAS could fully support their work. As such, constant communications with ATC professionals in addressing their needs via suitable steering forums and communication channels would be critical to the smooth operations on ATMAS. Following the system commissioning, a technical team, comprising ANSP engineering professionals, system supplier and MSP, could be established with ATC professionals to oversee system performance and deployment of new software builds and system data updates to ensure smooth operation of the ATMAS.

## **7.2 Resources Requirement**

Necessary resources are mandatory for system maintenance, and the main considerations are as follows:

### **7.2.1 Staffing**

MSP should ensure sufficient staffs are employed to form a maintenance team and provide 24-hour operation and maintenance.

Before stepping into the system maintenance phase, MSP and ANSP should ensure the personnel are fully trained by the SP or certified trainers. This ensures that the personnel involved in the maintenance work grasp knowledge and skills related to the system. It is also recommended to arrange on-site training by SP for MSP and ANSP after system installation. Before the training, the training plans and training course materials should be fully review by ANSP/ MSP in accordance with contract requirements, and define training topics for different users.

Before the system is put into operation, MSP and ANSP are recommended to send personnel to work in different phases for technical reserves in advance, and enhance

their comprehension and familiarity with the system, which will be conducive to the subsequent maintenance work:

a. System design phase

MSP and ANSP are recommended to send personnel to participate in the design of the system to track the project development progress in SP factory, check the rationality and applicability of the design of each functional module of the system and put forward suggestions, and review technical documentation at milestone, including the consistency of requirements, product design, handbooks and acceptance test book.

b. Factory acceptance test phase

MSP and ANSP shall send personnel to participate in factory acceptance test in accordance with the contract requirement. MSP and ANSP personnel shall review the acceptance test books provided by SP in advance. The acceptance test shall be executed according to the approved test book in the test environment such as platform, signal, instrument, etc. prepared by SP, and the result shall be recorded in the report.

c. Installation phase

After the work of on-site equipment installation starts, MSP should send personnel to participate in the whole process of hardware installation, software debugging, on-site acceptance test, and flight inspection, etc. At this stage, personnel should be well familiar with important information such as equipment installation location, cabling, signal routing, position layout, label and signs, etc. They also need to learn software debugging and testing methods, and master the knowledge of system's functions and performance during on-site testing and flight inspection.

Besides above all, MSP and ANSP should set up their own maintenance personnel training systems, maintenance personnel access mechanism, and regular assessment about personnel skills to ensure that qualified personnel can perform the operation, maintenance and management of the system.

## **7.2.2 Documents**

Before the start of the system maintenance phase, MSP and ANSP should make sure necessary documents are in placed to run the system. The documents should include at least the following:

- a. System Design Specification: a set of technical documentation including system architecture, interface control documents, function module principle, etc.
- b. Maintenance Manual: the service and maintenance manual include system installation, parameters setting, maintenance suggestions, as well as troubleshooting procedures in hardware and software (it is recommended to

- provide a flow chart to locate and solve the problems, and a method to identify the alarm and error, etc.)
- c. User handbook: detailed description and operation guide of HMI for supervisors, controllers and coordinators.
  - d. Installation documentation: including details of each component of the system, cabinet layout, figure with data flow, mechanical and wiring schematic diagram, as-built drawing, etc.
  - e. Training documentation: including training materials or documents related to factory and on-site training.

Besides, MSP and ANSP should work out their working procedures, maintenance plans and contingency plan of running the system.

All documents should be reviewed and approved before application which should be updated continuously to keep the accuracy according to the changes of system behavior during the long-term operation.

### **7.2.3 Maintenance Tools**

MSP and ANSP are recommended to be equipped with instruments and maintenance tools required for system maintenance, for examples, the simulator used to simulate track and message for system test. Training for maintenance personnel shall cover the use of instruments, maintenance tools and simulators by MSP and SP.

### **7.2.4 Spare parts**

Sufficient hardware spare parts shall be reserved for the ATMAS, including servers, workstations, monitors, network equipment, etc. The percentage of spare parts is related to scale of the system. The mechanism of spare parts management should be setup, including periodically testing and checking the reserve status to make sure that the spare parts are sufficient and available.

Since it is very common that computer hardware will be updated frequently, ANSP/MSP should review the list of hardware and confirm with the SP a list of obsolete hardware and replacement solutions regularly. The replacement hardware should be reserved as spare parts after finishing site compatibility assessment.

If condition allowed, ATMAS Test and Validate System (TVS) is recommended to be deployed for supporting new software testing, system parameter adjustment, and personnel training, etc.

## **7.3 Maintenance Content**

System maintenance is recommended to include the following at least:

### **7.3.1 Periodic maintenance**

Periodic maintenance including daily, weekly and monthly, etc. Which maintenance matters should be worked out according to the real operational requirements, it is recommended to cover the followings:

- a. Check the running status of system software, dual nodes redundancy.
- b. Check the running status and health of the system hardware, including network load and the usage of resource such as CPU, memory, and disk of servers, workstations and network devices. Please refer to section 4.5.2 for the inspection standards.
- c. Check the validation of external data, including surveillance data, AFTN, AIDC, meteorological data, GNSS, and the status of data interaction with external system if any.
- d. Check the integrity of the recorded data to prevent the data lost.
- e. Check the status of basic function on bypass server.
- f. Perform active/standby switch between the redundant servers to ensure both servers can operate normally.
- g. Backup critical files and data periodically, including the system configuration parameters, database and log, etc.
- h. Manually clean and reboot the server and workstation regularly.
- i. Check the physical system operating environment regularly, including temperature, humidity, equipment grounding, electromagnetic environment, etc.
- j. Switch the backup system to operational mode regularly to achieve a balanced use for both main and backup systems.

### **7.3.2 Troubleshooting**

MSP should promptly execute troubleshooting, correct system errors, and ensure that the system work normally by replacing components, updating software or parameter configuration and other methods.

SP should response in time to the requirements of MSP or ANSP after a failure occurs, and assist MSP to handle and correct the failure within the predetermined response time according to the severity.

MSP should make detailed records and investigation to the failure, and provide PCRs to SP for software defects, which will help SP to survey and correct the failure. The detailed software defects management, please refer to section 5.2.



**Appendix A**

**ATMAS IGD Request for Change Form**

<b>RFC Nr:</b>	
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<b>1. SUBJECT:</b>			
<b>2. REASON FOR CHANGE:</b>			
<b>3. DESCRIPTION OF PROPOSAL: [expand / attach additional pages if necessary]</b>			
<b>4. REFERENCE(S):</b>			
<b>5. PERSON INITIATING:</b>			<b>DATE:</b>
<b>ORGANISATION:</b>			
<b>TEL/FA/X/E-MAIL:</b>			
<b>6. CONSULTATION</b>		<b>RESPONSE DUE BY DATE:</b>	
<b>Organization</b>	<b>Name</b>	<b>Agree/Disagree</b>	<b>Date</b>
<b>7. ACTION REQUIRE :</b>			
<b>8. AIGD EDITOR</b>		<b>DATE REC'D :</b>	
<b>9. FEEDBACK PASSED</b>		<b>DATE :</b>	

**Appendix B**

**Table 3.2.10-1A Flight Specific Flight Data**

Aircraft ID	Traversed Sector/s	Controlled Airspace	Flight Rule	Flight Type	No. of Danger Area Infringements	No. of Uplink Messages		No. of Downlink Messages		No. of Delivery Timeouts	
						Rejected	Accepted	Rejected	Accepted	Uplink	Downlink

[Selected Time Period]

Aircraft ID	No. of AIDC Messages		No. of AIDC Messages	
	Rejected	Accepted	Transmitted	Received

**Table 3.2.10-1B Collective Flight Data**

Day/Week/Month	Total No. of Flights	Airspace Sector				No. of Danger Area Infringements	No. of Uplink Messages		No. of Downlink Messages		No. of Delivery Timeouts	
		N	W	E	S		Rejected	Accepted	Rejected	Accepted	Uplink	Downlink

Day/Week/Month	Controlled Airspace				Flight Rule				Flight Type				
	ARR	DEP	OVF	DOM	I	V	Y	Z	S	N	G	M	X

**Table 3.2.10-2 Flight Specific Surveillance Data**

[Selected Time Period]

Aircraft ID	Surveillance Track Type				Source of Surveillance Track				Quality of Surveillance Track			
	Secondary	Mode S	Multilat	ADS-B	Secondary	Mode S	Multilat	ADS-B	Secondary	Mode S	Multilat	ADS-B
	o	o	x	o	1	2	-	2	Coast	Normal	-	High

