***International Civil Aviation Organization***

**The First Meeting of Air Traffic Management Automation System Task Force of APANPIRG (ATMAS TF/1)**

**Web-conference, 28 – 30 October 2020**

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**Agenda Item 6: Guidance Material of Implementation of ATM Automation System in Asia/Pacific Region (APAC ATMAS IGD)**

# RECOMMENDED FUNCTIONS AND PERFORMANCES OF ATM AUTOMATION SYSTEM

(Presented by China, Hong Kong China and Singapore)

**SUMMARY**

The development of a guidance material of implementation of ATM automation system is one of the deliverables of ATM automation system task force (ATMAS/TF) according to the Terms of Reference. The Recommended Functions and Performances of ATM Automation System (**RFAP of ATM AS**) is proposed to be formulated as the guidance material for systems planning, design, testing and implementation of ATM automation system in the Asia and Pacific Regions. China, in collaboration with Hong Kong China and Singapore, has taken a lead to prepare a framework and initial draft of the **RFAP of ATM AS** for consideration by the working group.

## 1. INTRODUCTION

1.1 According to the Terms of Reference of ATM automation system task force (ATMAS/TF) pertaining to 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), the development of a guidance material of implementation of ATM automation system is one of the deliverables of ATMAS/TF.

1.2 The guidance material aims to provide recommendations of ATM automation systems in developing and implementation in the Asia and Pacific Regions, with the view of facilitating the provision of robust, safe, efficient and orderly ATM services by the use of existing and/or new procedures, facilities and technologies in relation to ATM automation systems; with the view of realizing interoperability in regional ATM automation systems.

## 2. DISCUSSION

2.1 The Recommended Functions and Performances of ATM Automation System (**RFAP of ATM AS**) is proposed to be formulated as the guidance material for systems planning, design, testing and implementation of ATM automation system in the Asia and Pacific Regions. China, in collaboration with Hong Kong China and Singapore, has taken a lead to prepare a framework and initial draft of the **RFAP of ATM AS** for consideration by the working group.

2.2 The proposed framework is outlined as follows:

Section 1 Introduction
- Purpose
- Background

Section 2 Acronyms and Abbreviations

Section 3 Reference Documents

Section 4 System Functional Baseline
- System compulsory functions
- System optional functions

Section 5 System Design
- System architecture
- Position roles and types
- Main and backup configuration
- System operational mode
- Capacity and performance
- External interface
- Systems Interoperability
- Cyber threats and mitigation

Section 6 System Software Management
- System Requirements Analysis and Management
- System Fault Management
- Software Release & Patch Management

Section 7 System Transition
- Transition Plan and Assessment
- Transition Rehearsal
- System Operational Check
- Flight Check For System Performance Acceptance

Section 8 System Maintenance
- System supplier
- Maintenance Service Provider(MSP)
- Air Navigation Service Provider(ANSP)

2.3 In the proposed framework, Section 1 gives the background information and goals of the guidance material; Section 4 introduces the basic and enhanced functions of ATM automation system; Section 5 presents the considerable aspects in system design; Section 6 recommends the main contents in system software management; Section 7 talks about the consideration factors before system transition; Section 8 describes the system supplier, MSP, and ANSP from a close coordination trio in operating and supporting the maintenance framework.

2.4 Based on the above framework, an initial draft of the **RFAP of ATM AS** has been prepared and given in the Attachment. This initial draft document requires further development before it becomes ready for approval as the regional guidance material.

2.5 A working team is proposed to be established to continue developing the document. The working team will work through emails and web/teleconference. States/Administrations are invited to contribute to the **RFAP of ATM AS** through joining the working team.

## 3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) Review the proposed framework of the **RFAP of ATM AS**, and provide any suggestion;

b) Establish a working team to fulfill the document of the **RFAP of ATM AS**; and

c) Encourage States/Administrations to participate in the working team to share experiences and knowledge for incorporating into the **RFAP of ATM AS**.

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

# RECOMMENDED FUNCTIONS AND PERFORMANCES

# OF AIR TRAFFIC MANAGEMENT AUTOMATION SYSTEM

**Edition 0.0 - October 2020**

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# 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.

Along with carrying out of the Asia/Pacific Seamless ATM Plan, and many times' meeting discussion, it is getting more and more clear, a specific recommendations and developing guidance material related to Air Traffic Management Automation System (ATM AS) is necessary, 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.

This Recommended Functions and Performances of ATM AS (RFAP of ATM AS) provides guidance for systems planning, design, testing and implementation of ATM automation system in the Asia and Pacific Regions, with the purpose of ensuring continuous and coherent development of the ATM automation systems that is harmonized with adjacent regions.

The system requirements and operational procedures for ATM automation system are detailed in the relevant States' projects and AIP. This RFAP is intended to provide the basic and the most important functions and performances of ATM automation system, based on the operations and maintenances 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 1-1.

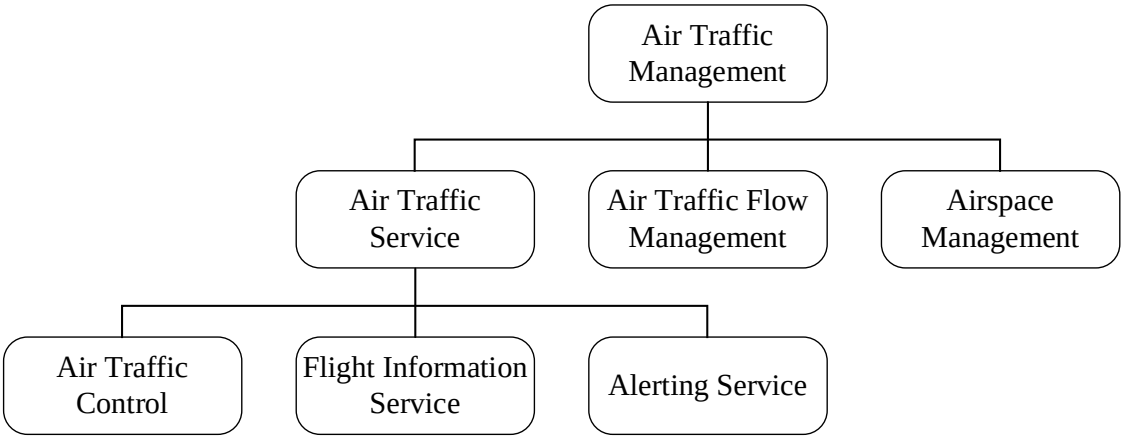


Figure 1-1 Composition of air traffic management.

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 ATM Automation System

The ATM automation system 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 an air traffic management system to provide functional capabilities to air traffic controllers in the Area Control Centers (ACC), Approach (TCUs and TMAs) and towers. The ATM automation system helps controllers keeping conformance monitor, hazard monitor, and assuring safety separation to air traffic flow.

Normally，the ATM automation system has a modular design and has a 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 a high capacity redundant LAN. 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, in order to provide an uninterrupted service to the controllers.

Popularly, considering about the safety and redundancy requirements, the ATM automation system has two individual LANs. Two of the LANs are called working LAN, where the redundancy computers connected. The working LANs keep sharing information all the time and work as main and backup mode. Besides, for the air traffic control airspace with high flight flow, it is recommended to build the third LANs. The third LAN is called service LAN, its mainly function is collecting system’s trace and handle recording and playback functions, etc.

### 1.2.4 Challenges and Solutions

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

The system functions are stacking huge, and the system is getting more and more complex. These problems result in that the new ATM automation system is taking more time and much more effort to develop, some system functions are seldom used, the system is getting hard to maintain and spending much more money to deploy.

The outbreak of COVID-19 has a devastating impact on the economy and the aviation industry worldwide. It will not be surprising that the ICAO members, including those in the APAC Region, have to review and even reduce both their capital and operational expenses (CAPEX and OPEX) in coming years, including the expenditure in ATM automation system.

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

To meet the above challenges, it is important to work out a specific recommendation and guidance materials of ATM automation system in main functions/performances, which aim at facilitating the implementation or provision of the robust, safe, efficient ATM automation systems. This will help the APAC regional ATM automation systems share common/core functions/performances, and achieve seamless easily. At the same time, rather than encouraging the APAC CAAs/ANSPs to invest more CAPEX/OPEX to cope with future increase in air

traffic, it is important for the APAC members to put focus on (a) application of new/innovative technologies would help making good business cases, (b) incorporating baseline/key optional features into their system design at early stage, and (c) getting ready/completing system changes during low air traffic periods, with lower costs and risks, before full traffic recovery.

### 1.2.5 Outcomes and Endorsements

To ensure continuous and coherent development of the ATM automation systems that is 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 ATM automation system has been focusing and fruiting in APAC Region since 2018.

The ICAO Asia Pacific Regional ATM Automation System Symposium (APAC RATMS) was held in Nanjing, China, from 22 to 23 November 2018. The symposium successfully addressed the Action Item 54/13 of 54th DGCA Conference on ATM automation system, and it also suggested 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 in regard to 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 ATM Automation System Symposium (APAC RATMS) and other SURICG/4 papers relevant to ATM automation system, 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), was held at the ICAO Regional Office, Bangkok, Thailand, from 2 to 6 September 2019. The meeting 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 ATM automation system issue was also provided to ATM SG/7 meeting. A number of 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 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 ATM automation system. 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 RFAP of ATM AS

This Recommended Functions and Performances of Air Traffic Management Automation System consists of the following parts:

| | |
|---|---|
| Section 1 | Introduction |
| Section 2 | Acronyms and Abbreviations |

| | |
|---|---|
| Section 3 | Reference Documents |
| Section 4 | System Functional Baseline |
| Section 5 | System Design |
| Section 6 | System Software Management |
| Section 7 | System Transition |
| Section 8 | System Maintenance |

## 1.4 Document History and Management

The framework of this document was first introduced in the first Working Group Meeting of ATM Automation System Task Force (ATM AS TF/1) of video conference, which is held in Oct. 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 member states (names of member states will be listed after decided), was established by the Meeting to contribute to the content of the document.

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 ATM automation systems.

## 1.5 Copies

Paper copies of this RFAP of ATM AS 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 emailing APANPIRG through the ICAO Asia and Pacific Regional Office who will send a copy by return email.

## 1.6 Changes to RFAP of ATM AS

Whenever a user identifies a need for a change to this document, a Request for Change (RFC) Form (see Section 1.6 below) should be completed and submitted to the ICAO Asia and Pacific Regional Office. 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 RFAP of ATM AS will be prepared, with the changes marked by an "|" in the margin, and an endnote indicating the relevant RFC, so a reader can see the origin of the change. If the change is in a table cell, the outside edges of the table will be highlighted; e.g.:

| | | |
|---|---|---|
| | | |

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

## 1.7 Editing Conventions

(Intentionally blank)

## 1.8 RFAP of ATM AS Request for Change Form

| **RFC Nr:** | |
|---|---|

Please use this form when requesting a change to any part of this RFAP of ATM AS. 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

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

## 1.9 Amendment Record

| Amendment Number | Date | Amended by | Comments |
|---|---|---|---|
| 0.0 | Feb 2020 | China | The framework of this document is firstly work out by China. |
| 0.1 | | | First completed draft based on the agreed document framework in **XXX** for review and comment by States |
| 0.2 | | | Based on Version 0.1 draft, States make a full comment on the XXX. This is a revised document according to those comments. |
| | | | |
| | | | |

## 2. ACRONYMS AND ABBREVIATIONS

**(To be developed)**

## 3. 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 | 2016 | 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 | |
| 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 | |

# 4. SYSTEM FUNCTIONAL BASELINE

The functional baseline, forming the core of the ATM automation system, 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.

## 4.1 System Compulsory Functions

The compulsory functions are the necessary functions of ATM automation system.

### 4.1.1 Surveillance Data Processing Function (SDP)

The Surveillance Data Processing function receives and processes surveillance data, including single and multiple radar data can form a single radar track and conduct tracking processing, and also can process multi-radar coupling, multi-radar target data fusion.

### 4.1.2 Flight Data Processing Function (FDP)

The Flight Data Processing Function receives and processes flight information data from different sources including AFTN line, SITA line, database, Human Machine Interface Function input and so on. This function follows the progress of a flight through the system, and use relevant data to dynamically optimize 4-D trajectory planning and operation, provides accurate flight information to controllers, and interacts with Human Machine Interface Function.

### 4.1.3 Bypass Surveillance Data Processing Function (BSDP)

The Bypass Surveillance Data Processing Function receives and processes bypass e radar data. This function distributes bypass surveillance data to the system in case of failure of the Surveillance Data Processing Function, acting as a redundancy in the system.

### 4.1.4 Correlation of Surveillance and Flight Data

The Correlation of Surveillance and Flight Data Function combines surveillance data and flight data, establishing an association between a surveillance track and a flight plan, based on the surveillance track’s and the flight plan’s identification codes, as well as the surveillance track’s position in relation to the plan’s route.

### 4.1.5 Alerts and Warning Function

The Alerts and Warning Function provides many alerts and warnings to controllers that are mandatory features of a safe operational system. The presentation of alerts and warnings to controllers occurs through audible alarm, color change and warning text.

**MSAW:** The Minimum Safe Altitude Warning function detects and advises controllers of impending penetrations of hazardous airspace by aircraft (aircraft to ground conflict).

**STCA:** The Short-term Conflict Alert function detects and advises controllers of impending violation of separation standards between two aircraft (aircraft to aircraft conflicts).

**APW:** The Area Proximity Warning function detects and advises controllers of impending penetrations of danger areas to aircraft traffic, (aircraft to airspace conflict).

**Approach Path Monitoring Warning Function (APM) :** The Approach Path Monitoring Warning Function informs the controller the aircraft detected to be outside the predefined approach path profile

**Departure Path Monitoring Warning Function (DPM) :** The DPM monitors the flight trajectory of departing aircraft from each runway and generates visual and audio warning when a departing associated track leaves the required track keeping tolerances.

### 4.1.6 Meteorological Information Processing Function

The Meteorological Information Processing Function receives and processes meteorological information, including QNH and GRIB. This function takes meteorological messages into flight computation, when necessary.

### 4.1.7 Air Ground Data Link Function (AGDL)

The Air Ground Data Link Function manages dialogue between pilots and controllers by the PILOT-CONTROLLER two-way data link, and handles ADS-C reports to establish ADS-C tracks. The Functions support ATS applications, such as Controller–Pilot Data Link Communications (CPDLC), Automatic Dependent Surveillance - contract (ADS-C) and departure clearance (DCL).

### 4.1.8 Variable System Parameter Management Function

The Variable System Parameter Management Function enables the system optimized by the use of Variable System parameter (VSP) settings that can be handled offline and online by specific position.

### 4.1.9 ATS Inter-facility Data Communication Function

The ATS Inter-facility Data Communication Function receives and processes AIDC messages, enabling flight handover between different ATM Automation systems.

### 4.1.10 Human Machine Interface Function (HMI)

The Human Machine Interface Function provides an environment whereby the controller is able to comfortably use the hardware and software technology as tools to enhance the air traffic control service.

### 4.1.11 Recording and Playback Function

The Recording and Playback Function enables the recording of operational data and allows playback of air traffic situations for subsequent analysis. Normally, the playback function is required to be synchronized with voice.

### 4.1.12 System Monitoring and Controlling Function

The System Monitoring and Controlling Function provides monitoring and control facilities for the system.

### 4.1.13 Software Version Management Function

The Software Version Management Function provides a tool to manage software patch and version, for system upgrade and rollback.

### 4.1.14 GNSS Time Synchronization

The GNSS Time Synchronization Function enables the system to synchronize with external GNSS time signals, and ensures that all components of the system are time synchronized.

## 4.2 System Optional Function

For the air traffic control airspace with high flight flow, the ATM automation system optional functions can be added according to the requirements of the air control operation. The optional functions, playing a decisive and strategic role in system, enhance the operational and technical capacity of the ATM automation system.

### 4.2.1 Extended Surveillance Data Processing

ATM automation system should be capable of processing multi-source surveillance data such as ADS-B, WAM, MODE S RADAR, etc.

The system should also be capable of processing DAPs in surveillance data.

### 4.2.2 Extended Correlation

The extension correlation function should use the ICAO 24-bit aircraft address, aircraft identification and the Mode 3/A code to correlate an aircraft’s track with flight plan.

### 4.2.3 Extended Alerts and Warning

**Multi Runway NTZ Alert Function：** The Multiple Runway NTZ Alert Function informs the controller if a track is predicted to infringe an NTZ area within a predefined time interval, or has already infringed an NTZ area in multiple runways mode.

**Medium Term Conflict Detection Warning Function (MTCD)：** The purpose of the MTCD function is to provide information on present and future loss of separation between two

aircrafts for executive controllers, at a tactical time horizon. MTCD facilitates a more pro-active air traffic control, thereby balancing more evenly the workload of tactical and planning tasks, enhancing sector team efficiency and providing an even safer and better service to airspace users. By maximizing the opportunity of pro-actively solving problems during sector planning especially between smaller and highly-sectorized airspaces, it is hoped to reduce tactical workload of air traffic controllers.

**Route Adherence Monitoring (RAM)**: Route Adherence Monitoring (RAM) capability shall check if an aircraft (i.e. surveillance track) is following the planned route, as stated in the associated flight plan.

**Cleared Level Adherence Monitoring (CLAM)** checks the conformance of the actual flight level of a surveillance track with respect to the Cleared Flight Level.

**Departure No Transgression Zone (DTZ)** Warning. This function informs the controller if a track is predicted to infringe a Departure No Transgression Zone area within a predefined time interval, or has already infringed a Departure No Transgression Zone area.

**Similar Callsign Warning Function (SC)：** The Similar Callsign Warn Function informs the controller if aircraft carries similar callsign with other one in sector.

**Reduced Vertical Separation Minimum Warning Function (RVSM)：** The Reduced Vertical Separation Minimum Warning Function inform the controller if the aircraft competent of RVSM capacity.

**Position Report Monitoring** (PMON) Warning. The PMON alerts the controller when the ATO and/or ETO next point stated in the position report differ from that calculated by the flight trajectory by more than a defined time interval.

### 4.2.4 Downlink Aircraft Parameters Processing and Display Function

Downlink Aircraft Parameters can be obtained from Mode S data link or ADS-B broadcast data. The former Application is called Mode S DAPs, and the latter Application is called ADS-B derived data (ADS-B ADD). All these data come from different registers of aircrafts' avionics system, which include aircraft identification, flight status, operation and etc. These data can be used by ATM AS to improve many functions.

**24-Bit Code Mismatch Warning:** When the 24-bit code of the coupled surveillance track does not match the 24-bit code of the FDR, an ICAO 24-bit code mismatch warning shall be presented to the responsible controller.

**Callsign Mismatch Warning:** When the callsign of the coupled surveillance track, if available, does not match the callsign of the FDR, a callsign mismatch warning shall be presented to the responsible controller.

**SFL/CFL Mismatch Warning:** The Predicted Level Mismatch (PLM) function Should be continuously monitored the consistency of Selected Altitude from the airborne equipment and the Cleared Flight Level from controller and notify the controller of inconsistency.

**Resolution Advisory (RA) alert indication:** When a RA alert is established by airborne ACAS system for a risk of collision, on the ATM automation system, RA report via DAPs is gained and processed, and a RA notification is presented on the track label to the responsible controller.

**Downlink Aircraft Parameters (DAPs) display window：** The Downlink Aircraft Parameter Function provides downlink aircraft parameters from Mode S Radar or ADS-B.

### 4.2.5 AMAN

The Arrival Management Function generates advisories for the controller and provides functions including automatic runway allocation and separation calculation to properly expedite the incoming traffic to the managed airports and runways, aimed at reducing the workload of the supported sector controllers, as well as minimizing the aircraft delays and excessive fuel consumption.

### 4.2.6 System Log Management Function

The System Log Management Function manages system hardware and software logs.

### 4.2.7 Enhancement Record and Replay Function

The Air Traffic Situation Scenario Record and Replay Function enables controller position screen recording in common video file format (MP4, WMV, MOV, AVI ,etc ) and corresponding video-replaying. This function provides exact human machine interface recording and replaying.

### 4.2.8 Re-categorization Function

The Re-categorization Function provides wake turbulence re-categorization function to optimize the separation minimum between aircraft, based on safety as priority.

### 4.2.9 Operational Data Synchronization Function

In order to provide continuous ATM service in case of the working ATM AS 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.

### 4.2.10 Statistics and Analysis

Statistical Analysis Function provides statistical analysis based on surveillance and flight data originated or utilized by ATM automation system. This function involved tabulating and depicting of ATC operational data, based on flexible time slot.

## 5. SYSTEM DESIGN

### 5.1 System Architecture

Considering about the safety and redundancy requirements, the network of ATM automation system is recommended to build with A and B dual network structure. Besides, for the air traffic control airspace with high flight flow, it is recommended to build a large scale ATM automation system and add service network C to provide a higher level support. Network A / B are the redundant working LAN, which is used to transmit surveillance data, flight plan and other operational data. Network C is a separate service LAN, which is used to transmit bypass surveillance data, system log and replay data.

The system software should adopt modular designation and distributed architecture to ensure robustness under adverse operating conditions. Different software functions should be deployed on independent servers, and each individual sever connects to the redundancy network. For the key function modules, such as FDP and SDP, should be deployed on dual redundancy servers. Hot stand-by redundancy is achieved by the dual computer groups to ensure the safe, uninterrupted provision of Air Traffic Services by controllers

### 5.2 Position Roles and Types

The system positions may include: controller position, tower position, supervisor position, backup controller position, flight plan position, system monitoring position, technical supervisor position, software data management position, flow management position, coordination position, military coordination position, search and rescue position，operational supervisor position, NTZ monitor position. The position types and quantity can be configured according to the operational situation on each site.

### 5.3 Main and Backup Configuration

For the air traffic control airspace with high flight flow, the operational site requiring a higher level of support, it is recommended to build two sets of ATM automation systems (Main and Backup) simultaneously as the baseline. The Backup system should keep the consistent position scale, system configuration and software function with the Main system. In addition, the Main/Backup data synchronization function should be provided to ensure controllers can switch to the Backup system seamlessly in case of Main system failures.

For the ATM Automation systems handling busy and high density airspaces, it was recommended provision of the main and fallback ATM automation systems with same functions, capability and capacity but in separated systems in order to enhance robustness and continuity in provision of safe, efficient and orderly ATM services. In the APAC Region with high growth in air traffic, disruption to air traffic is not an option. As a best industry practice, the main and fallback systems with compatible data synchronization scheme should be able to switch their main and fallback roles seamlessly once required and regularly for use by ATC controllers and

air traffic engineers. To further enhance resilience and mitigate risks for users handling high air traffic demands, if main and fallback systems were with same functions, capability and capacity provided under the same manufacturer, an ultimate fallback system provided from different manufacturers could be a necessity. All in all, avoiding common software failure across main / fallback / ultimate fallback systems should be a critical consideration for system configuration design.

Should the ATM Automation systems of States/Administrations have not yet equipped with ultimate fallback systems, States/Administrations may consider to take chance of low traffic before traffic recovery by 2024. Likewise, if States/Administrations already have ultimate fallback systems, it could be a chance to plan to upgrade it with same capacity as Main/Fallback to cope with anticipated traffic recovery by 2024.

## 5.4 System Operational Mode

The system should have normal and degraded working modes. When the whole system key functions work normally, the HMI shows system in normal mode. When the system key function (such as FDP or SDP) is failure, the system should automatically change from normal mode to degraded mode. Therefore, the user could be noticed in HMI.

For the site which equipped with Main/Backup systems, the system should also have Main and Backup modes. In the Main operation mode, the system can process AFTN messages, assign SSR codes, and output flight plan data to the Backup system. In the Backup operation mode, the system does not carry out the above processing, but receives and processes the flight plan information from the Main system. It is suggested that the Main/Backup modes should be manually switched by the user at the special position.

## 5.5 Capacity and Performance

### 5.5.1 System Design Capacity

The technical indicators of system design capacity can also be distinguished according to the volume of air traffic control airspace flow, such as high level indicator requirements and low level indicator requirements can be proposed.

The technical indicators shown in the table are the minimum recommended values.

| Indicator name | high level requirements | low level requirements |
|---|---|---|
| System coverage | 4096km*4096km | 2048km*2048km |
| Maximum number of sectors | 48 | 20 |
| Maximum number of UCS | 120 | 40 |
| Simultaneously controlled aircraft | 1500 | 750 |
| Number of restricted areas | 256 | 128 |
| Maximum adjacent AIDC control centers | 40 | 20 |
| Server, workstation CPU load average | 20% | 20% |
| Server, workstation CPU maximum load | 40% | 40% |
| | | |

### 5.5.2 System Time Performance

The system time performance indicators shown in the table are the minimum recommended values.

| Performance parameter name | high level requirements | low level requirements |
|---|---|---|
| Single workstation cold start time | 5min | 5min |
| Cold start time of the entire system station | 10min | 10min |
| MTBF of surveillance data processing | 100000hours | 100000hours |
| MTBF of a single workstation | 10000hours | 10000hours |
| Maximum clock synchronization error | 100ms | 100ms |

### 5.5.3 Performance of Surveillance Data Processing

The performance of surveillance data processing indicators shown in the table are the minimum recommended values.

| Surveillance data processing performance indicators | | high level requirements | low level requirements |
|---|---|---|---|
| Root Mean Square Error of Aircraft Position | Straight flight | 200m | 200m |
| | Turn flight | 450m | 450m |
| Maximum aircraft position error | Straight flight | 500m | 500m |
| | Turn flight | 1100m | 1100m |
| The maximum number of tracks in the system | | 2048 | 1024 |
| Maximum number of radar inputs | | 48 | 16 |
| Maximum number of ADS-B inputs | | 8 | 8 |
| System track refresh cycle | | ⩽5s | ⩽4s |

### 5.5.4 Flight Data Processing Capacity

The capacity of flight data processing indicators shown in the table are the minimum recommended values.

| The capacity of flight data processing | high level indicator requirements | low level requirements |
|---|---|---|
| Number of flight plans | 10000 | 3000 |
| Activate the flight plan Simultaneously | 3000 | 1000 |

### 5.5.5 Record and Playback Function Capacity

The record and playback function capacity indicators shown in the table are the minimum recommended values.

| The record and playback function capacity | high level indicator | low level requirements |
|---|---|---|
| Minimum time for data retention in the system | 31d | 31d |
| Record historical flight plans and AFTN messages | 3months | 3months |

## 5.6 External Interface

The ATM automation system shall be able to receive and process data from radar sensor, ADS-B, WAM, AFTN, GRIB. Besides, the system shall provide interfaces to Voice Replay System interface, Adjacent ATC centers, Time Signals from GNSS, etc.

## 5.7 Systems Interoperability

The systems interoperability function enables ATM automation system to exchange data and interact with other ATM automation system, A-SMGCS, Tower electronic strip system, etc.

## 5.8 Cyber Threats and Mitigation

Cyber threats and mitigation prevent system from suffering cyber-attacks, intrusions, data theft, and the other potential risks in the interconnection environment.

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 manage potential risks arising from cyber security threats. To address the growing concerns on cyber security threats, ICAO published Doc 9985 “ATM Security Manual” in 2013 setting out the principles and guidelines for protecting ATC system infrastructure. States are encouraged to pursue appropriate level of compliance to the cyber security control requirements as stated in the ICAO Doc 9985 ATM Security Manual and make collaborative efforts to effectively address cyber security threats.

Experience from States and Administrations, such as presented in *WP19 of APANPIRG/27 Implementation of Effective Cyber Security Measures to Achieve a Safe, Secured and Efficient Air Traffic Control System by Hong Kong, China*, could be referred on the establishment of management framework in addressing challenges from cyber security threats. This Paper shared the key elements of an effective cyber security management framework for a safe and secured ATC system as well as the latest status achieved by Hong Kong, China in pursuing the ICAO’s ATM Cyber Security Manual.

From experience from Hong Kong, China, it is suggested to establish relevant Committee and Working Group to steer for proactive implementation of effective cyber security measures for their ATC system in Hong Kong. In preparing the transition to the new ATC Centre, a series of verification tests and inspections on the design and implementation of the new ATC system were conducted over the past few years both internally by the subject matter experts, as well as independent cyber security audits carried out by the external consultants from different perspectives.

## 6. SYSTEM SOFTWARE MANAGEMENT

The ATM automation system software management consists of system requirements analysis and management, system fault management, software release & patch management, etc. The purpose of system software management is to build a robust and practical ATM automation system, and keep it in the good operative mode in whole lifecycle.

### 6.1 System Requirements Analysis and Management

The objective of system requirements analysis and management is to ensure the quality, effectiveness and consistency of ATM automation systems' requirements, building robust and practical system with updated technologies to meet the challenge of civil aviation development.

### 6.2 System Fault Management

The ATM automation system fault management includes fault recording, fault diagnosis, fault handling, troubleshooting, etc.

### 6.3 Software Release & Patch Management

Software release & patch management focuses on software modification and test management to ATM automation system, in order to maintain system software stability in multi-sites, reduces system running risks.

## 7. SYSTEM TRANSITION

System Transition is the switch of automation system from old version to the new one. There are two types of transition. One is the software transition in which case there are almost no changes of the hardware. The other one is overall transition. The whole system will be transit to the new one with new hardware and new software.

### 7.1 Transition Plan and Assessment

Before the transition, the technical department and controller department should map out a scheme including the next information at least:

- The preconditions of transition;
- The necessary cooperation between technical department, controller department and other support departments;
- Operational procedure;
- The emergency plans.

### 7.2 Transition Rehearsal

To make sure the success of transition, rehearsals are necessary before implementation. During these rehearsals, all the departments should act according to the operational procedure. The purpose of rehearsal is to find out whether the operational procedure is smooth and the cooperation between departments is perfect.

### 7.3 System Operational Check

To ensure the transition successfully, a check list is necessary to make sure the new system work well. The list should include the technical tests and controller tests. The technical tests mainly focus on the interface test, network test and system monitor test. The controller tests pay attention to the controller functions including flight plan, system tracks, coupling, system warning, and HMI operations.

### 7.4 Flight Check for System Performance Acceptance

To ensure the performance of multi-sensor tracker for non-manoeuvring and manoeuvring aircraft shall be equal to or better than system specification and global/national requirements in performance specification for surveillance applications, such as *EUROCONTROL Specification for ATM Surveillance System Performance*, flight checks are recommended for system performance verification and acceptance.

A recommended check list is provided below to make sure the relevant items for multi-sensor tracker performance could meet the basic requirements for ATM Surveillance System, including but not limited to:

- Measurement interval for probability of update assessments
- Probability of update of horizontal position
- Ratio of missed position involved in long gaps
- Horizontal position RMS error, including
  - Total horizontal RMS error (m)
  - Ground speed RMS error (kt)
  - Course RMS error (deg.)
  - Ground speed std. dev. (stability) (kt)
  - Course std. dev. (stability) (deg.)
- Probability of update of pressure altitude with correct value
- Forwarded pressure altitude average data age

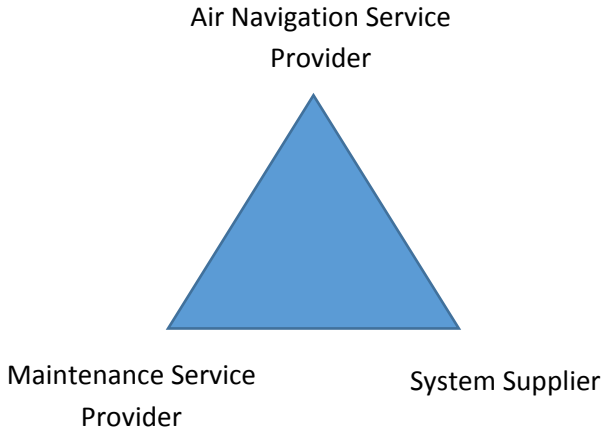
    - Forwarded pressure altitude maximum data age
    - Ratio of incorrect forwarded pressure altitude
    - Pressure altitude unsigned error
    - Delay of change in emergency indicator/SPI report
    - Delay of change in aircraft identity
    - Probability of update of aircraft identity with correct value
- Ratio of incorrect aircraft identity
- SSR Code Change Time in selected waypoints
- Flight Route Accuracy in Position Check in selected waypoints in flight profile, on difference combinations of sensors selectable for contributing to MST.

# 8. SYSTEM MAINTENANCE

As ATM automation system could comprise of provisions from different manufacturers, a robust and systematic maintenance management and practice should be set up with close cooperation with the system supplier, the maintenance service provider (MSP as the frontline maintenance agent, as well as the air navigation service provider (ANSP) as the system management authority, the contract management agent and the end-user to ensure the performance of the system.

Trio for Maintenance Management

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




## 8.1 System Supplier

The design of system plays a critical part for ease of maintenance in operation stage. 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 containing complete information for the 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. These documentation should include:

i) operating handbooks and user manuals for operating procedures and system functionalities for use by controllers, supervisors, assistants and support specialists;

ii) 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.; and

iii) 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 prior to use.

System supplier should prepare training plans and training course materials to ANSP and MSP for review with sufficient lead 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, has to set out the required training topics in the contract to system supplier. Training topics should be specific to different user groups.

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 training/assessment as needed during the start-up and run-in period after commissioning.

As ATMS 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. Same faults occur repeatedly should be handled with high priority by system supplier to investigate root cause and implement measures to prevent recurrences.

As technology is changing rapidly, some spare parts might become obsolete and will be 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 should form user groups to allow sharing of users' experience and gather feedbacks. System supplier should facilitate regular hosting of user group meetings.

### 8.2 Maintenance Service Provider (MSP)

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 ATMS, it would require extra steps or more frequent maintenance 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, ATMS 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 ATMS.

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.

### 8.3 Air Navigation Service Provider (ANSP)

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. For example, timely certification of invoice and payment in accordance with the contract requirements against their performance. 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 can 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 air traffic control (ATC) professionals to perform their work safely and satisfactorily, it is highly desirable for ANSP engineering professionals to understand the ATC needs such that the ATMS could fully support their work. As such, constant communications with ATC in addressing their needs via suitable steering forums and communication channels would be critical to the smooth operations on ATMS. Following the commissioning, an ATMS technical team comprising ANSP engineering professionals, system supplier and MSP was established with regular meetings with ATC to oversee system performance and deployment of software builds/system adaptation updates to ensure smooth operation of the ATMAS.