INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ASIA/PACIFIC REGION

EN-ROUTE MONITORING AGENCY (EMA)

HANDBOOK

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FOREWORD

The Regional Airspace Safety Monitoring Advisory Group (RASMAG) was established during 2004 by the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) to achieve a regional approach for coordination and harmonization of airspace safety monitoring activities, and to provide assistance to States in this respect.

The RASMAG noted that requirements for monitoring aircraft height-keeping performance and the safety of reduced vertical separation minimum (RVSM) operations had been more comprehensively developed than had requirements for monitoring other air traffic management (ATM) services, such as reduced horizontal separation based on performance based navigation (PBN), or for monitoring of air traffic services (ATS) data link systems. Although a handbook with detailed global guidance on the requirements for establishing and operating RVSM Regional Monitoring Agencies (RMA) had been developed by the ICAO Separation and Airspace Safety Panel (SASP), there was no comparable monitoring guidance document under development by ICAO for the safe use of a horizontal-plane separation minimum where PBN is applied and no suitable regional equivalent was available.

ICAO provisions require that the implementation of specified reduced separation minima, e.g. 50 NM lateral separation based on PBN RNAV 10, 50 NM longitudinal separation based on PBN RNAV 10 and Direct Pilot Controller Communication (DCPC), and PBN RNP 4 based 30 NM lateral and longitudinal separation based on Automatic Dependent Surveillance – Contract (ADS-C), Controller Pilot Data Link Communication (CPDLC), must first meet Annex 11 safety management system requirements and undergo a safety assessment based on collision risk modelling to confirm that the regionally established target level of safety (TLS) for the airspace has been met. Additionally, periodic safety reviews must be performed in order to permit continued operations. To date, the performance of safety assessments and continued monitoring for reduced horizontal separation minima had been carried out by a few specialized teams of technical experts and contractors supporting States within the region.

The recent inclusion of the previously independent RNP and RNAV concepts under ICAO's global PBN concept has led to some uncertainty amongst States regarding the monitoring requirements for reduced horizontal separation minima implementations where these minima are based on PBN approvals. The RASMAG agreed that there was a need to develop a handbook aimed at standardizing the principles and practices of the work of En-route Monitoring Agencies (EMAs) established to assess the safety performance of implementations utilizing reduced horizontal plane separations, in order to ensure the continued safe application of reduced horizontal separation standards in international airspace.

In anticipation of more widespread use of the PBN RNAV 10 and RNP 4 navigation specifications within the international airspace of the Asia/Pacific Region, this handbook is being provided to identify the safety assessment and monitoring requirements and related EMA duties and responsibilities associated with those navigation specifications, as well as the reduced separation minima which may be implemented based upon compliance with them. It should be noted that, with the exception of 50 NM lateral separation, introduction of the reduced horizontal minima additionally necessitates satisfaction of explicit communications and surveillance requirements as well as the navigation performance requirements.

The EMA Handbook is presented in two parts. Part 1 defines an EMA, describes its functions by means of a list of duties and responsibilities, and identifies the process by which an organization gains credentials as an EMA. Part 2 provides specific guidance to assist an EMA in carrying out the duties and responsibilities called for by Part 1.

APANPIRG has adopted this EMA Handbook under the terms of **Conclusion 20/25** as an Asia/Pacific regional guidance material. It is intended that the handbook will introduce a common set of principles and practices for safety assessment and ongoing safety monitoring in connection with operational usage of reduced horizontal-plane separation minima based on the application of PBN. The handbook will also help to promote an interchange of information among Asia/Pacific States in support of achieving common operational monitoring procedures, as well as supporting the acquisition and sharing of data resulting from the application of those procedures.

LIST OF ABBREVIATIONS AND ACRONYMS

ADS-C	Automatic Dependent Surveillance - Contract
ANSP	Air Navigation Service Provider
APANPIRG	Asia Pacific Air Navigation Planning and Implementation Regional Group
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CPDLC	Controller Pilot Data Link Communication
CRM	Collision Risk Model
EMA	En-route Monitoring Agency
FIR	Flight Information Region
FTP	File Transfer Protocol
ICAO	International Civil Aviation Organization
LLD	Large Lateral Deviation
LLE	Large Longitudinal Error
MASPS	Minimum Aviation System Performance Standard
NM	Nautical Miles
PBN	Performance-Based Navigation
RASMAG	Regional Airspace Safety Monitoring Advisory Group of APANPIRG
RMA	Regional Monitoring Agency
RNAV	Area navigation
RNP	Required Navigation Performance
RVSM	Reduced Vertical Separation Minimum
SASP	Separation and Airspace Safety Panel
SSR	Secondary Surveillance Radar
STC	Supplemental Type Certificate
TLS	Target Level of Safety

EXPLANATION OF TERMS

Collision risk.
The expected number of mid-air collisions in a prescribed volume of airspace for a specific number of flight hours due to loss of planned separation. (*Note: One collision is considered to produce two accidents.)*

Core (lateral) navigational performance.
That portion of overall navigational performance which accounts for the bulk of observed lateral errors and which can be characterized by a single statistical distribution, usually symmetric about the mean lateral error with the frequency of increasing-magnitude errors decaying at least exponentially.

Exclusionary PBN airspace.
Airspace in which flight cannot be planned by civil aircraft which do not hold a valid PBN approval from the appropriate State authority.

Horizontal separation.
The spacing provided between aircraft in the horizontal (lateral or longitudinal) plane to avoid collision.

Large lateral deviation (LLD).
Any deviation of 15 NM or more to the left or right of the current flight-plan track.

Large longitudinal error (LLE).
Any unexpected change in longitudinal separation between an aircraft pair, or for an individual aircraft the difference between an estimate for a given fix and the actual time of arrival over that fix, as applicable, in accordance with the criteria set out below:

Type of Error	Category of Error	Criterion for Reporting
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Infringement of longitudinal separation standard based on routine position reports
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Expected time between two aircraft varies by 3 minutes or more based on routine position reports
Longitudinal deviation	Individual-aircraft (Time-based separation applied)	Pilot estimate varies by 3 minutes or more from that advised in a routine position report
Longitudinal deviation	Aircraft-pair (Distance-based separation applied)	Infringement of longitudinal separation standard, based on ADS-C, radar measurement or special request for RNAV position report

Type of Error	Category of Error	Criterion for Reporting
Longitudinal deviation	Aircraft-pair (Distance-based separation applied)	Expected distance between an aircraft pair varies by 10NM or more, even if separation standard is not infringed, based on ADS-C, radar measurement or special request for RNAV position report

Occupancy.
A parameter of the collision risk model which is twice the count of aircraft proximate pairs in a single dimension divided by the total number of aircraft flying the candidate paths in the same time interval.

Operational Approval.
An approval granted to an operator by the State authority after being satisfied that the operator meets specific aircraft and operational requirements.

Operational risk.
The risk of collision due to operational errors and in-flight contingencies.

Overall risk.
The risk of collision due to all causes, which includes the technical risk and the operational risk.

Passing frequency.
The frequency of events in which the centers of mass of two aircraft are at least as close together as the metallic length of a typical aircraft when traveling in the opposite or same direction on adjacent routes separated by the planned lateral separation at the same flight level.

Target level of safety (TLS).
A generic term representing the level of risk which is considered acceptable in particular circumstances.

Technical Risk
The risk of collision associated with aircraft navigation performance.

PART 1

Description, Functions and Establishment of an En-route Monitoring Agency

1.1 Description

1.1.1 An En-route Monitoring Agency (EMA) is an organization providing airspace safety assessment and monitoring services to support the introduction and continued safe use of en-route horizontal-plane separation minima. An EMA comprises a group of specialists who carry out specific functions to provide these services. These functions are summarized in the following outline of EMA duties and responsibilities.

1.2 EMA Duties and Responsibilities

1.2.1 The duties and responsibilities of an EMA are:

a) to establish and maintain a database of operational approvals specific to the horizontal-plane separation applied in the EMA's area of responsibility;

b) to coordinate monitoring of horizontal-plane navigational performance and the identification of large horizontal-plane deviations;

c) to receive reports of large horizontal-plane deviations identified during monitoring; to take the necessary action with the relevant State authority and operator to determine the likely cause of the horizontal-plane deviation and to verify the approval status of the relevant operator;

d) to analyze data to detect horizontal-plane deviation trends and, hence, to take action as in the previous item;

e) to undertake data collections as required by RASMAG to:

1) investigate the navigational performance of the aircraft in the core of the distribution of lateral deviations;

2) establish or add to a database on the lateral navigational performance of:

- the aircraft population
- aircraft types or categories
- individual airframes;

3) examine the forecast accuracy of aircraft-provided times at future (i.e next position) required reporting points

f) to archive results of navigational performance monitoring and to conduct periodic risk assessments in light of agreed regional safety goals;

g) to contribute to a regional database of monitoring results;

h) to initiate necessary remedial actions and coordinate with specialist groups as necessary in the light of monitoring results;

i) to monitor the level of risk as a consequence of operational errors and in-flight contingencies as follows:

1) determine, wherever possible, the root cause of each horizontal plane deviation together with its size and duration;

2) calculate the frequency of occurrence;

3) assess the overall risk in the system against the overall safety objectives; and

4) initiate remedial action as required;

j) to initiate checks of the approval status of aircraft operating in the relevant airspace where horizontal-plane separation is applied, identify non-approved operators and aircraft using the airspace and notify the appropriate State of Registry/State of the Operator accordingly;

k) to coordinate/establish appropriate contacts for PBCS via RMA POCS for PBCS non-compliance, compile the submission of PBCS non-compliance reports by States each month and, where necessary, propose APANPIRG ATM Deficiencies, for lack of reporting; and

l) to submit reports as required to APANPIRG through RASMAG.

1.3 Process for Establishing an EMA

1.3.1 An organization proposing to offer EMA services must be approved by the Regional Airspace Monitoring Safety Advisory Group of APANPIRG (RASMAG).

1.3.2 In order to effectively carry out the duties and responsibilities of an EMA, an organization must be able to demonstrate an acceptable level of competence. Competence may be demonstrated by:

a) previous monitoring experience; or

b) participation in ICAO technical panels or other bodies which develop horizontal separation requirements or criteria for establishing separation minima based on PBN; or

c) establishment of a formal relationship with an organization qualified under (a) or (b).

1.3.3 Once competence has been demonstrated, including presentation of sufficient material to RASMAG on which to make a reasoned assessment, the EMA should receive a formal approval by RASMAG as recorded in the relevant RASMAG meeting report and in the *RASMAG List of Competent Airspace Safety Monitoring Organizations.*

1.3.4 The RASMAG regionally approved EMAs and the Asia/Pacific FIRs for which they hold EMA responsibility can be found on the ICAO website – APAC eDocuments, ATM, Safety monitoring. APAC Electronic Documents (icao.int).

PART 2

Responsibilities and Standardized Practices of En-route Monitoring Agencies

2.1 Purpose of this part

2.1.1 The purpose of this Part of the EMA Handbook is to document experience gained by organizations supporting the introduction of reduced horizontal-plane separation minima within the Asia/Pacific Region, and elsewhere, in order to assist an EMA in fulfilling its responsibilities. Where necessary to ensure standardized practices among EMAs, detailed guidance is elaborated further in appendices.

2.2 Establishment and Maintenance of database of PBN and other Approvals

2.2.1 The experience gained through the introduction of RVSM within Asia/Pacific has shown that the concept of utilising monitoring agencies is essential to ensure safety in the region. Monitoring agencies have a significant role to play in all aspects of the safety monitoring process. One of the functions of an EMA is to establish a database of operators and aircraft or aircraft types approved by State authorities for PBN operations and, if necessary, for use of data link (ADS-C/CPDLC) in the region for which the EMA has responsibility. This information is of vital importance in effectively assessing the risk in the airspace.

2.2.2 Aviation is a global industry; many operators may be approved for PBN and data link operations and their approvals registered with an EMA operating in a region where reduced horizontal separation has been implemented. Thus, there is considerable opportunity for information sharing among EMAs. While a region or sub-region introducing reduced horizontal-plane separation may need its own EMA to act as a focal point for the collection and collation of approvals for aircraft operating solely in that region, it may not need to maintain a complete database of all approved aircraft globally. It will, however, be required to establish links with other EMAs in order to determine the PBN and/or data link status of aircraft.

2.2.3 To avoid duplication by States in registering approvals with EMAs, the concept of a designated EMA for the processing of approval data has been established. Under the designated EMA concept, all States are associated with a specified EMA for the reporting of PBN and data link approvals. **Appendix ~~B~~ A** provides a listing of States and the respective designated EMA for PBN and data link approvals. EMAs may contact any State to address safety matters without regard to the designated EMA for approvals.

2.2.4 It is important to note that, in general, the aircraft operating in airspace where implementation of PBN-based separation is planned can be grouped into two categories. Some aircraft operate solely within the airspace targeted for introduction of reduced separation standards (and therefore may not have PBN and other required approval status**)** and others operate both within that airspace and other portions of airspace requiring PBN and other approvals.

2.2.5 It is the responsibility of the EMA supporting implementation of reduced separation to gather State approvals data for the former category of aircraft from authorities responsible for issuing those approvals. To do so requires the EMA to establish a communication link with each such State authority and to provide a precise description of the approvals information required. **Appendix ~~C~~ B** provides typical forms, with a brief description of their use, that an EMA might transmit to a State authority to obtain information on aircraft PBN or data link approval status.

2.2.6 To avoid duplication of work effort, wherever possible the EMA should collect State approvals information for the latter category of aircraft – those already operating in other airspace where reduced horizontal-plane separation minima are applied – from other EMAs. This collection will be facilitated if each EMA maintains, in a similar electronic form, a database of State PBN and data link approvals.

2.2.7 **Appendix ~~D~~ C** describes the minimum database content required and the format in which it should be maintained by an EMA. Appendix ~~D~~ C also contains a description of the data to be shared by EMAs and proposes procedures for data sharing.

2.3 Monitoring of Horizontal Plane Navigation Performance

2.3.1 An EMA must be prepared to collect the information necessary to monitor horizontal-plane navigational performance as part of the risk assessment. It must institute procedures to monitor core navigational performance and to continuously collect information descriptive of large deviations and operational errors in the horizontal plane.

Monitoring Core Navigational Performance

2.3.2 The EMA will investigate the navigational performance of the aircraft in the core of the distribution of lateral deviations by comparing aircraft reported position information with non-aircraft generated position information such as radar data. The EMA analysis of core navigation performance contributes to the determination of lateral overlap probability used in conducting a safety assessment. An EMA must enlist the cooperation of States and air navigation service providers (ANSPs) in monitoring horizontal-plane core navigational performance through the use of secondary surveillance radar or other appropriate surveillance systems. States and ANSPs have the responsibility to cooperate with the EMA and supply any requested data that will contribute to the evaluation of core navigational performance.

Monitoring of Large Lateral Deviations and Large Longitudinal Errors

2.3.3 Experience has shown that LLDs and LLEs have had significant influence on the outcome of safety assessments before and after implementation of PBN-based separation in a portion of airspace. Accordingly, a principal duty of an EMA is to ensure the existence of a programme to collect this information, assess the occurrences and initiate remedial action to correct systemic problems. Section 2.6 provides guidance to an EMA for initiating such remedial actions as may be necessary to resolve systemic problems uncovered by this programme. One way to ensure the existence of such a programme is to develop letters of agreement between States.

2.3.4 A programme to assess the occurrence of LLDs and LLEs will usually include a regional Scrutiny Group to support the EMA monitoring function. A Scrutiny Group is comprised of operational and technical subject matter experts that support the evaluation and classification of LLDs and LLEs.

2.3.5 Within the airspace for which it is responsible, each ANSP will need to establish the means to detect and report the occurrence of large horizontal-plane deviations. Experience has shown that the primary sources for reports of large horizontal-plane deviations are the ATC units providing air traffic control services in the airspace where reduced separation is or will be applied. The surveillance information available to these units – in the form of voice or ADS-C reports and, where available, surveillance radar or ADS-B returns – provides the basis for identifying large horizontal-plane deviations.

2.3.6 A programme for identifying large horizontal-plane deviations should be established and ATC units should report such events monthly. An example format for these monthly reports is shown in **Appendix ~~E~~ D.** These reports should contain, as a minimum, the following information:

a) Reporting unit;
b) Location of deviation, either as latitude/longitude, ATS route waypoint or other ATC fix;
c) Date and time of large horizontal-plane deviation;
d) Sub-portion of airspace, such as established route system, if applicable;
e) Flight identification and aircraft type;
f) Actual flight level or altitude;
g) Horizontal separation being applied;
h) Size of deviation;
i) Duration of large deviation;
j) Cause of deviation;
k) Any other traffic in potential conflict during deviation;
l) Crew comments when notified of deviation; and
m) Remarks from ATC unit making report.

2.3.7 Other sources for reports of large horizontal-plane deviations should also be explored. An EMA is encouraged to determine if operators within the airspace for which it is responsible are willing to share pertinent summary information from internal safety oversight databases. In addition, an EMA should enquire about access to State databases of safety incident reports which may be pertinent to the airspace. An EMA should also examine voluntary reporting safety databases, where these are available, as possible sources of large horizontal-plane deviations incidents in the airspace for which it is responsible.

2.3.8 While an EMA will be the recipient and archivist for reports of large horizontal-plane deviations, it is important to note that an EMA alone cannot be expected to conduct all activities associated with a comprehensive programme to detect and report large horizontal-plane deviations. Rather, an EMA should enlist the support of RASMAG, the ICAO Regional Office, appropriate implementation task forces, scrutiny groups or any other entity that can assist in the establishment of such a programme.

2.4 Conducting Safety Assessments and Reporting Results

Safety Assessment

2.4.1 In order to conduct a safety assessment, an EMA will need to acquire an in-depth knowledge of the use of the airspace, typical aircraft types etc within which the reduced horizontal-plane separation will be implemented. Experience has shown that such knowledge can be gained through acquisition of charts and other material describing the airspace, and through periodic collection and analysis of samples of traffic movements within the airspace. The collation and consideration of this information results in a “Know Your Airspace” (KYA) analysis that documents matters of relevance to the reduced horizontal separation implementation being proposed. An example of a typical KYA analysis is included as **Appendix ~~F~~ E.**

2.4.2 A safety assessment conducted by an EMA consists of estimating the risk of collision associated with the horizontal-plane separation standard and comparing this risk to the established TLS. Examples of internationally recognised Collision Risk Models (CRMs) used in the development and implementation of reduced separation minima and their application in an example safety assessment (for the South China Sea area) are included in **Appendix G** of this document and in the ICAO Doc 9689 *Manual of Airspace Planning Methodology for the Determination of Separation Minima*.

2.4.3 RASMAG will determine the safety reporting requirements (e.g. format and periodicity) for the EMA.

Establishing the Competence Necessary to Conduct a Safety Assessment

2.4.4 Conducting a safety assessment is a complex task requiring specialized skills which are not practiced widely. As a result, prior to receiving RASMAG approval to operate as an EMA, the organization will need to demonstrate to RASMAG the necessary competence to complete the required tasks.

2.4.5 Ideally, an EMA will have the internal competence to conduct a safety assessment. However, recognizing that personnel with the required skills may not be available internally, an EMA may find it necessary to augment its staff, either through arrangements with another EMA or with an external (i.e. non EMA) organization possessing the necessary competence.

2.4.6 If it is necessary to use an external organization to conduct a safety assessment, an EMA must have the competence to judge that such an assessment is done properly. This competence could be acquired through an arrangement with an EMA which has conducted safety assessments.

2.4.7 An EMA will need to take into account that a safety assessment must reflect the factors which influence collision risk within the airspace where the reduced horizontal-plane separation will be applied. Thus, an EMA will need to establish a method to collect and organize pertinent data and other information descriptive of these airspace factors. As will be noted below, some data sources from other airspace where reduced horizontal-plane separation has been implemented may assist an EMA in conducting a safety assessment. However, an EMA may not use the safety assessment results from another portion of airspace as the sole justification for concluding that the TLS will be met in the airspace where the EMA has safety assessment responsibility.

Assembling a sample of traffic movements from the airspace

2.4.8 Samples of traffic movement data should be collected for the entire airspace where reduced horizontal-plane separation will be implemented. As a result, ANSPs providing services within the airspace are required to cooperate in providing this data.

2.4.9 In planning the timing and duration of a traffic movement data sample, an EMA should take into account the importance of capturing any periods of heavy traffic flow which might result from seasonal or other factors. The duration of any traffic sample should be at least 30 days, with a longer sample period left to the judgment of an EMA. By regional agreement, as recorded in APANPIRG Conclusion 16/4, traffic sample data within the Asia/Pacific Region is collected by all States for the month of December each year for purposes of RVSM monitoring. During 2009, APANPIRG 20 expanded the usage of this data under certain conditions to support regional implementations, including reduced horizontal plane separation minima.

2.4.10 The following information should be collected for each flight in the sample:

a) date of flight;
b) flight identification or aircraft call sign, in standard ICAO format;
c) aircraft registration mark, if available;
d) PBN approval type;
e) aircraft type conducting the flight, as listed in the applicable edition of ICAO Doc 8643, Aircraft Type Designators;
f) origin aerodrome, as listed in the applicable edition of ICAO Doc 7910, Location Indicators;
g) destination aerodrome, as listed in the applicable edition of ICAO Doc 7910, Location Indicators;
h) entry point (fix or latitude/longitude) into the airspace;
i) time (UTC) at entry point;
j) flight level (and assigned Mach number if available) at entry point;

k) route after entry point;
l) exit point from the airspace;
m) time (UTC)at exit point;
n) flight level (and assigned Mach number if available) at exit point;
o) route before exit fix; and
p) additional fix/time/flight-level/route combinations that the EMA judges are necessary to capture the traffic movement characteristics of the airspace.

2.4.11 Where possible, in coordinating collection of the sample, an EMA should specify that information be provided in electronic form (for example, in a spreadsheet). **Appendix H** contains a sample specification for collection of traffic movement data in electronic form, where the entries in the first column may be used as column headings on a spreadsheet template.

2.4.12 Acceptable sources for the information required in a traffic movement sample could include one or more of the following: ATC observations, ATC automation system data, automated air traffic management system data and secondary surveillance radar (SSR) reports.

Data Link Performance Monitoring

2.4.13 Applications specific to communication systems required for PBN-based operations such as data link introduce operational and technical risk into the system. Therefore end-to-end safety performance monitoring of air-ground and ground-air data link communication services should be ongoing, in accordance with the information contained in the *Guidance Material for End-to-End Safety and Performance Monitoring of Air Traffic Service (ATS) Data Link Systems in the Asia/Pacific Region***,** issued by the ICAO Asia and Pacific Office, Bangkok. In the assessment of risk levels, an EMA may find it necessary to use data link performance data from data link Central Reporting Agencies (CRAs).

2.4.14 In conducting data link monitoring, CRA's could evaluate the following communication and surveillance performance elements:

a) Position reporting methods and usage;
b) Flight plans and data link capabilities;
c) ADS-C downlink message traffic;
d) ADS-C downlink transit times;
e) ADS-C uplink message traffic;
f) ADS-C uplink transit and response times;
g) Anomalies identified in ADS-C data;
h) Uplink messages with no response;
i) CPDLC uplink and downlink message traffic, including response times; and
j) Communication service provider outages and the effect on data link performance

Determining whether the Safety Assessment satisfies the TLS

2.4.15 "Technical risk" is the term used to describe the risk of collision associated with aircraft navigation performance. Some of the factors which contribute to technical risk are:

a) errors in aircraft navigation systems; and

b) aircraft equipment failures resulting in unmitigated deviation from the cleared flight path, including those where not following the required procedures further increases the risk.

2.4.16 "Operational risk" is the term used to describe the risk of collision due to operational errors and in-flight contingencies. The term "operational error" is used to describe any horizontal deviation of an aircraft from the correct flight path as a result of incorrect action by ATC or the flight crew. Examples of such actions include:

a) a flight crew misunderstanding an ATC clearance, resulting in the aircraft operating on a flight path other than that issued in the clearance;

b) ATC issuing a clearance which places an aircraft on a flight path where the required separation from other aircraft cannot be maintained;

c) a coordination failure between ATC units in the transfer of control responsibility for an aircraft, resulting in either no notification of the transfer or in transfer at an unexpected transfer point;

d) weather deviation (Note: these deviations may be instances where the aircraft captain initiates the manoeuvre using operational authority but without advising ATC, and are not necessarily deemed as being incorrect action. However, they still contribute to operational risk and should be reported).

2.4.17 The TLS which must be satisfied is established by regional agreement and documented in the *Regional Supplementary Procedures* (Doc 7030). The generic Asia/Pacific TLS is presently established, for each dimension (lateral, longitudinal and vertical), as 5×10^{-9} fatal accidents per flight hour due to loss of planned separation; however, specific TLS values may be determined by ICAO for application of a particular separation minimum.

2.5 Monitoring Operator Compliance with State Approval Requirements

2.5.1 The overall intent of post-implementation EMA activities is to support continued safe use of the reduced horizontal-plane separation. One important post-implementation activity is monitoring operator compliance with State approval requirements by carrying out periodic checks of the approval status of operators and aircraft using airspace where PBN-based separation is applied. This is vital if reduced separation is applied on an exclusionary basis, that is, if State PBN and data link approval is a prerequisite for use of the airspace.

2.5.2 An EMA will require two sources of information to monitor operator compliance with State approval requirements: a listing of the operators, and the type and registration marks of aircraft conducting operations in the airspace; and the database of State PBN and data link approvals.

2.5.3 Ideally, this compliance monitoring should be done for the entire airspace on a daily basis. Clearly, difficulties in accessing traffic movement information may make such daily monitoring impossible. However, as a minimum an EMA should conduct compliance monitoring of the complete airspace for at least a 30-day period annually. A flow chart depicting the process required for monitoring operator compliance with State approvals has been included as **Appendix ~~I~~ H**.

2.5.4 When conducting compliance monitoring, the filed PBN or data link approval status shown on the flight plan of each aircraft movement should be compared to the database of State PBN and data link approvals. When a flight plan shows a PBN or data link approval not confirmed in the database, the appropriate State authority should be contacted for clarification of the discrepancy. An EMA should use a letter similar in form to that shown in **Appendix ~~J~~ I** as the official notification.

2.5.5 An EMA should keep in mind that the responsibility to take any action should an operator be found to have filed an incorrect declaration of State PBN or data link approval lies clearly with the State authority, not the EMA. The EMA responsibility is only to make the appropriate State authority aware of the issue, and provide advice or information as requested by the State authority.

2.6 Remedial Actions

2.6.1 Remedial actions are those measures taken to remove causes of systemic problems associated with factors affecting safe use of the PBN-based separation. Remedial actions may be necessary to remove the causes of problems such as the following:

a) failure of an aircraft to comply with PBN or data link requirements,

b) aircraft operating practices resulting in large horizontal-plane deviations, and

c) operational errors.

2.6.2 Monitoring results should be periodically reviewed by the EMA and the associated regional Scrutiny Group in order to determine if there is evidence of any recurring problems or adverse trends. Guidance on the functions of a Scrutiny Group is contained in **Appendix ~~K~~ J.**

2.6.3 As a minimum, an EMA and the associated Scrutiny Group should conduct an annual review of reports of large horizontal-plane deviations with a view toward uncovering systemic problems and initiating remedial action. Should such problems be identified, an EMA should report its findings to the body overseeing horizontal-plane separation implementation, or to the RASMAG. An EMA should include in its report the details of large horizontal-plane deviations suggesting the root cause of the problem.

2.7 Review of Operational Concept

2.7.1 Experience has shown that the operational concept for the application of the horizontal-plane separation adopted by bodies overseeing horizontal-plane separation implementations can substantially affect the collision risk in airspace.

2.7.2 An EMA should review carefully the operational concept agreed by the body overseeing horizontal-plane separation implementation, generally the ANSP, with a view to identifying any features of airspace use which may influence risk. The flow chart at **Appendix ~~L~~ K** provides an overview of the implementation process for reduced horizontal plane separation minima and draws attention to the interrelationships between the implementation activities of the ANSP and the safety assessment and monitoring responsibilities of the EMA. An EMA should inform the oversight body of any aspects of the operational concept which it considers important in this respect.

APPENDIX A

States and Designated EMA for the reporting of En-route PBN and Data Link Approvals

The following table provides a listing of States and the respective designated EMA for the reporting of en-route PBN and data link approvals. Each EMA should advise the relevant States of its requirements with respect to reporting of en-route PBN and data link approvals.

ICAO Contracting State	Designated EMA for PBN and Data Link Approvals
Afghanistan	
Australia	AAMA
Bangladesh	
Bhutan	
Brunei Darussalam	
Cambodia	
China (for Sanya FIR)	SEASMA
China (for Lanzhou and Urumqi FIR)	China RMA
Cook Islands	
Democratic People's Republic of Korea	
Fiji	
India	
Indonesia	
Japan	JASMA
Kiribati	
Lao People's Democratic Republic	
Malaysia	SEASMA
Maldives	
Marshall Islands	
Micronesia (Federated States of)	
Mongolia	
Myanmar	
Nauru	
Nepal	
New Zealand	
Pakistan	
Palau	
Papua New Guinea	
Philippines	SEASMA
Republic of Korea	
Samoa	
Singapore	SEASMA
Solomon Islands	
Sri Lanka	
Thailand	
Tonga	
United States	PARMO
Vanuatu	
Viet Nam	SEASMA

APPENDIX B

<u>EMA Forms For Use in Obtaining Records of En-route PBN and Data Link Approvals from a State Authority</u>

There are 3 EMA forms for the collection of essential information relating to en-route PBN and data link approvals:

EMA A1 – Point of Contact Details for Matters Relating to PBN or Data Link Approvals
EMA A2 – Record of en-route PBN or Data Link Approval
EMA A3 – Withdrawal of en-route PBN or Data Link Approval

1. Please read these notes before attempting to complete forms EMA A1, A2 and A3.

2. It is important for the EMAs to have an accurate record of a point of contact for any queries that might arise from the monitoring of horizontal-plane separation. Recipients are therefore requested to include a completed EMA A1 with their first reply to the EMA. Thereafter, there is no further requirement unless there has been a change to the information requested on the form.

3. Form EMA A2 must be completed for each operator/aircraft granted a PBN or data link approval.

4. Form EMA A3 must be completed and submitted immediately whenever a State of Registry has cause to withdraw an operator/aircraft en-route PBN or data link approval.

5. Note: the fields in the forms EMA A2 and EMA A3 should be completed as indicated below.

Fields	Instruction
State of Registry State of Operator State of PBN Approval	Enter the 2-letter ICAO identifier as contained in ICAO Doc 7910. In the case of there being more than one identifier designated for the State, use the letter identifier that appears first.
Operator Identifier	Enter the operator's 3 letter ICAO identifier as contained in ICAO Doc 8585. For International General Aviation, enter "IGA". If none, place an X in this field and enter the name of the operator/owner in the Remarks row.
Operator Type	Enter or Select Operator Type. E.g. Civil or Military
Registration Date Date of Approval Date of Expiry	Enter date in dd/mm/yyyy format, e.g. for 26 October 2007 enter 26/10/2007.
Aircraft Type	Enter the ICAO designator as contained in ICAO Doc 8643, e.g., for Airbus A320-211, enter A320; for Boeing B747-438 enter B744.
Aircraft Series	Enter series of aircraft type or manufacturer's customer designation, e.g., for Airbus A320-211, enter 211; for Boeing B747-438, enter 400 or 438.
Mode S Address Code (Hex)	Enter ICAO allocated Aircraft Mode S address code in hexadecimal format.
PBN Approval Type	Enter or select the type of PBN Approval, e.g. RNP 2, RNP 4, RNAV 10 or Others. Enter new line for each approval type.
Remarks	Any Remarks

EMA A1

POINT OF CONTACT DETAILS
FOR MATTERS RELATING TO EN-ROUTE PBN OR DATA LINK APPROVALS

This form should be completed and returned to the address below on the first reply to the EMA and when there is a change to any of the details requested on the form. ***PLEASE USE BLOCK CAPITALS THROUGHOUT.***

NAME OF STATE AUTHORITY OR ORGANISATION			
STATE OF REGISTRY			
STATE OF REGISTRY (ICAO 2 letter identifier)			

If there is more than one identifier for the State, please use the first that appears in the list.

ADDRESS DETAILS	
STREET	
CITY	
STATE/PROVINCE	
ZIP/POSTAL CODE	
COUNTRY/REGION	

CONTACT PERSON	
TITLE	
FIRST NAME	
MIDDLE NAME	
LAST NAME	
JOB TITLE	
EMAIL	

PHONE DETAILS			
COUNTRY CODE		AREA CODE	
DIRECT LINE		FAX NUMBER	

Please Tick One: ☐ Initial Reply ☐ Change of details

When complete, please return to:

EMA Address

Telephone:
Fax:
E-Mail

EMA A2

RECORD OF EN-ROUTE PBN APPROVAL

When a State of Registry approves or amends the approval of an operator/aircraft for en-route PBN operations, details of that approval must be recorded and sent to the appropriate EMA without delay.

Please refer to the accompanying notes on the following page before providing the information requested below. **PLEASE USE BLOCK CAPITALS**.

Aircraft & Operator Details	
Registration No	
State of Registry	
Registration Date	
Name of Operator	
State of Operator	
Operator Identifier	
Operator Type	*[CIV/MIL]*
Aircraft Type	
Aircraft Series	
Manufacturers Serial No	
Mode S Address Code	

Approval	*Airworthiness Approval* (State)	*Primary Sensor Type* (DME-DME/ INS/IRS/GNSS)	*Time Limit* (hrs)	*Vertical Guidance* (APV/LPV)	*RF Leg Capable* (Yes/No)	*Limitations* (text)	*Date*	*Operational Approval* (State)	*Date*	*Expiry date*	*Approval withdrawn* (date)	*Information provided by State authority*	*Regional approval*
RNAV10													
RNAV5													
RNAV2													
RNAV1													
RNP4													
RNP2													
Basic RNP1													
Advanced RNP1													
RNP APCH													
RNP AR APCH													
RVSM													
VDL													
Mode S													
SATCOM													
HF													
Remarks													

When complete, please return to the following address.

EMA Address

Telephone:
Fax:
Email:

Fields	Instruction
State of Registry State of Operator State of PBN Approval	Enter the 2-letter ICAO identifier as contained in ICAO Doc 7910. In the case of there being more than one identifier designated for the State, use the letter identifier that appears first.
Operator Identifier	Enter the operator's 3 letter ICAO identifier as contained in ICAO Doc 8585. For International General Aviation, enter "IGA". If none, place an X in this field and enter the name of the operator/owner in the Remarks row.
Operator Type	Enter or Select Operator Type. E.g. Civil or Military
Registration Date Date of Approval Date of Expiry	Enter date in dd/mm/yyyy format, e.g. for 26 October 2007 enter 26/10/2007.
Aircraft Type	Enter the ICAO designator as contained in ICAO Doc 8643, e.g., for Airbus A320-211, enter A320; for Boeing B747-438 enter B744.
Aircraft Series	Enter series of aircraft type or manufacturer's customer designation, e.g., for Airbus A320-211, enter 211; for Boeing B747-438, enter 400 or 438.
Mode S Address Code (Hex)	Enter ICAO allocated Aircraft Mode S address code in hexadecimal format.
PBN Approval Type	Enter or select the type of PBN Approval, e.g. RNP 2, RNP 4, RNAV 10 or Others. Enter new line for each approval type.
Remarks	Any Remarks

EMA A3

WITHDRAWAL OF EN-ROUTE PBN OR DATALINK APPROVAL

When a State of Registry has cause to withdraw the en-route PBN or data link approval of an operator/aircraft, the details requested below must be sent to the EMA without delay.

Please refer to the accompanying notes on the following page before providing the information requested. **PLEASE USE BLOCK CAPITALS**.

State of Registry												
Operator Identifier												
State of Operator												
Aircraft Type												
Aircraft Series												
Manufacturers Serial Number												
Registration Mark												
Mode S Address Code (Hex)												

Approval Withdrawn (PBN or DL)				
Date of Withdrawal				
PBN Withdrawn CAA Official				

Reason for Withdrawal	

When complete, please return to the following address.

EMA Address

Telephone:
Fax:
Email:

Fields	Instruction
State of Registry State of Operator	Enter the 2-letter ICAO identifier as contained in ICAO Doc 7910. In the case of there being more than one identifier designated for the State, use the letter identifier that appears first.
Operator Identifier	Enter the operator's 3 letter ICAO identifier as contained in ICAO Doc 8585. For International General Aviation, enter "IGA". If none, place an X in this field and enter the name of the operator/owner in the Remarks row.
Date of Withdrawal	Enter date in dd/mm/yyyy format, e.g. for 26 October 2007 enter 26/10/2007.
Aircraft Type	Enter the ICAO designator as contained in ICAO Doc 8643, e.g., for Airbus A320-211, enter A320; for Boeing B747-438 enter B744.
Aircraft Series	Enter series of aircraft type or manufacturer's customer designation, e.g., for Airbus A320-211, enter 211; for Boeing B747-438, enter 400 or 438.
Mode S Address Code (Hex)	Enter ICAO allocated Aircraft Mode S address code in hexadecimal format.
Approval Withdrawn	Enter or select the type of PBN Approval, e.g. RNP 2, RNP 4, RNAV 10 or Others. Enter new line for each approval type.

APPENDIX C

Minimal Informational Content for Each State En-route PBN or Data Link Approval to Be Maintained In Electronic Form by an EMA

Aircraft PBN and Data Link Approvals Data

To properly maintain and track PBN and data link approval information some basic aircraft identification information is required (e.g., manufacturer, type, serial number, etc.) as well as details specific to an aircraft's PBN and data link approval status. Table 1 below lists the minimum data fields to be collected by an EMA for an individual aircraft. Table 2 on the following page describes the approvals database record format.

Table 1: *Aircraft PBN and Data Link Approvals Data*

Field	Description
Registration Mark	Aircraft's current registration mark
Mode S Address Code (Hex)	Aircraft's current Mode S code 6 hexadecimal digits
Manufacturer Serial Number	Aircraft Serial Number as given by manufacturer
Aircraft Type	Aircraft Type as defined by ICAO document 8643
Aircraft Series	Aircraft generic series as described by the aircraft manufacturer (e.g., 747-100, series = 100)
State of Registry	State to which the aircraft is currently registered as defined in ICAO document 7910
Registration Date	Date registration was active for current operator
Operator Identifier	ICAO code for the current Operator as defined in ICAO document 8585
Operator Name	Name of the current Operator
State of Operator	State of the current Operator as defined in ICAO document 7910
Operator Type	Aircraft is civil or military
PBN approval type	PBN approval – e.g. RNP 4, RNAV 2, RNP 1
State of PBN approval	State granting PBN approval as defined in ICAO document 9613
Date PBN approved	Date of PBN Approval
Date of PBN expiry	Date of Expiry for PBN Approval
Date of Data Link approval	Date of Data Link Approval
Remarks	Open comments
Date of withdrawal of PBN approval	Date of withdrawal of the aircraft's PBN approval (if applicable)

***Table 2**: Approvals Database Record Format*

Field	Description	Type	Width	Valid Range
State of Registry	State of Registry	Alphabetic	2	AA-ZZ
Operator	Operator	Alphabetic	3	AAA-ZZZ
State of Operator	State of Operator	Alphabetic	2	AA-ZZ
AC Type	Aircraft Type	Alphanumeric	4	e.g. MD11
AC Mark/Series	Aircraft Mark / Series	Alphanumeric	6	
Serial Number	Manufacturer's Serial/Construction Number	Alphanumeric	12	
AC Registration Mark	Aircraft registration mark	Alphanumeric	10	
Mode S	Aircraft Mode "S" address (Hexadecimal)	Alphanumeric	6	000001-FFFFFF
PBN approval type	PBN approval type	Alphanumeric	6	e.g. RNP4
Approval Date	Date PBN approval issued (dd/mm/yyyy)	Date	10	e.g. 31/12/1999
Date of expiry	Date of expiry of PBN approval (if any) (dd/mm/yyyy)	Date	10	e.g. 31/12/1999
DL Approval Date	Date Data Link approval issued (dd/mm/yyyy)	Date	10	e.g. 31/12/1999
Remarks	National remarks	Alphanumeric	60	ASCII text

Aircraft Re-Registration/Operating Status Change Data

Aircraft frequently change registration information. Re-registration and change of operating status information is required to properly maintain an accurate list of the current population. Table 3 below lists the minimum data fields to be maintained by an EMA to manage aircraft re-registration/operating status change data.

Table 3: *Aircraft Re-Registration/Operating Status Change Data*

Field	Description
Reason for change	Reason for change. Aircraft was re-registered, destroyed, parked, etc.
Previous Registration Mark	Aircraft's previous registration mark.
Previous Mode S	Aircraft's previous Mode S code.
Previous Operator Name	Previous name of operator of the aircraft.
Previous Operator ICAO Code	ICAO code for previous aircraft operator.
Previous State of Operator	ICAO code for the previous State of the operator
New State of Operator	ICAO code for the State of the current aircraft operator.
New Registration Mark	Aircraft's current registration mark.
New State of Registration	Aircraft's current State of Registry.
New Operator Name	Current name of operator of the aircraft.
New Operator ICAO Code	ICAO code for the current aircraft operator.
Aircraft ICAO Type designator	Aircraft Type as defined by ICAO document 8643
Aircraft Series	Aircraft generic series as described by the aircraft manufacturer (e.g., 747-100, series = 100).
Serial Number	Aircraft Serial Number as given by manufacturer
New Mode S	Aircraft's current Mode S code 6 hexadecimal digits.
Date change is effective	Date new registration/ change of status became effective.

Point of Contact Data

An accurate and up to date list of contact officers essential for an EMA to conduct its business. Table 4 lists the minimum content for organizational contacts and Table 5 lists the minimum content for individual points-of-contact.

Table 4: *Organizational Contact Data*

Field	Description
Type	Type of contact (e.g., Operator, Airworthiness Authority, Manufacturer)
State	State in which the company is located.
State ICAO	ICAO code for the State in which the company is located.
Company/Authority	Name of the company/authority as used by ICAO (e.g., Bombardier)
Fax No	Fax number for the company.
Telephone number	Telephone number for the company.
Address (1-4)	Address lines 1-4 filled as appropriate for the company.
Place	Place (city, etc.) in which the company is located.
Postal code	Postal code for the company.
Country	Country in which the company is located.
Remarks	Open comments
Modification date	Last Modification Date.
Web-site	Company Web HTTP Location.
e-mail	Company e-mail address.
Civ/mil	Civil or Military.

Table 5: *Individual Point of Contact Data*

Field	Description
Title contact	Mr., Mrs., Ms., etc.
Surname contact	Surname or family name of point of contact.
Name contact	Given name of point of contact.
Position contact	Work title of the point of contact.
Company/Authority	Name of the company/authority as used by ICAO (e.g., Bombardier)
Department	Department for the point of contact.
Address (1-4)	Address lines 1-4 filled as appropriate for the point of contact.
Place	Place (city, etc.) in which the point of contact is located.
Postal code	Postal code for the location of the point of contact.
State	State in which the point of contact is located.
Country	Country in which the point of contact is located.
E-mail	E-mail of the point of contact.
Telex	Telex number of the point of contact.
Fax No	Fax number of the point of contact.
Telephone no 1	First telephone number for the point of contact.
Telephone no 2	Second telephone number for the point of contact.

Data Exchange between EMAs

The following sections describe how data is to be shared between EMAs as well as the minimum data set that should be passed from one EMA to another. This minimum sharing data set is a sub-set of the data defined in previous sections of Appendix ~~D~~ C.

All EMAs receiving data have responsibility to help ensure data integrity. A receiving EMA must report back to the sending EMA any discrepancies or incorrect information found in the sent data.

Data Exchange Procedures

The standard mode of exchange shall be e-mail or FTP, with frequency of submission in accordance with Table 6 below. Data shall be presented in Microsoft Excel or Microsoft Access.

EMAs must be aware that the data are current only to the date of the created file.

Table 6: *EMA Data Exchange Procedures*

Data Type	Data Subset	Frequency	When
PBN and Data Link approvals	All	Monthly	First week in month
Aircraft Re-registration/ status	New since last broadcast	Monthly	First week in month
Contact	All	Monthly	First week in month
Non-Compliant Aircraft	All	As Required.	Immediate

In addition to regular data exchanges, one-off queries shall be made between EMAs as necessary. This includes requests for data in addition to the minimum exchanged data set such as service bulletin information.

Exchange of Aircraft Approvals Data

An EMA shall exchange PBN and Data Link Approvals data with other EMAs. Table 7 below defines the fields required for sending a record to another EMA.

Table 7: *Exchange of Aircraft Approvals Data*

Field	Need to Share
Registration Mark	**Mandatory**
Mode S	Desirable
Serial Number	Desirable
Aircraft Type	**Mandatory**
Aircraft Series	**Mandatory**
State of Registry	**Mandatory**
Registration date	Desirable
Operator Identifier	**Mandatory**
Operator Name	Desirable
State of Operator	**Mandatory**
Civil or military indication (not a field on its own. It is indicated in the ICAO operator code as MIL except when the military has a code)	Desirable
PBN approval type	**Mandatory**
State of PBN approval	**Mandatory**
Date PBN approved	**Mandatory**
Date of PBN approval expiry	**Mandatory**
Date Data Link approved	**Mandatory**
Remarks	No
Date of withdrawal of PBN approval	**Mandatory**
Information by Authority	**Mandatory**

Aircraft Re-Registration/Operating Status Change Data

An EMA shall share all re-registration information.

Table 8: *Exchange of Aircraft Re-Registration/Operating Status Change Data*

Field	Need to Share
Reason for change (i.e. re-registered, destroyed, parked)	**Mandatory**
Previous Registration Mark	**Mandatory**
Previous Mode S	Desirable
Previous Operator Name	Desirable
Previous Operator ICAO Code	**Mandatory**
Previous State of Operator	**Mandatory**
State of Operator	**Mandatory**
New Registration Mark	**Mandatory**
New State of Registration	**Mandatory**
New Operator Name	Desirable
New Operator Code	Desirable
Aircraft ICAO Type designator	**Mandatory**
Aircraft Series	**Mandatory**
Serial Number	**Mandatory**
New Mode S	**Mandatory**
Date change is effective	Desirable

Exchange of Contact Data

An EMA shall share all organization and individual point of contact data in accordance with Tables 9 and 10 below.

Table 9: *Exchange of Organizational Contact Data Fields*

Field	Need to Share
Type	**Mandatory**
State	**Mandatory**
State ICAO	Desirable
Company/Authority	**Mandatory**
Fax No	Desirable
Telephone number	**Mandatory**
Address (1-4)	**Mandatory**
Place	**Mandatory**
Postal code	**Mandatory**
Country	**Mandatory**
e-mail	Desirable
civil/military	Desirable

Table 10: *Exchange of Individual Point of Contact Data Fields*

Field	Need to Share
Title contact	Desirable
Surname contact	**Mandatory**
Name contact	Desirable
Position contact	Desirable
Company/Authority	**Mandatory**
Department	Desirable
Address (1-4)	**Mandatory**
Place	**Mandatory**
Postal code	**Mandatory**
Country	**Mandatory**
State	**Mandatory**
E-mail	Desirable
Fax No	Desirable
Telephone no 1	**Mandatory**
Telephone no 2	Desirable

Confirmed Non-Compliant Information

As part of its monitoring assessments an EMA may identify a non-compliant aircraft. This information should be made available to other EMAs. When identifying a non-compliant aircraft an EMA should include:

- Notifying EMA
- Date sent
- Registration Mark
- Mode S
- Serial Number
- ICAO Type Designator
- State of Registry
- Registration Date
- Operator ICAO Code
- Operator Name
- State of Operator
- Date(s) of non-compliance(s)
- Action started (y/n)
- Date non-compliance resolved

Fixed parameters -Reference Data Sources

The sources of some standard data formats used by an EMA are listed below.

- ICAO Doc. 7910 " Location Indicators"
- ICAO Document 8585 " Designators for Aircraft Operating Agencies, Aeronautical Authorities, and Services"
- ICAO Document 8643 " Aircraft Type Designators"
- IATA "Airline Coding Directory"

APPENDIX D

<u>Suggested Form for ATC Unit Monthly Report of LLD or LLE</u>

[EN-ROUTE MONITORING AGENCY NAME]

Report of Large Lateral Deviation or Large Longitudinal Error

Report to the (*En-route Monitoring Agency Name*) of a large lateral deviation (LLD) or a large longitudinal error (LLE), as defined below:

*Note: Do not include ATC-approved deviation due to weather or other contingency events, unless the deviation magnitude is greater than the approved deviation

Type of Error	Category of Error	Criterion for Reporting
Lateral deviation	Individual-aircraft error	15NM or greater magnitude
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Infringement of longitudinal separation standard based on routine position reports
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Expected time between two aircraft varies by 3 minutes or more based on routine position reports
Longitudinal deviation	Individual-aircraft (Time-based separation applied)	Pilot estimate varies by 3 minutes or more from that advised in a routine position report
Longitudinal deviation	Aircraft-pair (Distance-based separation applied)	Infringement of longitudinal separation standard, based on ADS-C, radar measurement or special request for RNAV position report
Longitudinal deviation	Aircraft-pair (Distance-based separation applied)	Expected distance between an aircraft pair varies by 10NM or more, even if separation standard is not infringed, based on ADS-C, radar measurement or special request for RNAV position report

Name of ATC unit:____

Please complete Section I or II as appropriate

SECTION I:

There were no reports of LLDs or LLEs for the month of __________

SECTION II:

There was/were _____ report(s) of LLD

There was/were _____ report(s) of LLE

Details of the LLDs and LLEs are attached.

(Please use a separate form for each report of lateral deviation or longitudinal error).

When complete please forward the report(s) to:

En-route Monitoring Agency Name
Postal address
Telephone:
Fax:
E-Mail:

NAVIGATION ERROR INVESTIGATION FORM

PART 1 - To be completed by responsible officer in the Service Provider (and aircraft owner/operator if necessary)		
ATC Unit Observing Error:		
Date/Time (UTC):		
Duration of Deviation:		
Type of Error: (tick one)	☐ LATERAL	☐ LONGITUDINAL
Details of Aircraft		
	First Aircraft	**Second Aircraft (when longitudinal deviation observed)**
Aircraft Identification:		
Name of owner/Operator:		
Aircraft Type:		
Departure Point:		
Destination:		
Route Segment:		
Cleared Track:		
Position where error was observed: (BRG/DIST from fixed point or LAT/LONG)		
Extent of deviation – magnitude and direction: (NM for lateral, min/NM for longitudinal)		
Flight Level:		
Approximated Duration of Deviation (minutes)		
For All Errors		
Action taken by ATC:		
Crew Comments when notified of Deviation:		
Other Comments:		

**** (Please Attach ATS Flight Plan)**

NAVIGATION ERROR INVESTIGATION FORM

PART 2 - Details of Aircraft, and Navigation and Communications Equipment Fit (To be completed by aircraft owner/operator)			
LRNS	**Number of Systems (0, 1, 2 etc.)**	**Make**	**Model**
INS			
IRS			
GNSS			
FMS			
Others (please Specify)			
COMS			
HF			
VHF			
SATCOM			
CPDLC			
Which navigation system was coupled to the autopilot at the time of observation of the error?			
Which Navigation Mode was selected at the time of observation of the error?			
Which Communication System was in use at the time of observation of the error?			
Aircraft registration and model/series			
Was the aircraft operating according to PBN requirements?	☐ Yes	☐ No	

NAVIGATION ERROR INVESTIGATION FORM

PART 3 – Detailed description of incident **(To be completed by owner/operator – use separate sheet if required)**
Please give your assessment of the actual track flown by the aircraft, and the cause of the deviation:
Corrective action proposed:

PART 4 – To be completed by owner/operator, only in the event of partial or total navigation equipment failure.			
Navigation System Type	**INS**	**IRS/FMS**	**Others (Please specify)**
Indicate the number of units of each type which failed			
Indicate position at which failure(s) occurred			
Give an estimate of the duration of the equipment failure(s)			
At what time were ATC advised of the failure(s)?			

NAVIGATION ERROR INVESTIGATION FORM

PART 5 – To be completed by investigating agency		
Have all required data been supplied?	☐ Yes	☐ No
Is further investigation warranted?	☐ Yes	☐ No
Will this incident be the subject of a separate report?	☐ Yes	☐ No
Description of Error:		
Classification: (please circle) A B C D E F G H I		

CLASSIFICATION OF NAVIGATION ERRORS	
Deviation Code	**Cause of Deviation**
Operational Errors	
A	Flight crew deviate without ATC Clearance;
B	Flight crew incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.);
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position;
D	ATC system loop error (e.g. ATC issues incorrect clearance, Flight crew misunderstands clearance message etc);
E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility;
Deviation due to navigational errors	
F	Navigation errors, including equipment failure of which notification was not received by ATC or notified too late for action;
Deviation due to Meteorological Conditions	
G	Turbulence or other weather related causes (other than approved);
Others	
H	An aircraft without PBN approval;
I	Others (Please specify)

APPENDIX E

Example "Know Your Airspace" Analysis

Examination of Operations conducted on South China Sea - RNAV routes L642 and M771

1. INTRODUCTION

1.1 This appendix shows how the characteristics of ATS routes L642 and M771 airspace analysis, derived from the traffic movement data collected during December 2007 and other sources, could support the safety assessment on the implementation of the reduced horizontal separation minima. This is an example of a "Know Your Airspace" analysis.

2. BACKGROUND

2.1 As the result of APANPIRG agreement, traffic movement information is collected each December from all Asia/Pacific Region flight information regions (FIRs) within which the Reduced Vertical Separation Minimum (RVSM) is applied. The traffic movement sample is termed the Traffic Sample Data (TSD). The TSD contains the following information for each flight operating in RVSM airspace during the month:

a) call sign;
b) aircraft type;
c) origin aerodrome;
d) destination aerodrome;
e) on entry into the RVSM airspace of the FIR, the entry fix, entry time, entry flight level and route followed after the entry fix;
f) on exit from RVSM airspace, the exit fix, corresponding time and flight level, and route followed after the exit fix; and
g) optionally, for fixes internal to RVSM airspace, the fix name, corresponding time and flight level and routing after the fix

2.2 These data contribute to the conduct of an annual assessment of the safety of continued RVSM use. With proper treatment, these data are also useful to support assessment of the safety of reduced lateral and longitudinal separation minima.

2.3 Four FIRs – Ho Chi Minh, Hong Kong, Sanya and Singapore – have air traffic control responsibility for L642 and M771. Records of all flights operating on L642 and M771 from each of the four TSDs were merged through a software process to avoid duplicate counting of flights. The resulting combined TSD was compared to the TSD from each FIR in order to check for flights missing from individual TSDs but reported in others, and for agreement of times at fixes common to two TSDs. These and other consistency checks led to the conclusion that the quality of data-entry in each of the TSD samples was very high, and that, as a consequence, the combined December 2007 TSD provided a highly reliable basis for gaining insight into the airspace characteristics of flight operations on L642 and M771.

2.4 After processing and merging, a total of 5743 flight operations were observed on L642 and M771 during December 2007.

3. CHARACTERISTICS OF L642 AND M771

3.1 Flights operating on L642 and M771 in the combined December 2007 TSD were examined to identify and quantify several important characteristics of airspace use. Principal among these are the profile of operators using the routes, the aircraft types observed on the routes, the origin-destination aerodrome pairs for operations, flight level use on the routes and the operator/aircraft-type pairs seen to have used L642 or M771.

<u>Operator Profile</u>

3.2 Each traffic movement was examined to determine the operator conducting the flight. A total of 61 unique three-letter ICAO operator designators were observed in the merged TSD. Table 1 presents the top 25 of these operator-designator counts, which account for nearly 97 percent of the operations. As will be noted, the top four operators account for nearly half of the operations, while the top 10 account for about three operations in four.

Number	Operator	Count	Proportion	Cumulative Count	Cumulative Proportion
1	SIA	1045	0.1820	1045	0.1820
2	CPA	839	0.1461	1884	0.3281
3	AXM	439	0.0764	2323	0.4045
4	MAS	393	0.0684	2716	0.4729
5	CES	334	0.0582	3050	0.5311
6	CSN	328	0.0571	3378	0.5882
7	TGW	327	0.0569	3705	0.6451
8	CCA	248	0.0432	3953	0.6883
9	CXA	191	0.0333	4144	0.7216
10	GIA	159	0.0277	4303	0.7493
11	SLK	157	0.0273	4460	0.7766
12	CAL	142	0.0247	4602	0.8013
13	SQC	139	0.0242	4741	0.8255
14	HVN	139	0.0242	4880	0.8497
15	JSA	125	0.0218	5005	0.8715
16	UAL	99	0.0172	5104	0.8887
17	CSZ	97	0.0169	5201	0.9056
18	HKE	62	0.0108	5263	0.9164
19	SHQ	58	0.0101	5321	0.9265
20	AHK	46	0.0080	5367	0.9345
21	TSE	42	0.0073	5409	0.9418
22	CRK	41	0.0071	5450	0.9490
23	VVM	39	0.0068	5489	0.9558
24	KAL	31	0.0054	5520	0.9612
25	CSH	31	0.0054	5551	0.9666

Table 1. Top 25 Operator Designators Observed in Combined December 2007 TSD

3.3 A total of 37 unique ICAO four-letter aircraft-designators were found in the combined December 2007 TSD. Inspection of the data showed that less than one-half of one percent of December 2007 operations on L642 and M771 were conducted by either international general aviation (IGA) or State aircraft. The top 15 aircraft types, accounting for 97 percent of the December 2007 operations, are shown in table 2.

Number	Type	Count	Proportion	Cumulative Count	Cumulative Proportion
1	A320	1083	0.1886	1083	0.1886
2	B772	900	0.1567	1983	0.3453
3	A333	791	0.1377	2774	0.4830
4	B773	557	0.0970	3331	0.5800
5	B738	554	0.0965	3885	0.6765
6	B744	465	0.0810	4350	0.7574
7	A319	314	0.0547	4664	0.8121
8	A306	148	0.0258	4812	0.8379
9	B737	147	0.0256	4959	0.8635
10	A321	145	0.0252	5104	0.8887
11	B752	125	0.0218	5229	0.9105
12	B742	108	0.0188	5337	0.9293
13	MD11	90	0.0157	5427	0.9450
14	B763	82	0.0143	5509	0.9593
15	A343	62	0.0108	5571	0.9701

Table 2. Top 15 Aircraft-Type Designators Observed in Combined December 2007 TSD

3.4 Application of 50 NM longitudinal separation requires availability of Direct Controller-Pilot Communication (DCPC). In previous applications of 50 NM longitudinal separation within the Asia/Pacific Region, this requirement has been satisfied through direct high frequency radio communication between pilots and controllers, as well as through availability of controller-pilot data link communications (CPDLC) and the contract mode of automatic dependent surveillance (ADS-C).

3.5 As can be seen from the table above, the most frequently occurring aircraft type, the A320, accounts for nearly 19 percent of the operations. The DCPC requirement for operations of this aircraft type will likely need to be satisfied by other than CPDLC or ADS-C. The A320 are not known to be among those aircraft types equipped with either CPDLC or ADS-C. Likewise, types 5, 7, 8, 9, 10, 11, 12 and 14 (B738, A319, A306, B737, A321, B757, B742 and B763, respectively) – which account for an additional 19 percent of the operations in the December 2007 sample – are not known to be equipped, typically, with these technologies.

<u>Origin-Destination Aerodromes</u>

3.5 A total of 46 aerodromes appeared as either origins or destinations of flights in the combined December 2007 TSD. These aerodromes gave rise to a total of 106 origin-destination pairings.

3.6 The top 20 origin-destination pairs, in terms of operations, are shown in table 3. As can be seen from the table, nearly one in five operations flew between Singapore Changi Airport and Hong Kong International Airport.

Number	Origin/ Destination	Count	Proportion	Cumulative Count	Cumulative Proportion
1	WSSS VHHH	549	0.0956	549	0.0956
2	VHHH WSSS	509	0.0886	1058	0.1842
3	ZSPD WSSS	297	0.0517	1355	0.2359
4	WSSS ZSPD	271	0.0472	1626	0.2831
5	VHHH WMKK	221	0.0385	1847	0.3216
6	WMKK VHHH	207	0.0360	2054	0.3577
7	VVTS WSSS	177	0.0308	2231	0.3885
8	ZBAA WSSS	174	0.0303	2405	0.4188
9	WSSS ZBAA	174	0.0303	2579	0.4491
10	ZSPD WMKK	159	0.0277	2738	0.4768
11	WSSS ZSAM	156	0.0272	2894	0.5039
12	VHHH VVTS	143	0.0249	3037	0.5288
13	WMKK ZSPD	142	0.0247	3179	0.5535
14	WSSS ZGGG	133	0.0232	3312	0.5767
15	VMMC WMKK	130	0.0226	3442	0.5993
16	ZGGG WSSS	128	0.0223	3570	0.6216
17	WMKK VMMC	127	0.0221	3697	0.6437
18	VHHH WIII	124	0.0216	3821	0.6653
19	WIII VHHH	119	0.0207	3940	0.6861
20	ZSAM WSSS	115	0.0200	4055	0.7061

Table 3. Top 20 Origin-Destination Pairs Observed in Combined December 2007 TSD

Use of the RNAV Routes

3.7 Table 4 shows use of the two routes in the combined December 2007 TSD. As can be seen, the proportion of operations on the two routes is not balanced.

Number	Route	Count	Proportion	Cumulative Count	Cumulative Proportion
1	L642	3067	0.5340	3067	0.5340
2	M771	2676	0.4660	5743	1.0000

Table 4. Count of Operations on L642 and M771

Flight-Level Usage on L642 and M771

3.8 Table 5 below presents the flight levels (FLs) and associated frequencies observed in the traffic sample. As can be seen, in order of use, FLs 360, 380 and 340 are the preferred altitudes on the routes, and account for 77 percent of the operations. The one observation at FL220 is very likely due to a minor error in data transcription or interpretation.

Number	FL	Count	Proportion	Cumulative Count	Cumulative Proportion
1	360	1738	0.3026	1738	0.3026
2	380	1442	0.2511	3180	0.5537
3	340	1244	0.2166	4424	0.7703
4	400	565	0.0984	4989	0.8687
5	320	459	0.0799	5448	0.9486
6	390	93	0.0162	5541	0.9648
7	300	90	0.0157	5631	0.9805
8	310	36	0.0063	5667	0.9868
9	410	29	0.0050	5696	0.9918
10	330	24	0.0042	5720	0.9960
11	370	9	0.0016	5729	0.9976
12	350	7	0.0012	5736	0.9988
13	290	6	0.0010	5742	0.9998
14	220	1	0.0002	5743	1.0000

Table 5. Flight-Level Use on L642 and M771

Operator/Aircraft-Type Combinations

3.9 In all, 107 combinations of operator and aircraft type were observed in the combined December 2007 TSD. The top 21 such combinations, accounting for 70 percent of the operations, are shown in Table 6, with both the operator and aircraft type designations shown in standard ICAO notation. The knowledgeable reader can determine readily those combinations likely to be equipped with CPDLC and ADS-C.

Pair Number	Operator-Aircraft Type	Count	Proportion	Cumulative Count	Cumulative Proportion
1	SIA-B772	611	0.1064	611	0.1064
2	AXM-A320	439	0.0764	1050	0.1828
3	CPA-A333	336	0.0585	1386	0.2413
4	TGW-A320	327	0.0569	1713	0.2983
5	SIA-B773	312	0.0543	2025	0.3526
6	CPA-B773	245	0.0427	2270	0.3953
7	MAS-A333	193	0.0336	2463	0.4289
8	CXA-B737	144	0.0251	2607	0.4539
9	SQC-B744	139	0.0242	2746	0.4781
10	JSA-A320	125	0.0218	2871	0.4999
11	CES-A333	124	0.0216	2995	0.5215
12	CES-A319	122	0.0212	3117	0.5427
13	SIA-B744	122	0.0212	3239	0.5640
14	CSN-A320	103	0.0179	3342	0.5819
15	MAS-B772	103	0.0179	3445	0.5999
16	UAL-B744	99	0.0172	3544	0.6171
17	CSN-A319	99	0.0172	3643	0.6343
18	CSZ-B738	97	0.0169	3740	0.6512
19	CPA-B772	95	0.0165	3835	0.6678
20	SLK-A319	93	0.0162	3928	0.6840
21	GIA-B738	92	0.0160	4020	0.7000

Table 6. Top 21 Operator/Aircraft-Type Combinations Observed in Combined December 2007 TSD

4. SUMMARY

4.1 The above reviews the Top 25 operators, Top 15 aircraft types, Top 20 origin-destination pairs, flight level use and Top 21 operator/aircraft-type combinations observed in the TSDs in light of the planned introduction of 50 NM lateral and longitudinal separation standards on L642 and M771. Using published information about data link use in other portions of Asia/Pacific Region airspace, this analysis notes the possible aircraft types and operators which might qualify for application of the reduced horizontal separation minima.

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APPENDIX F

Example Safety Assessment

South China Sea Collision Risk Model and Safety Assessment

1. Introduction

1.1 The South East Asia Safety Monitoring Agency (SEASMA), an En-route Monitoring Agency (EMA), is responsible for supporting continued safe use of the six major air traffic service routes in South China Sea international airspace. This support consists of discharging the EMA duties listed in the Asia/Pacific En-route Monitoring Agency Handbook.

1.2 The purpose of this appendix is to present an example of a safety assessment, as conducted by SEASMA on the six major South China Sea routes, together with the collision risk model used, to assess compliance with APANPIRG-agreed Target Level of Safety (TLS) values for the maintenance of lateral and longitudinal separation standards. The examination period covered is 1 May 2008 through 30 April 2009.

2. Background

2.1 The six South China Sea routes – L642, M771, N892, L625, N884 and M767 – were introduced in November 2001 in order to relieve congestion in the airspace. At the same time, State approval for Required Navigation Performance 10 (RNP 10) (now RNAV 10 under Performance Based Navigation (PBN) terminology) became mandatory for operation at or above flight 290 (FL 290).

2.2 This performance requirement was the basis for employing a minimum lateral separation standard of 60NM between-route centerlines. As shown in Table 1, the six routes are organized into three route-pairs to serve principal origin destination points, no pre-departure clearance (No-PDC) flight levels by route and some information about routes crossing the RNAV routes.

Route	Principal Service	Direction of Flow	No-PDC Flight Levels
RNAV L642	Hong Kong/Singapore-Kuala Lumpur	Northeast-southwest	310, 320, 350, 360, 390 and 400
RNAV M771	Singapore-Kuala Lumpur /Hong Kong	Southwest-northeast	Same as L642
RNAV N892	Northeast Asia-Taiwan/Singapore	Northeast-southwest	Same as L642
RNAV L625	Singapore /Northeast Asia-Taiwan	Southwest-northeast	Same as L642
RNAV N884	Singapore /Manila	Southwest-northeast	Same as L642
RNAV M767	Manila/Singapore	Northeast-southwest	Same as L642
Crossing Routes	Various	Bidirectional	Dependent upon route

Table 1: Characteristics of Air Traffic Service Routes in South China Sea

2.3 The longitudinal separation minimum published for the six routes in November 2001 was 10 minutes with Mach Number Technique (MNT), or 80NM RNAV.

2.4 Radar monitoring of horizontal plane navigational performance was initiated with introduction of the RNAV routes. The enabling Letter of Agreement (LOA) – signed by China, Hong Kong China, Indonesia, Malaysia, Singapore, Thailand, Vietnam, and Philippines – specified details concerning the categories of errors to be monitored and reported to Singapore on a monthly basis. The LOA also called for reporting associated counts of flights monitored.

2.5 In anticipation of horizontal-plane separation changes being pursued by the ICAO South-East Asia RNP Task Force (RNP-SEA/TF), the LOA was revised in 2008 to formalize certain monitoring activities which had been carried out previously on an informal basis. Table 2 indicates the fixes where monitoring is taking place under the revised LOA.

Route	Fixes	Monitoring Authority
L642	ESPOB to ENREP	Singapore
M771	DULOP and DUMOL	Hong Kong, China
N892	MELAS and MABLI	Singapore
L625	AKOTA and AVMUP	Philippines
N884	LULBU and LEGED	Philippines
M767	TEGID to BOBOB	Singapore

Table 2: Monitored Fixes in South China Sea Airspace

2.6 Since adoption of the original LOA, all instances of certain types of lateral and longitudinal errors have been reported to Singapore. The specifics of error-reporting are shown in Table 3. As will be noted, monitoring systems include automatic dependent surveillance – contract (ADS-C) and position reports, in addition to radar.

Type of Error	Category of Error	Criterion for Reporting
Lateral deviation	Individual-aircraft error	15NM or greater magnitude
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Infringement of longitudinal separation standard based on routine position reports
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Expected time between two aircraft varies by 3 minutes or more based on routine position reports
Longitudinal deviation	Aircraft-pair (Time-based separation applied)	Pilot estimate varies by 3 minutes or more from that advised in a routine position report
Longitudinal deviation	Aircraft-pair (Distance-based separation applied)	Infringement of longitudinal separation standard, based on ADS, radar measurement or special request for RNAV position report
Longitudinal deviation	Aircraft-pair (Distance-based separation applied)	Expected distance between an aircraft pair varies by 10NM or more, even if separation standard is not infringed, based on ADS, radar measurement or special request for RNAV position report

Table 3. Reporting Criteria for South China Sea Monitoring Programme

2.7 The monitoring criteria in Table 3 were chosen to support eventual work by the RNP-SEA/TF to introduce PBN separation standards, specifically RNAV 10-based 50NM lateral and longitudinal separation and RNP 4-based 30NM lateral and longitudinal separation. On 2 July 2008, the first of these separation reductions was introduced: the lateral separation standard between L642 and M771 was changed to 50NM and the preferred basis for longitudinal separation on these routes was changed to distance from time, with the minimum longitudinal separation standard between co-altitudes pairs reduced to 50NM.

3. Results of Data Collection

3.1 Table 4 shows the record of ANSP reporting of observed large errors and corresponding traffic counts covered by the South China Sea monitoring programme LOA (2008 revision) for the period May 2008 through April 2009.

Month	Report received from:		
	Hong Kong, China	**Philippines**	**Singapore**
May 2008	Yes	No	Yes
June 2008	Yes	No	Yes
July 2008	Yes	No	Yes
August 2008	Yes	Yes	Yes
September 2008	Yes	Yes	Yes
October 2008	Yes	Yes	Yes
November 2008	Yes	Yes	Yes
December 2008	Yes	Yes	Yes
January 2009	Yes	Yes	Yes
February 2009	Yes	Yes	Yes
March 2009	Yes	Yes	Yes
April 2009	Yes	Yes	Yes

Table 4. Record of ANSP Reporting by Month for Period May 2008 through April 2009

3.2 *Reported Traffic Counts for May 2008 through April 2009 Monitoring Period*

3.2.1 Table 5 presents the total traffic counts reported by month transiting all South China Sea monitoring fixes.

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
May 2008	8123	81591
June 2008	7743	83239
July 2008	8423	85383
August 2008	7568	86638
September 2008	7293	87800
October 2008	7673	89029
November 2008	6576	89457
December 2008	6665	89597
January 2009	7244	90880
February 2009	6380	89434
March 2009	7016	88438
April 2009	6603	87307

Table 5. Monthly Count of Monitored Flights Operating on South China Sea RNAV Routes

3.3 *Reports of LLD for May 2008 to April 2009 Monitoring Period*

3.3.1 There were no reported LLDs during the period May 2008 through April 2009.

3.3.2 Table 6 below presents the cumulative totals of LLDs in a manner similar to the traffic counts of table 5.

Monitoring Month	Cumulative 12-Month Count of LLDs Reported Over Monitored Fixes Through Monitoring Month
May 2008	2
June 2008	2
July 2008	2
August 2008	2
September 2008	2
October 2008	2
November 2008	1
December 2008	0
January 2009	0
February 2009	0
March 2009	0
April 2009	0

Table 6. Monthly Count of LLDs on South China Sea RNAV Routes

3.4 *Reports of LLEs for May 2008 through April 2009 Monitoring Period*

3.4.1 No ANSP reported an LLE in any of the categories shown in table 3 during the monitoring period.

4 The Collision risk model

4.1 *Lateral Collision risk model: Compliance with Lateral TLS Value*

4.1.1 Currently, the lateral separation standard between RNAV routes L642 and M771 is 50NM and 60NM otherwise for the other RNAV routes. The form of the lateral collision risk model used in assessing the safety of operations on the South China Sea RNAV routes is:

$$N_{ay} = P_y(S_y)P_z(0)\frac{\lambda_x}{S_x}\left\{E_y(same)\left[\frac{\overline{|\dot{x}|}}{2\lambda_x}+\frac{\overline{|\dot{y}(S_y)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]+E_y(opp)\left[\frac{\overline{V}}{\lambda_x}+\frac{\overline{|\dot{y}(S_y)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]\right\} \quad (1)$$

4.1.3 Table 7 presents the following descriptive information concerning equation (1) and its use in the ongoing assessment of RNAV-route lateral collision risk compliance with the APANPIRG-agreed TLS value of 5 x 10^{-9} fatal accidents per flight hour: (a) parameter definition, (b) parameter estimate value used in compliance assessment and (c) source for value of parameter estimate.

4.1.4 It should be noted that the value for the opposite-direction lateral occupancy parameter, a measure of the proximity of co-altitude aircraft on laterally adjacent routes, shown in table 7 has been updated based on the December 2008 TSD. The value is based solely on the passings observed between aircraft operating on L642 and M771 and is considered conservative, that is, leading to a higher lateral collision risk estimate than might be the case if operations on all RNAV routes were used in developing an occupancy estimate. Because of the opposite-direction flow on a pair of RNAV routes, no value of $\overline{|\dot{x}|}$, the same-direction relative along-track speed of a co-altitude aircraft pair on laterally adjacent routes, is presented.

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
N_{ay}	Risk of collision between two aircraft with planned 50NM lateral separation	5.0 x 10^{-9} fatal accidents per flight hour	TLS adopted by APANPIRG for changes in separation minima
S_y	Lateral separation minimum	50NM	Current lateral separation minimum between L642 and M771; used as common South China Sea lateral separation standard in compliance assessment
$P_y(50)$	Probability that two aircraft assigned to parallel routes with 50NM lateral separation will lose all planned lateral separation	2.69 x 10^{-9}	Value required to meet exactly the APANPIRG-agreed TLS value using equation (1), given other parameter values shown in this table.
λ_x	Aircraft length	0.0399NM	Based on December 2008 TSD operations on L642/M771
λ_y	Aircraft wingspan	0.0329NM	
λ_z	Aircraft height	0.0099NM	
$P_z(0)$	Probability that two aircraft assigned to same flight level are at same geometric height	0.538	Commonly used in safety assessments
S_x	Length of half the interval, in NM, used to count proximate aircraft at adjacent fix for occupancy estimates	120NM, equivalent to the +/- 15-minute pairing criterion	Arbitrary criterion which does not affect the estimated value of lateral collision risk
$E_y(same)$	Same-direction lateral occupancy	0.0	Result of direction of traffic flows on each pair of RNAV routes
$E_y(opp)$	Opposite-direction lateral occupancy	0.78	Based on December 2008 TSD; only operations on L642/M771 used to derive estimate
$\overline{V}$	Individual-aircraft along-track speed	483.9 knots	Combined December 2008 TSD
$\overline{\lvert \dot{y}(S_y) \rvert}$	Average relative lateral speed of aircraft pair at loss of planned lateral separation of S_y	75 knots	Conservative value based on assumption of waypoint insertion error
$\lvert \dot{z} \rvert$	Average relative vertical speed of a co altitude aircraft pair assigned to the same route	1.5 knots	Conservative value commonly used in safety assessments

Table 7 - Summary of Risk Model Parameters Used in Lateral Safety Assessment

4.2 *Longitudinal Collision Risk model: Compliance with Longitudinal TLS Value*

4.2.1 Currently, the longitudinal separation standard for co-altitude aircraft on RNAV routes, L642 and M771, is 50NM; the longitudinal separation standard for the other RNAV routes is either 10 minutes with Mach Number Technique (MNT) or 80NM.

4.2.2 The form of the longitudinal collision risk model used in assessing the safety of operations on the South China Sea RNAV routes is:

$$N_{ax} = P_y(0)P_z(0)\frac{2\lambda_x}{\overline{|\dot{x}|}}\left[\frac{\overline{|\dot{x}|}}{2\lambda_x}+\frac{\overline{|\dot{y}(0)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]\times\sum_{k=m}^{N}\sum_{K=k}^{M}Q(k)\times P(K>k) \qquad (2)$$

4.2.3 Table 8 below presents information about the parameters of the longitudinal collision risk model not already discussed in Table 7.

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
N_{ax}	Risk of collision between two co-altitude aircraft with planned longitudinal separation equal to at least the applicable minimum longitudinal separation standard	5.0×10^{-9} fatal accidents per flight hour	TLS adopted by APANPIRG for changes in separation minima
$P_y(0)$	Probability that two aircraft assigned to same route will be at same across-track position	0.2	May 2008 safety assessment of 50NM longitudinal separation minimum presented at RASMAG/9
$\overline{\lvert\dot{x}(m)\rvert}$	Minimum relative along-track speed necessary for following aircraft in a pair separated by m at a reporting point to overtake lead aircraft at next reporting point	100 knots	RASMAG/9 safety assessment
$\overline{\lvert\dot{y}(0)\rvert}$	Relative across-track speed of same-route aircraft pair	1 knot	RASMAG/9 safety assessment
m	Longitudinal separation minimum	50NM	Current preferred longitudinal separation minimum on RNAV routes L642 and M771; used for all RNAV routes in TLS compliance assessment

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
N	Maximum initial longitudinal separation between aircraft pair which will be monitored by air traffic control in order to prevent loss of longitudinal separation standard	150NM	Arbitrary value of actual initial separation beyond which there is negligible chance that actual longitudinal separation will erode completely before next air traffic control check of longitudinal separation based on position reports
M	Maximum longitudinal separation loss over all pairs of co-altitude aircraft	Dependent on initial longitudinal separation distance	RASMAG/9 safety assessment showed that amount of initial longitudinal separation lost depends upon initial separation value
$Q(k)$	Proportion of aircraft pairs with initial longitudinal separation k	Initial distribution of longitudinal separation for RNAV routes L642 and M771 used in RASMAG/9 safety assessment	Combined December 2007 TSD
$P(K > k)$	Probability that a pair of same-route, co-altitude aircraft with initial longitudinal separation k will lose at least as much as k longitudinal separation before correction by air traffic control	Values derived to satisfy TLS of 50NM longitudinal separation minimum presented at RASMAG/9	Result of direction of traffic flows on each pair of RNAV routes

Table 8. Summary of Additional Risk Model Parameters Used in Longitudinal Safety Assessment

5. Safety Assessment

5.1 Results from the monitoring programme found in paragraph 3 have shown consistently that adherence to track and maintenance of inter-aircraft longitudinal separation are good in the airspace. Since initiation of monitoring in November 2001, there have been only two instances of a lateral deviation of 15NM or more from centerline and no reported large longitudinal error reported to Singapore.

5.2 Since January 2005, States have monitored roughly 300,000 flights while recording the two instances of large lateral deviations and no instances of reportable longitudinal errors. A reasonable conclusion from these results is that, whatever the values that pertain in the lateral and longitudinal dimensions, the rates of occurrence of large horizontal-plane navigational errors are so low that they do not evidence themselves frequently in the number of flights monitored.

5.3 The few instances of reported large errors are consistent with several facts about the South China Sea operational environment, as follows:

- the six RNAV routes have been fixed at the same coordinates since November 2001,
- more than 97 percent of operations are conducted by commercial operators regularly flying the routes,
- more than 98 percent of the operations are conducted using aircraft types of the most recent generations, and
- more than 60 percent of South China operations are conducted on the L642 and M771 routes where radar surveillance and very high frequency radio coverage are extant throughout almost all of the route lengths, providing the opportunity for controller intervention in the event that an aircraft or aircraft pair begins to stray.

5.4 Given the small number of reported large errors, the estimation of lateral and longitudinal collision risk is more challenging. This is because it is more difficult to estimate the two key probabilities on which the risk values depend: the probability that a pair of aircraft will lose, respectively, all planned 50 NM lateral separation and 50 NM minimum longitudinal separation – repressed symbolically as $Py(50)$ and $Px(Sx \mid Sx \geq 50)$.

5.5 The approach taken to estimating the two probability values is the same. It will be described for the case of lateral separation; differences in the outcome for longitudinal separation will be discussed after the lateral-separation case is explained.

5.6 <u>*Direct estimation of Lateral Collision Risk*</u>

5.6.1 This approach considers that the process of monitoring a flight has the following properties:

- a flight's performance observed at a monitored fix is the same as its performance during that portion of its operation where performance is not monitored formally,
- from the standpoint of the monitoring programme, there are only two possible outcomes for a flight: either observing a 15-NM or greater magnitude lateral deviation – the monitoring criterion for reporting a large lateral deviation in South China Sea airspace – or not observing a large lateral deviation
- p is the probability that a large lateral deviation occurs during a flight,
- p is constant from flight to flight
- Monitoring programme observation of a large lateral deviation for a flight does not influence the chance that a large lateral deviation will be observed for any other flight.

5.6.2 As a result, monitoring a flight can be considered to be a Bernoulli trial with probability, p, of "success" (observing a large lateral deviation) and probability $q = (1 - p)$, of "failure" (observing a lateral error less than 15NM in magnitude). Thus, the statistical distribution describing the probability of obtaining k "successes" (or large lateral deviations) in M successive trials (or monitoring observations) is the binomial:

$$b(M; k, p) = \binom{M}{k} p^k (1-p)^{(M-k)} = (M!)/(((M-k)!) \bullet (k!))$$

where, for example, k! = k • (k-1) • (k-2)….2 • 1

The expected number of successes in n trials is given by:

M • p

For Bernoulli trials, it is well known that, if the number of trials, M, increases while the probability, p, of success from trial to trial decreases such that the product expected number of successes, M • p, remains sensibly constant, the probability of k successes in M trials, b(M; k ,p), can be approximated by the Poisson distribution, p(k; λ), where:

$$p(k;\lambda) = e^{-\lambda}\lambda^k/(k!)$$

The parameter, λ, termed as the "intensity parameter", is the expected value of the distribution, or expected number of successes, given by:

$$\lambda = M \bullet p$$

As can be seen by comparing the two, the expected value of the binomial distribution, M • p, and the Poisson distribution, λ = M • p. are the same.

It is common to refer to p as the "success rate."

5.6.3 The Poisson distribution has application in estimating the number of arrivals of requests for service at a telephone switchboard, for example, higher values of λ will correspond to a more intense traffic at the switchboard. In the case of the South China Sea monitoring programme, the Poisson distribution is used to describe the number of large lateral deviations observed for M flights in the regions of the monitored fixes.

5.6.4 It is important to recognize that many values of λ could have produced the observed monitored results. The first recorded instance of a large lateral deviation was November 2007. From January 2005 to that time, roughly 167,000 flights were monitored without observation of a large lateral deviation. The occurrence of no errors during this period would have been consistent with a value of λ = 0.0, which would have corresponded to a success rate, p, of 0.0. In addition, it is intuitive that small "success" rates greater than 0.0 could have produced no observed large lateral deviations in 167,000 trials. For example, it is highly likely that a success rate, p, or rate of large lateral deviations, of 1×10^{-16} per flight could have produced no large lateral deviations in 167,000 monitored flights, since the expected number of large lateral errors, or successes, with this error rate is given by:

λ = M • p = expected number of successes

or:

λ = p • n = (1×10^{-16} large lateral deviations/flight) • (167,000 flights)
= 1.67×10^{-11}

which is nearly 0 successes, or observed large lateral deviations.

5.6.5 The process of increasing the possible error rate and determining if the expected number of large lateral errors in 167,000 trials would be consistent with the number observed could be continued until some reasonable upper bound is determined. That upper rate value could then be used as a conservative estimate of the true, but unknown, error rate which is consistent with the monitored results.

5.6.6 The procedure used to produce an upper bound on the rate of large lateral deviations is to determine the value of the Poisson-distribution parameter, λ, which corresponds to a probability of 0.05 that the true, but unknown, rate of large lateral deviations would lead to more errors than the k errors, observed during a monitoring period. That is, to determine a value of λ such that:

$$0.05 = \text{Probability of more than k errors} = \sum_{N>k}^{\infty} p(N;\lambda)$$

Since p(k; λ) is a probability distribution,

$$\sum_{N>k}^{\infty} p(N;\lambda) = 1 - \sum_{N=0}^{k} p(N;\lambda)$$

Thus, the expression can be re-written into the computationally more convenient form:

$$\sum_{N=0}^{k} p(N;\lambda) = 1 - 0.05 = 0.95$$

For the period from November 2001 until November 2007, the number of observed large lateral deviations was 0 each month. That is, k took on the value 0 for each month. In these cases, the expression above becomes:

$$\begin{aligned} 0.95 &= \sum_{N=0}^{k} p(N;\lambda) \\ &= \sum_{N=0}^{0} p(N;\lambda) \\ &= p(k=0;\lambda) \\ &= e^{-\lambda}\lambda^{k}/(k!) \\ &= e^{-\lambda}\lambda^{0}/(0!) \end{aligned}$$

Since both λ^0 and (0!) evaluate to 1, the expression above reduces to

$$0.95 = e^{-\lambda}$$

or,

$$\lambda = -\ln(0.95)$$

where ln(0.95) is the Natural logarithm of 0.95

Since the value of -ln(0.95) is roughly 0.05,

$$\lambda \approx 0.05$$

or, taking the approximate value as exact for ease of use and substituting the expression for λ in terms of p and M,

λ	$= 0.05$
$p \bullet M$	$= 0.05$
p	$= 0.05/M$

where
p is the error rate per flight, and
M is the number of monitored flights

5.6.7 In the method to estimate South China Sea lateral risk, the cumulative numbers of flights and reported large lateral deviations reported for the 12 months up to and including month N are used to estimate the lateral risk for month N. Thus, M is taken to be the total number of flights monitored within the last 12 months up to and including month N.

5.6.8 The two large lateral deviations were reported as single occurrences in November and December 2007. In the cases of the months November 2007 through November 2008, determination of the value of λ involves evaluation of the expression

$$0.95 \quad = \sum_{N=0}^{k} p(N;\lambda)$$

for k =1 and k = 2, depending upon the month from November 2007 through November 2008.

When k = 1 or 2, the expression is a transcendental equation in λ, most easily solved numerically. The values of λ for k =0, 1 and 2 are 0.051293, 0.35540 and 0.81770, respectively.

This approach yields a proportion, p, of lateral deviations at least as large in magnitude as 15NM for each month of the monitoring programme.

5.6.9 It is now necessary to impose a further assumption in order to obtain a value for Py(50), the probability that two aircraft with planned lateral separation of 50NM lose all planned lateral separation, for risk computation. Many years of experience by a number of States in analyzing lateral navigational performance has resulted in agreement on a general form for the distribution of lateral errors. The distribution, usually termed a "double double exponential" is a combination of two double exponential, or First Laplace, distributions which can be represented symbolically as:

$$f(y;\beta_1,\beta_2) = ((1-\alpha)/2\beta_1)e^{-|y|/\beta_1} + (\alpha/2\beta_2)e^{-|y|/\beta_2}$$

for $\quad -\infty < y < \infty$

$\beta_2 > \beta_1 > 0$

$\alpha > 0$

5.6.10 The first exponential is usually referred to as the "core" distribution since it is intended to describe typical lateral navigational performance; the second is generally called the "tail" distribution since it is intended to model the atypical, large lateral errors. For each distribution, the standard deviation, σ, is related to the parameter, β, by:

$$\beta = \sigma / 2$$

The parameter, α, is the weight of the larger-error component of the overall distribution.

The proportion of the overall distribution in excess of some absolute value of lateral deviation, Y, is given by:

Probability $\{y \geq |Y|\} = (1-\alpha)e^{-|Y|/\beta_1} + \alpha e^{-|Y|/\beta_2}$

The self-convolution of this distribution, C(z), evaluated at the separation standard, Sy, is related to the probability of lateral overlap by

$$p_y(S_y) = 2\lambda_y \bullet C(S_y)$$

It is well known that if β_2 is much greater thanβ_1, then

Probability $\{y \geq |Y|\} = e^{-|Y|/\beta_2}$

and

$$p_y(S_y) = (2\alpha\lambda_y / \beta_2)e^{-S_y/\beta_2}$$

Further, for a fixed value of α, the maximum value of C(Sy) is reached whenβ_2= Sy , expressed as α/(e • Sy).

5.6.11 In the approach to estimating collision risk for South China Sea airspace, it has been assumed, conservatively, that the convolution will take on its maximum. Thus, for the value of Py(Sy) necessary to meet exactly the Target Level of Safety (TLS), the required value of α is thus:

(Py(Sy) e • Sy)/ 2 λy

The approach, thus, reduces to determining whether the constraint that, for k large lateral deviations observed in M flights,

$$\lambda(k)/M = (1-\alpha)e^{-|15|/S_y} + \alpha e^{-|15|/S_y}$$

can be satisfied for α which results in meeting exactly the TLS. Radar data collected in the Singapore FIR, although of a limited amount, indicates that the standard deviation of lateral deviations arising form typical navigational performance is 0.5NM to 1.0NM. Values in this range result in the value of $(1-\alpha)e^{-|15|/S_y}$ to be negligible in comparison to $\alpha e^{-|15|/S_y}$. As a result,

$$\lambda(k)/M = \alpha e^{-|15|/S_y}$$

This constraint results in a computed value of α. The proportion by which the lateral collision risk differs from the TLS, multiplied by the TLS value, becomes the estimated lateral collision risk.

5.7 *Estimation of Longitudinal Collision Risk*

5.7.1 For the case of longitudinal collision risk estimation, the results from South China Sea monitoring indicate that there have been no reported instances of 3-minute or greater unexpected separation loss between a pair of co-altitude aircraft. These monitored data represent a sample of the convolution density function directly, rather than a sample of individual-aircraft deviation which then must go through the process of distribution identification and fitting in order to produce a sample convolution density function.

5.7.2 It is assumed that the unexpected loss of longitudinal decays exponentially as the value of unexpected separation loss increases. If x represents unexpected separation loss, this assumption results in using an exponential distribution to characterize the probability of unexpected longitudinal separation loss between a pair of co-altitude aircraft. Using g(x) to represent distribution of unexpected longitudinal separation loss, the form of this distribution is:

$$g(x) = \varphi e^{-\varphi x}$$

5.7.3 In a manner similar to the approach for estimating lateral collision risk, the parameter φ is estimated from the proportion of 3-minute or greater unexpected longitudinal separation loss which is derived from the Poisson–variate assumption. Once determined, this exponential distribution is used in conjunction with the distribution of initial inter-aircraft separation determined from data collection to support longitudinal risk estimation.

5.8 *Compliance with Lateral and Longitudinal TLS Values*

5.8.1 Figure 1 below presents the results of taking the direct estimation shown above for the monitoring period May 2008 to April 2009

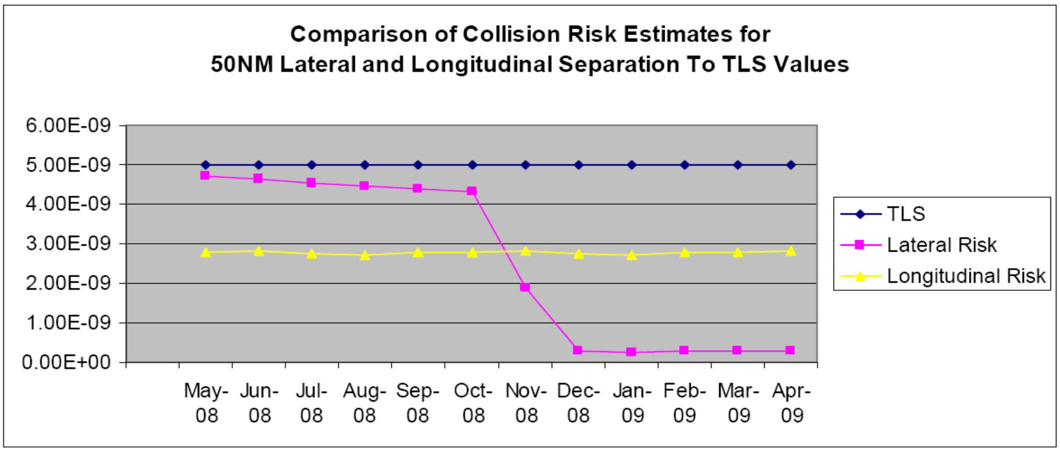


Figure 1. Assessment of Compliance with Lateral and Longitudinal TLS Values Based on Navigational Performance Observed During South China Monitoring Programme

5.8.2 As can be seen, both the estimates of lateral and longitudinal risk during the monitoring showed compliance with the TLS during all months of the monitoring period.

APPENDIX G

<u>Sample Content and Format for Collection of Sample of Traffic Movements</u>

The following table lists the information required for each flight in a sample of traffic movements.

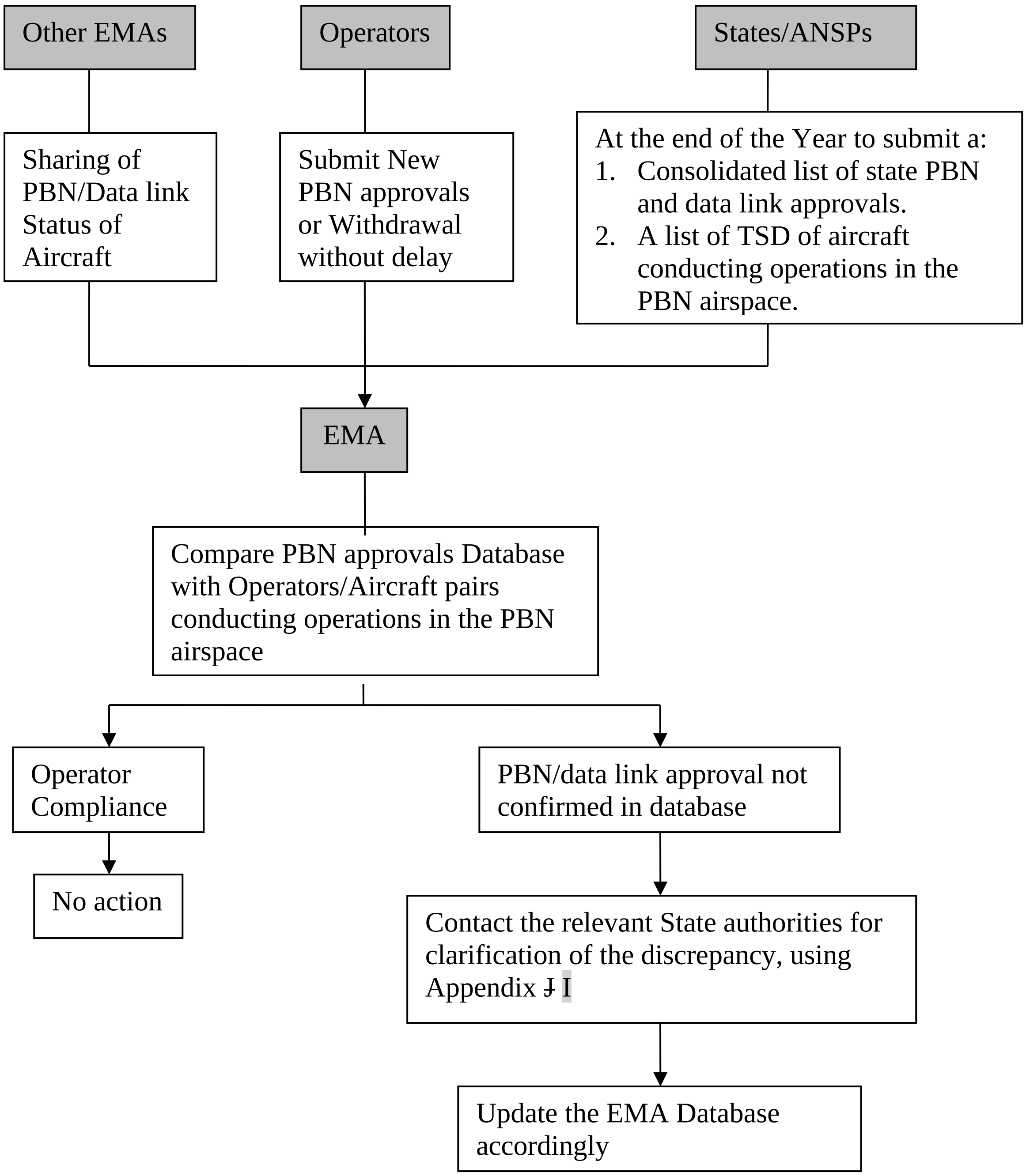
INFORMATION FOR EACH FLIGHT IN THE SAMPLE

The information requested for a flight in the sample is listed in the following table with an indication as to whether the information is necessary or is optional:

FIELD	EXAMPLE	MANDATORY OR OPTIONAL
Date (dd/mm/yyyy)	08/05/2007 for 8 May 2007	MANDATORY
Aircraft Call Sign	XXX704	MANDATORY
Aircraft Registration Mark	VH-ABC	MANDATORY
PBN Approval type	RNP 4	MANDATORY
Aircraft Type	B734	MANDATORY
Origin Aerodrome	WMKK	MANDATORY
Destination Aerodrome	RPLL	MANDATORY
Entry Fix into Airspace	MESOK	MANDATORY
Time at Entry Fix (UTC)	0225 or 02:25	MANDATORY
Flight Level at Entry Fix	330	MANDATORY
Assigned Mach number at Entry Fix	M0.77	OPTIONAL
Route after Entry Fix		MANDATORY
Exit Fix from Airspace	NISOR	MANDATORY
Time at Exit Fix (UTC)	0401 or 04:01	MANDATORY
Flight Level at Exit Fix	330	MANDATORY
Assigned Mach number at Exit Fix	M0.77	OPTIONAL
Route before Exit Fix		MANDATORY
First Fix Within the Airspace OR First Airway Within the Airspace	MESOK OR G582	OPTIONAL
Time at First Fix (UTC)	0225 or 02:25	OPTIONAL
Flight Level at First Fix	330	OPTIONAL
Route after first fix		OPTIONAL
Second Fix Within the Airspace OR Second Airway Within the Airspace	MEVAS OR G577	OPTIONAL
Time at Second Fix (UTC)	0250 or 02:50	OPTIONAL
Flight Level at Second Fix	330	OPTIONAL
Route after second fix		OPTIONAL
(Continue with as many Fix/Time/Flight-Level/Route entries as are required to describe the flight's movement within the airspace)		OPTIONAL

APPENDIX G

Monitoring Operator Compliance with State Approval Requirements Flow Chart



APPENDIX I

Letter To State Authority Requesting
Clarification Of The State En-route PBN or Data Link Approval Status Of An Operator

When the en-route PBN or data link approval status shown in filed flight plan is not confirmed in an EMA's database of State approvals, a letter similar to the following should be sent to the relevant State authority.

<STATE AUTHORITY ADDRESS>

1. The (*EMA name*) has been established by the ICAO Asia/Pacific Regional Airspace Safety Monitoring Advisory Group (RASMAG) to support safe implementation and use of the horizontal-plane separation in (*airspace where the EMA has responsibility*), in accordance with guidance published by the International Civil Aviation Organization.

2. Among the other activities, the (*EMA name*) conducts a comparison of the State en-route PBN and data link approval status, provided by an operator to an air traffic control unit, to the record of State en-route PBN and data link approval available to us. This comparison is considered vital to ensuring the continued safe use of horizontal-plane separation.

3. This letter is to advise you that an operator which we believe is on your State registry provided notice of State en-route PBN or data link approval which is not confirmed by our records. The details of the occurrence are as follows:

Date:
Operator name:
Aircraft flight identification:
Aircraft type:
Registration mark:
Filed PBN Approval type:
Filed Data Link Approval Status:
ATC unit receiving notification:

4 We request that you advise this office of the en-route PBN and data link approval status of this operator. In the event that you have not granted an en-route PBN or data link approval to this operator, we request that you advise this office of any action which you propose to take.

Sincerely,

(*EMA official*)

APPENDIX J

Scrutiny Group Guidance

1. Composition

The Scrutiny Group requires a diverse set of subject-matter expertise. The Scrutiny Group could consist of subject matter experts in air traffic control, aircraft operation, operational pilot groups, regulation and certification, data analysis, and risk modeling from the involved regions.

If necessary, a working group could be formed to discuss specific subject matters, and might consist of subject matter experts and specialists from member States, EMA, CRA, etc. The working group would be responsible for executing the preparatory work for a meeting of the Scrutiny Group, including the analysis and categorization of selected LLDs and LLEs.

2 Purpose

The goal of the Scrutiny Group is to examine reports of LLDs and LLEs from the EMA monitoring programme with the objective of determining which reports from the monitoring programme will influence the risk of collision associated with the reduced horizontal separation. For example, the Scrutiny Group could examine possible LLDs and LLEs affected by the reliability and accuracy of the avionics within the aircraft and/or by external meteorological events and/or by the human element in the development of the safety assessment.

Once the Scrutiny Group has made its initial determination, the data are reviewed to look for performance trends. If any adverse trends exist, the Scrutiny Group may make recommendations to either ANSPs or regulatory authorities for reducing or mitigating the effect of those trends as a part of ongoing reduced horizontal separation safety oversight.

3 Process

The primary method employed is to examine existing databases as well as other sources and analyze events resulting in:

- Lateral tracking errors based on a deviation of 15 NM either side of track, or a lesser deviation value determined by the EMA as necessary where lower value PBN specifications are used

- Variations of longitudinal separation of three minutes or more; or

- Variations of longitudinal separation of 10 NM or more.

These events are usually the result of operational errors, navigation errors or meteorologically influenced events etc. The largest source of reports useful for these purposes comes from existing reporting systems, such as the reporting system established by regional agreement.

The Scrutiny Group should meet to analyze reports of LLDs and LLEs so that adverse trends can be identified quickly and remedial actions can be taken to ensure that risk due to operational errors has not increased following the implementation of reduced horizontal separation.

4 Analysis and Methodology

The working group is tasked to analyse the reports of interest and examine the category assigned to each event. The event categories can be found in the EMA handbook, Appendix ~~E~~ D.

The working group relies on its expert judgment and operational experience to analyse these reports. Upon completion of their preliminary analysis, the working group will present the results to the Scrutiny Group.

The Scrutiny Group shall examine its working group's analysis results and take follow-up action as required.

APPENDIX K

Pre/Post-Implementation Reduced Horizontal Separation Minima Flow Chart