



International Civil Aviation Organization

**The Twenty-First Meeting of the Regional Airspace Safety Monitoring
Advisory Group (RASMAG/21)**

Bangkok, Thailand, 14-17 June 2016

Agenda Item 3: Reports from Asia/Pacific RMAs and EMAs

MAAR SAFETY REPORT

(Presented by MAAR)

Summary

This paper provides the results of the airspace safety oversight for the RVSM operation in Bay of Bengal (BOB), Western Pacific/South China Sea (WPAC/SCS), and Mongolian Airspace. The paper also proposes some actions in regards to Traffic Sample Data (TSD) and safety issues in the regions.

1. INTRODUCTION

1.1. This paper provides the executive summary of airspace safety oversight for the RVSM operation in Bay of Bengal (BOB), Western Pacific/South China Sea (WPAC/SCS), and Mongolian Airspace.

1.2. The reports of BOB, WPAC/SCS, and Mongolia are provided in **Attachment 1, 2 and 3** respectively. Each report contains:

- Traffic Sample Data (TSD) and LHD reports used in risk estimation,
- summary of LHD occurrences and their associated risk,
- risk estimation parameters and results,
- further discussion including geographical location of LHDs and hot spots,
- Long Term Height-keeping Monitoring (LTHM) status, and
- an appendix containing details of LHD reports.

2. DISCUSSION

Executive Summary

2.1. **Table 1** summarizes Bay of Bengal (BOB) airspace RVSM technical, operational, and total risks. **Figure 1** presents collision risk estimate trends during the period from Jan 2015 to Dec 2015.

BOB Airspace – estimated annual flying hours = 2,326,493 hours (note: estimated hours based on Dec 2015 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 20 Total Risk	18.73×10^{-9}	5.0×10^{-9}	Above TLS

Technical Risk	0.83×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	31.44×10^{-9}	-	-
Total Risk	32.27×10^{-9}	5.0×10^{-9}	Above TLS

Table 1: BOB Airspace RVSM Risk Estimates

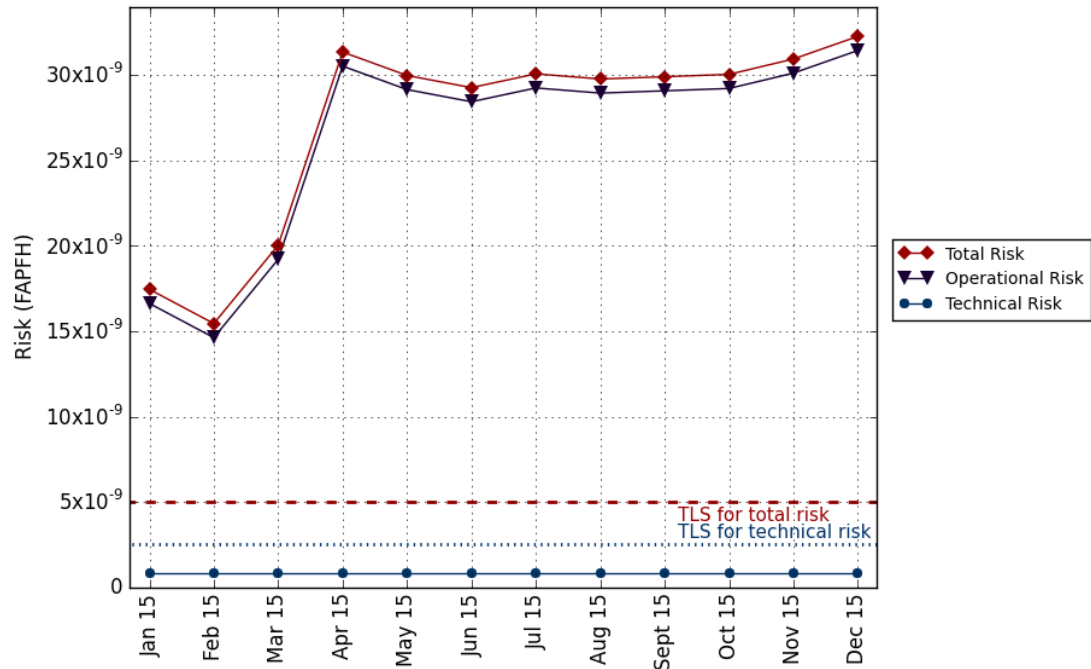


Figure 1: BOB Airspace RVSM Risk Estimate Trends

2.2. **Table 2** presents a summary of the LHD causes within BOB airspace from Jan 2015 to Dec 2015.

Code	LHD Category Description	No.	LHD Min	# FLs crossed	Risk $\times 10^{-9}$
A	Flight crew fails to climb or descend the aircraft as cleared	1	0	0	0.00
B	Flight crew climbing or descending without ATC clearance	2	29	8	0.71
C	Incorrect operation or interpretation of airborne equipment	0	0	0	0.00
D	ATC system loop error	6	34	3	0.91
E	ATC transfer of control coordination errors due to human factors	366	1426	12	27.85
F	ATC transfer of control coordination errors due to technical issues	0	0	0	0.00
G	Aircraft contingency leading to sudden inability to maintain level	0	0	0	0.00
H	Airborne equipment failure and unintentional or undetected level change	0	0	0	0.00
I	Turbulence or other weather related cause	2	29	0	0.53

J	TCAS resolution advisory and flight crew correctly responds	1	0	1	0.25
K	TCAS resolution advisory and flight crew incorrectly responds	0	0	0	0.00
L	Non-approved aircraft is provided with RVSM separation	0	0	0	0.00
M	Other	2	13	0	1.19
Total		380	1531	24	31.44

Table 2: Summary of LHD Causes within BOB Airspace

2.3. **Figure 2 and 3** provide the geographic location of risk bearing LHD reports within BOB Airspace during the assessment period.

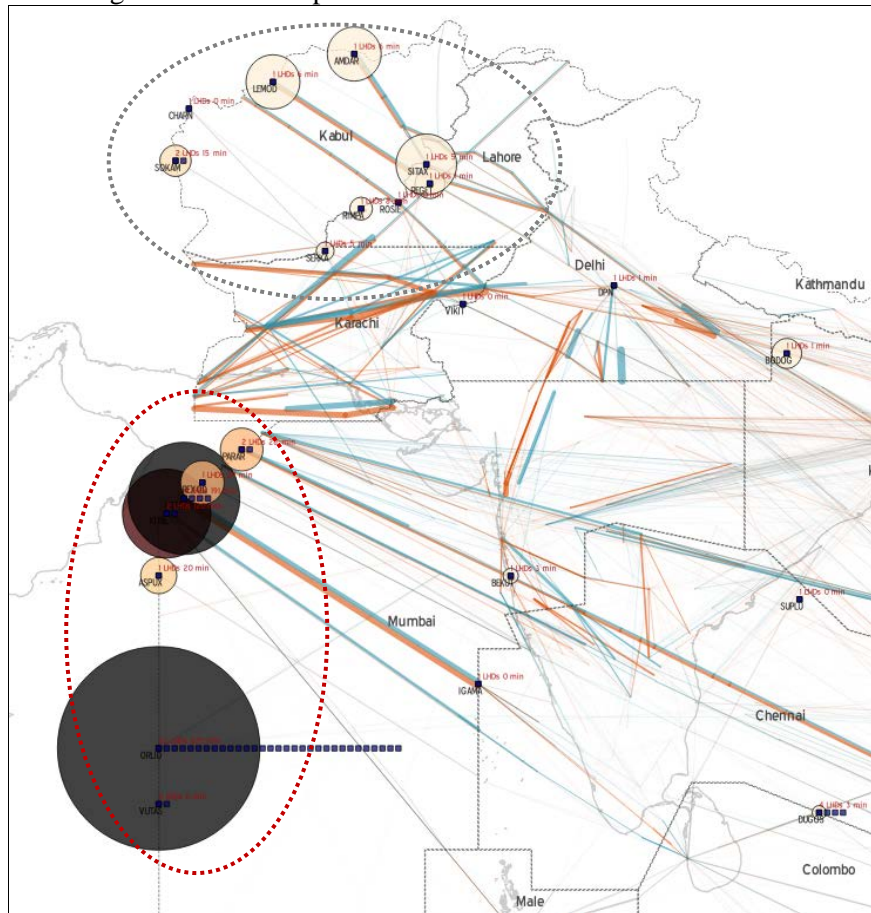


Figure 2: Geographical Location of LHDs in BOB Airspace

2.4. The first area of interest is the boundary of Kabul FIR. In 2014, the hot spot consists of 20 occurrences of 124 minutes in total at GADER, which reduced to 0 in 2015. In 2015, there are only 9 occurrences along the Kabul FIR boundary, most of which involved aircraft entering Kabul FIR at upper flight levels instead of lower flight levels in accordance with the LOA. These aircraft were, then, instructed to descend to the correct flight levels. For each occurrence of this type, Kabul ACC Supervisor/Controller either contacted the transferring ACC and reiterated the instructions IAW the LOA or notified the correct routing information to the flight crew.

2.5. A new hot spot emerged in the year 2015 – **the western boundary of the Mumbai FIR**, which interfaces with Mogadishu, Sana, and Muscat FIRs. The total risk in Mumbai FIR accounted for 19×10^{-9} FAPFH or 61% of total operational risk in BOB. This area is mostly remote oceanic airspace and therefore, has poor communication coverage. The LHDs either have short duration or very long duration. Three LHDs, occurring in March and April, each have duration greater than 100 minutes. The longest duration LHD of 120 minutes, which occurred in March, involved an aircraft passing the entire Mumbai FIR without Mumbai OCC’s knowledge.

2.6. Please note that the surge in long-duration LHDs in March and April coincided with the temporary closure of Sana FIR, and therefore, may be attributed to an increase in re-directed traffic through Mogadishu FIR. However, two long-duration LHDs were reported in the first quarter of 2016 even with the reopening of Sana FIR.

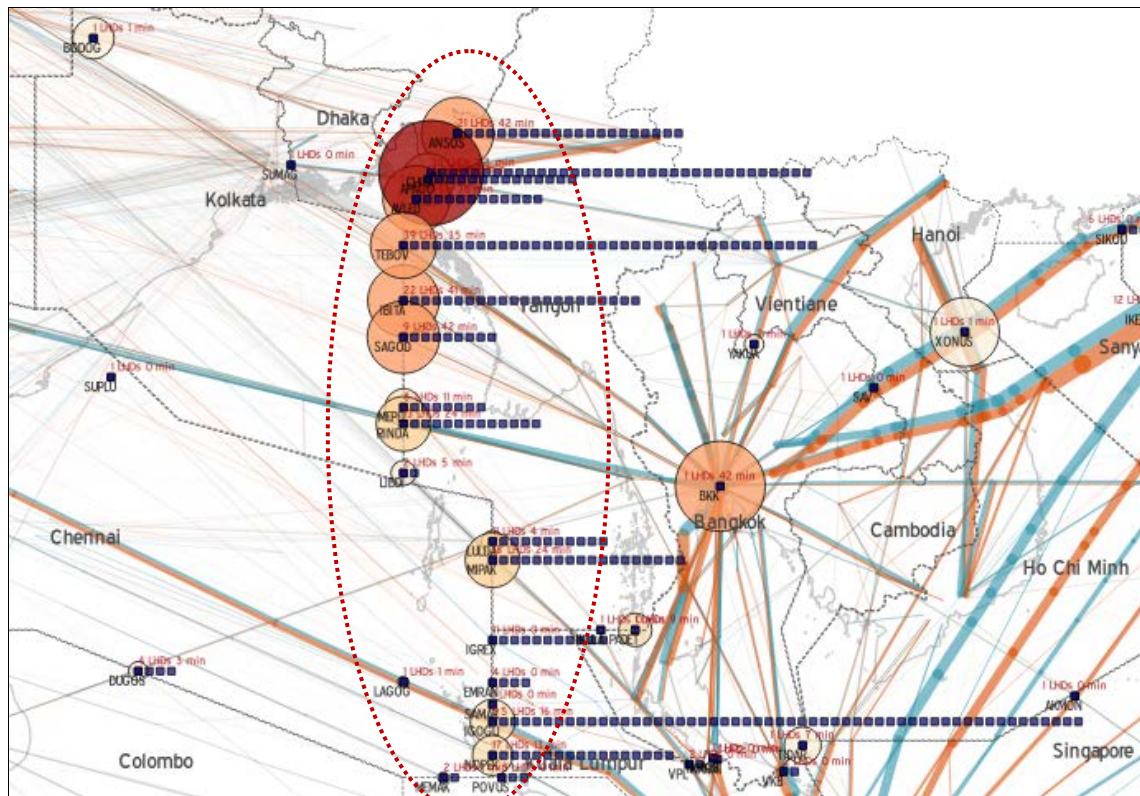


Figure 3: Geographical Location of LHDs in BOB Airspace

2.7. **The TCPs along Kolkata-Chennai FIRs and Yangon-Kuala Lumpur FIRs** continue to be the major hot spot in the region. A total of 310 occurrences in this hot spot area accounted for 7.66×10^{-9} FAPFH or 24% of risk in BOB region - decreased from 10.44×10^{-9} FAPFH in 2014. The reported LHDs seemed to concentrate in the upper part near Dhaka FIR and the lower part around IGOGU.

2.8. More detailed analysis of the two 2015 hot spots in the BOB region and the action plan to address the issue is provided in a separate WP.

2.9. **Table 3** summarizes Western Pacific/South China Sea (WPAC/SCS) airspace RVSM technical, operational, and total risks. **Figure 4** presents collision risk estimate trends during the period from Jan 2015 to Dec 2015.

WPAC/SCS Airspace – estimated annual flying hours = 1,769,352 hours (note: estimated hours based on Dec 2015 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 20 Total Risk	4.14×10^{-9}	5.0×10^{-9}	Below TLS
Technical Risk	1.48×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	4.25×10^{-9}	-	-
Total Risk	5.73×10^{-9}	5.0×10^{-9}	Above TLS

Table 3: WPAC/SCS Airspace RVSM Risk Estimates

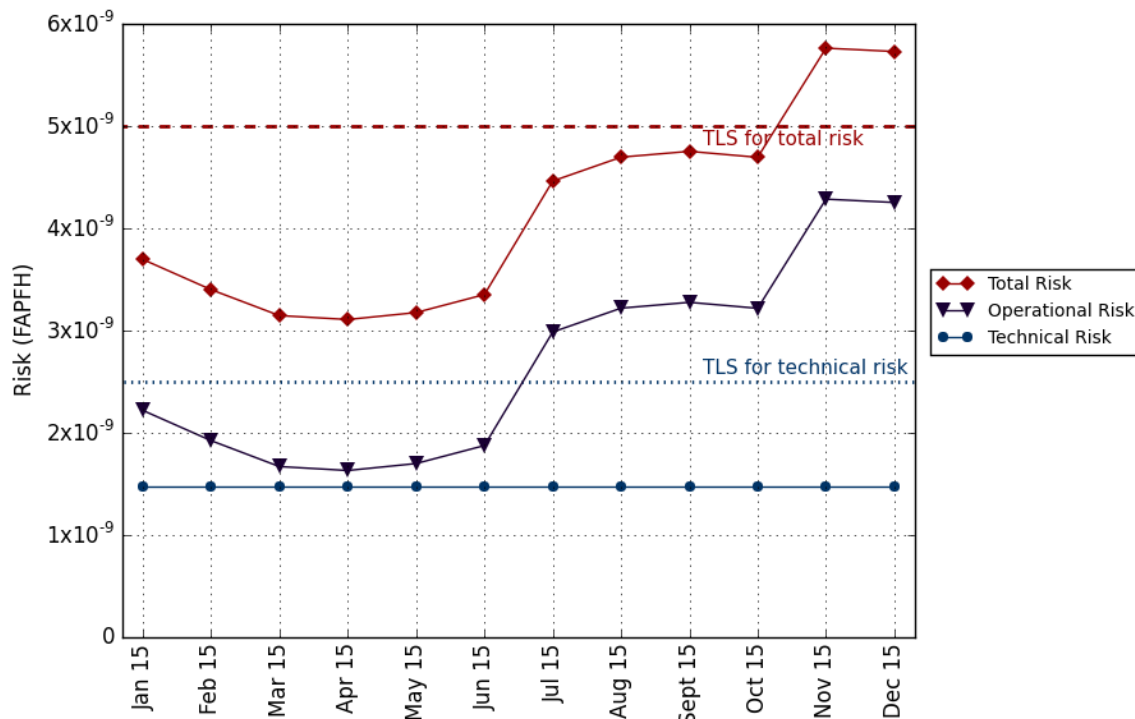


Figure 4: WPAC/SCS Airspace RVSM Risk Estimate Trends

2.10. **Table 4** presents a summary of the LHD causes within WPAC/SCS airspace from Jan 2015 until Dec 2015.

Code	LHD Category Description	No.	LHD Min	# FLs crossed	Risk $\times 10^{-9}$
A	Flight crew fails to climb or descend the aircraft as cleared	1	0	1	0.71
B	Flight crew climbing or descending without ATC clearance	1	0	4	0.13
C	Incorrect operation or interpretation of airborne equipment	0	0	0	0
D	ATC system loop error	5	0	0	0
E	ATC transfer of control coordination errors due to human factors	143	82	0	2.17
F	ATC transfer of control coordination errors due to technical issues	6	0	0	0

G	Aircraft contingency leading to sudden inability to maintain level	0	0	0	0
H	Airborne equipment failure and unintentional or undetected level change	0	0	0	0
I	Turbulence or other weather related cause	0	0	0	0
J	TCAS resolution advisory and flight crew correctly responds	0	0	0	0
K	TCAS resolution advisory and flight crew incorrectly responds	0	0	0	0
L	Non-approved aircraft is provided with RVSM separation	0	0	0	0
M	Other	10	44	0	1.24
Total		166	126	5	4.25

Table 4: Summary of LHD Causes within WPAC/SCS Airspace

2.11. **Figure 5** provides the geographic location of risk bearing LHD reports within WPAC/SCS Airspace during the assessment period.

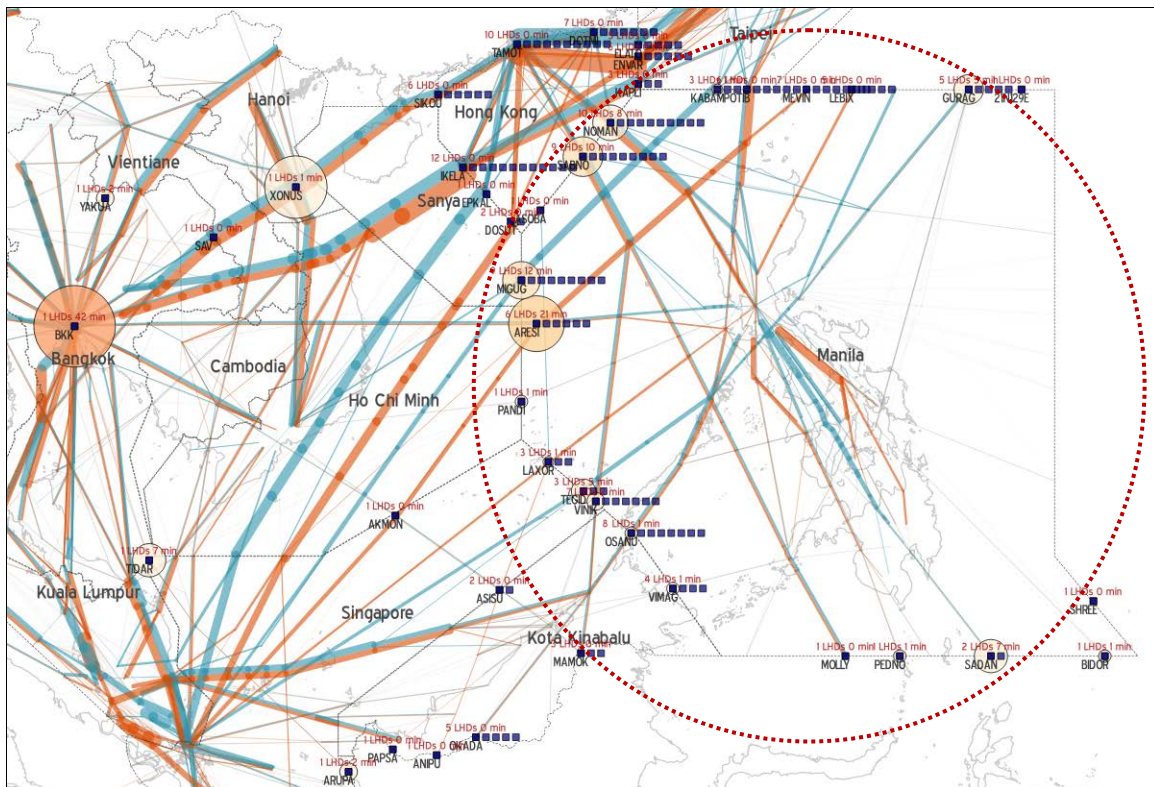


Figure 5: Geographical Location of LHDs in WPAC/SCS Airspace

2.12. The main hot spot for this region remains the interfaces around Manila FIR boundary. Most LHDs in this hot spot have zero duration since the area has good communication and surveillance coverage. A few LHDs have short duration at the areas where there are holes in surveillance coverage such as the Manila-Hong Kong and Manila-Ho Chi Minh interfaces.

2.13. The overall risk in the region exceeds the TLS due one occurrence with a long duration inside the Bangkok FIR in July, caused by a human error, and then induced a loss of separation.

2.14. More detailed analysis of the hot spot around Manila FIR boundary and the action plan to address the issue is provided in a separate WP.

2.15. **Table 5** summarizes Mongolian airspace RVSM technical, operational, and total risks. **Figure 6** presents collision risk estimate trends during the period from Jan 2015 to Dec 2015.

Mongolian Airspace – estimated annual flying hours = 116,664 hours (note: estimated hours based on Dec 2015 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 20 Total Risk	2.98×10^{-9}	5.0×10^{-9}	Below TLS
Technical Risk	0.96×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	0.96×10^{-9}	5.0×10^{-9}	Below TLS

Table 5: Mongolian Airspace RVSM Risk Estimates

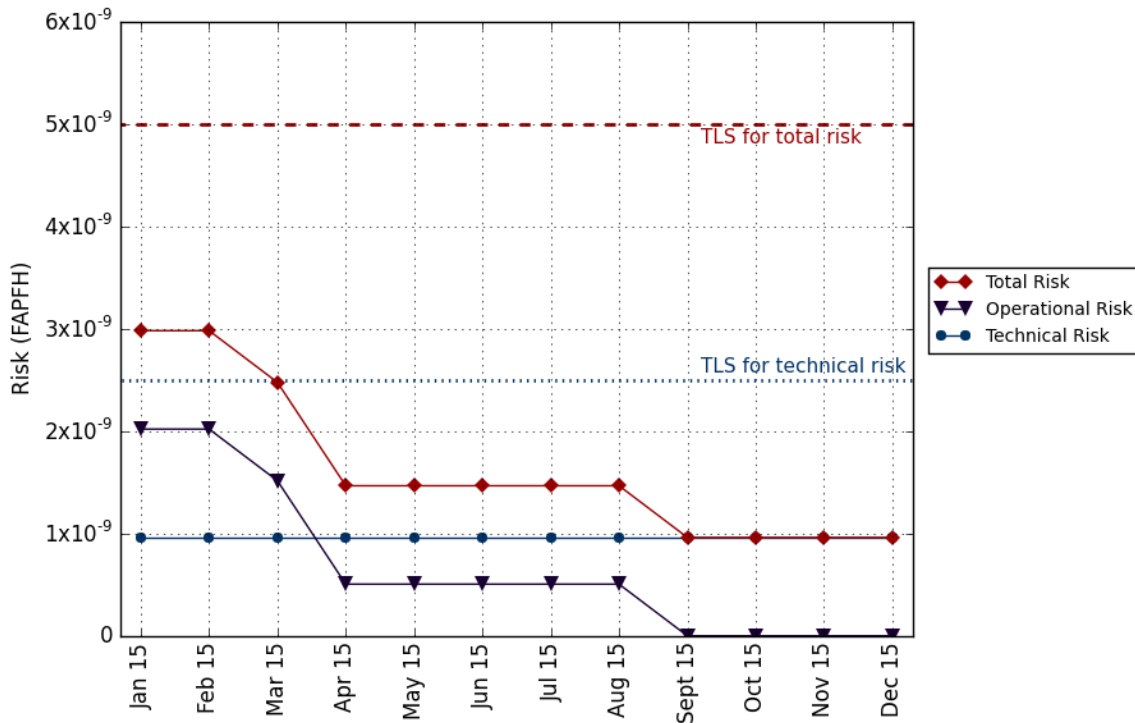


Figure 6: Mongolian Airspace RVSM Risk Estimate Trends

2.16. **Table 6** presents a summary of the LHD causes within Mongolian airspace from Jan 2015 until Dec 2015.

Code	LHD Category Description	No.	LHD Min	# FLs crossed	Risk x10 ⁷
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					9
A	Flight crew fails to climb or descend the aircraft as cleared	0	0	0	0.00
B	Flight crew climbing or descending without ATC clearance	0	0	0	0.00
C	Incorrect operation or interpretation of airborne equipment	0	0	0	0.00
D	ATC system loop error	0	0	0	0.00
E	ATC transfer of control coordination errors due to human factors	1	0	0	0.00
F	ATC transfer of control coordination errors due to technical issues	0	0	0	0.00
G	Aircraft contingency leading to sudden inability to maintain level	0	0	0	0.00
H	Airborne equipment failure and unintentional or undetected level change	0	0	0	0.00
I	Turbulence or other weather related cause	0	0	0	0.00
J	TCAS resolution advisory and flight crew correctly responds	0	0	0	0.00
K	TCAS resolution advisory and flight crew incorrectly responds	0	0	0	0.00
L	Non-approved aircraft is provided with RVSM separation	0	0	0	0.00
M	Other	0	0	0	0.00
Total		1	0	0	0.00

Table 6: Summary of LHD Causes within Mongolian Airspace

2.17. **Figure 7 and 8** provides the geographic location of risk bearing LHD reports within Mongolian Airspace on LHD reports from January to December 2014 and January to December 2015, respectively.

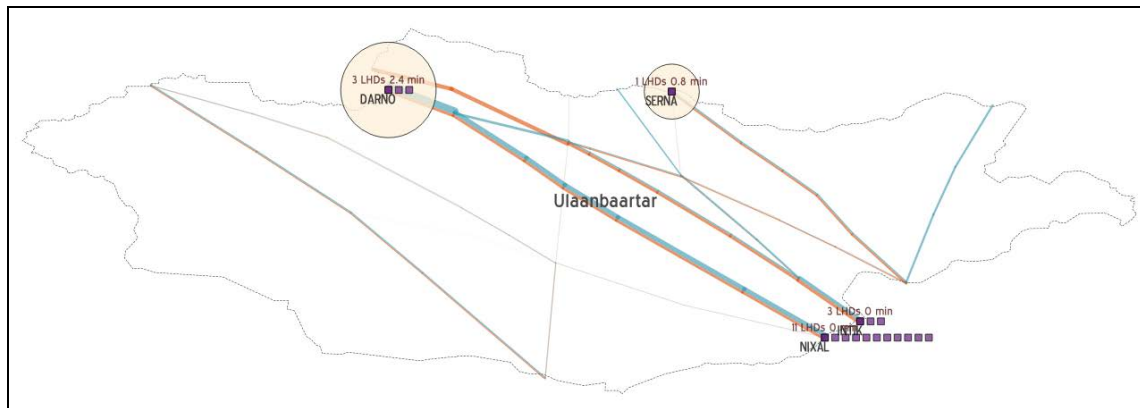


Figure 7: Geographical Location of LHDs in Mongolian Airspace of 2014

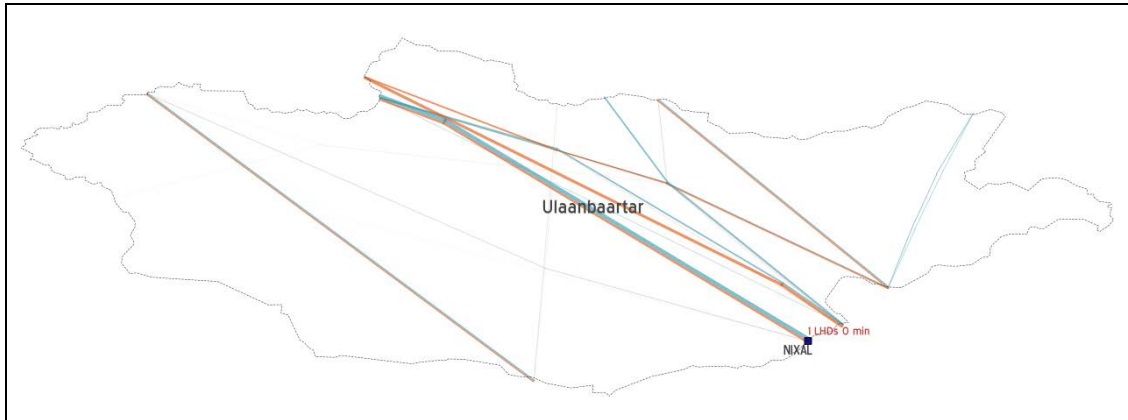


Figure 8: Geographical Location of LHDs in Mongolian Airspace of 2015

5.1 The figure shows significant reduction in number of LHD events at the southeast boundary of Ulaanbaatar FIR next to Beijing FIR (NIXAL and INTIK) and the northwest boundary next to Krasnoyarsk FIR (DARNO). These hot spots no longer exist in year 2015.

5.2 The reduction in LHD occurrences near NIXAL and INTIK is likely to be a result from both Mongolia and China's effort. Mongolia extended their SSR coverage for approximately 30NM further from NIXAL and INTIK since December 2015. Beijing ACC also adjusted their coordination procedure around how EST messages are sent and handled, especially when there are flight level changes. Beijing ACC also upgraded their automation system, which greatly improved its reliability.

3. ACTIONS BY THE MEETING

- 3.1 The meeting is invited to:
- a) note the information contained in this paper;
 - b) discuss any relevant matters as appropriate.

MONITORING AGENCY FOR ASIA REGION (MAAR)



**Airspace Safety Review of RVSM in
Bay of Bengal Airspace**

January 2015 to December 2015

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE BAY OF BENGAL AIRSPACE**
Assessment Period: January 2015 to December 2015

Prepared by
Monitoring for Asia Region (MAAR)
(An ICAO APANPIRG approved Regional Monitoring Agency)

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **Bay of Bengal, Arabian Sea, and Indian Ocean (BOBASIO)** airspace (abbreviated as BOB in this paper). The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2015** and monthly Large Height Deviation (LHD) reports between **January 2015** and **December 2015** submitted by concerning States in the BOB region.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2015 of aircraft operating in BOB airspace was used as required by ICAO regional agreement.

2.2. **Large Height Deviation (LHD).** Accumulative 12-month data set of LHD reports was covering January 2015 to December 2015. **Table 1** indicates those FIRs which submitted LHD reports including nil returns. **Appendix A** provides details of LHD reports, including full description of some uncommon LHDs and LHDs with large duration.

FIR/ Month	Dhaka	Chennai	Delhi	Kolkata	Mumbai	Kuala Lumpur	Male	Yangon	Katmandu	Karachi	Lahore	Colombo	Bangkok
January	X	X	X	X	X	X	X	X	X	X	X	X	X
February	X	X	X	X	X	X	X	X	X	X	X	X	X
March	X	X	X	X	X	X	X	X	X	X	X	X	X
April	X	X	X	X	X	X	X	X	X	X	X	X	X
May	X	X	X	X	X	X	X	X	X	X	X	X	X
June	X	X	X	X	X	X	X	X	X	X	X	X	X
July	X	X	X	X	X	X	X	X	X	X	X	X	X
August	X	X	X	X	X	X	X	X	X	X	X	X	X
September	X	X	X	X	X	X	X	X	X	X	X	X	X
October	X	X	X	X	X	X	X	X	X	X	X	X	X
November	X	X	X	X	X	X	X	X	X	X	X	X	X
December	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 1: Summary of LHD Reports Submitted by FIRs

3. Summary of LHD Occurrences

3.1. **Table 2** and **Figure 1** summarize the number of Non-NIL LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2015 to December 2015.

Month (2015)	No. of Non-NIL LHD	LHD Duration (Min)	No. Levels Crossed	Operational Risk ($\times 10^{-9}$)
January	14	41	0	0.75
February	24	30	0	0.55
March	34	335	1	6.41
April	48	654	1	12.05
May	25	31	0	0.57
June	30	96	0	1.77
July	47	74	0	1.36
August	39	85	8	1.74
September	19	38	1	0.95
October	27	55	1	1.02
November	42	33	6	2.38
December	31	59	6	1.91
Total	380	1531	24	31.44

Table 2: Summary of LHD by Month for BOB Airspace

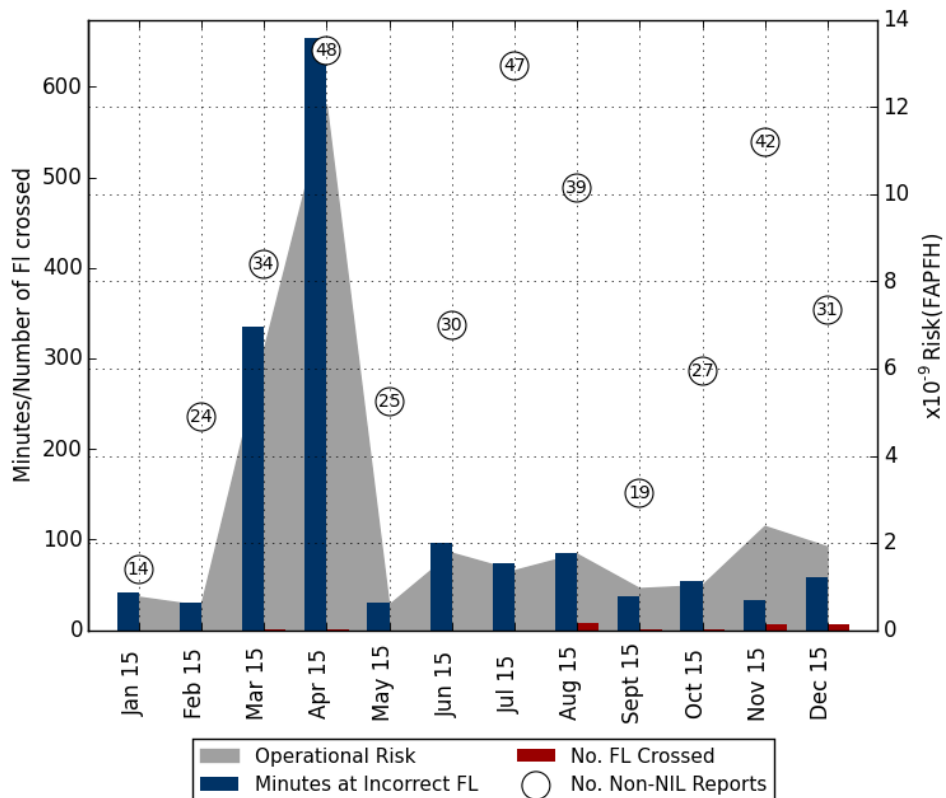


Figure 1: Summary of LHD Occurrences by Month for BOB Airspace

3.2. Compared to 2014, the number of non-nil LHD reports rose from 224 to 380. The total of LHD duration increased from 561 to 1531 minutes. Therefore, operational risk in BOB region doubles from 2014 value to 31.44×10^{-9} FAPFH in 2015.

3.3. **Table 3** and **Figure 2** summarize the number of LHD occurrences, the associated LHD duration (in minutes), and number of flight levels crossed without clearance, by LHD category from January 2015 to December 2015.

LHD Category Code	LHD Category Description	No. of LHDs	LHD Duration (Min)	No. levels crossed	Operational Risk ($\times 10^{-9}$)
A	Flight crew failing to climb/descend the aircraft as cleared	1	0.0	0	0.00
B	Flight crew climbing/descending without ATC Clearance	2	29.0	8	0.71
C	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)	0	0.0	0	0.00
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message)	6	34.0	3	0.91
E	Coordination errors in the ATC to ATC transfer or control responsibility as a result of human factors issues (e.g. late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route etc not in accordance with agreed parameters)	366	1426.0	12	27.85
F	Coordination errors in the ATC to ATC transfer or control responsibility as a result of equipment outage or technical issues	0	0.0	0	0.00
G	Deviation due to aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0.0	0	0.00
H	Deviation due to airborne equipment failure leading to unintentional or undetected change of flight level	0	0.0	0	0.00
I	Deviation due to turbulence or other weather related cause	2	29.0	0	0.53
J	Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory	1	0.0	1	0.25
K	Deviation due to TCAS resolution advisory, flight crew incorrectly following the resolution advisory	0	0.0	0	0.00
L	An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan)	0	0.0	0	0.00
M	Other – this includes situations of flights operating (including climbing/descending) in airspace where flight crews are unable to establish normal air-ground communications with the responsible ATS unit.	2	13.0	0	1.19
Total		380	1531.0	24	31.44

Table 3: Summary of LHD by LHD Category for BOB Airspace

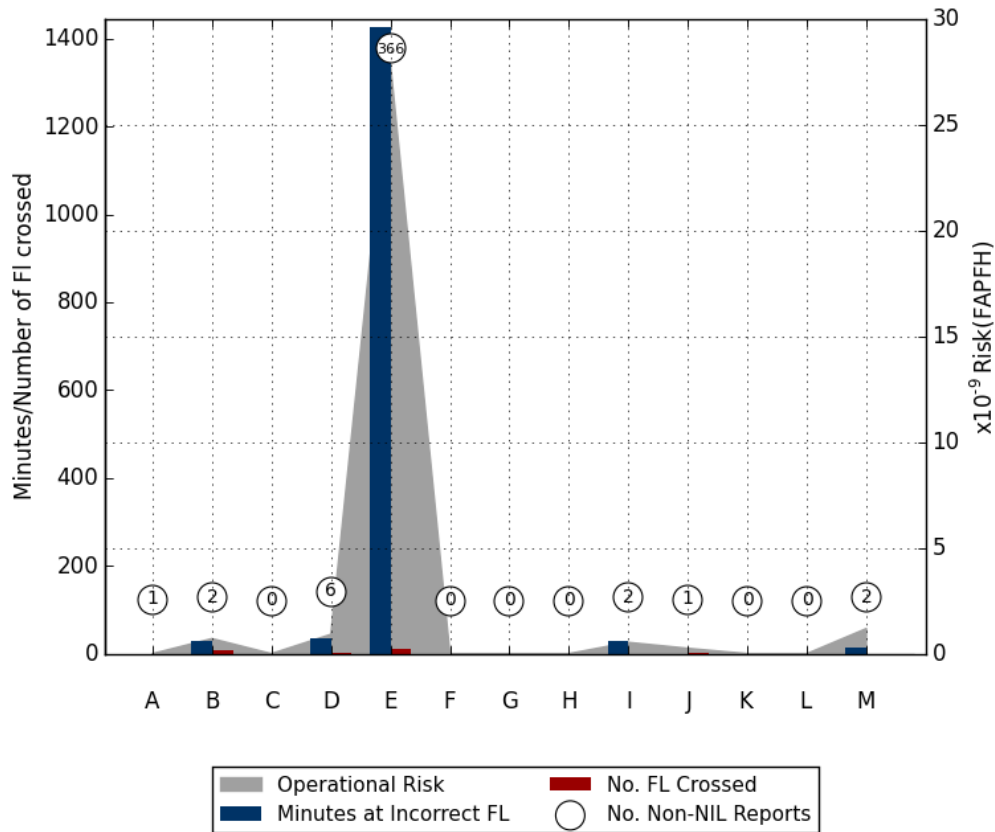


Figure 2: Summary of LHD by LHD Category for BOB Airspace

3.4. Category E LHDs still account for most of LHD duration and occurrences in the region. These occurrences can be further categorized into the following sub-categories. **Figure 3** shows contribution of each sub-category in term of number of occurrences and **Figure 4** shows contribution in term of risk.

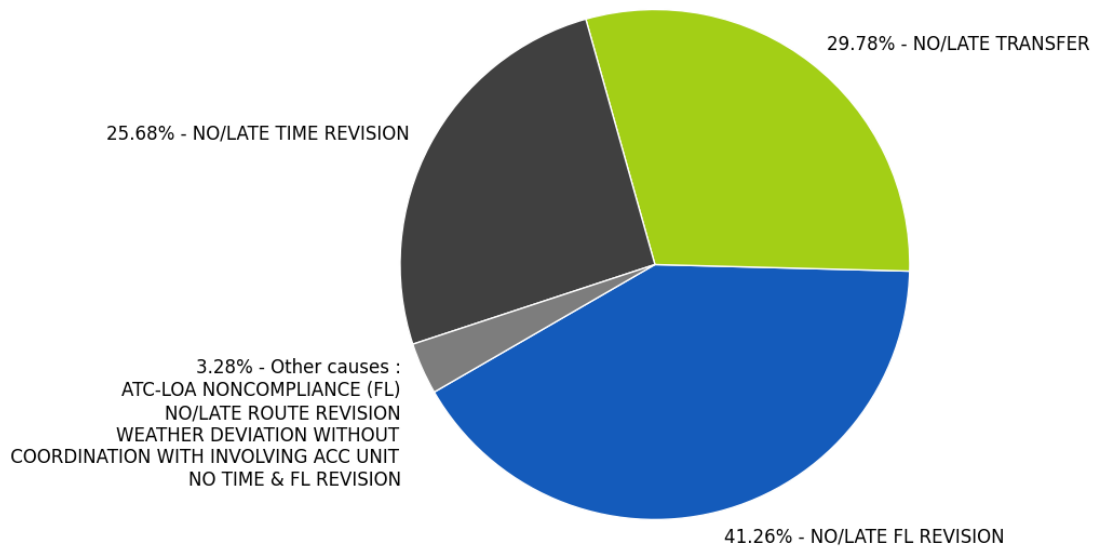


Figure 3: Sub-categories of Category-E LHDs for BOB Airspace (number of occurrences)

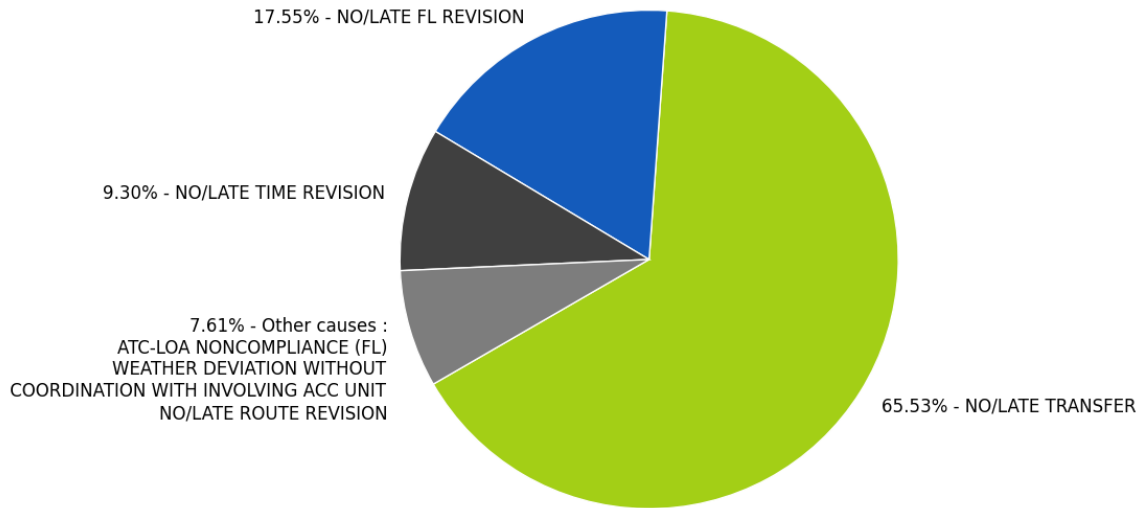


Figure 4: Sub-categories of Category-E LHDs for BOB Airspace (risk)

4. Risk Assessment and Safety Oversight

4.1. **Collision Risk Model (CRM) Parameters.** The value and the source of the parameters in the CRM used to estimate risk in the RVSM airspace are summarized in **Table 4**.

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	1,942,670	383,823	Hour	Dec 2015 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.3818/ 0.0289	0.0967	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.1640	0.0489	-	
λ_x	Average aircraft length	0.0286	0.0245	NM	
λ_y	Average aircraft wingspan	0.0264	0.0228	NM	
λ_z	Average aircraft height	0.0081	0.0073	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0286	0.0245	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	Conservative value used in previous assessments
$ \overline{\Delta V} $	Average relative along-track speed between aircraft on same direction routes	27.69	52.55	Knot	Dec 2015 TSD

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
$\overline{ V }$	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for BOB Airspace

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. The technical risk **meets** the agreed TLS value of no more than 2.5×10^{-9} fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft and to all causes. **The total risk exceeds the specified TLS value for these components of 5.0×10^{-9} .**

Bay of Bengal RVSM Airspace – estimated annual flying hours = 2,326,493 hours (note: estimated hours based on December 2015 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.83×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	31.44×10^{-9}	-	-
Total Risk	32.27×10^{-9}	5.0×10^{-9}	Above Overall TLS

Table 5: Risk Estimates for BOB Airspace

4.3 **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports.

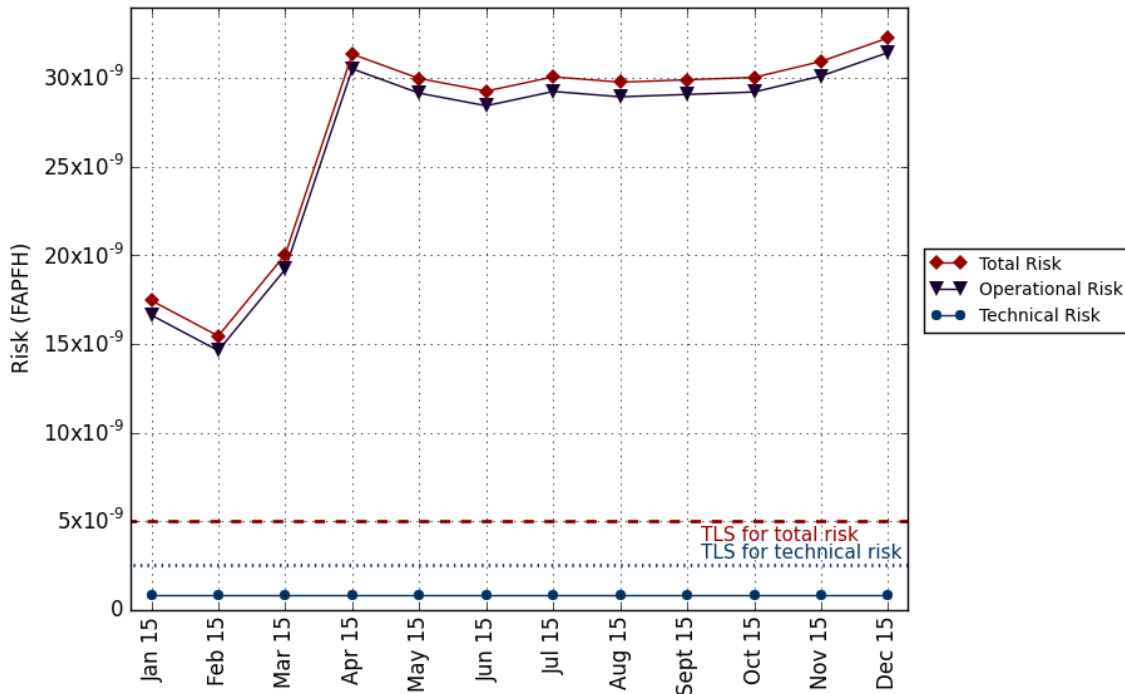


Figure 5: Trends of Risk Estimates for BOB Airspace

4.4 A monthly LHD risk value is determined to provide real-time information on actual risk without reliance on historical high-time errors resident within the 12 month data sample. The data in **Figure 6** below shows that the monthly risks are **significantly above** the average monthly risk of the annual risk of 5.0×10^{-9} (red line in **Figure 6** below, which is approximately 0.4167×10^{-9} fatal accidents per flight hour).

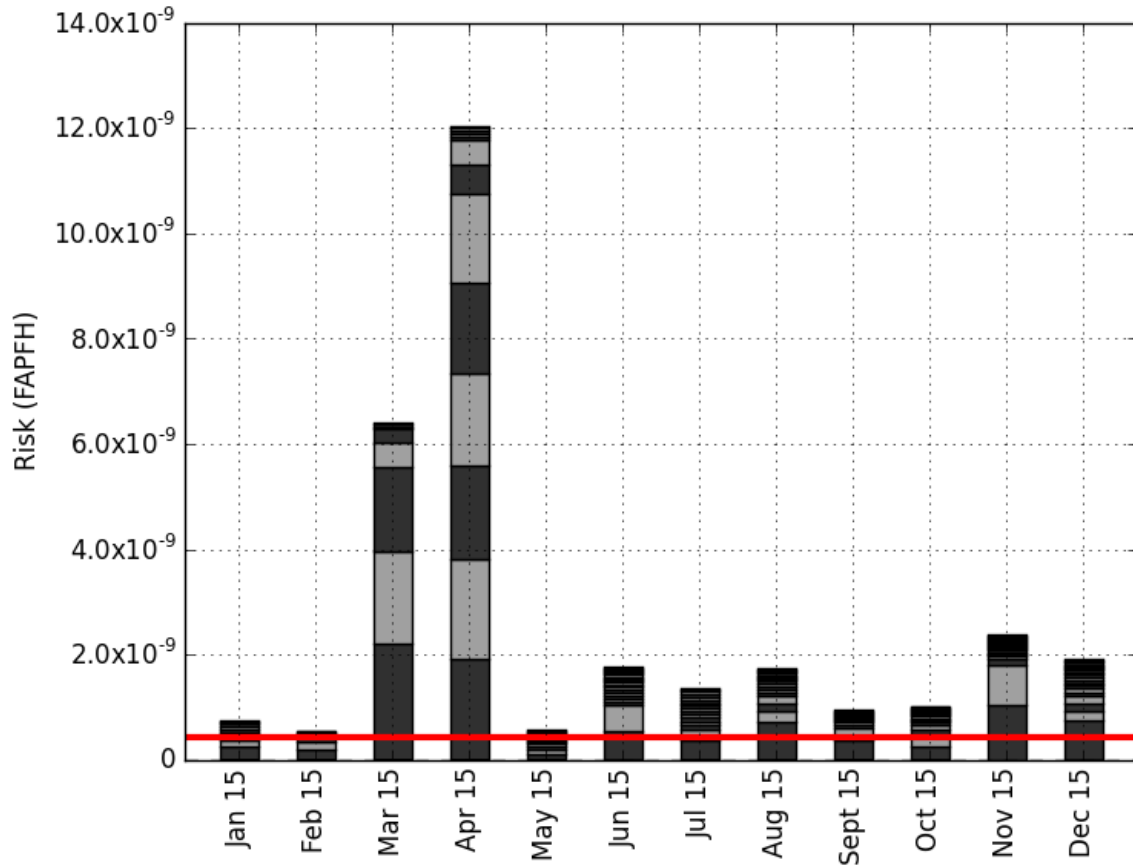


Figure 6: Monthly LHD Risk Estimates for BOB Airspace. Red line is the average monthly value for an annual risk of 5.0×10^{-9} . Risk is measured in Fatal Accidents per Flight Hour (FAPFH).

5. Analysis of Operational Errors

5.1 **Figure 7 and 8** depict geographic location of non-nil LHDs and hot spots in BOB airspace based on LHD reports from January to December 2015 where:

- the navy dotted line represents the frequency of occurrences at the labeled waypoint,
- the color of each circle represents the sum of minutes at incorrect flight level and the number of flight levels crossed without clearance (darker orange represents higher value) associated with LHDs occurring at or near the labeled waypoint,
- the area of the circle represents the sum of operational risk associated with LHDs occurring at or near the labeled waypoint, and
- the turquoise lines represent west-bound traffic movements while the orange lines represent east-bound traffic movements.

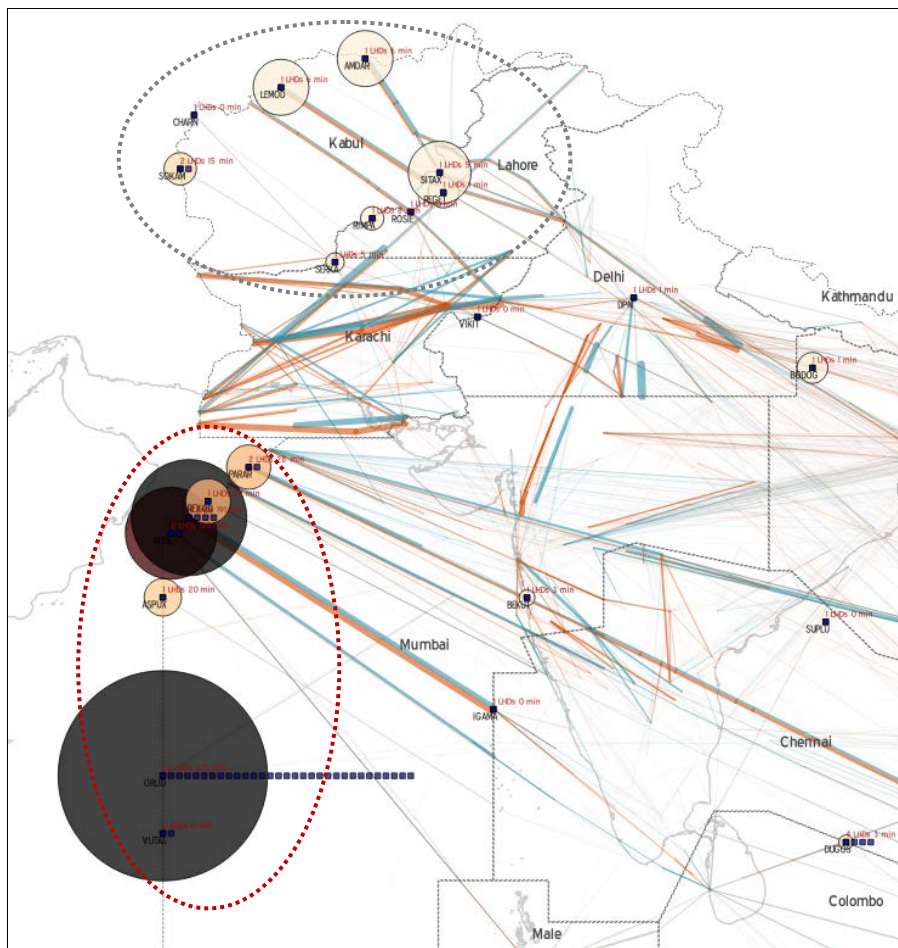


Figure 7: Geographical Location of LHDs in BOB Airspace

5.2 The first area of interest is the boundary of Kabul FIR. In 2014, the hot spot consist of 20 occurrences of 124 minutes in total at GADER, which reduced to 0 in 2015. In 2015, there are only 9 occurrences along the Kabul FIR boundary, most of which involved aircraft entering Kabul FIR at upper flight levels instead of lower flight levels in accordance with the LOA. These aircraft were, then, instructed to descend to the correct flight levels. For each occurrence of this type, Kabul ACC Supervisor/Controller either contacted the transferring ACC and reiterated the instructions IAW the LOA or notified the correct routing information to the flight crew.

5.3 A new hot spot area just emerged in the year 2015 – **the western boundary of the Mumbai FIR**, which interfaces with Mogadishu, Sana, and Muscat FIRs. The total risk in Mumbai FIR accounted for 19×10^{-9} FAPFH or 61% of total operational risk in BOB. This area is mostly remote oceanic airspace and therefore, has poor communication coverage. The LHDs either have short duration or very long duration. Three LHDs, occurring in March and April, each have duration greater than 100 minutes. The longest duration LHD of 120 minutes, which occurred in March, involved an aircraft passing the entire Mumbai FIR without Mumbai OCC’s knowledge.

5.4 Please note that the surge in long-duration LHDs in March and April coincided with the temporary closure of Sana FIR, and therefore, may be attributed to an increase in re-directed traffic through Mogadishu FIR. However, two long-duration LHDs were reported in the first quarter of 2016 even with the reopening of Sana FIR.

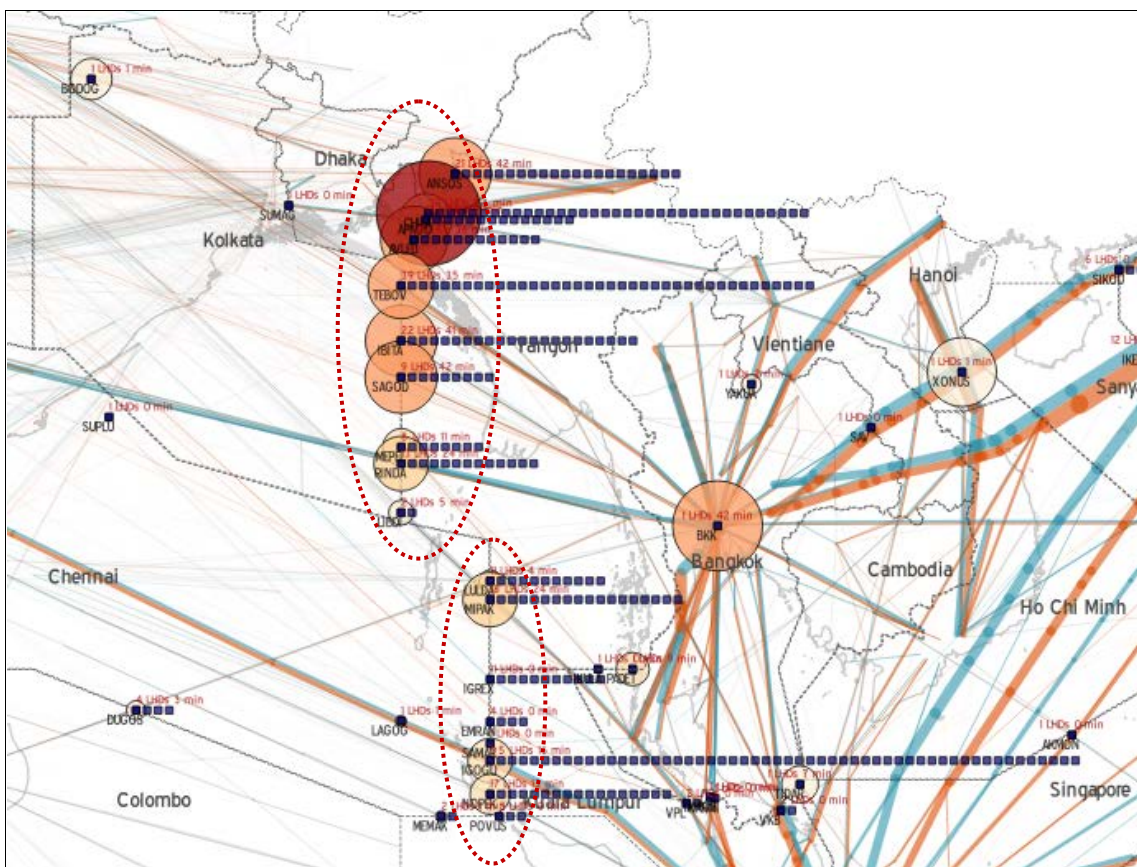


Figure 8: Geographical Location of LHDs in BOB Airspace

5.5 **The TCPs along Kolkata-Chennai FIRs and Yangon-Kuala Lumpur FIRs** continue to be the major hot spot in the region. A total of 310 occurrences in this hot spot area accounted for 7.66×10^{-9} FAPFH or 24% of risk in BOB region - decreased from 10.44×10^{-9} FAPFH in 2014. The reported LHDs seemed to concentrate in the upper part near Dhaka FIR and the lower part around IGOGU.

5.6 More detailed analysis of the two hot spots in the BOB region and an action plan to address the issue can be found in a separate report.

6. Long Term Height-keeping Monitoring (LTHM)

To meet the ICAO Annex 6 LTHM requirements, the MAAR undertakes a monitoring program. The current monitoring burden data for BOB States is detailed in **Table 6** below.

State	Total RVSM Approved Airframes	Resultant Monitoring Burden	Total Airframes Remaining to be Monitored	% Airframes Remaining to be Monitored
Afghanistan (OA)	13	10	2	20%
Bangladesh (VG)	29	20	13	65%
Bhutan (VQ)	5	4	3	75%
India (VA)	517	197	33	17%
Malaysia (WM)	280	39	17	44%
Maldives (VR)	7	5	0	0%
Myanmar (VY)	14	11	5	45%
Nepal (VN)	5	5	1	20%
Pakistan (OP)	78	42	27	64%
Sri Lanka (VC)	28	8	0	0%
Thailand (VT)	332	109	46	42%
Grand Total	1,308	450	147	33%

Table 6: LTHM Burden

Appendix A: Details of the Reported LHD Events in the BOB Airspace

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
3/1/2015	SOF		FL240	0.0 min	E	No/late transfer
4/1/2015	RRA		FL380	1.0 min	E	No/late transfer
4/1/2015	JLS	FL360	FL340	0.0 min	E	No/late FL revision
5/1/2015	NWA	FL350	FL370	4.0 min	E	No/late FL revision
5/1/2015	NWA	FL350	FL370	4.0 min	E	No/late FL revision
8/1/2015	RRA	FL340	FL360	0.0 min	E	No/late FL revision
18/1/2015	SOF		FL360	0.0 min	E	No/late transfer
18/1/2015	NWA	FL370	FL390	6.0 min	E	No/late FL revision
18/1/2015	NWA	FL390	FL410	3.0 min	E	No/late FL revision
22/1/2015	JLS	FL360	FL360	1.0 min	E	No/late time revision
23/1/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
25/1/2015	NWA		FL370	14.0 min	E	No EST given by VECC. No Breakdown in Separation.
26/1/2015	NWA	FL330	FL350	4.0 min	E	No/late FL revision
29/1/2015	AXL	FL370	FL350	1.0 min	E	No/late FL revision
1/2/2015	NWA	FL350	FL350	1.0 min	E	No/late time revision
1/2/2015	HID	FL290	FL370	7.0 min	E	ATC-LOA noncompliance (FL)
3/2/2015	NWA	FL350	FL370	4.0 min	E	No/late FL revision
6/2/2015	AXL	FL350	FL370	0.0 min	E	No/late FL revision
6/2/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
8/2/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
8/2/2015	JLS	FL320	FL320	0.0 min	E	No/late time revision
8/2/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
9/2/2015	AXL	FL350	FL350	11.0 min	E	Expected A/C at 2236 Actual arrival time : 2214 Detected at : 2225 via pilot report
10/2/2015	AXL	FL350	FL350	0.0 min	E	No/late time revision
10/2/2015	AXL	FL410	FL410	0.0 min	E	No/late time revision
11/2/2015	AXL	FL350	FL350	1.0 min	E	No/late time revision
11/2/2015	AXL	FL370	FL370	1.0 min	E	No/late time revision
12/2/2015	AXL	FL350	FL350	0.0 min	E	No/late time revision
14/2/2015	AXL	FL310	FL310	0.0 min	E	No/late time revision
14/2/2015	AXL	FL330	FL330	0.0 min	E	No/late time revision
18/2/2015	JLS	FL320	FL320	0.0 min	E	No/late time revision
18/2/2015	JLS	FL340	FL340	0.0 min	E	No/late transfer
18/2/2015	AXL	FL340	FL340		E	No/late transfer
19/2/2015	AXL	FL410	FL410	0.0 min	E	No/late time revision
21/2/2015	AXL	FL350	FL350	0.0 min	E	No/late transfer
21/2/2015	AXL	FL390	FL390	0.0 min	E	No/late transfer
21/2/2015	SOF	FL330	FL370	0.0 min	E	No/late transfer
27/2/2015	NWA	FL370	FL370	5.0 min	E	No/late time revision

3/3/2015	ANG		FL350	96.0 min	E	No estimate was passed by Muscat control. No Breakdown in separation reported. Aircraft established contact with Chennai control over IGAMA, flying time from LOTAV to IGAMA 1Hr 36 Minutes
8/3/2015	ANG		FL390	86.0 min	E	No estimate was passed by Muscat control. No Breakdown in separation reported. Aircraft established contact over OSIRI, flying time from LOTAV to OSIRI 1Hr 26 Minutes
1/3/2015	NWA	FL350	FL330	3.0 min	E	No/late FL revision
8/3/2015	ANG		FL390	120.0 min	E	No estimate was passed by Muscat control. No Breakdown in separation reported. Aircraft established contact over with Male control over BIBGO , flying time from KITAL to BIBGO 2 Hrs
7/3/2015	AXL		FL410	0.0 min	E	No/late transfer
9/3/2015	RRA		FL380	0.0 min	E	No/late transfer
9/3/2015	RRA		FL300	0.0 min	E	No/late transfer
10/3/2015	AXL	FL370	FL350		E	No/late FL revision
10/3/2015	RRA	FL340	FL340	0.0 min	E	No/late time revision
10/3/2015	AXL	FL350	FL370		E	No/late FL revision
10/3/2015	RRA	FL300	FL340	0.0 min	E	No/late FL revision
11/3/2015	JLS	FL360	FL340	0.0 min	E	No/late FL revision
11/3/2015	AXL	FL360	FL340		E	No/late FL revision
11/3/2015	RRA	FL340	FL320	0.0 min	E	No time & FL revision
11/3/2015	RRA	FL340	FL340	0.0 min	E	No/late time revision
11/3/2015	RRA	FL360	FL360	0.0 min	E	No/late time revision
11/3/2015	RRA	FL320	FL320	0.0 min	E	No/late time revision
12/3/2015	RRA		FL300	0.0 min	E	No/late transfer
13/3/2015	RRA	FL400	FL400	0.0 min	E	No/late time revision
13/3/2015	RRA	FL340	FL340	0.0 min	E	No/late transfer
14/3/2015	RRA	FL360	FL340	0.0 min	E	No/late FL revision
15/3/2015	AXL	FL350	FL370	0.0 min	E	No/late FL revision
15/3/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
18/3/2015	RRA		FL320	0.0 min	E	No/late transfer
22/3/2015	RRA	FL340	FL340	0.0 min	E	No/late time revision
22/3/2015	RRA	FL360	FL360	0.0 min	E	No/late time revision
25/3/2015	RRA	FL380	FL340	0.0 min	E	No/late FL revision
27/3/2015	AXL	FL390	FL390	0.0 min	E	No/late time revision
29/3/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
29/3/2015	RRA		FL340	0.0 min	E	No/late transfer
31/3/2015	RRA	FL280	FL280	0.0 min	E	No/late time revision
2/4/2015	ANG		FL370	105.0 min	E	No estimate was passed by Mogadishu control. Aircraft established contact over with Mumbai control over DARMI, flying time from ORLID to DARMI is 1Hr 45 Minutes
3/4/2015	ANG		FL330	92.0 min	E	No estimate was passed by Mogadishu control. Aircraft established contact

						over with Mumbai control over DARMI, flying time from ORLID to DARMI is 1 Hr 32 Minutes
1/4/2015	RRA		FL320	0.0 min	E	No/late transfer
1/4/2015	RRA		FL300	0.0 min	E	No/late transfer
3/4/2015	ANG		FL310	95.0 min	E	No estimate was passed by Mogadishu control. Aircraft established contact over with Mumbai control over DARMI, flying time from ORLID to DARMI is 1 Hr 35 Minutes
3/4/2015	RRA	FL300	FL340	0.0 min	E	No/late FL revision
3/4/2015	RRA	FL320	FL300	0.0 min	E	No/late FL revision
3/4/2015	ANG		FL350	95.0 min	E	No estimate was passed by Mogadishu control. Aircraft established contact over with Mumbai control over DARMI, flying time from ORLID to DARMI is 1 Hr 35 Minutes
3/4/2015	ANG		FL350	97.0 min	E	No estimate was passed by Mogadishu control. Aircraft established contact over with Mumbai control over DARMI, flying time from ORLID to DARMI is 1 Hr 37 Minutes
3/4/2015	ANG		FL330	102.0 min	E	No estimate was passed by Mogadishu control. Aircraft established contact over with Mumbai control over DARMI, flying time from ORLID to DARMI is 1Hr 42 Minutes
10/4/2015	ANG	FL330	FL370	3.0 min	E	No/late FL revision
19/4/2015	ANG	FL410	FL390	0.0 min	E	No/late FL revision
3/4/2015	RRA	FL340	FL340	0.0 min	E	No/late time revision
4/4/2015	RRA	FL320	FL300	25.0 min	E	No level change was given by Yangon. No Breakdown in separation. Aircraft established contact with Kolkata over BUBKO at 2317 and reported maintaining FL300. SAGOD to BUBKO is 25 minutes flying time
7/4/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
9/4/2015	JLS	FL390	FL370	3.0 min	E	No/late FL revision
11/3/2015	FKM	FL320	FL340	1.0 min	D	?
20/4/2015	ANG	FL330	FL350	0.0 min	E	No/late FL revision
10/4/2015	FKM	FL370	FL350	0.0 min	E	No/late FL revision
11/4/2015	AXL	FL410	FL410	0.0 min	E	No/late time revision
13/4/2015	RRA		FL340	0.0 min	E	No/late transfer
13/4/2015	RRA		FL320	0.0 min	E	No/late transfer
13/4/2015	RRA		FL360	0.0 min	E	No/late transfer
13/4/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
13/4/2015	JLS	FL340	FL340	0.0 min	E	No/late time revision
14/4/2015	RRA		FL360	0.0 min	E	No/late transfer
14/4/2015	RRA		FL320	0.0 min	E	No/late transfer
14/4/2015	RRA		FL300	0.0 min	E	No/late transfer
18/4/2015	RRA	FL340	FL360	0.0 min	E	No/late FL revision

27/3/2015	FKM	FL350	FL340	0.0 min	D	
20/4/2015	ANG	FL350	FL290	0.0 min	E	No/late FL revision
20/4/2015	RRA		FL360	0.0 min	E	No/late transfer
20/4/2015	ANG	FL350	FL310	30.0 min	E	No level change was passed by Mogadishu. No Breakdown in separation. Aircraft established contact with Mumbai over UNRIV at 0038 and reported maintaining FL310.
30/3/2015	ANG	FL360	FL360	26.0 min	D	UAE706 FL360 was given Direct Routing from ATEMA to KITAL and ETD622 on direct routing from KITAL to VUTAS was issued climb to FL360. Other Traffic: ETD622 FL360 on Direct route from KITAL to VUTAS RA Reported by both UAE706 & ETD622
20/4/2015	ANG	FL330	FL350	0.0 min	E	No/late FL revision
21/4/2015	ANG	FL350	FL330	0.0 min	E	No/late FL revision
24/4/2015	ANG	FL410	FL330	0.0 min	E	No/late FL revision
20/4/2015	RRA	FL300	FL320	0.0 min	E	No/late FL revision
20/4/2015	RRA	FL300	FL320	0.0 min	E	No/late FL revision
24/4/2015	ANG	FL350	FL330	0.0 min	E	No/late FL revision
23/4/2015	JLS	FL380	FL400	0.0 min	E	No/late FL revision
23/4/2015	NWA		FL390	3.0 min	E	No/late transfer
26/4/2015	ANG	FL270	FL330	0.0 min	E	No/late FL revision
24/4/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
24/4/2015	NWA	FL410		2.0 min	E	No/late transfer
26/4/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
27/4/2015	AXL	FL350	FL370	0.0 min	E	No/late FL revision
28/4/2015	AXL	FL330	FL350	0.0 min	E	No/late FL revision
28/4/2015	JLS	FL340	FL340	0.0 min	E	No/late time revision
29/4/2015	RRA	FL300	FL300	0.0 min	E	No/late time revision
12/5/2015	ANG	FL410	FL390	0.0 min	E	No/late FL revision
26/5/2015	ANG		FL390	0.0 min	E	No/late transfer
12/4/2015	ANG	FL330	FL320	2.0 min	D	
11/5/2015	JLS	FL400	FL400	0.0 min	E	No/late time revision
13/5/2015	RRA	FL360	FL300	0.0 min	E	No/late transfer
13/5/2015	NWA		FL350	2.0 min	E	No/late transfer
14/5/2015	NWA	FL370	FL370	6.0 min	E	No/late time revision
14/5/2015	RRA		FL320	0.0 min	E	No/late transfer
15/5/2015	NWA	FL390	FL370	3.0 min	E	No/late FL revision
15/5/2015	NWA		FL370	2.0 min	E	No/late transfer
16/5/2015	AXL	FL330	FL330	0.0 min	E	No/late FL revision
17/5/2015	NWA	FL410	FL390	1.0 min	E	No/late FL revision
17/5/2015	NWA		FL410	2.0 min	E	No/late transfer
20/5/2015	JLS		FL380	0.0 min	E	No/late time revision
20/5/2015	NWA		FL350	1.0 min	E	No/late transfer
21/5/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
21/5/2015	RRA	FL380	FL380	0.0 min	E	No/late time revision
21/5/2015	AXL	FL350	FL350	0.0 min	E	No/late transfer

24/5/2015	RRA	FL320	FL360	0.0 min	E	No/late transfer
26/5/2015	NWA	FL350	FL370	1.0 min	E	No/late FL revision
26/5/2015	AXL		FL370	0.0 min	E	No/late transfer
28/5/2015	NWA	FL390	FL370	2.0 min	E	No/late FL revision
28/5/2015	NWA	FL410	FL390	1.0 min	E	No/late FL revision
29/5/2015	AXL	FL410	FL410	0.0 min	E	No/late time revision
31/5/2015	NWA	FL350	FL350	2.0 min	E	No/late route revision
10/6/2015	ANG	FL410	FL370	0.0 min	E	No/late FL revision
10/6/2015	ANG	FL330	FL410	0.0 min	E	No/late FL revision
2/6/2015	AXL	FL330	FL330	0.0 min	E	No/late time revision
4/6/2015	NWA		FL390	2.0 min	E	No/late transfer
4/6/2015	JLS	FL340	FL340	0.0 min	E	No/late time revision
4/6/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
6/6/2015	NWA		FL350	2.0 min	E	No/late transfer
8/6/2015	NWA	FL330	FL350	3.0 min	E	No/late FL revision
8/6/2015	NWA		FL330	3.0 min	E	No/late transfer
9/6/2015	NWA	FL390	FL390	2.0 min	E	No/late route revision
22/6/2015	ANG		FL330	0.0 min	E	No/late transfer
23/6/2015	ANG	FL410	FL390	0.0 min	E	No/late FL revision
11/6/2015	NWA	FL370	FL390	3.0 min	E	No/late FL revision
11/6/2015	NWA		FL390	3.0 min	E	No/late transfer
15/6/2015	RRA	FL320	FL340	0.0 min	E	No/late transfer
15/6/2015	RRA	FL380	FL380	0.0 min	E	No/late time revision
17/6/2015	NWA	FL310	FL270	3.0 min	E	No/late FL revision
17/6/2015	NWA	FL370	FL410	2.0 min	E	No/late FL revision
19/6/2015	JLS	FL280	FL300	0.0 min	E	No/late FL revision
20/6/2015	NWA	FL370	FL370	2.0 min	E	No/late route revision
20/6/2015	NWA	FL390	FL370	1.0 min	E	No/late FL revision
21/6/2015	NWA	FL350	FL370	2.0 min	E	No/late FL revision
25/6/2015	NWA		FL350	2.0 min	E	No/late transfer
27/6/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
27/6/2015	AXL	FL390	FL350	0.0 min	E	No/late FL revision
30/6/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
30/6/2015	NWA		FL330	2.0 min	E	No/late transfer
5/7/2015	ANG	FL330	FL350	0.0 min	E	No/late FL revision
27/5/2015	FKM	FL290	FL310	5.0 min	D	?
9/7/2015	ANG	FL370	FL330	0.0 min	E	No/late FL revision
1/7/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
1/7/2015	AXL		FL350	0.0 min	E	No/late transfer
2/7/2015	RRA	FL380	FL400	0.0 min	E	No/late FL revision
1/6/2015	ANG	FL380	FL400	29.0 min	B	Aircraft climbed to FL400 from FL380 without ATC instruction. No Breakdown in separation. Flight crew climbing/descending without ATC Clearance
2/7/2015	AXL		FL370	0.0 min	E	No/late transfer
3/7/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
5/7/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
5/7/2015	JLS	FL340	FL340	0.0 min	E	No/late time revision
5/7/2015	JLS	FL280	FL280	0.0 min	E	No/late time revision

5/7/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
9/7/2015	ANG	FL330	FL350	0.0 min	E	No/late FL revision
5/7/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
5/7/2015	JLS	FL340	FL340	0.0 min	E	No/late time revision
5/7/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
5/7/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
15/6/2015	JLS	FL330	FL325	1.0 min	I	
6/7/2015	NWA	FL350	FL350	0.0 min	E	No/late time revision
6/7/2015	NWA	FL350	FL350	21.0 min	E	No Revised EST given by VECC. No Breakdown in Separation.
12/7/2015	ANG	FL410	FL350	0.0 min	E	No/late FL revision
14/7/2015	ANG	FL330	FL350	0.0 min	E	No/late FL revision
10/7/2015	AXL	FL350	FL350	0.0 min	E	No/late time revision
20/6/2015	ANG	FL370	FL367	28.0 min	I	RA Reported by UAE345. Deviation due to turbulence or other weather related cause Other Traffic: UAE345/FL360
10/7/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
10/7/2015	AXL	FL350	FL350	2.0 min	E	No/late time revision
10/7/2015	AXL	FL390	FL390	3.0 min	E	No/late time revision
14/7/2015	ANG	FL410	FL390	0.0 min	E	No/late FL revision
13/7/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
20/7/2015	ANG	FL410	FL390	0.0 min	E	No/late FL revision
15/7/2015	SOF		FL360	0.0 min	E	No/late transfer
15/7/2015	JLS	FL380	FL360	3.0 min	E	No/late FL revision
15/7/2015	AXL	FL330	FL330	0.0 min	E	No/late time revision
16/7/2015	RRA	FL320	FL340	0.0 min	E	No/late FL revision
17/7/2015	RRA		FL300	0.0 min	E	No/late transfer
17/7/2015	AXL	FL330	FL330	1.0 min	E	No/late time revision
17/7/2015	AXL	FL410	FL410	3.0 min	E	No/late time revision
19/7/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
19/7/2015	AXL	FL390	FL390	0.0 min	E	No/late time revision
20/7/2015	NWA	FL390	FL410	3.0 min	E	No/late FL revision
22/7/2015	JLS	FL300	FL300	0.0 min	E	No/late time revision
24/7/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
25/7/2015	NWA		FL290	4.0 min	E	No/late transfer
25/7/2015	NWA		FL370	4.0 min	E	No/late transfer
25/7/2015	NWA		FL290	3.0 min	E	No/late transfer
26/7/2015	NWA		FL290	4.0 min	E	No/late transfer
26/7/2015	NWA	FL370	FL370	11.0 min	E	No Revised EST given by VECC. No Breakdown in Separation.
27/7/2015	NWA	FL330	FL370	3.0 min	E	No/late FL revision
28/7/2015	JLS	FL380	FL380	0.0 min	E	No/late time revision
30/7/2015	AXL	FL330	FL350	0.0 min	E	No/late FL revision
10/8/2015	ANG	FL410	FL390	0.0 min	E	No/late FL revision
28/8/2015	ANG	FL310	FL370	9.0 min	E	No/late FL revision
1/8/2015	AXL	FL350	FL350	0.0 min	E	No/late time revision
1/8/2015	AXL	FL330	FL330	0.0 min	E	No/late time revision
1/8/2015	AXL	FL350	FL350	0.0 min	E	No/late time revision
1/8/2015	AXL	FL390	FL390	0.0 min	E	No/late time revision

2/8/2015	NWA		FL330	3.0 min	E	No/late time revision
2/8/2015	NWA		FL370	3.0 min	E	No/late transfer
3/8/2015	RRA	FL380	FL400	0.0 min	E	No/late FL revision
4/8/2015	NWA	FL370	FL390	2.0 min	E	No/late FL revision
4/8/2015	NWA	FL390	FL370	1.0 min	E	No/late FL revision
4/8/2015	RRA	FL340	FL360	0.0 min	E	No/late FL revision
5/8/2015	NWA	FL390	FL370	3.0 min	E	No/late FL revision
6/8/2015	NWA	FL370	FL390	2.0 min	E	No/late FL revision
9/8/2015	AXL	FL330	FL330	0.0 min	E	No/late time revision
31/8/2015	ANG	FL410	FL370	0.0 min	E	No/late FL revision
11/8/2015	RRA		FL320	0.0 min	E	No/late transfer
12/8/2015	NWA	FL350	FL370	1.0 min	E	No/late FL revision
13/8/2015	JLS	FL380	FL380	0.0 min	E	No/late time revision
15/8/2015	NWA	FL330	FL390	2.0 min	E	No/late FL revision
16/8/2015	AXL	FL310	FL310	0.0 min	E	No/late transfer
16/8/2015	RRA	FL340	FL340	0.0 min	E	No/late route revision
17/8/2015	NWA	FL350	FL370	1.0 min	E	No/late FL revision
17/8/2015	JLS	FL320	FL360	0.0 min	E	No/late FL revision
19/8/2015	JLS	FL360	FL380	0.0 min	E	No/late FL revision
20/8/2015	NWA	FL370	FL330	2.0 min	E	No/late FL revision
21/8/2015	HID	FL290	FL290	8.0 min	E	Weather deviation without coordination with involving ACC unit
21/8/2015	NWA		FL410	3.0 min	E	No/late transfer
22/8/2015	RRA	FL360	FL320	0.0 min	E	No/late FL revision
22/8/2015	AXL	FL390	FL390	0.0 min	E	No/late time revision
22/8/2015	RRA	FL450	FL380	0.0 min	E	No/late FL revision
23/8/2015	JLS	FL360	FL360	0.0 min	E	No/late time revision
25/8/2015	NWA	FL400	FL410	3.0 min	E	No/late FL revision
25/8/2015	AXL	FL410	FL410	0.0 min	E	No/late transfer
25/8/2015	NWA	FL350	FL370	2.0 min	E	No/late FL revision
28/8/2015	JLS	FL320	FL320	0.0 min	E	No/late time revision
28/8/2015	XMV	FL380	FL380	40.0 min	E	Estimate passed as NISOK 0518 FL380 Aircraft reported NISOK 0415 FL380 on route P756 and Estimating Position OBDAL 0447 FL380. To avoid conflict with GIA6305 at FL380 on converging route M766 at position OBDAL TGW2502 climbed to nonstandard FL390 by Colombo Oceanic Controller. Other Traffic : GIA6305 A333 Estimating OBDAL 0448 FL380
31/8/2015	RRA	FL340	FL380	0.0 min	E	No/late FL revision
15/9/2015	ANG	FL350	FL410	20.0 min	E	No level change was passed by Muscat. No Breakdown in separation. (Note: Muscat control did not release the aircraft at coordinated level) KQA860, FL410, route-G450. Traffic conflicting over DONSA
6/9/2015	AXL	FL330	FL330	0.0 min	E	No/late time revision

6/9/2015	AXL	FL310	FL310	0.0 min	E	No/late time revision
9/9/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
9/9/2015	AXL	FL390	FL390	0.0 min	E	No/late time revision
29/9/2015	AXL	FL370	FL390	0.0 min	E	No/late FL revision
12/9/2015	NWA	FL370	FL350	2.0 min	E	No/late FL revision
18/9/2015	NWA	FL350	FL390	3.0 min	E	No/late FL revision
18/9/2015	NWA	FL370	FL390	2.0 min	E	No/late FL revision
20/9/2015	NWA		FL370	1.0 min	E	No/late transfer
20/9/2015	NWA		FL410	1.0 min	E	No/late transfer
24/9/2015	NWA		FL370	2.0 min	E	No/late transfer
24/9/2015	NWA	FL410	FL390	1.0 min	E	No/late FL revision
17/8/2015	ANG	FL410	FL330	0.0 min	B	
24/9/2015	NWA		FL370	1.0 min	E	No/late transfer
24/9/2015	NWA	FL370	FL350	2.0 min	E	No/late FL revision
24/9/2015	NWA	FL330	FL350	1.0 min	E	No/late FL revision
25/9/2015	NWA		FL390	1.0 min	E	No/late transfer
25/9/2015	NWA		FL370	1.0 min	E	No/late transfer
27/10/2015	ANG		FL330	0.0 min	E	No/late transfer
1/10/2015	AXL		FL390	0.0 min	E	No/late transfer
3/10/2015	RRA	FL320	FL300	0.0 min	E	No/late FL revision
12/10/2015	RRA	FL350	FL370	0.0 min	E	No/late FL revision
18/10/2015	HID	FL280	FL320	5.0 min	E	ATC-LOA noncompliance (FL)
18/10/2015	JLS	FL340	FL340	0.0 min	E	No/late time revision
20/10/2015	AXL	FL350	FL390	0.0 min	E	No/late FL revision
24/10/2015	RRA	FL280	FL320	0.0 min	E	No/late FL revision
26/10/2015	RRA		FL340	0.0 min	E	No/late transfer
28/10/2015	JLS		FL370	0.0 min	E	No/late transfer
28/10/2015	RRA	FL380	FL340	0.0 min	E	No/late FL revision
9/10/2015	NWA	FL370	FL390	1.0 min	E	No/late FL revision
20/10/2015	NWA	FL350	FL370	12.0 min	E	No Revised FL given by VECC
21/10/2015	NWA	FL330	FL350	1.0 min	E	No/late FL revision
22/10/2015	NWA		FL410	2.0 min	E	No/late transfer
24/10/2015	NWA	FL350	FL370	2.0 min	E	No/late FL revision
24/10/2015	NWA		FL350	1.0 min	E	No/late transfer
24/10/2015	NWA		FL390	1.0 min	E	No/late transfer
24/10/2015	NWA	FL390	FL410	1.0 min	E	No/late FL revision
25/10/2015	NWA		FL370	2.0 min	E	No/late transfer
27/10/2015	NWA		FL390	1.0 min	E	No/late transfer
3/10/2015	FKM	FL380	FL365		D	
27/10/2015	NWA	FL390	FL410	3.0 min	E	No/late FL revision
28/10/2015	NWA	FL350	FL370	2.0 min	E	No/late FL revision
29/10/2015	NWA		FL390	5.0 min	E	No/late transfer
30/10/2015	NWA	FL370	FL370	14.0 min	E	No Revised EST given by VECC
26/9/2015	VQK	FL380	FL384		J	
31/10/2015	NWA		FL410	2.0 min	E	No/late transfer
1/11/2015	NWA	FL330	FL350	1.0 min	E	No/late FL revision
2/11/2015	JLS		FL320	0.0 min	E	No/late transfer
3/11/2015	NWA		FL390	2.0 min	E	No/late transfer

3/11/2015	NWA		FL350	2.0 min	E	No/late transfer
3/11/2015	AXL	FL290	FL410	0.0 min	E	No/late FL revision
3/11/2015	RRA		FL300	0.0 min	E	No/late transfer
5/11/2015	NWA	FL330	FL350	1.0 min	E	No/late FL revision
6/11/2015	NWA		FL350	1.0 min	E	No/late transfer
6/11/2015	NWA	FL390	FL410	1.0 min	E	No/late FL revision
6/11/2015	AXL	FL330	FL370	0.0 min	E	No/late FL revision
7/11/2015	NWA		FL410	1.0 min	E	No/late transfer
8/11/2015	RRA		FL320	0.0 min	E	No/late transfer
8/11/2015	RRA		FL360	0.0 min	E	No/late transfer
8/11/2015	RRA		FL320	0.0 min	E	No/late transfer
8/11/2015	RRA		FL340	0.0 min	E	No/late transfer
8/11/2015	RRA		FL360	0.0 min	E	No/late transfer
11/11/2015	NWA		FL390	1.0 min	E	No/late transfer
11/11/2015	NWA	FL370	FL390	1.0 min	E	No/late FL revision
13/11/2015	NWA	FL350	FL370	1.0 min	E	No/late FL revision
14/11/2015	NWA	FL310	FL390	1.0 min	E	No/late FL revision
15/11/2015	NWA		FL350	1.0 min	E	No/late transfer
15/11/2015	NWA	FL370	FL350	1.0 min	E	No/late FL revision
16/11/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
19/11/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
19/11/2015	AXL	FL410	FL410	0.0 min	E	No/late time revision
21/11/2015	AXL	FL370	FL370	0.0 min	E	No/late time revision
22/11/2015	AXL	FL390	FL390	0.0 min	E	No/late time revision
22/11/2015	RRA		FL300	0.0 min	E	No/late transfer
23/11/2015	NWA	FL370	FL390	1.0 min	E	No/late FL revision
28/11/2015	AXL	FL410	FL410	1.0 min	E	No/late time revision
29/11/2015	NWA		FL370	1.0 min	E	No/late transfer
17/11/2015	ANG	FL330	FL310	0.0 min	E	No/late FL revision
22/11/2015	ANG		FL390	0.0 min	E	No/late transfer
30/11/2015	NWA	FL330	FL350	2.0 min	E	No/late FL revision
30/11/2015	NWA	FL350	FL370	1.0 min	E	No/late FL revision
30/11/2015	NWA	FL370	FL370	6.0 min	E	No/late time revision
30/11/2015	NWA	FL410	FL390	1.0 min	E	No/late FL revision
30/11/2015	RRA	FL360	FL380	0.0 min	E	No/late FL revision
30/11/2015	RRA	FL380	FL360	0.0 min	E	No/late FL revision
3/11/2015	HID	FL290	FL350	0.0 min	E	ATC-LOA noncompliance (FL)
3/11/2015	HID	FL360	FL350	5.0 min	M	ATC-LOA noncompliance (FL)
2/12/2015	NWA	FL390	FL410	1.0 min	E	No/late FL revision
2/12/2015	AXL	FL410	FL410	4.0 min	E	No/late transfer
2/12/2015	AXL	FL410	FL410	0.0 min	E	No/late transfer
6/12/2015	NWA		FL370	3.0 min	E	No/late transfer
6/12/2015	NWA		FL410	2.0 min	E	No/late transfer
6/12/2015	ANG	FL360	FL380	0.0 min	E	No/late FL revision
8/12/2015	NWA	FL330	FL350	3.0 min	E	No/late FL revision
11/12/2015	NWA	FL330	FL350	2.0 min	E	No/late FL revision
11/12/2015	NWA	FL350	FL370	2.0 min	E	No/late FL revision
12/12/2015	NWA	FL350	FL410	3.0 min	E	No/late FL revision
14/12/2015	ANG		FL290	0.0 min	E	No/late transfer
14/12/2015	ANG		FL370	0.0 min	E	No/late transfer

14/12/2015	RRA	FL360	FL380	0.0 min	E	No/late FL revision
16/12/2015	NWA		FL330	3.0 min	E	No/late transfer
16/12/2015	NWA		FL410	1.0 min	E	No/late transfer
18/12/2015	RRA	FL320	FL300	0.0 min	E	No/late FL revision
19/12/2015	JLS	FL310	FL330	0.0 min	E	No/late FL revision
23/12/2015	NWA	FL370	FL350	2.0 min	E	No/late FL revision
23/12/2015	NWA	FL350	FL370	2.0 min	E	No/late FL revision
23/12/2015	RRA	FL360	FL340	8.0 min	E	No/late FL revision
24/12/2015	NWA	FL350	FL370	3.0 min	E	No/late FL revision
24/12/2015	NWA	FL330	FL350	2.0 min	E	No/late FL revision
26/12/2015	NWA	FL340	FL340	9.0 min	E	No/late time revision
27/12/2015	AXL	FL330	FL330	1.0 min	E	No/late time revision
27/12/2015	RRA		FL320	0.0 min	E	No/late transfer
12/12/2015	HID	FL290	FL350	8.0 min	M	
12/12/2015	HID	FL290	FL350	0.0 min	E	ATC-LOA noncompliance (FL)
13/12/2015	HID	FL320	FL340	0.0 min	E	No/late FL revision
26/12/2015	HID	FL290	FL265	0.0 min	A	
30/12/2015	SOF	FL300	FL320	0.0 min	E	No/late FL revision

MONITORING AGENCY FOR ASIA REGION (MAAR)



**Airspace Safety Review of RVSM in
Western Pacific/South China Sea Airspace**

January 2015 to December 2015

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
 THE WESTERN PACIFIC/SOUTH CHINA SEA AIRSPACE**
Assessment Period: January 2015 to December 2015

Prepared by
Monitoring for Asia Region (MAAR)
(An ICAO APANPIRG approved Regional Monitoring Agency)

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in **Western Pacific/South China Sea (WPAC/SCS)** airspace. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2015** and monthly Large Height Deviation (LHD) reports between **January 2015** and **December 2015** submitted by concerning States in the WPAC/SCS region.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2015 of aircraft operating in WPAC/SCS airspace was used as required by ICAO regional agreement.

2.2. **Large Height Deviation (LHD).** A cumulative 12-month data set of LHD reports was, covering January 2015 to December 2015. **Table 1** indicates those FIRs which submitted LHD reports including nil returns. **Appendix A** provides details of LHD reports, including full description of LHDs with large duration.

FIR/ Month	Phnom Penh	Sanya	Hong Kong	Vientiane	Kota Kinabalu	Kuala Lumpur	Manila	Singapore	Bangkok	Hanoi	Ho Chi Minh
January	X	X	X	X	X	X	X	X	X	X	X
February	X	X	X	X	X	X	X	X	X	X	X
March	X	X	X	X	X	X	X	X	X	X	X
April	X	X	X	X	X	X	X	X	X	X	X
May	X	X	X	X	X	X	X	X	X	X	X
June	X	X	X	X	X	X	X	X	X	X	X
July	X	X	X	X	X	X	X	X	X	X	X
August	X	X	X	X	X	X	X	X	X	X	X
September	X	X	X	X	X	X	X	X	X	X	X
October	X	X	X	X	X	X	X	X	X	X	X
November	X	X	X	X	X	X	X	X	X	X	X
December	X	X	X	X	X	X	X	X	X	X	X

Table 1: Summary of LHD Reports Submitted by FIRs

3. Summary of LHD Occurrences

3.1. **Table 2** and **Figure 1** summarize the number of Non-NIL LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2015 to December 2015.

Month (2015)	No. of Non-NIL LHD	LHD Duration (Min)	No. Levels Crossed	Operational Risk ($\times 10^{-9}$)
January	20	9	0	0.21
February	13	10	0	0.26
March	5	0	0	0
April	12	0	0	0
May	13	8	0	0.18
June	13	8	4	0.33
July	11	43	0	1.23
August	27	27	0	0.73
September	14	2	0	0.06
October	13	0	0	0
November	17	18	1	1.2
December	8	1	0	0.03
Total	166	126	5	4.25

Table 2: Summary of LHD by Month for WPAC/SCS Airspace

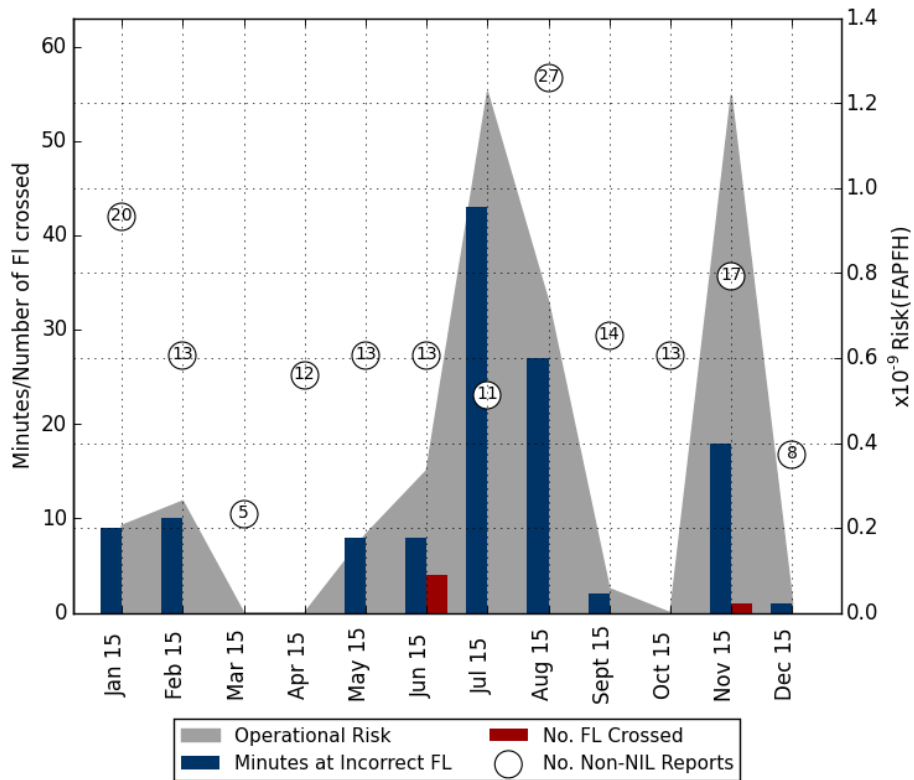


Figure 1: Summary of LHD Occurrences by Month for WPAC/SCS Airspace

3.2. Compared to 2014, the number of non-nil LHD reports increased from 144 to 166 and the total LHD duration increased from 99 minutes to 126 minutes. As a result the total risk in 2015 increases from that 2014 and exceeds target level of safety.

3.3. **Table 3** and **Figure 2** summarize the number of LHD occurrences, the associated LHD duration (in minutes), and number of flight levels crossed without clearance, by LHD category from January 2015 to December 2015.

LHD Category Code	LHD Category Description	No. of LHDs	LHD Duration (Min)	No. levels crossed	Operational Risk (x10 ⁻⁹)
A	Flight crew failing to climb/descend the aircraft as cleared	1	0	1	0.71
B	Flight crew climbing/descending without ATC Clearance	1	0	4	0.13
C	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)	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message)	5	0	0	0
E	Coordination errors in the ATC to ATC transfer or control responsibility as a result of human factors issues (e.g. late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route etc not in accordance with agreed parameters)	143	82	0	2.17
F	Coordination errors in the ATC to ATC transfer or control responsibility as a result of equipment outage or technical issues	6	0	0	0
G	Deviation due to aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0
H	Deviation due to airborne equipment failure leading to unintentional or undetected change of flight level	0	0	0	0
I	Deviation due to turbulence or other weather related cause	0	0	0	0
J	Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory	0	0	0	0
K	Deviation due to TCAS resolution advisory, flight crew incorrectly following the resolution advisory	0	0	0	0
L	An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan)	0	0	0	0
M	Other – this includes situations of flights operating (including climbing/descending) in airspace where flight crews are unable to establish normal air-ground communications with the responsible ATS unit.	10	44	0	1.24
Total		166	126	5	4.25

Table 3: Summary of LHD by LHD Category for WPAC/SCS Airspace

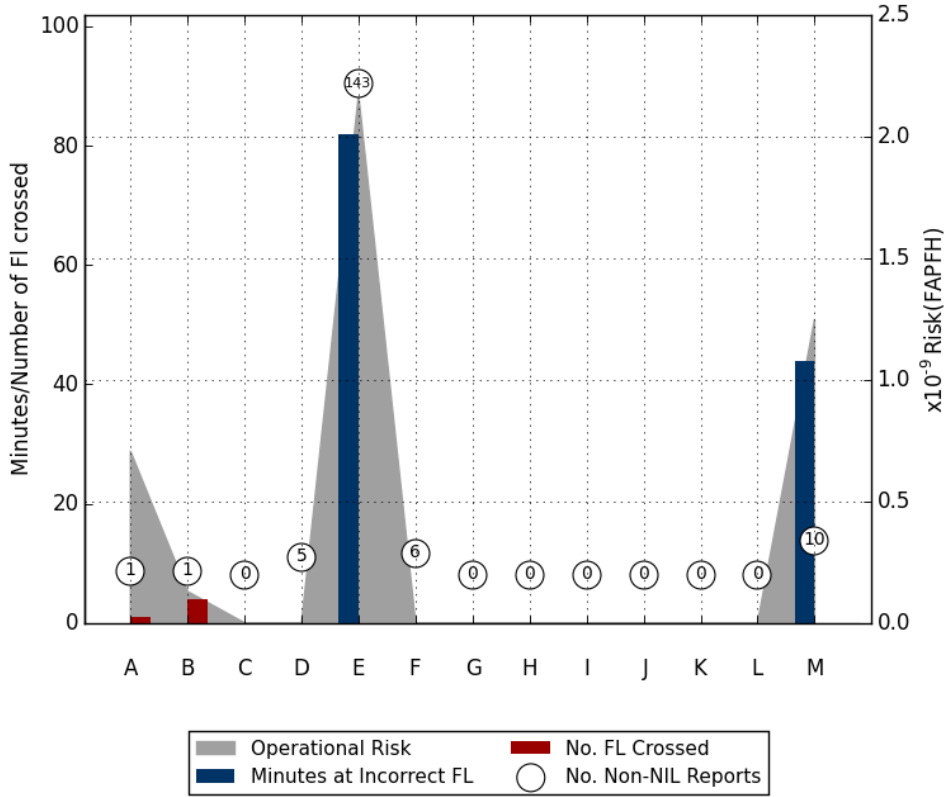


Figure 2: Summary of LHD by LHD Category for WPAC/SCS Airspace

3.4. Category E LHDs still account for most of LHD duration and occurrences in the region. These occurrences can be further categorized into the sub-categories. **Figure 3** and **Figure 4** depict contribution of each sub-category in term of number of occurrences and risk, respectively.

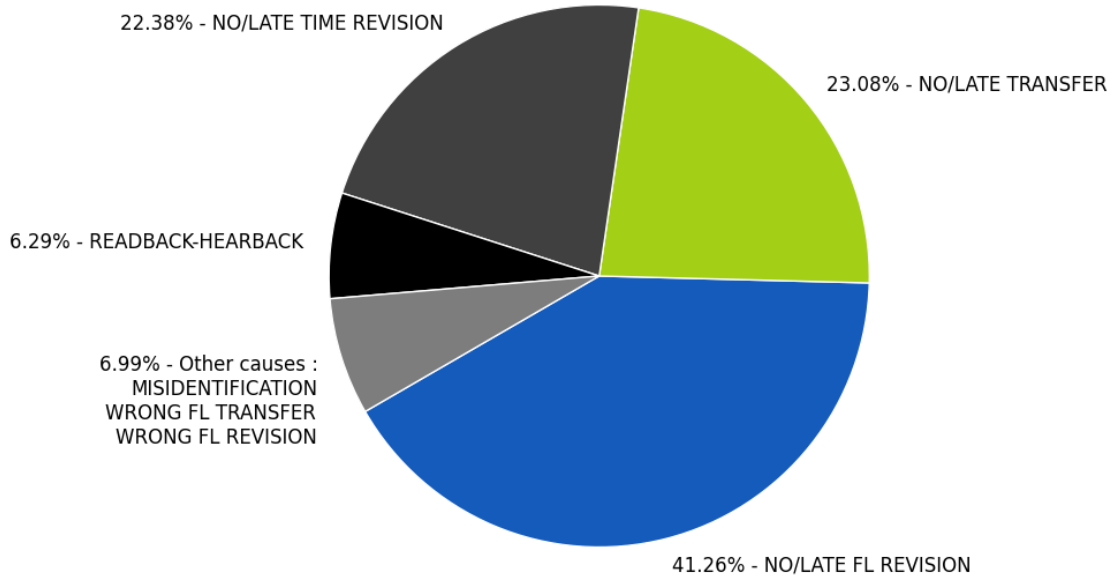


Figure 3: Sub-categories of Category-E LHDs for WPAC/SCS Airspace (number of occurrences)

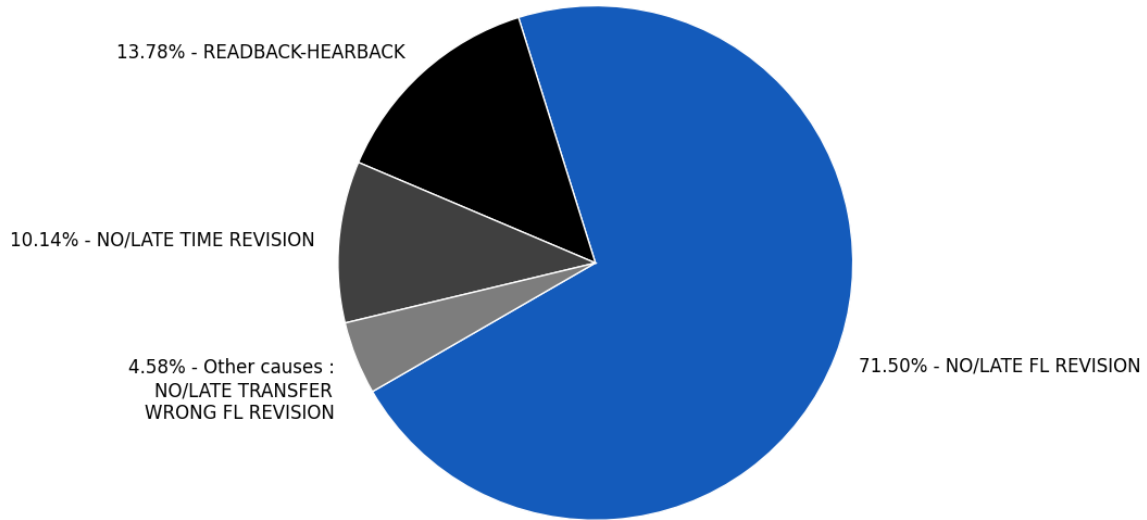


Figure 4: Sub-categories of Category-E LHDs for WPAC/SCS Airspace (risk)

4. Risk Assessment and Safety Oversight

4.1. **Collision Risk Model (CRM) Parameters.** The value and the source of the parameters in the CRM used to estimate risk in the RVSM airspace are summarized in **Table 4**.

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	1,199,261	570,091	Hour	Dec 2015 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.387733/ 0.0489	0.3336	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.3747	0.0085	-	
λ_x	Average aircraft length	0.0263	0.0282	NM	
λ_y	Average aircraft wingspan	0.0242	0.0259	NM	
λ_z	Average aircraft height	0.0076	0.0080	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0263	0.0282	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	Conservative value used in previous assessments
$ \overline{\Delta V} $	Average relative along-track speed between aircraft on same direction routes	31.74	27.79	Knot	Dec 2015 TSD

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
\overline{V}	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for WPAC/SCS Airspace

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. The technical risk **meets** the agreed TLS value of no more than 2.5×10^{-9} fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft and to all causes. **The total risk exceeds the specified TLS value for these components of 5.0×10^{-9} .**

Western Pacific/South China Sea RVSM Airspace – estimated annual flying hours = 1,769,352 hours (note: estimated hours based on December 2015 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	1.48×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	4.25×10^{-9}	-	-
Total Risk	5.73×10^{-9}	5.0×10^{-9}	Above Overall TLS

Table 5: Risk Estimates for WPAC/SCS Airspace

4.3 **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports.

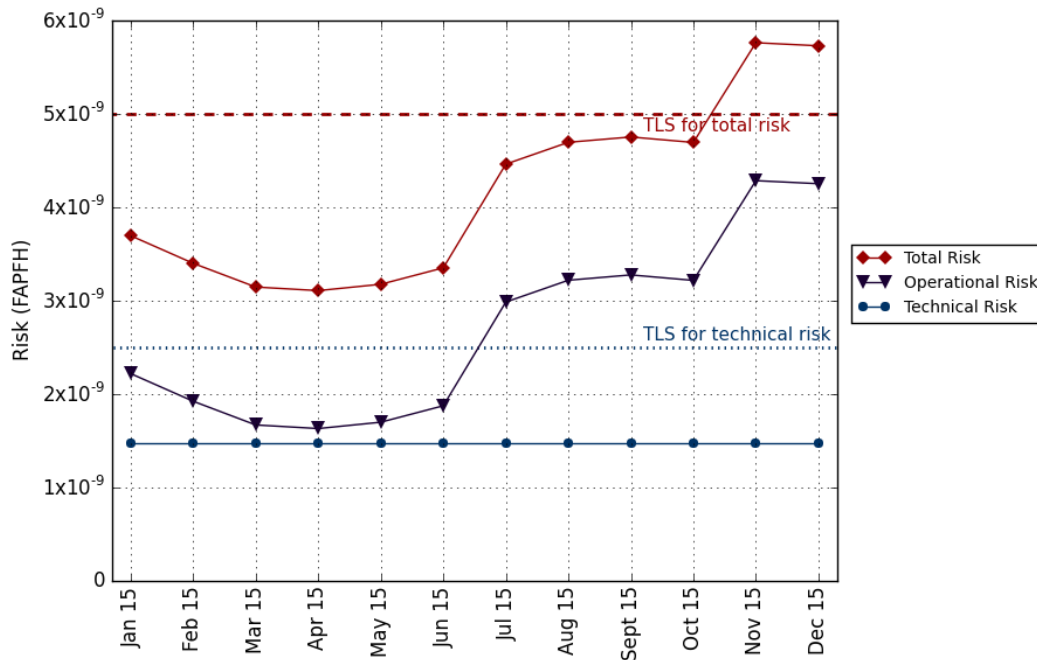


Figure 5: Trends of Risk Estimates for WPAC/SCS Airspace

4.4 A monthly LHD risk value is determined to provide real-time information on actual risk without reliance on historical high-time errors resident within the 12 month data sample. **Figure 6** demonstrates monthly LHD risk, where each individual block represents one LHD event and the red horizontal line represents the average monthly risk of approximately 0.4167×10^{-9} fatal accidents per flight hour. According to **Figure 6**, risk occurred in July was dominated by a single high risk LHD event, which accounts for approximately 1.2×10^{-9} FAPFH. Similarly, risk in November and December was the result of a few high risk events.

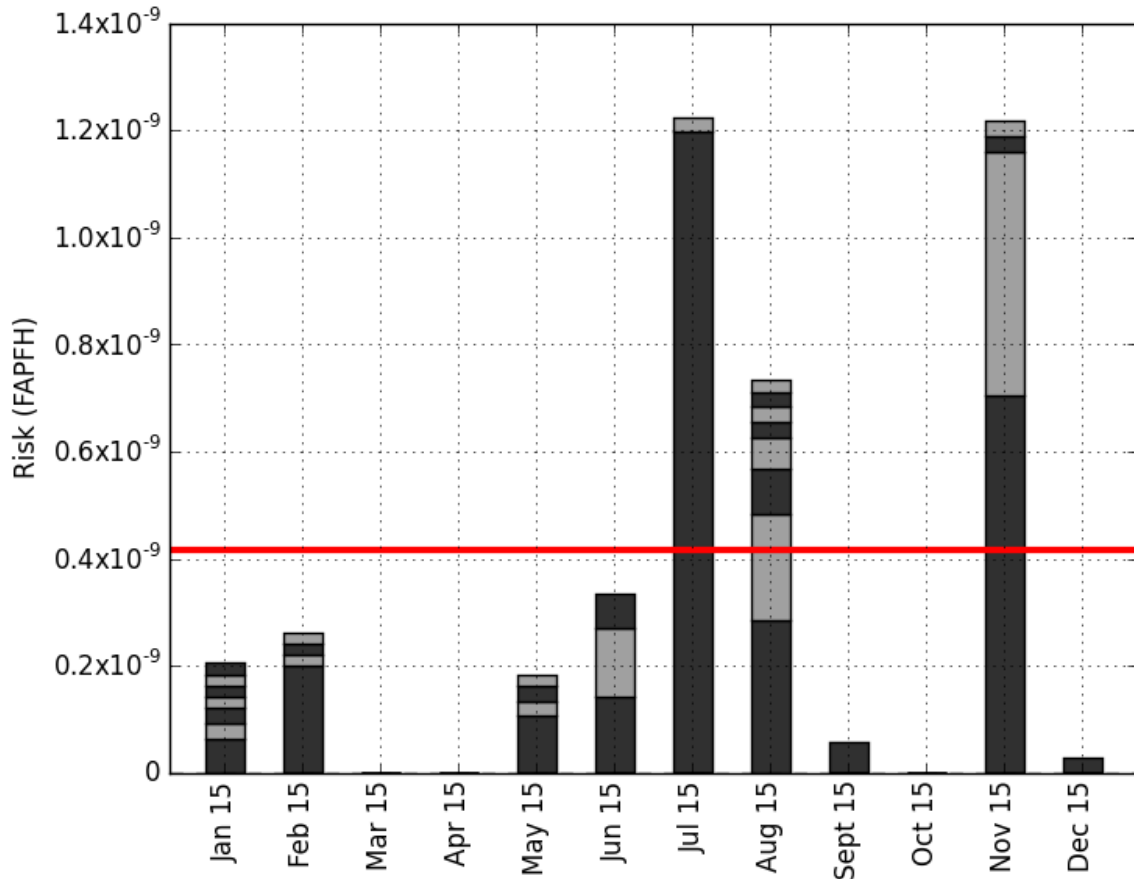


Figure 6: Monthly LHD Risk Estimates for WPAC/SCS Airspace. Red line is the average monthly value for an annual risk of 5.0×10^{-9} . Risk is measured in Fatal Accidents per Flight Hour (FAPFH).

5. Analysis of Operational Errors

5.7 **Figure 7** depicts geographic location of risk bearing LHDs and hot spots in WPAC/SCS airspace based on LHD reports from January to December 2015 where:

- the navy dotted line represents the frequency of occurrences at the labeled waypoint,
- the color of each circle represents the sum of minutes at incorrect flight level and the number of flight levels crossed without clearance (darker orange represents higher value) associated with LHDs occurring at or near the labeled waypoint, and
- the area of the circle represents the sum of operational risk associated with LHDs occurring at or near the labeled waypoint, and
- the turquoise lines represent west-bound traffic movements while the orange lines represent east-bound traffic movements.

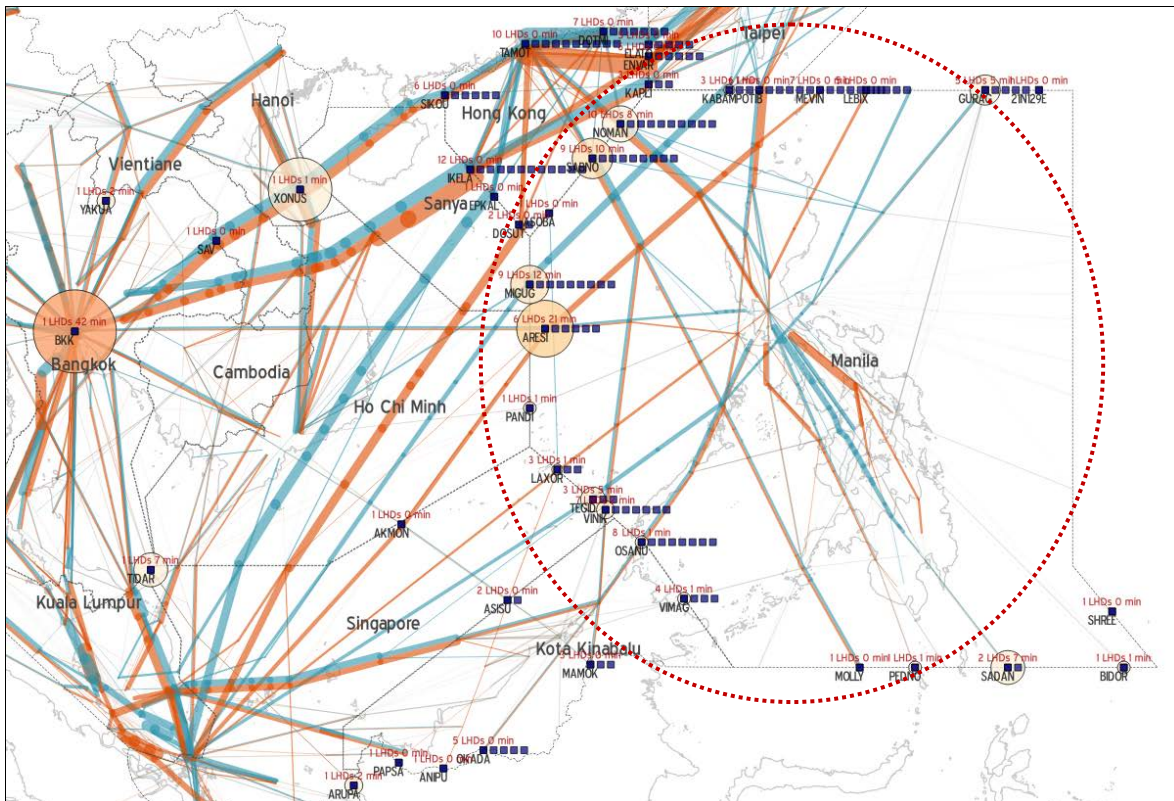


Figure 7: Geographical Location of LHDs in WPAC/SCS Airspace

5.8 The main hot spot for the region still remains the interfaces around Manila FIR boundary. Most LHDs in this hot spot have zero duration since the area has good communication and surveillance coverage. A few LHDs have short duration at the areas where there are holes in surveillance coverage such as the Manila-Hong Kong and Manila-Ho Chi Minh interfaces.

5.9 The overall risk in the region exceeds the TLS due one occurrence with a long duration inside the Bangkok FIR in July, caused by a human error, and then induced a loss of separation.

6. Long Term Height-keeping Monitoring (LTHM)

To meet the ICAO Annex 6 LTHM requirements, the MAAR undertakes a monitoring program. The current monitoring burden data for WPAC/SCS States is detailed in **Table 6** below.

State	Total RVSM Approved Airframes	Resultant Monitoring Burden	Total Airframes Remaining to be Monitored	% Airframes Remaining to be Monitored
Brunei (WB)	15	8	0	0%
Cambodia (VD)	14	6	0	0%
Hong Kong, China (VH)	272	52	2	4%
Laos (VL)	4	2	0	0%
Macau, China (VM)	18	3	0	0%
Malaysia (WM)	280	39	17	44%
Philippines (RP)	167	49	15	31%
Singapore (WS)	202	29	2	7%
Taiwan, China (RC)	216	49	6	12%
Thailand (VT)	332	109	46	42%
Viet Nam (VV)	119	18	0	0%
Grand Total	1639	364	88	24%

Table 6: LTHM Burden

Appendix A: Details of the Reported LHD Events in the WPAC/SCS Airspace

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
14/1/2015	PKT		FL321	0.0 min	E	No/late time revision
17/1/2015	PKT	FL350	FL370	0.0 min	E	No/late FL revision
20/1/2015	PKT	FL391	FL371	0.0 min	E	Wrong FL transfer
21/1/2015	PKT		FL341	0.0 min	E	No/late transfer
22/1/2015	PKT	FL391	FL371	0.0 min	E	No/late FL revision
29/1/2015	PKT		FL330	0.0 min	F	
7/1/2015	JOA	FL370	FL330	0.0 min	E	No/late FL revision
11/1/2015	JOA			0.0 min	E	No/late time revision
21/1/2015	JOA			0.0 min	E	No/late transfer
1/1/2015	KHI	FL360	FL400	1.0 min	E	Wrong FL revision
3/1/2015	KHI	FL390	FL390	1.0 min	E	No/late time revision
13/1/2015	KHI	FL340	FL300	0.0 min	E	No/late FL revision
17/1/2015	KHI	FL340	FL380	0.0 min	E	Wrong FL revision
20/1/2015	KHI	FL320	FL360	1.0 min	E	Readback-hearback
21/1/2015	KHI	FL410	FL410	0.0 min	E	Readback-hearback
25/1/2015	KHI	FL310	FL350	1.0 min	E	Readback-hearback
27/1/2015	KHI	FL380	FL380	1.0 min	E	No/late time revision
31/1/2015	KHI	FL360	FL360	0.0 min	E	No/late time revision
1/1/2015	BFW	FL350	FL360	1.0 min	E	No/late FL revision
11/1/2015	BFW	FL360	FL350	3.0 min	E	No/late FL revision
8/2/2015	WPY	FL350	FL350	1.0 min	M	Pilot-inaccurate time estimate
7/2/2015	PKT		FL370	0.0 min	E	No/late transfer
14/2/2015	PKT		FL381	0.0 min	E	No/late transfer
15/2/2015	PKT	FL371	FL351	0.0 min	E	No/late FL revision
23/2/2015	PKT		FL390	0.0 min	F	No/late transfer
23/2/2015	PKT		FL360	0.0 min	F	No/late transfer
24/2/2015	JOA	FL380	FL400	0.0 min	E	No/late FL revision
24/2/2015	JOA	FL340	FL380	0.0 min	E	No/late FL revision
15/2/2015	KHI	FL330	FL330	0.0 min	E	No/late transfer
16/2/2015	KHI	FL300	FL340	0.0 min	E	No/late FL revision
23/2/2015	KHI	FL390	FL390	1.0 min	E	Readback-hearback
6/2/2015	BFW	FL370	FL390	7.0 min	E	No/late FL revision
26/2/2015	BFW	FL360	FL320	1.0 min	E	No/late FL revision
22/3/2015	PKT	FL371	FL391	0.0 min	E	No/late FL revision
26/3/2015	JOA			0.0 min	E	No/late time revision
18/3/2015	KHI	FL380	FL380	0.0 min	E	No/late time revision
26/3/2015	KHI	FL310	FL310	0.0 min	M	Pilot-inaccurate time estimate
29/3/2015	KHI	FL350	FL330	0.0 min	E	No/late FL revision
9/4/2015	WPY	FL390	FL390		E	No/late transfer
12/4/2015	PKT		FL320	0.0 min	E	No/late transfer
12/4/2015	PKT	FL371	FL391	0.0 min	E	No/late FL revision

14/4/2015	PKT		FL400	0.0 min	E	No/late transfer
14/4/2015	PKT	FL301	FL321	0.0 min	E	No/late FL revision
18/4/2015	PKT	FL320	FL360	0.0 min	E	No/late FL revision
19/4/2015	PKT	FL310	FL330	0.0 min	E	No/late FL revision
3/4/2015	JOA			0.0 min	E	No/late time revision
3/4/2015	JOA			0.0 min	E	No/late time revision
2/4/2015	KHI	FL380	FL380	0.0 min	E	No/late time revision
9/4/2015	KHI	FL370	FL350	0.0 min	M	Forgot/unable to climb/descend the aircraft
27/4/2015	KHI	FL310	FL340	0.0 min	E	Wrong FL transfer
6/5/2015	WPY	FL390	FL390	1.0 min	E	No/late transfer
30/5/2015	WPY	FL310	FL320	5.0 min	E	No/late FL revision
8/5/2015	PKT	FL340	FL380	0.0 min	E	No/late FL revision
10/5/2015	PKT	FL371	FL391	0.0 min	E	No/late FL revision
10/5/2015	PKT	FL390	FL390	0.0 min	E	Misidentification
14/5/2015	PKT	FL341	FL381	0.0 min	E	No/late FL revision
19/5/2015	PKT		FL401	0.0 min	E	No/late transfer
31/5/2015	PKT	FL310	FL390	0.0 min	F	
15/5/2015	JOA	FL390	FL380	0.0 min	M	Forgot/unable to climb/descend the aircraft
24/5/2015	JOA			0.0 min	E	No/late time revision
20/5/2015	KHI	FL340	FL340	1.0 min	E	No/late time revision
20/5/2015	KHI	FL370	FL370	1.0 min	E	No/late transfer
27/5/2015	KHI	FL350	FL340	0.0 min	E	No/late FL revision
8/6/2015	WPY	FL340	FL300	0.0 min	E	No/late FL revision
26/6/2015	PKT	FL330	FL370	0.0 min	E	Readback-hearback
28/6/2015	PKT	FL280	FL320	0.0 min	E	No/late FL revision
6/6/2015	JOA			0.0 min	E	No/late transfer
6/6/2015	JOA			0.0 min	E	No/late transfer
15/6/2015	JOA			0.0 min	E	No/late time revision
19/6/2015	JOA			0.0 min	E	No/late time revision
1/6/2015	KHI	FL360	FL390	0.0 min	E	No/late FL revision
2/6/2015	KHI	FL330	FL290	5.0 min	E	No/late FL revision
13/6/2015	KHI	FL310	FL350	0.0 min	B	
17/6/2015	KHI	FL310	FL350	3.0 min	E	No/late FL revision
22/6/2015	KHI	FL300	FL310	0.0 min	D	
22/6/2015	KHI	FL380	FL390	0.0 min	D	
21/7/2015	SOF	FL370	FL330	42.0 min	M	FL370 was marked on a strip but the intention was to climb A/C from FL330 to FL370. ATC did not instruct A/C to climb. ATC thought the A/C was at FL370 a(as written no the strip), but the actual level is FL330
1/7/2015	PKT	FL320	FL320	0.0 min	E	No/late transfer
6/7/2015	PKT	FL380	FL380	0.0 min	F	No/late transfer
24/7/2015	PKT	FL370	FL330	0.0 min	E	No/late FL revision
26/7/2015	PKT	FL320	FL320	0.0 min	E	No/late transfer
10/7/2015	JOA	FL350	FL330	0.0 min	E	No/late FL revision
18/7/2015	JOA	FL300	FL340	0.0 min	E	No/late FL revision
28/7/2015	JOA			0.0 min	E	No/late time revision
9/7/2015	KHI	FL390	FL390	0.0 min	E	Readback-hearback

20/7/2015	KHI	FL380	FL380	1.0 min	E	No/late time revision
29/7/2015	KHI	FL270	FL300	0.0 min	E	Readback-hearback
20/8/2015	SOF	FL360	FL340	2.0 min	E	No/late FL revision
27/8/2015	SOF	FL340	FL340	0.0 min	E	No/late time revision
10/8/2015	WPY	FL320	FL360	1.0 min	E	No/late FL revision
15/8/2015	WPY	FL350	FL350	4.0 min	E	No/late time revision
29/8/2015	WPY	FL360	FL360	0.0 min	E	Misidentification
1/8/2015	PKT	FL360	FL380	0.0 min	E	No/late FL revision
5/8/2015	PKT	FL290	FL290	0.0 min	F	FPL not received
10/8/2015	PKT	FL361	FL371	0.0 min	E	No/late FL revision
12/8/2015	PKT	FL370	FL330	0.0 min	D	ATC-clearance not delivered to Pilot
13/8/2015	PKT	FL290	FL370	0.0 min	D	ATC-clearance not delivered to Pilot
15/8/2015	PKT	FL350	FL350	0.0 min	E	No/late transfer
23/8/2015	PKT	FL350	FL350	0.0 min	E	No/late time revision
27/8/2015	PKT	FL330	FL350	0.0 min	E	No/late FL revision
29/8/2015	PKT			0.0 min	E	No/late time revision
21/8/2015	JOA		FL410	0.0 min	E	No/late transfer
31/8/2015	JOA			0.0 min	E	No/late time revision
3/8/2015	KHI	FL390	FL410	0.0 min	E	No/late FL revision
6/8/2015	KHI	FL380	FL380	1.0 min	E	Readback-hearback
6/8/2015	KHI	FL410	FL410	0.0 min	E	No/late transfer
13/8/2015	KHI	FL390	FL360	0.0 min	E	No/late FL revision
17/8/2015	KHI	FL330	FL370	10.0 min	E	No/late FL revision
18/8/2015	KHI	FL390	FL390	0.0 min	E	No/late time revision
22/8/2015	KHI	FL340	FL340	7.0 min	E	Readback-hearback
23/8/2015	KHI	FL350	FL350	0.0 min	E	No/late time revision
30/8/2015	KHI	FL370	FL370	0.0 min	E	No/late time revision
31/8/2015	KHI	FL370	FL370	1.0 min	E	No/late time revision
31/8/2015	KHI	FL350	FL370	1.0 min	E	No/late FL revision
6/9/2015	WPY	FL340	FL340	0.0 min	E	No/late time revision
27/9/2015	WPY		FL350		E	No/late transfer
13/9/2015	PKT			0.0 min	E	No/late transfer
14/9/2015	PKT			0.0 min	E	No/late transfer
15/9/2015	PKT	FL341	FL381	0.0 min	E	No/late FL revision
17/9/2015	PKT	FL340	FL380	0.0 min	E	Wrong FL revision
26/9/2015	PKT			0.0 min	E	No/late transfer
17/9/2015	JOA			0.0 min	E	No/late time revision
28/9/2015	JOA			0.0 min	E	No/late time revision
9/9/2015	KHI	FL390	FL400	0.0 min	E	No/late FL revision
25/9/2015	KHI	FL330	FL350	0.0 min	E	No/late FL revision
26/9/2015	KHI	FL430	FL430	0.0 min	E	No/late transfer
27/9/2015	KHI	FL330	FL350	0.0 min	E	Wrong FL transfer
17/9/2015	BFW	FL380	FL360	2.0 min	E	No/late FL revision
8/10/2015	PKT	FL300	FL340	0.0 min	E	No/late FL revision
8/10/2015	PKT	FL380	FL360	0.0 min	E	No/late FL revision
14/10/2015	PKT	FL320	FL280	0.0 min	E	No/late FL revision
23/10/2015	PKT	FL330	FL370	0.0 min	E	No/late FL revision
23/10/2015	PKT	FL340	FL380	0.0 min	E	No/late FL revision
3/10/2015	JOA	FL350	FL330	0.0 min	E	No/late FL revision
6/10/2015	JOA		FL330	0.0 min	E	No/late transfer

4/10/2015	KHI	FL390	FL370	0.0 min	M	Forgot/unable to climb/descend the aircraft
4/10/2015	KHI	FL370	FL350	0.0 min	M	Forgot/unable to climb/descend the aircraft
11/10/2015	KHI	FL340	FL340	0.0 min	E	No/late transfer
23/10/2015	KHI	FL350	FL370	0.0 min	E	No/late FL revision
25/10/2015	KHI	FL370	FL350	0.0 min	M	Forgot/unable to climb/descend the aircraft
21/10/2015	BFW	FL380	FL380	0.0 min	E	No/late transfer
29/11/2015	HME	FL330	FL326	0.0 min	A	
21/11/2015	WPY	FL340	FL340	1.0 min	E	No/late transfer
3/11/2015	PKT	S0980	S0980	0.0 min	E	No/late transfer
4/11/2015	PKT	FL330	FL330	0.0 min	E	No/late transfer
11/11/2015	PKT	FL360	FL380	0.0 min	E	No/late FL revision
15/11/2015	PKT	FL340	FL320	0.0 min	E	No/late FL revision
18/11/2015	PKT	FL330	FL330	0.0 min	E	No/late transfer
19/11/2015	PKT	FL300	FL340	0.0 min	E	No/late FL revision
7/11/2015	JOA		FL360	0.0 min	E	No/late transfer
4/11/2015	KHI	FL410	FL410	0.0 min	E	Misidentification
4/11/2015	KHI	FL410	FL370	0.0 min	E	Misidentification
8/11/2015	KHI	FL330	FL370	1.0 min	E	No/late FL revision
11/11/2015	KHI	FL350	FL350	0.0 min	M	Pilot-inaccurate time estimate
12/11/2015	KHI	FL390	FL410	0.0 min	E	No/late FL revision
13/11/2015	KHI	FL360	FL360	0.0 min	E	No/late time revision
20/11/2015	KHI	FL360	FL360	0.0 min	E	No/late time revision
20/11/2015	KHI	FL370	FL330	16.0 min	E	HCM ACC transferred UAE334 at FL370 but UAE334 reported ARESI at FL330. UAE334 did not establish communication with Manila HF. HCM ACC apologized
6/12/2015	PKT	S1040	S1040	0.0 min	E	No/late transfer
8/12/2015	PKT	FL390	FL380	0.0 min	E	No/late FL revision
25/12/2015	PKT		FL300	0.0 min	E	No/late transfer
18/12/2015	JOA	FL350	FL340	0.0 min	E	No/late FL revision
23/12/2015	JOA			0.0 min	E	No/late time revision
24/12/2015	JOA			0.0 min	E	No/late time revision
11/12/2015	KHI	FL270	FL270	0.0 min	D	
18/12/2015	KHI	FL410	FL400	1.0 min	M	Forgot/unable to climb/descend the aircraft

MONITORING AGENCY FOR ASIA REGION (MAAR)



**Airspace Safety Review of RVSM in
Mongolian Airspace**

January 2015 to December 2015

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE MONGOLIAN AIRSPACE**
Assessment Period: January 2015 to December 2015

Prepared by
Monitoring for Asia Region (MAAR)
(An ICAO APANPIRG approved Regional Monitoring Agency)

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in **Mongolian Airspace**. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2015** and monthly Large Height Deviation (LHD) reports between **January 2015** and **December 2015** submitted by Mongolia.

2. Data Sources

2.1. **Traffic Sample Data (TSD)**. A TSD covering the month of December 2015 of aircraft operating in Mongolian Airspace was used as required by ICAO regional agreement.

2.2. **Large Height Deviation (LHD)**. A cumulative 12-month data set of LHD reports was, covering January 2015 to December 2015. **Table 1** indicates Ulaanbaatar FIR which submitted LHD reports including nil returns. **Appendix A** provides details of LHD reports.

FIR/ Month	Ulaanbaatar
January	X
February	X
March	X
April	X
May	X
June	X
July	X
August	X
September	X
October	X
November	X
December	X

Table 1: Summary of LHD Reports Submitted by the FIR

3. Summary of LHD Occurrences

3.1. **Table 2** summarizes the number of Non-NIL LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2015 to December 2015.

- The number of LHD reports and their duration in 2015 reduced significantly from 2014 as there was only one LHD reported in 2015 with zero duration.

Month (2015)	No. of Non-NIL LHD	LHD Duration (Min)	No. Levels Crossed	Operational Risk (x10 ⁻⁹)
January	0	0.0	0	0.00
February	0	0.0	0	0.00
March	0	0.0	0	0.00
April	0	0.0	0	0.00
May	0	0.0	0	0.00
June	0	0.0	0	0.00
July	1	0.0	0	0.00
August	0	0.0	0	0.00
September	0	0.0	0	0.00
October	0	0.0	0	0.00
November	0	0.0	0	0.00
December	0	0.0	0	0.00
Total	1	0.0	0	0.00

Table 2: Summary of LHD by Month for Mongolian Airspace

3.2. **Table 3** summarizes the number of LHD occurrences, the associated LHD duration (in minutes), and number of flight levels crossed without clearance, by LHD category from January 2015 to December 2015.

LHD Category Code	LHD Category Description	No. of LHDs	LHD Duration (Min)	No. levels crossed	Operational Risk (x10 ⁻⁹)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0.0	0	0.00
B	Flight crew climbing/descending without ATC Clearance	0	0.0	0	0.00
C	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)	0	0.0	0	0.00
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message)	0	0.0	0	0.00
E	Coordination errors in the ATC to ATC transfer or control responsibility as a result of human factors issues (e.g. late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route etc not in accordance with agreed parameters)	1	0.0	0	0.00

F	Coordination errors in the ATC to ATC transfer or control responsibility as a result of equipment outage or technical issues	0	0.0	0	0.00
G	Deviation due to aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0.0	0	0.00
H	Deviation due to airborne equipment failure leading to unintentional or undetected change of flight level	0	0.0	0	0.00
I	Deviation due to turbulence or other weather related cause	0	0.0	0	0.00
J	Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory	0	0.0	0	0.00
K	Deviation due to TCAS resolution advisory, flight crew incorrectly following the resolution advisory	0	0.0	0	0.00
L	An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan)	0	0.0	0	0.00
M	Other – this includes situations of flights operating (including climbing/descending) in airspace where flight crews are unable to establish normal air-ground communications with the responsible ATS unit.	0	0.0	0	0.00
Total		1	0.0	0	0.00

Table 3: Summary of LHD by LHD Category for Mongolian Airspace

3.3. In 2015, there was only one LHD event, which is a Cat E LHD. However, the duration and risk associated with this event are zero. This results in zero operational risk for Mongolian airspace which substantially decreases from a value of 2.02×10^{-9} FAPFH last year.

4. Risk Assessment and Safety Oversight

4.1. **Collision Risk Model (CRM) Parameters.** The value and the source of the parameters in the CRM used to estimate risk in the RVSM airspace are summarized in **Table 4**.

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	110,134	6,529	Hour	Dec 2015 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.5190/ 0.0036	0.0000	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.1774	0.0738	-	
λ_x	Average aircraft length	0.0345	0.0341	NM	
λ_y	Average aircraft wingspan	0.0319	0.0314	NM	
λ_z	Average aircraft height	0.009	0.0091	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0345	0.0341	NM	

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	More conservative value used in previous assessments
$\overline{ \Delta V }$	Average relative along-track speed between aircraft on same direction routes	24.14		Knot	Dec 2015 TSD NOTE : $\overline{ \Delta V }$ was calculated based on relative speed of proximate pair on each route type. For uni-dir route, there was no proximate pair.
$\overline{ V }$	Average absolute aircraft ground speed	480	480	Knot	More conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for Mongolian Airspace

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. The technical risk **meets** the agreed TLS value of no more than 2.5×10^{-9} fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft and to all causes. **The total risk meets the specified TLS value for these components of 5.0×10^{-9} .**

Mongolia RVSM Airspace – estimated annual flying hours = 116,664 hours (note: estimated hours based on December 2015 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.96×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	0.96×10^{-9}	5.0×10^{-9}	Below Overall TLS

Table 5: Risk Estimates for Mongolian Airspace

4.3. **Figure 1** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports.

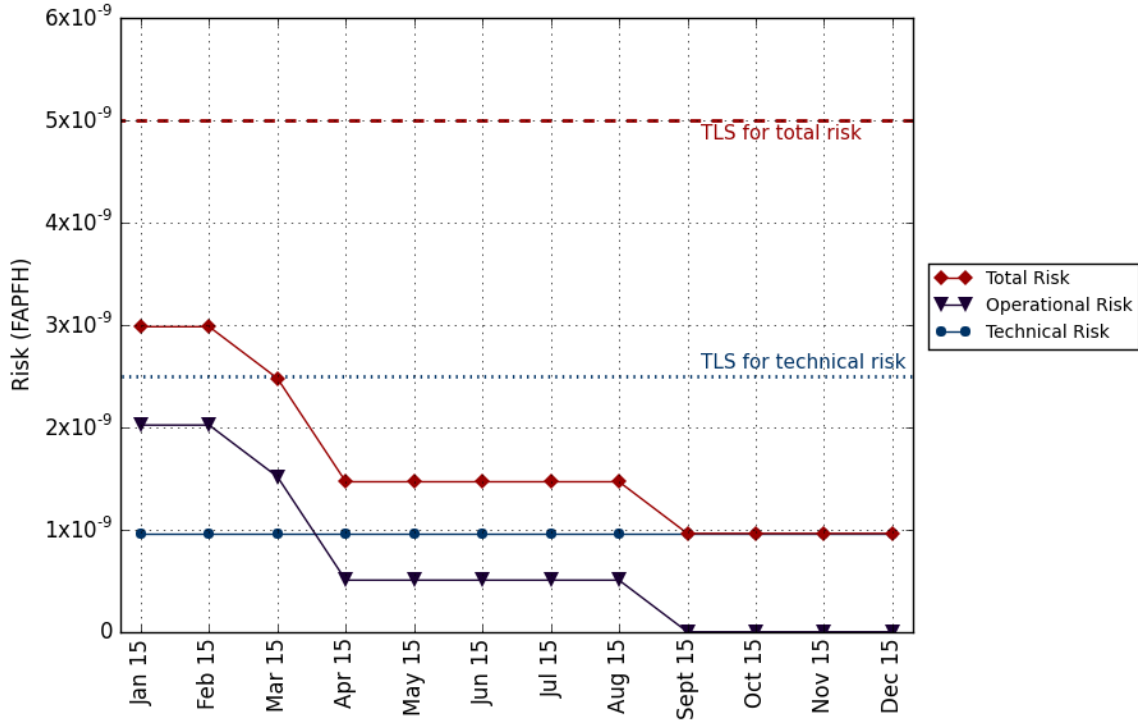


Figure 1: Trends of Risk Estimates for Mongolian Airspace

5. Analysis of Operational Errors

5.3 **Figure 2 and 3** depict geographic location of LHDs and hot spots in Mongolian Airspace based on LHD reports from January to December 2014 and from January to December 2015 where:

- the navy dotted line represents the frequency of occurrences at the labeled waypoint,
- the color of each circle represents the sum of minutes at incorrect flight level and the number of flight levels crossed without clearance (darker orange represents higher value) associated with LHDs occurring at or near the labeled waypoint,
- the area of the circle represents the sum of operational risk associated with LHDs occurring at or near the labeled waypoint, and
- the turquoise lines represent west-bound traffic movements while the orange lines represent east-bound traffic movements.

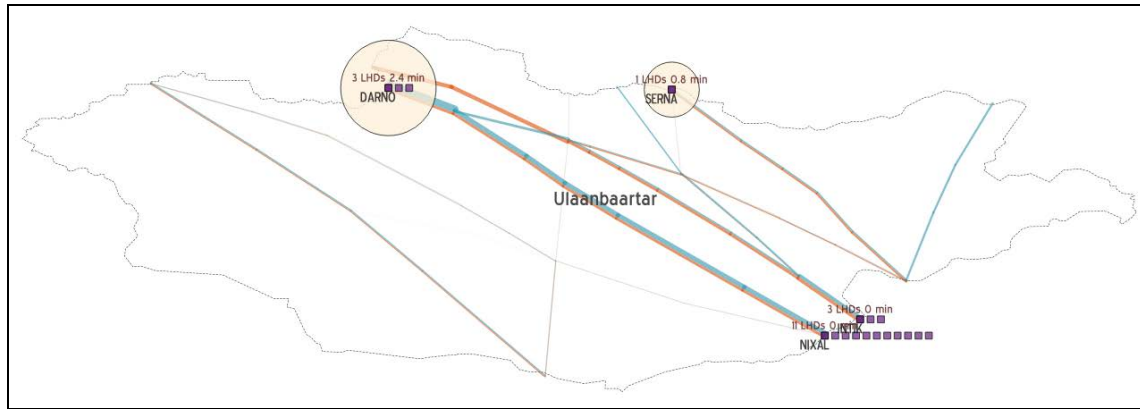


Figure 2: Geographical Location of LHDs in Mongolian Airspace of 2014

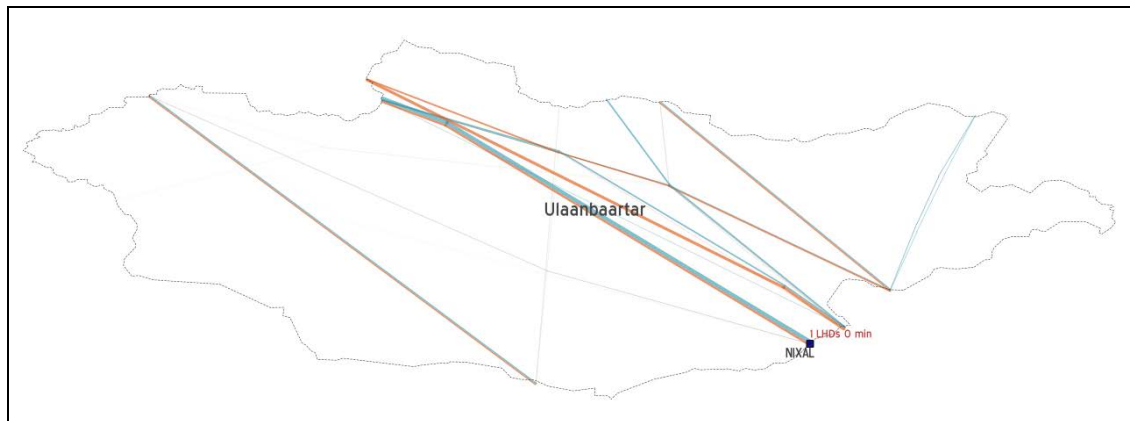


Figure 3: Geographical Location of LHDs in Mongolian Airspace of 2015

5.4 The figure shows significant reduction in number of LHD events at the southeast boundary of Ulaanbaatar FIR next to Beijing FIR (NIXAL and INTIK) and the northwest boundary next to Krasnoyarsk FIR (DARN0). These hot spots no longer exist in year 2015.

5.5 The reduction in LHD occurrences near NIXAL and INTIK is likely to be a result of both Mongolia and China's effort. Mongolia extended their SSR coverage for approximately 30NM further from NIXAL and INTIK since December 2015. Beijing ACC also adjusted their coordination procedure around how EST messages are sent and handled, especially when there are flight level changes. Beijing ACC also upgraded their automation system, which greatly improved its reliability.

6. Long Term Height-keeping Monitoring (LTHM)

To meet the ICAO Annex 6 LTHM requirements, the MAAR undertakes a monitoring program. The current monitoring burden data for Mongolia States is detailed in **Table 6** below.

State	Total RVSM Approved Airframes	Resultant Monitoring Burden	Total Airframes Remaining to be Monitored
Mongolia (ZM)	5	4	0

Table 6: LTHM Burden

Appendix A: Details of the Reported LHD Events in the Mongolian Airspace

Date	Assigned FL	Observe/ Reported FL	Duration at Incorrect FL	Category	Cause
14/7/2015	301	321	0.0 min	E	No FL revision