FInternational Civil Aviation Organization
Twenty-Fifth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/25)
Video Teleconference, 27 – 30 October 2020

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

MAAR SAFETY REPORT

(Presented by the Monitoring Agency for Asia Region)

SUMMARY
This paper provides the results of the airspace safety oversight for the RVSM operation in South Asia/Indian Ocean Airspace (SA/IO), Southeast Asia Airspace (SEA) and Mongolian Airspace.

1. INTRODUCTION

This paper provides the executive summary of airspace safety oversight for the RVSM operation in South Asia/Indian Ocean Airspace (SA/IO), Southeast Asia Airspace (SEA), and Mongolian Airspace. The reports of SA/IO, SEA, and Mongolian airspace are provided in Attachment. Each report contains:

- Traffic Sample Data (TSD) and Large Height Deviation (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,

2. DISCUSSION

Executive Summary: South Asia/Indian Ocean Airspace

2.1 **Table 1** summarizes South Asia/Indian Ocean (SA/IO) airspace RVSM technical, operational, and total risks. **Figure 1** presents collision risk estimate trends during the period from January 2019 to December 2019. The chart shows a downward trend in 2019.

South Asia/Indian Ocean Airspace (SA/IO) RVSM Airspace – estimated annual flying hours = 3,492,377 hours ***(note: estimated hours based on December 2019 traffic sample data)***			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	0.79×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	35.99×10^{-9}	-	-
Total Risk	**36.78×10^{-9}**	**5.0×10^{-9}**	**Above Overall TLS**

Table 1: Risk Estimates for SA/IO Airspace

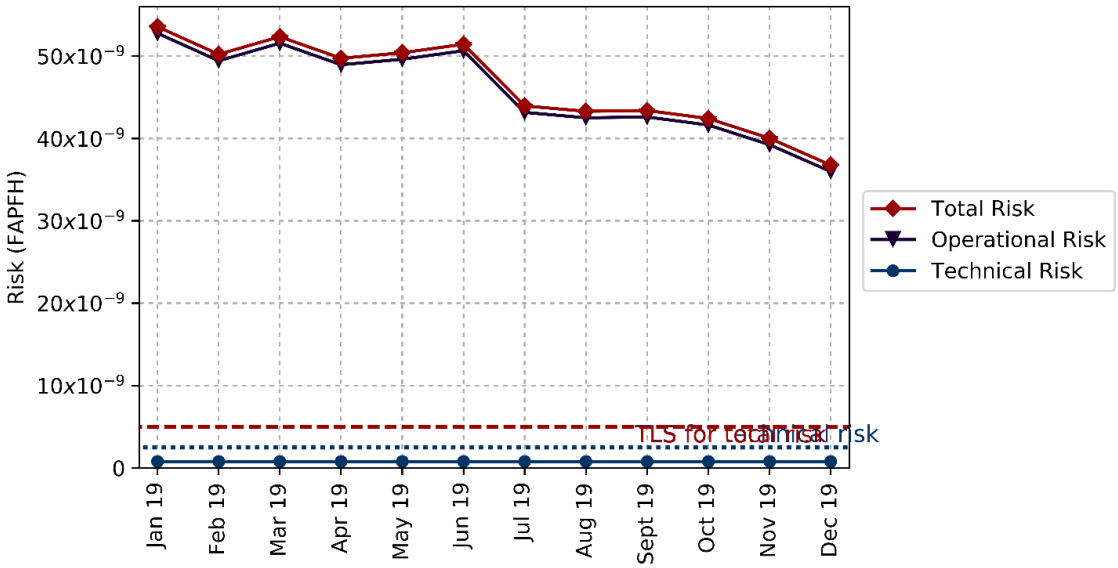

Figure 1: Trends of Risk Estimates for SA/IO Airspace

2.2 **Table 2** presents a summary of the LHDs by categories within SA/IO airspace from January 2019 to December 2019.

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	4	3	0	7	0.75
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	0	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	7	5	0	7	0.31
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	411	128	2,086	0	34.17
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	1	0	0	0	0

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
	(e.g. late or non-existent coordination of flight level).					
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	2	1	2	0	0.27
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	7	1	0	3	0.48
K	TCAS resolution advisory, flight crew incorrectly climb or descend following the resolution advisory.	0	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	0
M	Other	2	1	0	1	0.01
Total		434	139	2,088	18	35.99

Table 2: Summary of LHD by Category for SA/IO Airspace.

2.3 **Figure 2** provides geographical locations of all reported LHDs in SA/IO airspace based on LHD reports from January to December 2019. **Figure 3** provides only LHDs which are determined to be non-zero duration.

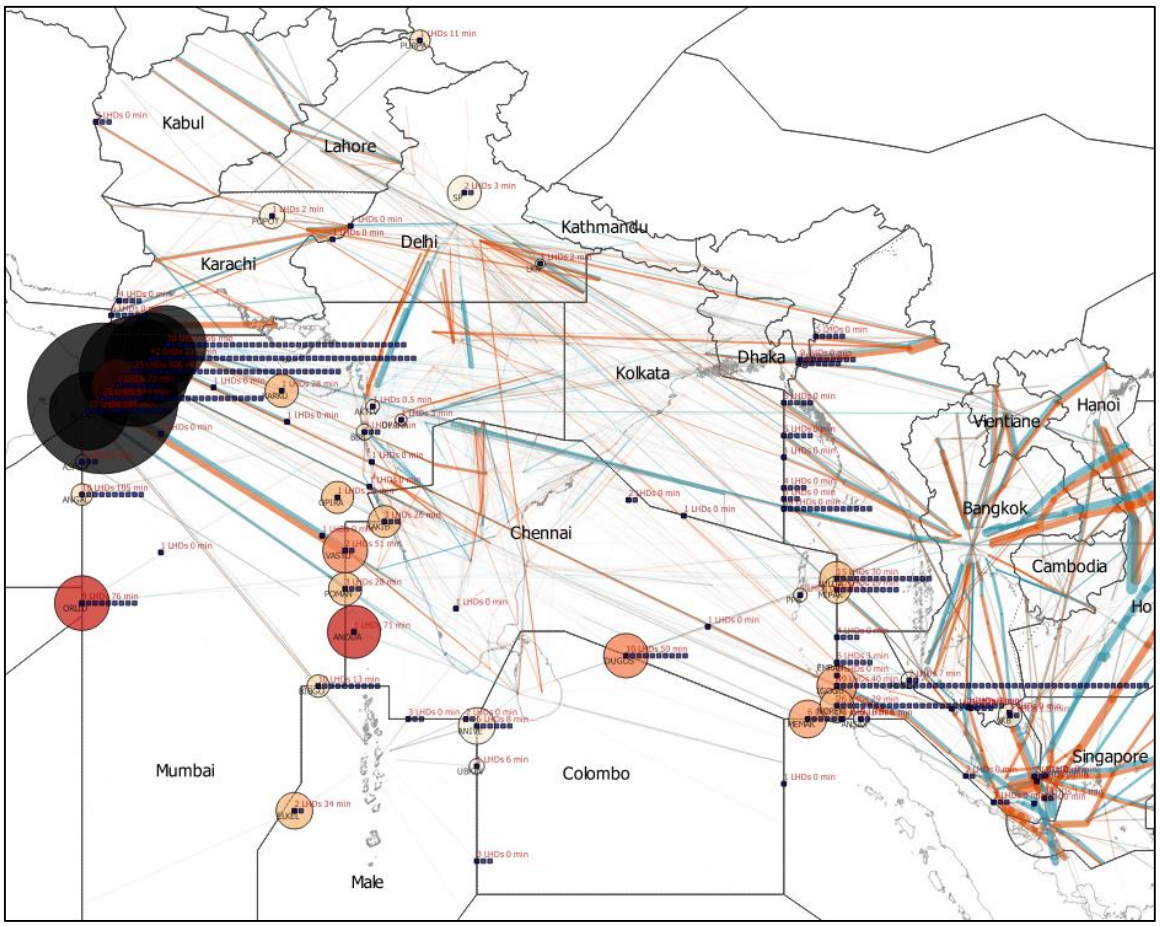

Figure 2: Geographical Location of **All LHDs** in SA/IO Airspace

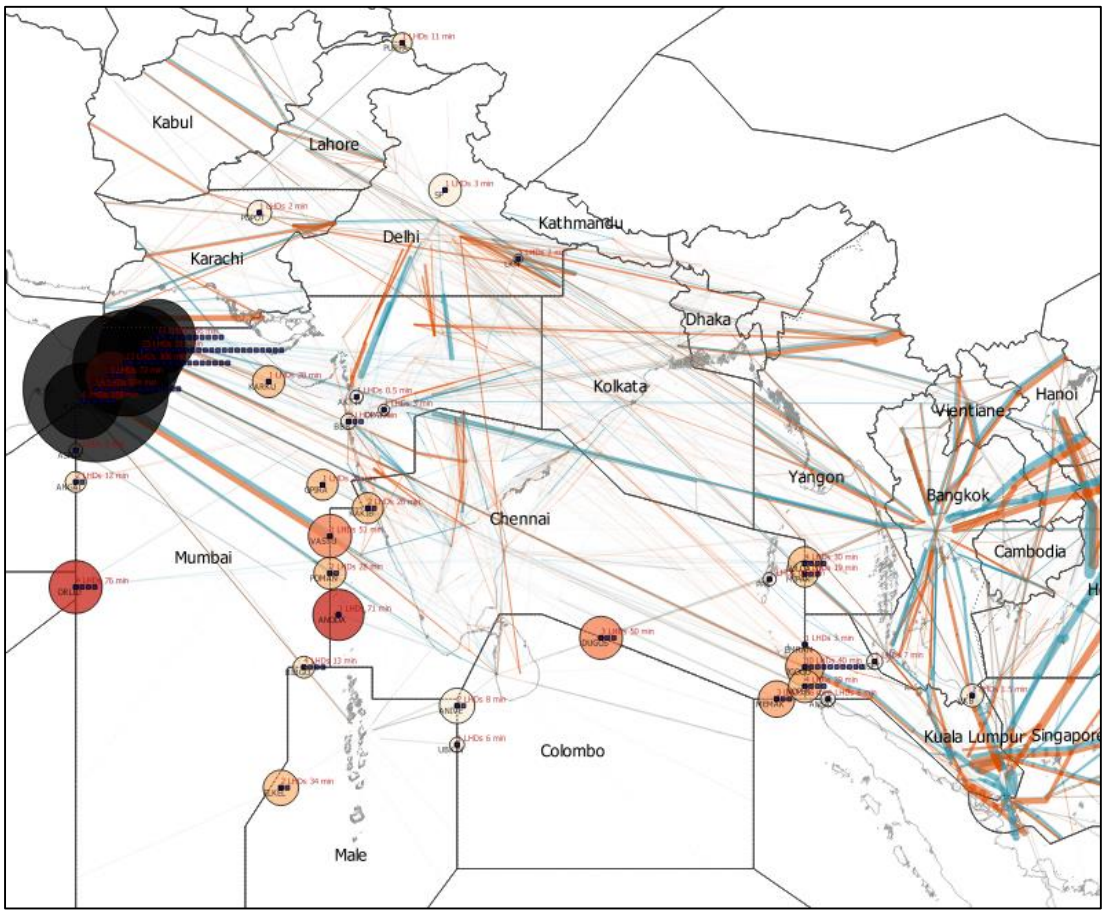

Figure 3: Geographical Locations of **'Non-zero-duration' LHDs** in SA/IO Airspace

2.4 **LHD Hot Spot G (Sanaa/Muscat – Mumbai) and LHD Hot Spot F (Mogadishu – Mumbai)** remained as LHD hot spots with three interfaces. In 2019, the operational risk of this hotspot accounted for 26.16 x 10-9 FAPFH, which was 73% of the SA/IO region. The number of non-zero-duration LHDs and risks at all interfaces decreased particularly at Sanaa-Mumbai and Mogadishu-Mumbai interfaces.

2.5 The 2019 operational risk in SA/IO airspace was dominated by LHDs at Mumbai-Muscat interface, accounting for 24.71 x 10^{-9} FAPFH which was 69% of the region. Out of 16 long duration LHDs in SA/IO airspace, 12 LHDs occurred at Mumbai-Muscat interface, accounting for 55% of the operational risk at Mumbai-Muscat interface and 38% of the total operational risk in SA/IO airspace as shown in **Figure 4**.

2.6 The majority of LHDs at this hot spot were Category E with sub-category being "No or Late FL revision" and "Negative Transfer". The poor communication services and lack of surveillance coverage at this interface worsened the situation by the long-duration occurrences before the incorrect presences of aircraft were resolved.

2.7 In addition, the Pakistani airspace closure from 27 February to 16 July 2019 contributed to the increase in LHDs particularly at waypoint RASKI, PARAR and TOTOX as shown in **Figure 5**.

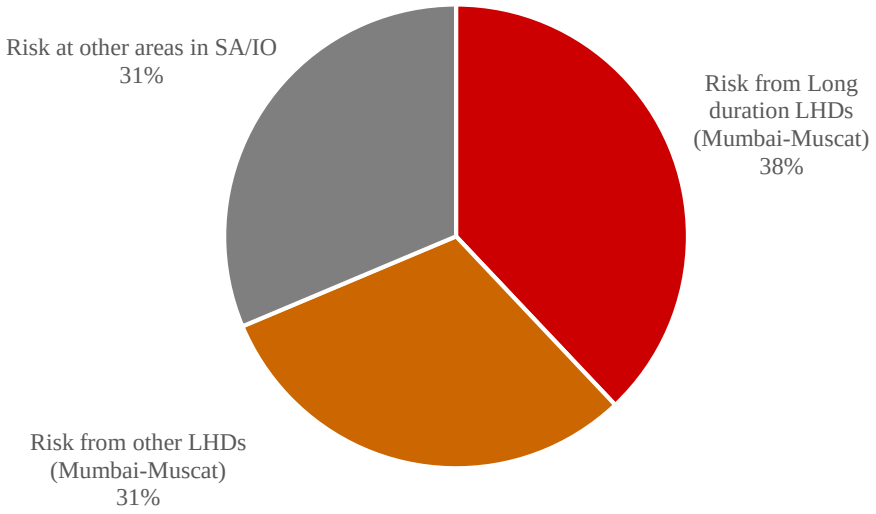

Figure 4: Proportion of the Operational Risk of
Long Duration LHDs at Mumbai-Muscat interface, Other LHDs at Mumbai-Muscat Interface, and LHDs at other areas in SA/IO.

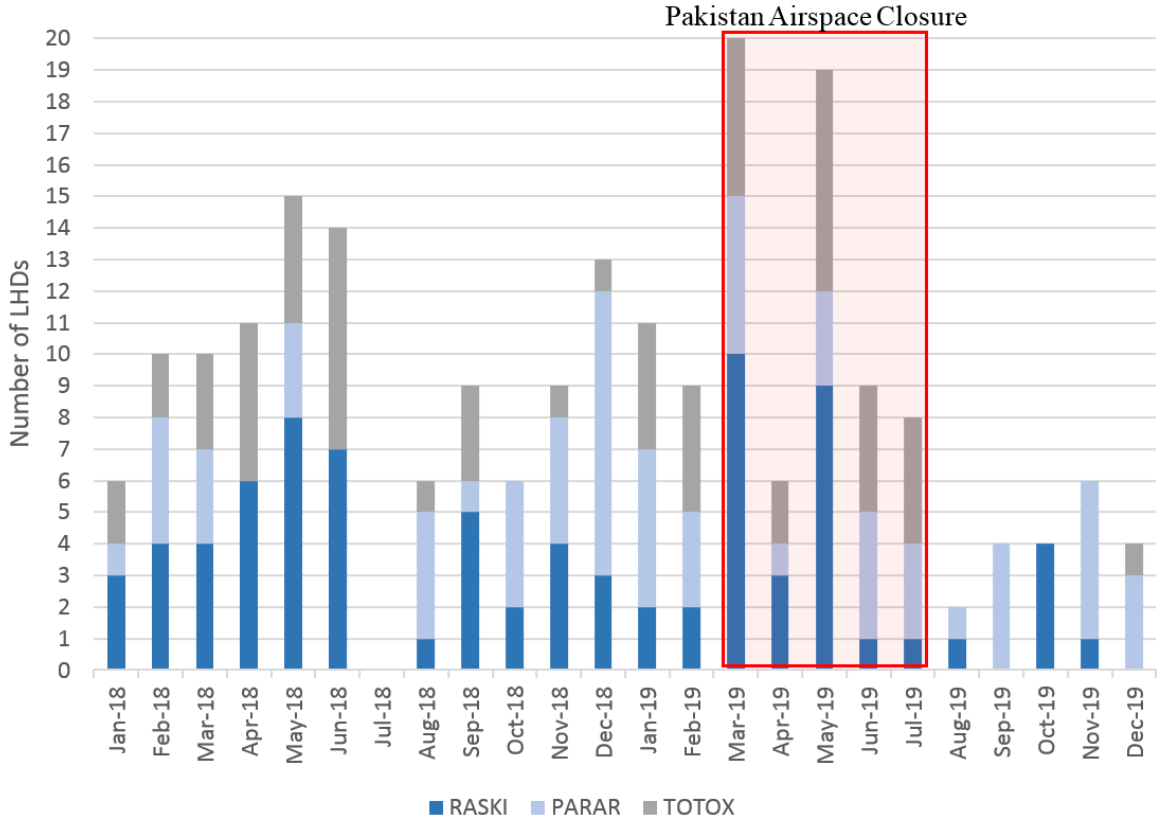

Figure 5: The Number of LHDs at RASKI, PARAR and TOTOX
from January 2018 to December 2019
(Pakistani Airspace Closure from 27 February to 16 July 2019).

2.8 **LHD Hot Spot A1 (Kolkata/Dhaka - Yangon) and LHD Hot Spot A2 (Chennai - Kuala Lumpur)** were first identified as hot spots in 2015. The operational risk at these interfaces were 2.97 x 10^{-9} FAPFH in 2017, decreased to 1.32 x 10^{-9} FAPFH in 2018, and slightly increased to 1.94 x 10^{-9} FAPFH in 2019.

2.9 **Figure 6** provided the geographical visualization of non-zero-duration LHDs and their associated risk grouped into the three interfaces in 2017, 2018 and 2019. The operational risk at Kolkata-Yangon interface decreased from 2017 to 2019.

2.10 The LHDs over waypoint APAGO and CHILA involved Dhaka, Kolkata and Yangon FIR. The ambiguity on handling of eastbound traffic between Dhaka FIR and Kolkata FIR (as well as coordination with Yangon FIR) was resolved by the implementation of a new procedure. A new Letter of Agreement (LOA) was signed between Bangladesh and India with effective date in June 2019.

2.11 The ADS-B data sharing between Kolkata ACC and Yangon ACC was also in place in June 2018. The ADS-B data sharing allowed the controllers to detect and resolve any issues before an aircraft passing the transfer-of-control points. This successfully mitigated the risk at the interface between Kolkata FIR and Yangon FIR where the operational risk decreased from 2.04 x 10^{-9} FAPFH in 2017, to 0.6 x 10^{-9} FAPFH in 2018, and to 0.31 x 10^{-9} FAPFH in 2019.

2.12 On the other hand, the operational risk in 2019 increased at Chennai-Yangon and Chennai-Kuala Lumpur interfaces (LULDA, MEPAK, IGOGU, NOPEK and MEMAK). At these interfaces, ADS-B data sharing was not implemented.

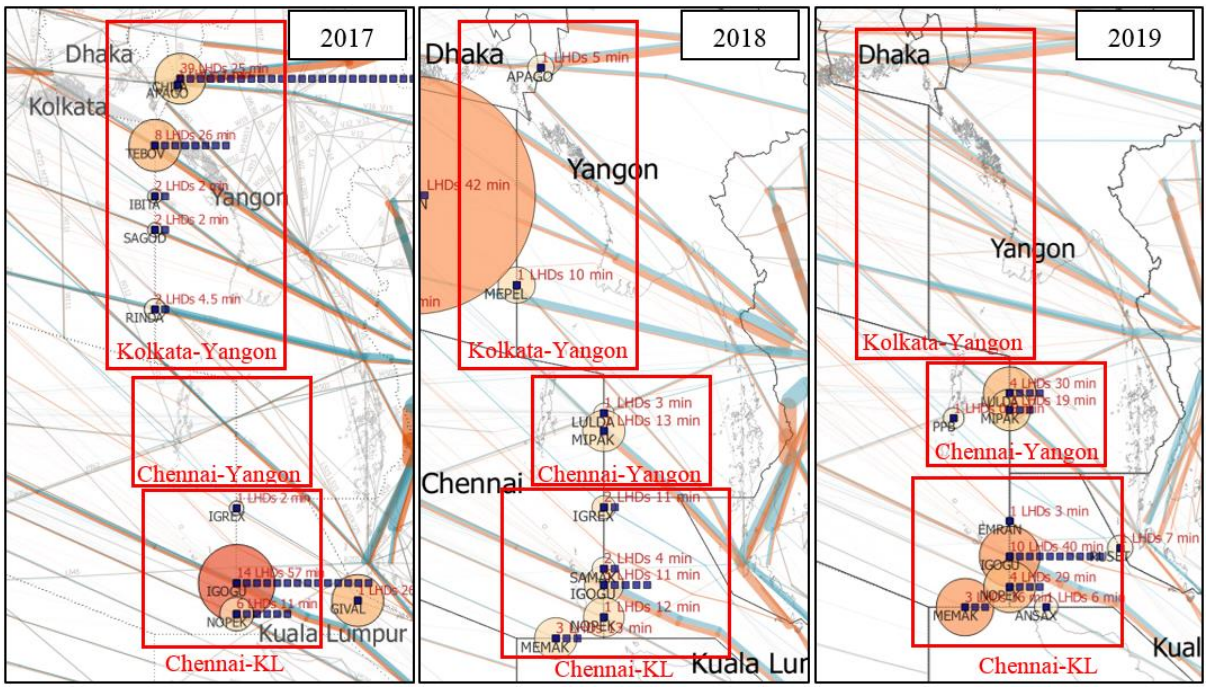

Figure 6: The Visualization of Non-zero-duration LHDs in 2017, 2018 and 2019 between Kolkata FIR, Chennai FIR, Yangon FIR and Kuala Lumpur FIR.

2.13 In **LHD Hot Spot I (Karachi – Kabul)**, the number of LHDs and the risk estimate significantly decreased since it was identified as an LHD Hot Spot in 2018. The new route Z627 was established between Tehran FIR and Kabul FIR in July 2019. Since then, the number of aircraft flying on A453 route through GADER had dropped and there was no LHD reported as shown in **Figure 7**.

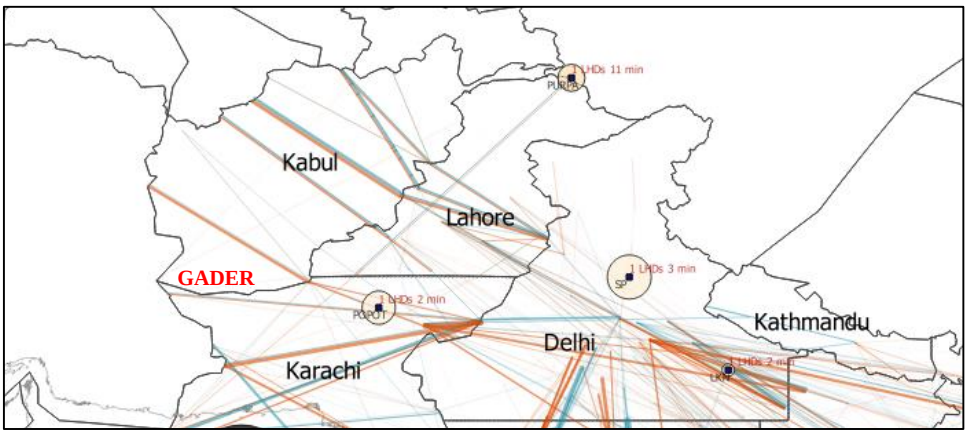

Figure 7: The Visualization of LHDs between Kabul and Karachi in 2019 (No LHD Report in 2019).

Executive Summary: Southeast Asian Airspace

2.14 **Table 3** summarizes Southeast Asia (SEA) airspace RVSM technical, operational, and total risks. **Figure 8** presents collision risk estimate trends during the period from January 2019 to December 2019. The chart shows that the technical and total risk are below the TLS. The risks decrease from January to November and then spike on December.

Southeast Asia (SEA) Airspace RVSM Airspace – estimated annual flying hours = 3,385,767 hours *(note: estimated hours based on December 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	1.50×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	2.09×10^{-9}	-	-
Total Risk	**3.59×10^{-9}**	**5.0×10^{-9}**	**Below Technical TLS**

Table 3: Risk Estimates for SEA Airspace

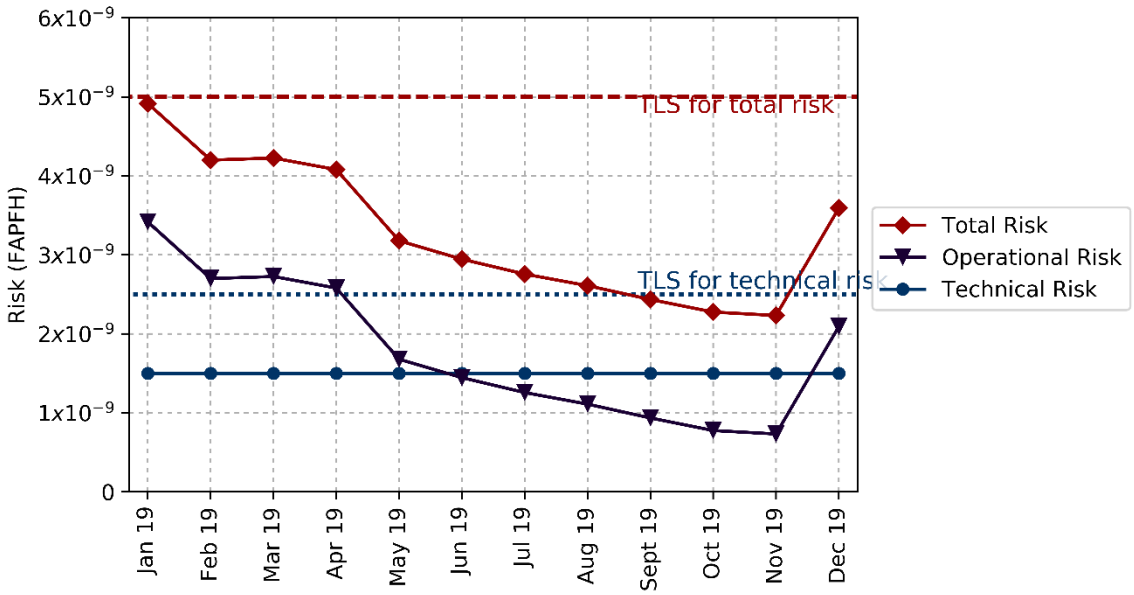

Figure 8: Trends of Risk Estimates for SEA Airspace.

2.15 **Table 4** presents a summary of the LHDs by categories within SEA airspace from January 2019 to December 2019.

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	1	1	0	1.5	0.02
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	5	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	3	1	0	4	0.08
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	120	15	123	1	1.99
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level).	9	0	0	0	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	1	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	5	0	0	0	0
K	TCAS resolution advisory, flight crew incorrectly climb or descend following the resolution advisory.	0	0	0	0	0
L	An aircraft being provided with RVSM	0	0	0	0	0

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
	separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan).					
M	Other	1	0	0	0	0
Total		145	17	123	6.5	2.09

Table 4: Summary of LHD by Category for SA/IO Airspace.

2.16 **Figure 9** depicts geographical locations of all reported LHDs in SEA airspace based on LHD reports from January to December 2019. **Figure 10** depicts only LHDs which are determined to be non-zero duration.

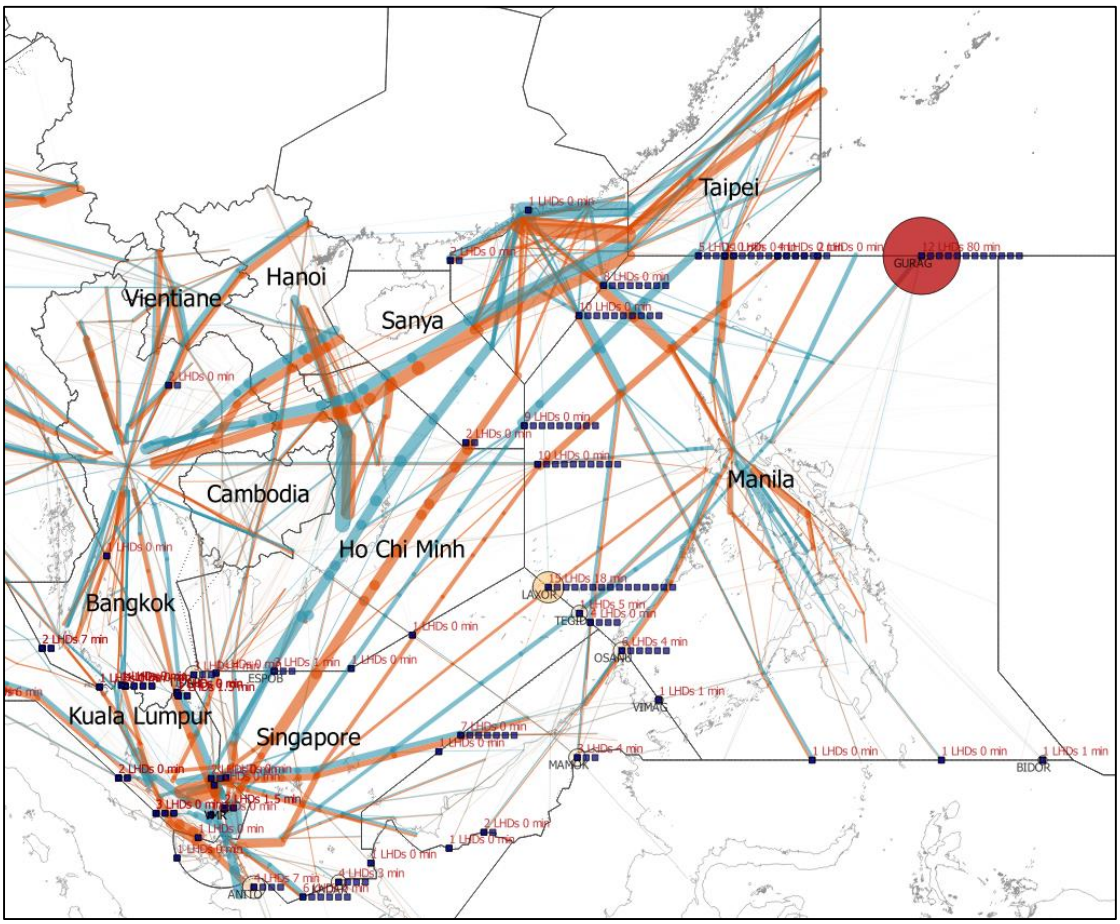

Figure 9: Geographical Locations of **All LHDs** in SEA Airspace

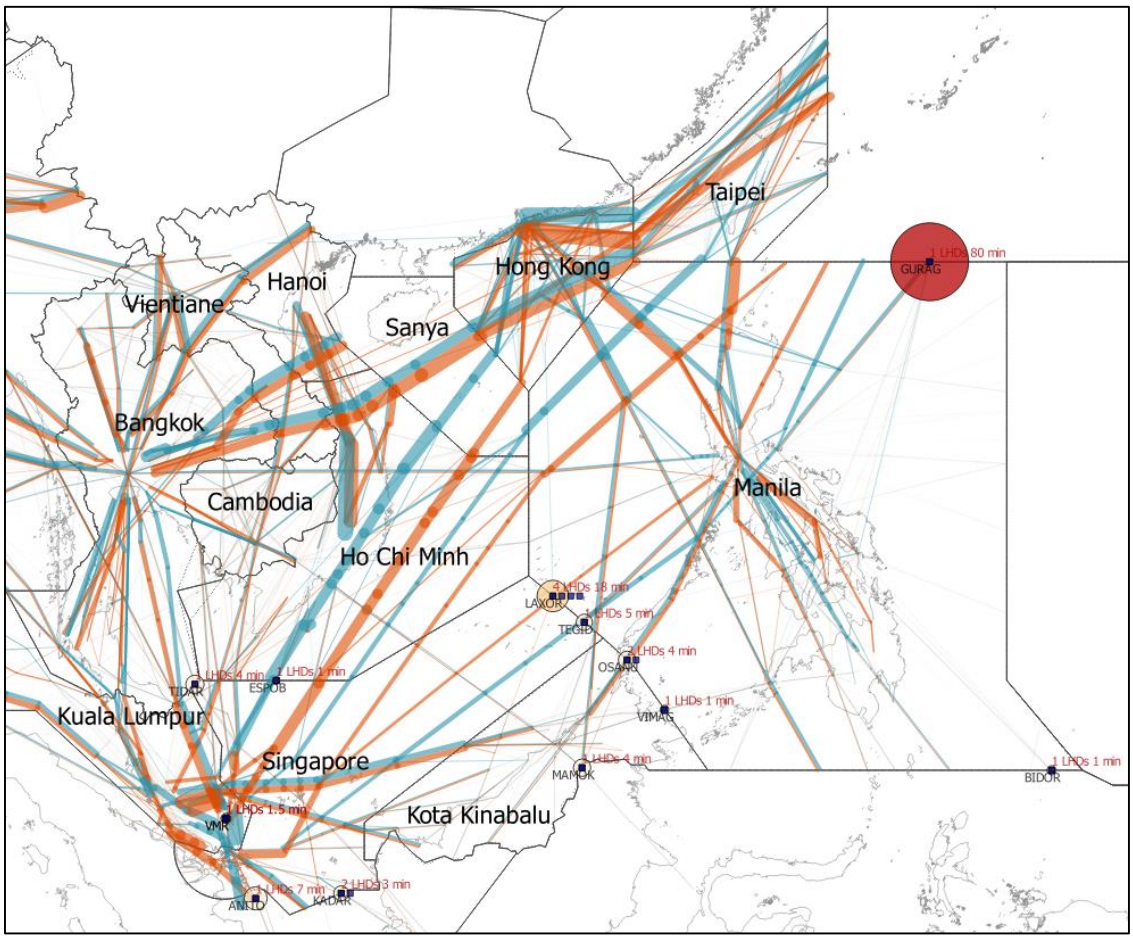

Figure 10: Geographical Locations of **'Non-zero-duration' LHDs** in SEA Airspace

2.17 Most number of LHDs and operational risk of SEA airspace located on **Hot Spot D (Manila and all adjacent FIRs)**. In 2019, the number of LHDs and operational risk in SEA airspace clearly decreased from 2018. This trend was contributed by the new Manila's ATMC which commenced in November 2018. The new ATM system also included the enhanced capabilities of VHF radio, radar and ADS-B coverage, and allowed ATC workload to be split into more sectors. Furthermore, the ADS-C/CPDLC implementation in oceanic airspace, AIDC implementation with Hong Kong FIR, Singapore FIR and Taipei FIR commenced as indicated in **Figure 7**.

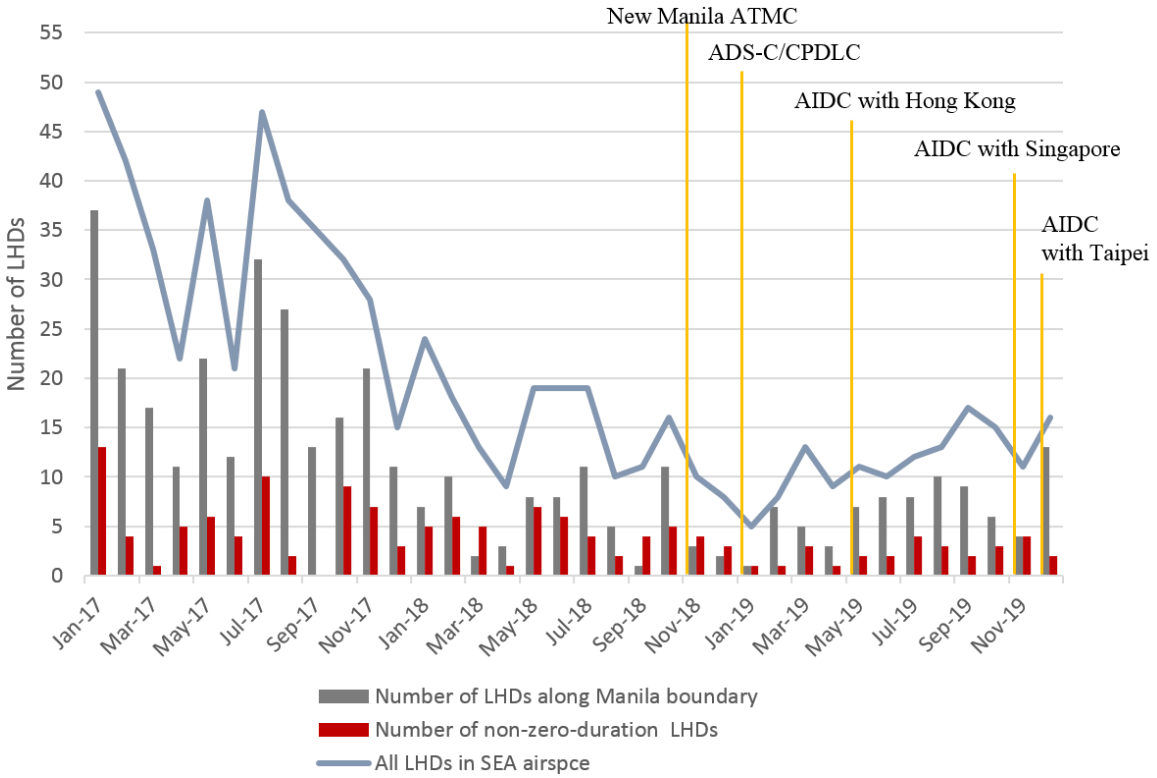

Figure 11: Number of LHDs and non-zero-duration LHDs along Manila Boundary Compared to all LHDs in SEA from 2017 to 2019

2.18 However, the number of Category F LHDs increased in SEA airspace. There were a total of 9 Category F LHDs reported in 2019. All were involved with Manila FIR, in which 7 out of 9 were due to AIDC errors. This could be the fact that the system failed to alert the controller in case of unsuccessful AIDC transfer.

Executive Summary: Mongolian Airspace

2.19 **Table 5** summarizes Mongolian airspace RVSM technical, operational, and total risks.

Mongolia RVSM Airspace – estimated annual flying hours = 164,276 hours *(note: estimated hours based on December 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	1.07×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	**1.07×10^{-9}**	**5.0×10^{-9}**	**Below Overall TLS**

Table 5: Mongolian Airspace RVSM Risk Estimates

2.20 There were a total of two LHDs reported in 2019. One Category-A LHD occurred at waypoint NIGOR, a transfer-of-control point between Ulaanbaatar FIR and Krasnoyarsk FIR. Another LHD was Category I, reported at waypoint HATGA located within Ulaanbaatar FIR. None of them resulted in operational risk.

APANPIRG List of Deficiencies

2.21 To enable the process of RVSM safety oversight, States are required to submit a December TSD on an annual basis (APANPIRG Conclusion 16/4) and ANSPs are responsible for submitting LHD data on a monthly basis to their Regional Monitoring Agencies (RMAs).

2.22 The MAAR received 2019 TSD from all States in timely manner. Furthermore, all States provided good cooperation in revising TSD to the new format.

2.23 The MAAR introduced the new LHD submission system starting in October 2019. Almost all States registered and submitted their LHD reports through the new system. Even though some States submitted their LHDs late, the MAAR received LHDs from all States via the previous submission system, the new/current system and also direct emails.

2.24 Bangladesh and Pakistan submitted 2019 TSD in timely manner. Both States also continuously submit their LHD reports up to present. The following table summarizes MAAR's proposal regarding the APANPIRG List of Deficiencies in the ATM/AIS/SAR fields, under "Non-Provision of Safety Related Data by States".

State	Proposed Action	Reason for Inclusion/Removal
Afghanistan	Inclusion (already on the list)	Already submitted 2019 LHD, but did not submit any 2020 LHDs
Bangladesh	Removal	Already submitted 2019 TSD in timely manner. Continuously submitted 2019 and 2020 LHDs.
Pakistan	Removal	Already submitted 2019 TSD in timely manner. Continuously submitted 2019 and 2020 LHDs.

Reporting

2.25 Measuring how well an organization reports hazards and incidents has been a challenge. Using the number of reported incidents as an indicator of reporting culture has a limitation. This is because there are many factors apart from the maturity of reporting cultures which influence the number of reports. The obvious example is the actual number of incidents. Low number of reported incidents could be a result of the improvement in safety level or a result of poor reporting cultures.

2.26 Despite the challenge in assessing the maturity of reporting cultures in the Asia Pacific region from analyzing the LHD data, the MAAR continues to see improvement signs in reporting cultures from 2018, as reported to RASMAG/24.

NIL Reports

2.26.1 States provides good coordination in submitting "NIL report" in the certain month that has no LHDs. FIRs that always submit NIL report are Phnom Penh, Hong Kong, Vientiane, Taipei, Hanoi, Ho Chi Minh, Dhaka, Karachi and Ulaanbaatar.

LHDs within FIRs

2.26.2 Normally, ATCOs report LHDs only when they are affected by mistakes made by ATCOs in their neighboring FIRs. In 2019, the number of reports for LHDs within FIRs increased particularly over the Indian airspace as shown in **Figure 2**.

Reporting Own Mistakes

2.26.3 In 2019, 15% of all LHDs were reported for ones' own mistake. For example, FIR A submitted a report which showed that FIR A transferred an aircraft with wrong flight level. Singapore, Manila, Hong Kong, Kota Kinabalu and Kuala Lumpur FIRs always submitted this sort of LHDs.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) consider the proposal in 2.24 to remove Bangladesh and Pakistan from the APANPIRG List of Deficiencies in the ATM/AIS/SAR fields in 2.24;

c) discuss any relevant matters as appropriate.

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MONITORING AGENCY FOR ASIA REGION (MAAR)

Airspace Safety Review of RVSM in South Asia/Indian Ocean Airspace (SA/IO) airspace

January 2019 to December 2019

AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN SOUTH ASIA/INDIAN OCEAN (SA/IO) AIRSPACE
Assessment Period: January 2019 to December 2019

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

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1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **South Asia/Indian Ocean Airspace (SA/IO)**. The review is conducted based on one-month traffic sample data (TSD) collected in **December 2019** and monthly Large Height Deviation (LHD) reports between **January 2019** and **December 2019** submitted by concerning States in the SA/IO region.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2019 of aircraft operating in SA/IO 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 2019 to December 2019. **Table 1** indicates those FIRs which submitted LHD reports including NIL reports. **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	Kabul	Colombo	Bangkok
January	X	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	X
March	X	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	X
May	X	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	X
July	X	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	X
September	X	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	X
November	X	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	X

Table 1: Summary of LHD Reports Submitted by FIRs in 2019

3. Summary of LHD Occurrences

3.1. **Table 2** and **Figure 1** summarize the number of LHDs assessed and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2019 to December 2019. In this report, the number of LHDs included the LHDs that had zero duration, unless indicated otherwise.

Month (2019)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk (x10^{-9} FAPFH)
January	43	20	299	3	4.96
February	45	18	145	0	2.38
March	47	15	419	1	6.89
April	30	12	169	3	3.25
May	40	18	310	0	5.08
June	38	19	367	0	6.02
July	35	10	146	4	2.67
August	34	4	32	3	0.99
September	34	5	29	2	0.56
October	34	6	48	2	0.91
November	29	7	68	0	1.35
December	25	5	56	0	0.92
Total	**434**	**139**	**2,088**	**18**	**35.99**

Table 2: Summary of LHD by Month for SA/IO Airspace

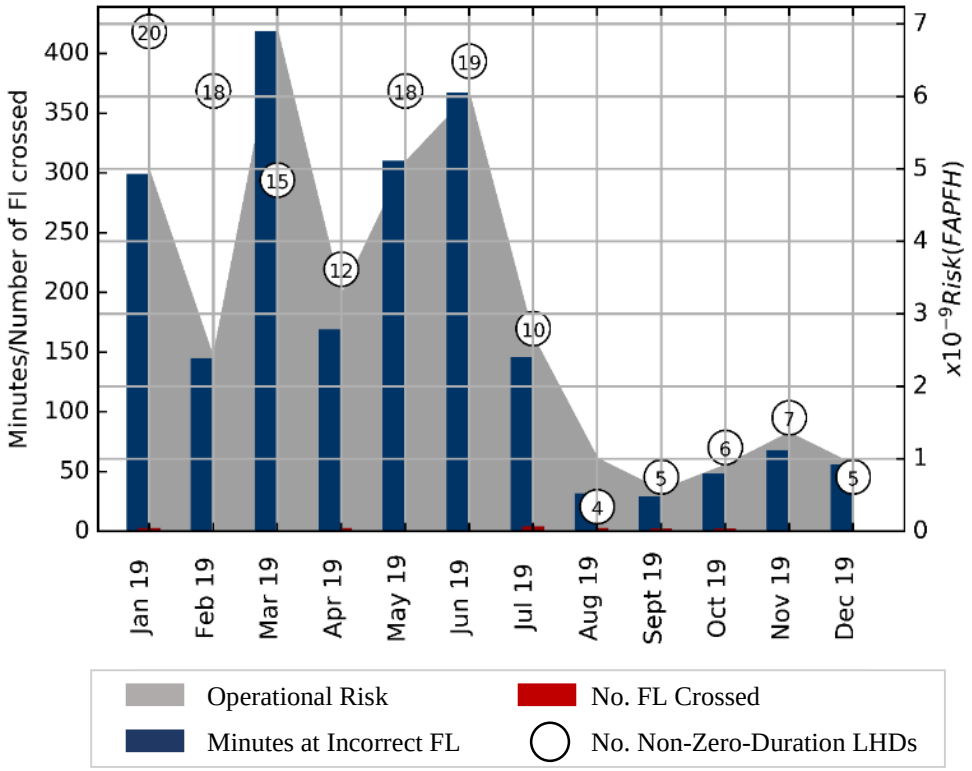

Figure 1: Summary of LHD Occurrences by Month for SA/IO Airspace

3.2. Compared to 2018, the number of LHD reports decreased from 666 to 434. Out of 434 LHDs reported this year, 139 LHDs were non-zero-duration LHDs, which resulted in the total deviation of 2,088 minutes. The operational risk decreased from 55.13 x 10^{-9} FAPFH in 2018 to 35.99 x 10^{-9} FAPFH in 2019.

3.3. **Figure 2** and **Table 3** summarize the number of LHDs, the associated LHD duration (in minutes), and the number of incorrect flight levels crossed, by LHD category from January 2019 to December 2019.

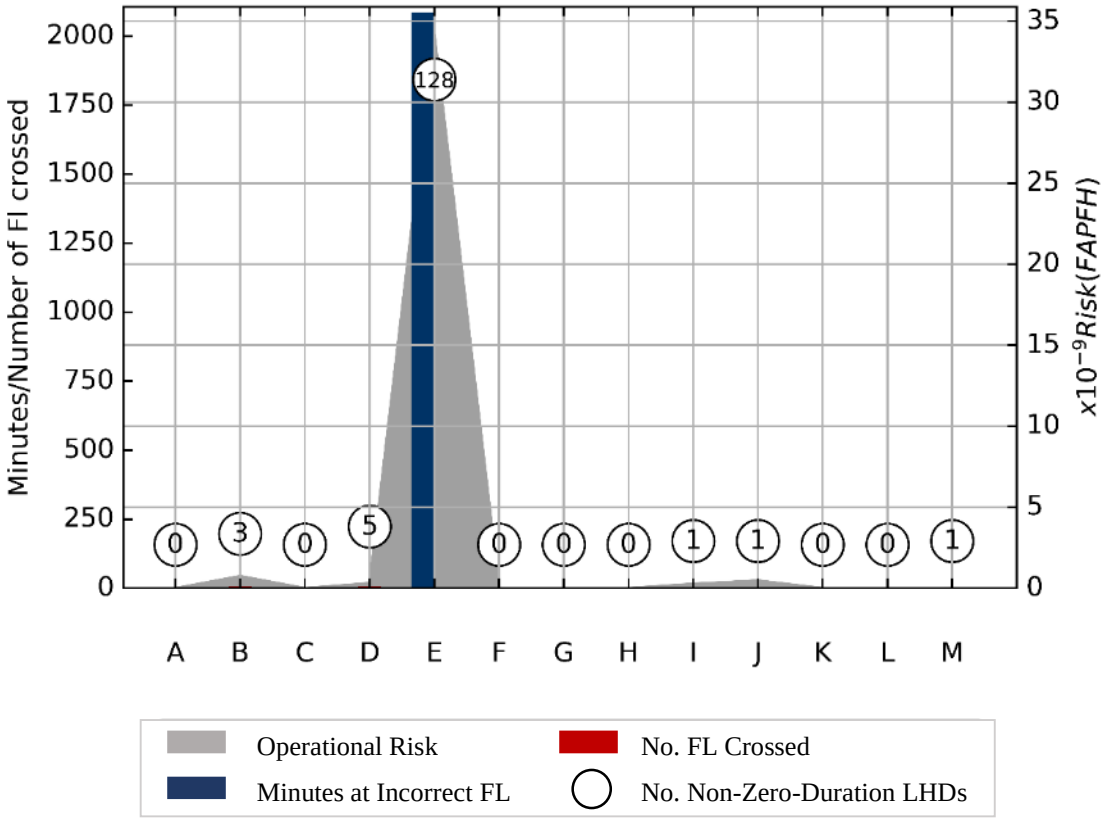

Figure 2: Summary of LHD by LHD Category for SA/IO Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	4	3	0	7	0.75
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	0	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	7	5	0	7	0.31
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	411	128	2,086	0	34.17
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level).	1	0	0	0	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	2	1	2	0	0.27
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	7	1	0	3	0.48
K	TCAS resolution advisory, flight crew incorrectly climb or descend following the resolution advisory.	0	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	0	0	0	0	0

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
	approved, ATC misinterpretation of flight plan).					
M	Other	2	1	0	1	0.01
Total		434	139	2,088	18	35.99

Table 3: Summary of LHD by Category for SA/IO Airspace.

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

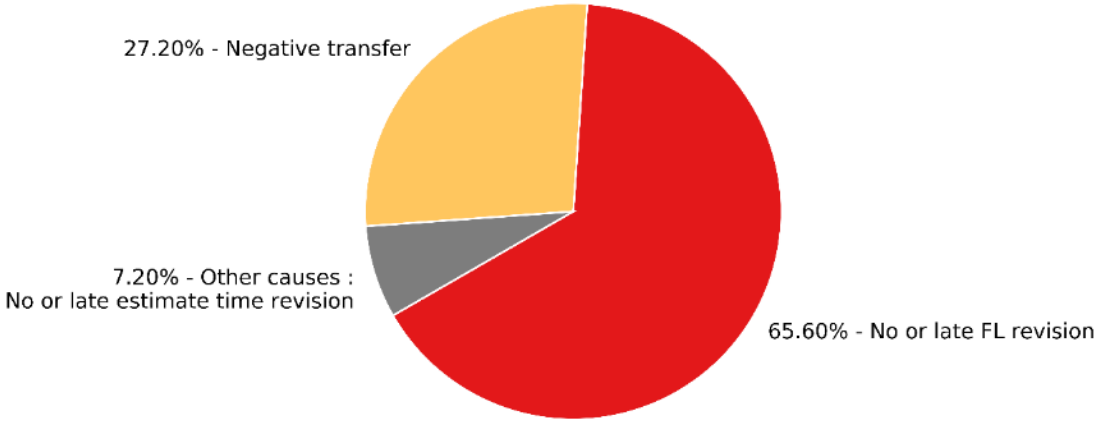

Figure 3: Sub-categories of Category-E LHDs for SA/IO Airspace

(Number of Non-zero-duration Occurrences)

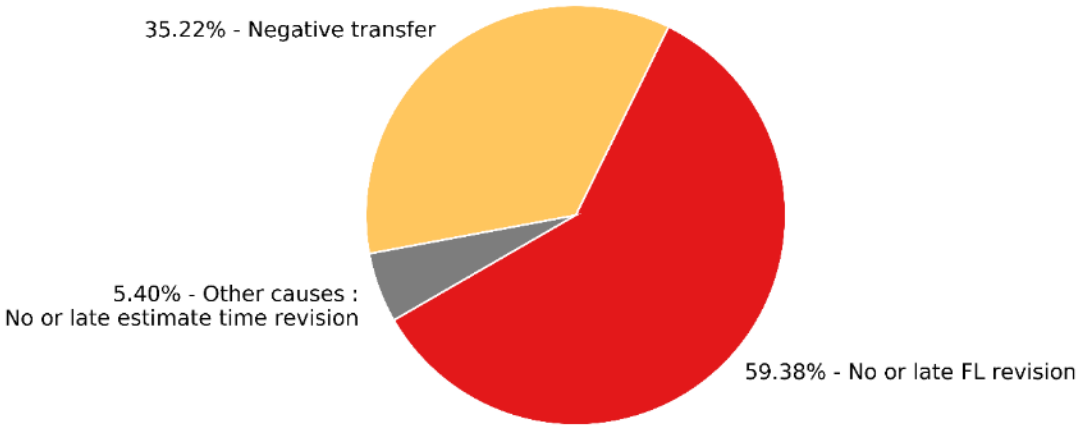

Figure 4: Sub-categories of Category-E LHDs for SA/IO Airspace (Risk)

3.5. In Category-E, "No or late flight level revision" sub-category is the most frequent sub-category, followed by "Negative transfer" sub-category. "No or late flight level revision" sub-category account for 65.60% of the total number of non-zero-duration LHDs. In term of contribution to risk, "No or late flight level revision" has the greatest contribution as 59.38% of the total risk.

3.6. Over the past years, a non-zero-duration LHD in "Negative transfer" sub-category contributed to more risk than an LHD in other sub-categories. In 2019 the numbers of LHDs in "No or late FL revision" and "Negative Transfer" sub-categories contributed to risk in the similar proportion.

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	2,871,609	620,768	Hour	Dec 2019 TSD
E_z(same)	Same-direction vertical occupancies	0.4440 / 0.0307	0.0631	-	
E_z(opposite)	Opposite-direction vertical occupancies	0.1607	0.0361	-	
λ_x	Average aircraft length	0.0273	0.0249	NM	
λ_y	Average aircraft wingspan	0.0251	0.0228	NM	
λ_z	Average aircraft height	0.0078	0.0073	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0273	0.0249	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	-	Conservative value used in previous assessments
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes	33.40	53.82	Knot	Dec 2019 TSD
$\overline{\lvert V\rvert}$	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for SA/IO 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**, defined as probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and to all causes, **meets the TLS** value of 2.5 x 10^{-9} FAPFH. The total risk is 36.78 x 10^{-9} FAPFH. Therefore, **the total risk exceeds the specified TLS** value for these components of 5.0 x 10^{-9} FAPFH.

South Asia/Indian Ocean (SA/IO) RVSM Airspace – estimated annual flying hours = 3,492,377 hours *(note: estimated hours based on December 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	0.79 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	35.99 x 10^{-9}	-	-
Total Risk	**36.78 x 10^{-9}**	**5.0 x 10^{-9}**	**Above Overall TLS**

Table 5: Risk Estimates for SA/IO Airspace

4.3. Compare to 2018, the total risk decreases from 56.06 x 10^{-9} FAPFH to 36.78 x 10^{-9} FAPFH, which is a 34.39% decrease.

4.4. **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports. The operational and total risk was steadily high from January to June and slightly decreased from July to December.

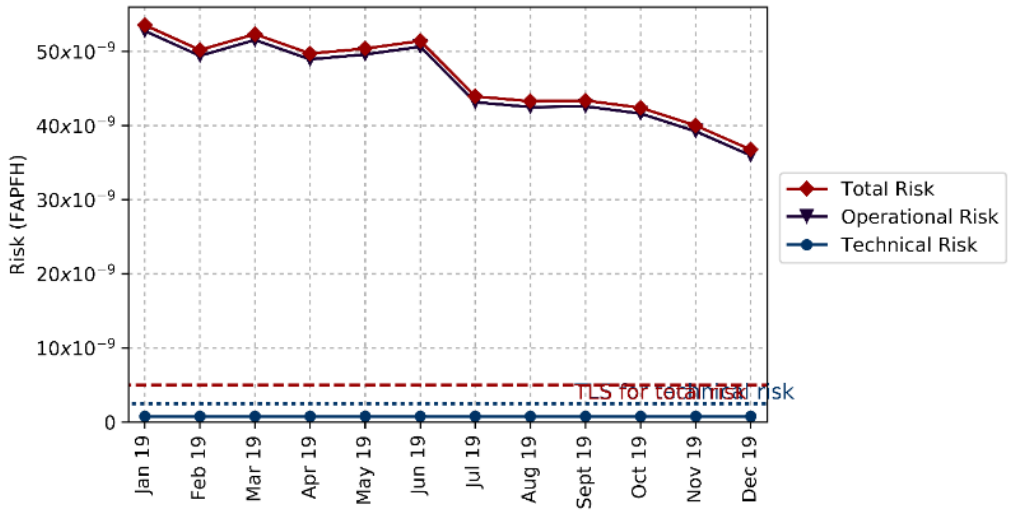

Figure 5: Trends of Risk Estimates for SA/IO Airspace

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 x 10^{-9} FAPFH (red line in **Figure 6** below, which is approximately 0.4167 x 10^{-9} FAPFH). Each block represents each LHD and the height of each block corresponds to risk.

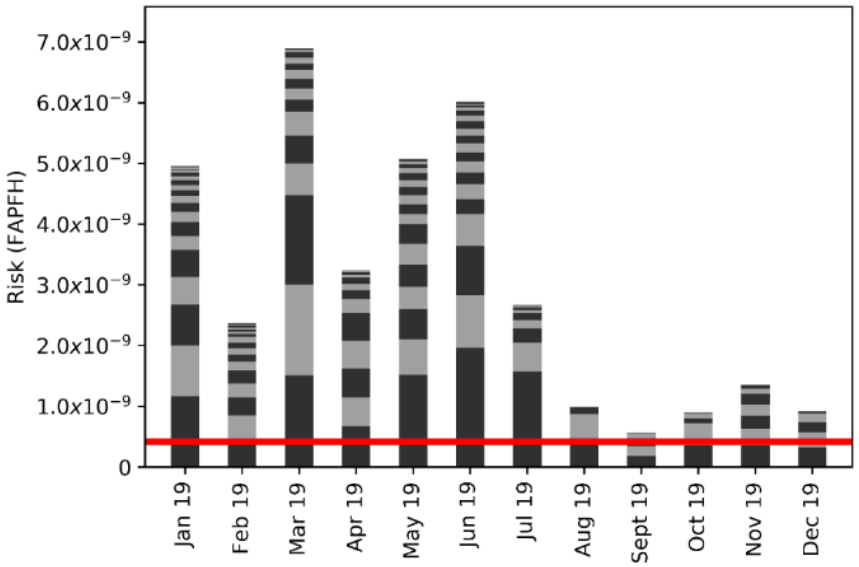

Figure 6: Monthly LHD Risk Estimates for SA/IO Airspace.
Red line is the average monthly value for an annual risk of 5.0 x 10^{-9} FAPFH. Risk is measured in Fatal Accidents per Flight Hour (FAPFH).

4.5 The 2019 annual operational risk was influenced by a number of long duration LHDs. There were 16 LHDs whose duration exceeded 30 minutes and resulted in 46% of the total operational risk. Further analysis would be presented in section 5.

5. Analysis of Operational Errors

5.1 **Figure 7** depicts geographical locations of all reported LHDs in SA/IO airspace based on LHD reports from January to December 2019. **Figure 8** depicts only LHDs which are determined to be non-zero duration. The following are symbols and color codes used in the visualizations:

- 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.

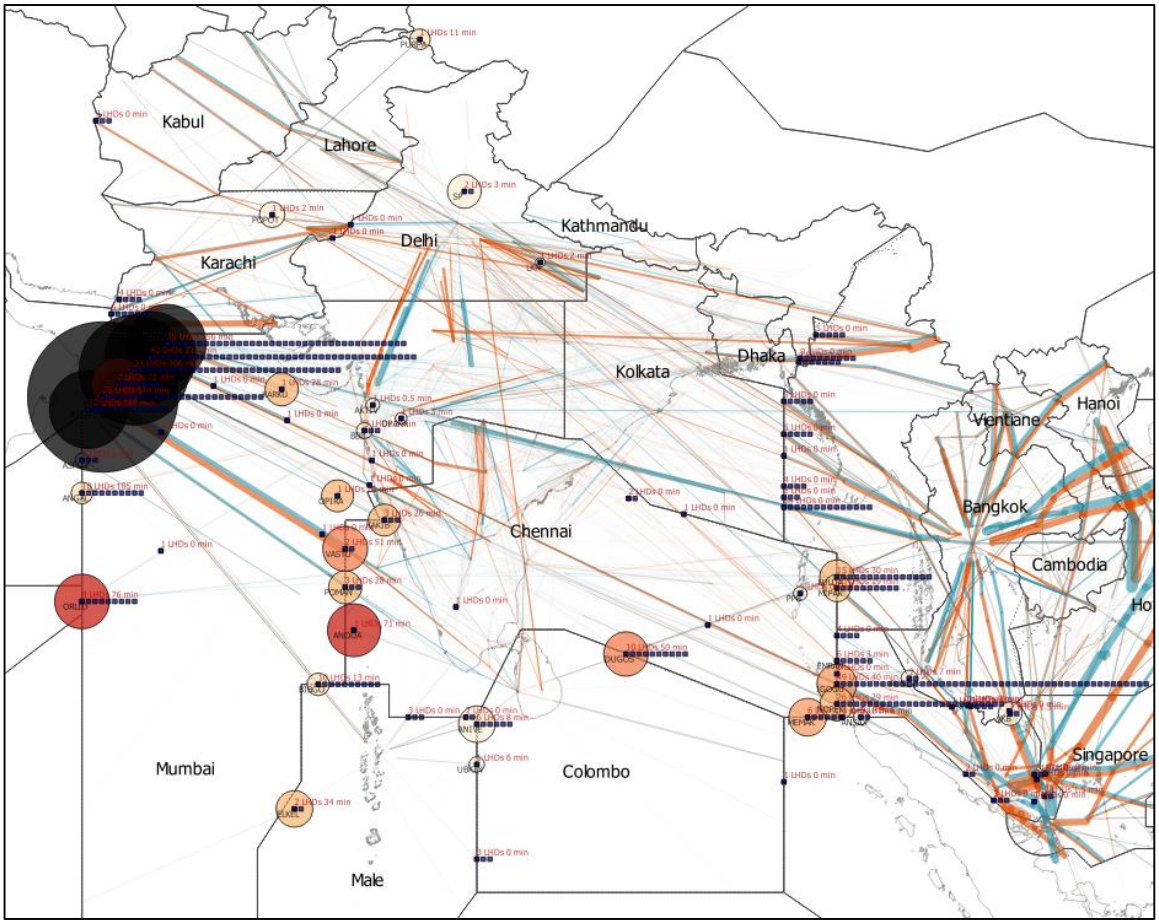

Figure 7: Geographical Locations of **All LHD Reports** in SA/IO Airspace

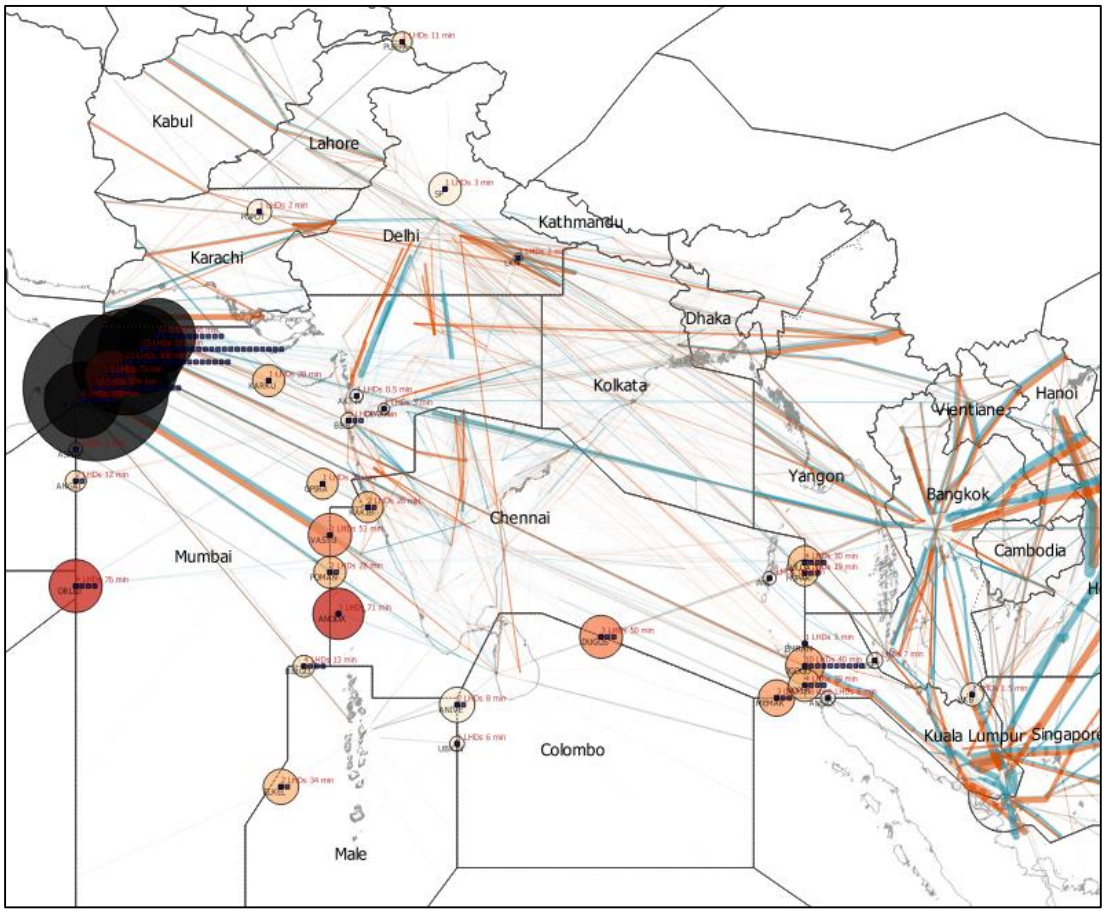

Figure 8: Geographical Locations of **'Non-zero-duration' LHDs** in SA/IO Airspace

LHD Hot Spot G (Sanaa/Muscat – Mumbai) and F (Mogadishu – Mumbai)

5.2 From data collected in 2019, the **Western boundary of Mumbai FIR** remains as an LHD hot spot with three interfaces. The first interface is the boundary between Muscat FIR and Mumbai FIR including waypoint RASKI, PARAR, TOTOX, REXOD, LOTAV, KITAL and ASPUX. The second interface is between Sanaa FIR and Mumbai FIR including waypoint ANGAL, GIDAS and NABIL. The last interface is the waypoint ORLID which lies between Mogadishu FIR and Mumbai FIR. In 2019, the operational risk of this hotspot accounts for 26.16 x 10^{-9} FAPFH, which is 73% of the SA/IO region.

5.3 **Table 6** summarizes the changes in LHDs in 2017, 2018, and 2019. When compared to the previous years, the number of non-zero-duration LHDs and the risks at all interfaces decreased in 2019 particularly at Mumbai-Mogadishu and Mumbai-Sanaa interfaces.

Interface	No. of non-zero-duration LHDs			Operational risk (FAPFH)		
	2017	2018	2019	2017	2018	2019
Mumbai-Muscat	93	97	76	32.82×10^{-9}	30.38×10^{-9}	24.71×10^{-9}
Mumbai-Mogadishu	20	9	3	7.28×10^{-9}	5.13×10^{-9}	0.74×10^{-9}
Mumbai-Sanaa	8	1	2	6.25×10^{-9}	2.28×10^{-9}	0.20×10^{-9}
Total	**121**	**107**	**81**	**46.35×10^{-9}**	**37.79×10^{-9}**	**25.65×10^{-9}**

Table 6: Comparison of 2017, 2018 and 2019 Operational Risk on the Western Boundary of Mumbai FIR Hot Spot

5.4 **Table 6** also showed that the 2019 operational risk in SA/IO airspace was dominated by LHDs at Mumbai-Muscat interface, accounting for 24.71×10^{-9} FAPFH which was 69% of the region. Out of 16 long duration LHDs in SA/IO airspace, 12 LHDs occurred at Mumbai-Muscat interface, accounting for 55% of the operational risk at Mumbai-Muscat interface and 38% of the total operational risk in SA/IO airspace as shown in **Figure 9**.

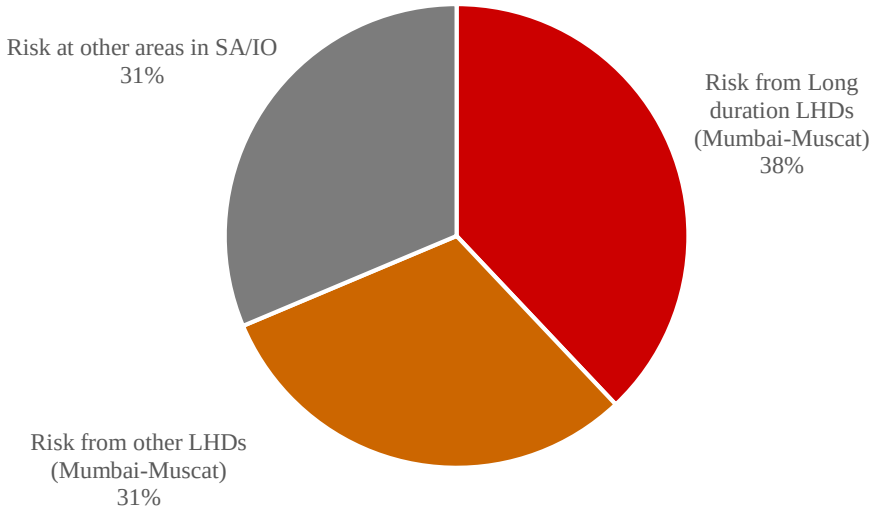

Figure 9: Proportion of the Operational Risk of Long Duration LHDs at Mumbai-Muscat interface, Other LHDs at Mumbai-Muscat Interface, and LHDs at other areas in SA/IO.

5.5 According to **Figure 5 and 6**, the number of LHDs as well as the estimated operational risk was high for the first half of the year, and then decreased from July to December. The number of reported LHDs and operational risk was highest in March 2019. The Mumbai-Muscat interface also exhibited this pattern as shown in **Figure 10**. This might be attributed by the Pakistani airspace closure from 27 February to 16 July 2019. **Figure 11** showed that the number of LHDs at waypoint RASKI, PARAR, and TOTOX spiked in March and May 2019. The pattern of flights during the airspace closure was re-routed through these waypoints as illustrated in **Figure 12**.

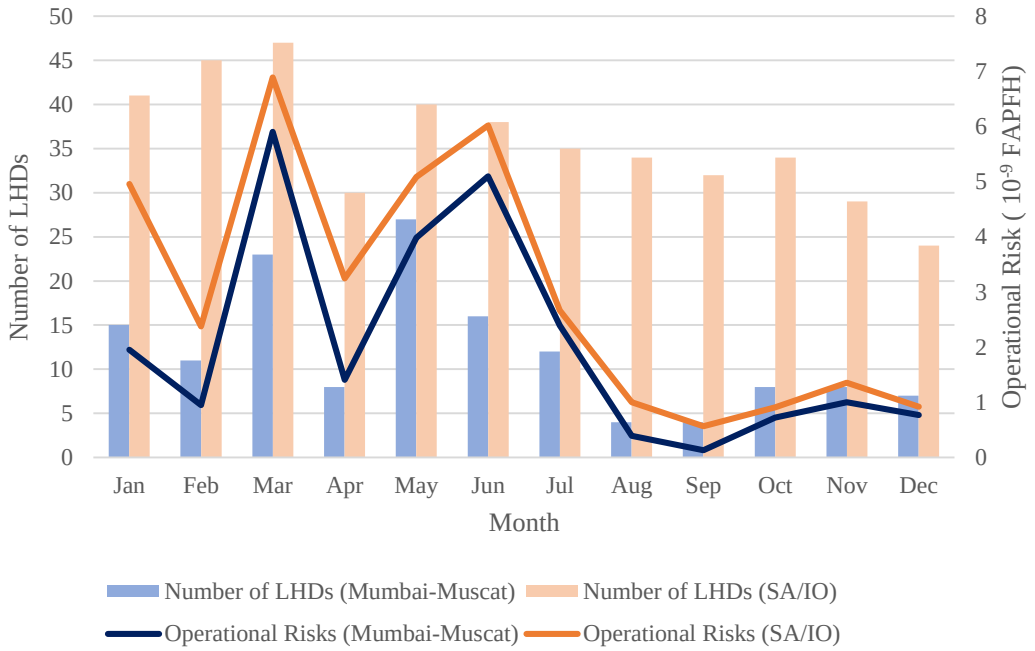

Figure 10: Number of LHDs and risks between Mumbai-Muscat Interface and SA/IO airspace.

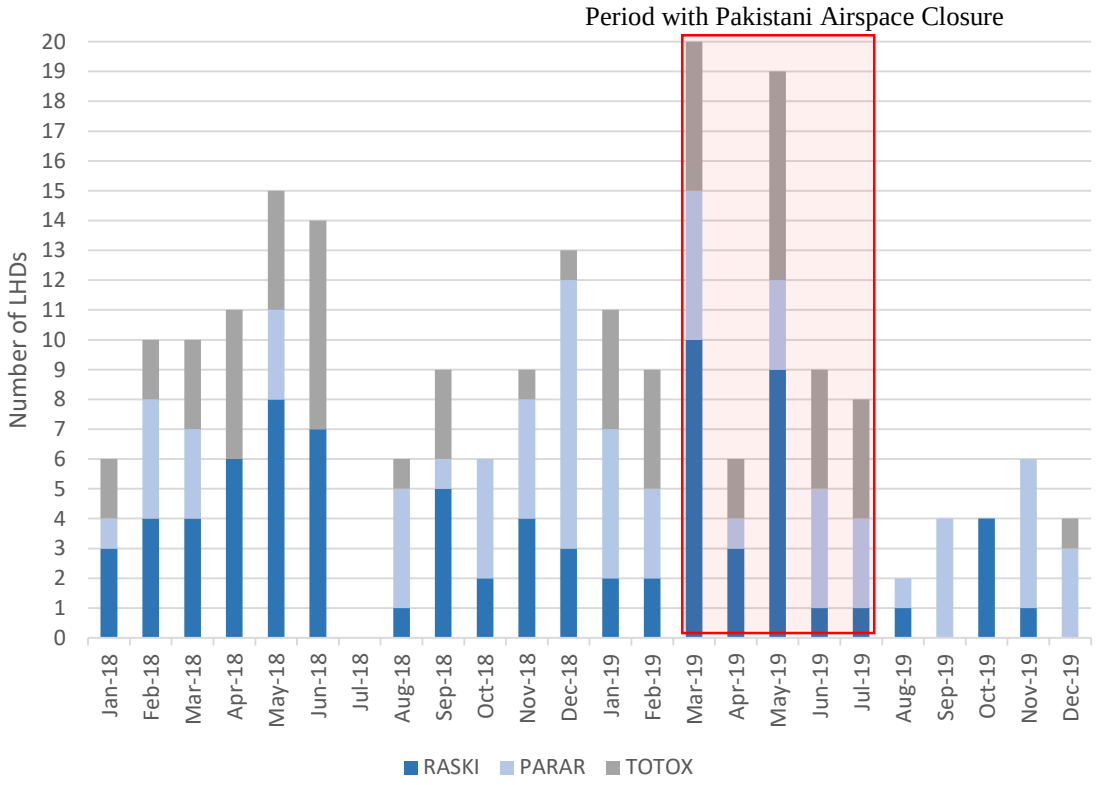

Figure 11: The Number of LHDs at RASKI, PARAR and TOTOX
from January 2018 to December 2019
(Pakistani Airspace Closure from 27 February to 16 July 2019).

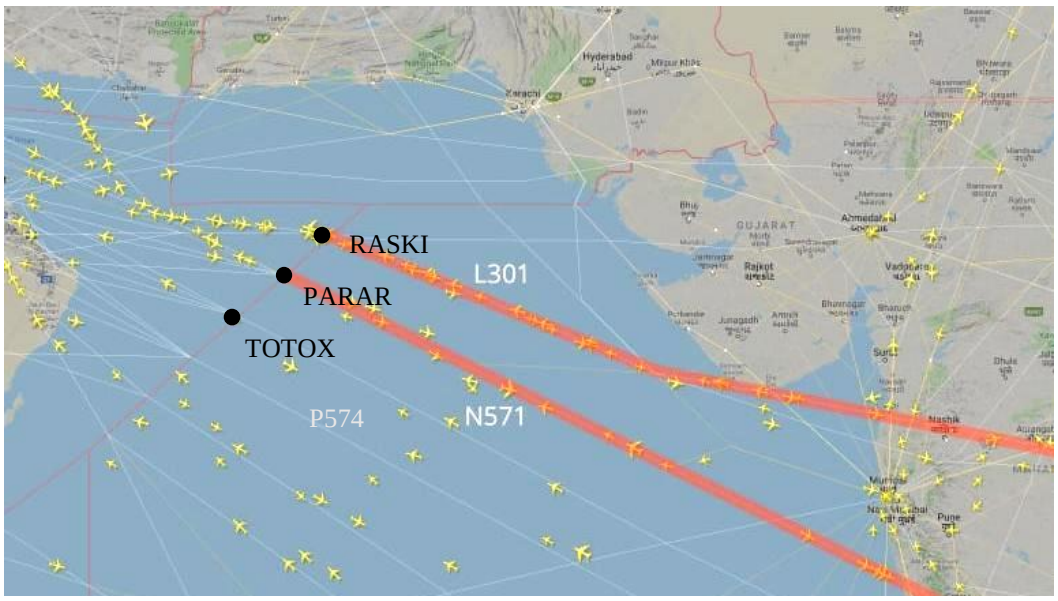

Figure 12: The Pattern of Flights During the Pakistani Airspace Closure.
Picture from: https://www.indiatoday.in/world/story/pakistan-airspace-to-remain-closed-today-1466811-2019-02-28

5.6 Out of 12 long duration LHDs at Mumbai-Muscat interface, 5 long duration LHDs were reported at LOTAV. This made LOTAV the waypoint with the highest operational risk in spite of its fewer number of LHDs at this interface, as shown in **Figure 13**. Each long-duration LHD reported at LOTAV was longer than 90 minutes and accounted for the operational risk of 7.58 x 10^{-9} FAPFH or 21% of operational risk in SA/IO.

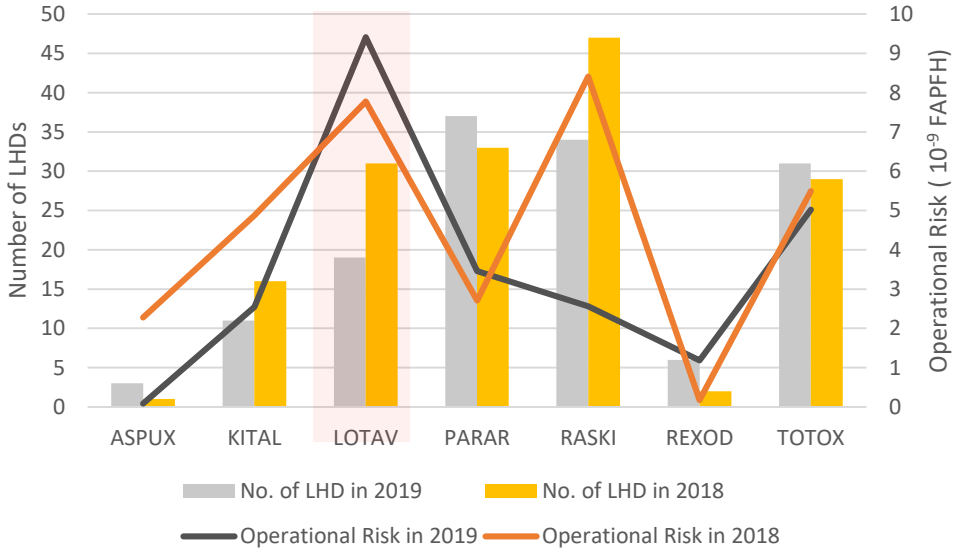

Figure 13: The number LHDs and operation risk between 2018 and 2019

5.7 Similar to picure of the SA/IO sub-region, the majority of LHDs at the Mumbai-Muscat interface is Category E with sub-category being “No or Late FL revision” and “Negative Transfer”. The poor communication services and lack of surveillance coverage at this interface

worsen the situation by the long-duration occurrences before the incorrect presences of aircraft were resolved.

5.8 There is a slightly decreasing trend of the risk in this hot spot, which might be due to the increasing awareness (soft barrier) of the issue. However, it is strongly recommended that an engineering solution such as AIDC (hard barrier) is implemented for the Mumbai-Muscat interface as soon as possible since the operational risk overwhelmingly exceeds the TLS.

LHD Hot Spot A1 (Kolkata/Dhaka - Yangon) and A2 (Chennai - Kuala Lumpur)

5.9 The interfaces between Kolkata/Chennai FIR and Yangon FIR, and between Chennai FIR and Kuala Lumpur FIR were first identified as a hotspot in 2015. The operational risk at these interfaces were 2.97 x 10^{-9} FAPFH in 2017, decreased to 1.32 x 10^{-9} FAPFH in 2018, and slightly increased to 1.94 x 10^{-9} FAPFH in 2019, as detailed in **Table 7**.

5.10 **Table 7** also provided the operational risk at each interface over the past 3 years. When compared to the previous years, the operational risk at Kolkata-Yangon interface significantly decreased from 2017 to 2019. **Figure 14** provided the geographical visualization of the reported LHDs and their associated risk grouped into the three interfaces in 2017, 2018 and 2019.

Interface	No. of LHDs			Operational risk (FAPFH)		
	2017	2018	2019	2017	2018	2019
Kolkata-Yangon	46	168	59	2.04 x 10^{-9}	0.60 x 10^{-9}	0.31 x 10^{-9}
Chennai-Yangon	1	14	16	0.02 x 10^{-9}	0.06 x 10^{-9}	0.49 x 10^{-9}
Chennai-Kuala Lumpur	13	93	88	0.91 x 10^{-9}	0.66 x 10^{-9}	1.14 x 10^{-9}
Total	**60**	**275**	**163**	**2.97 x 10^{-9}**	**1.32 x 10^{-9}**	**1.94 x 10^{-9}**

Table 7: Operational Risk at the Interfaces between Kolkata/Chennai FIR and Yangon FIR, and between Chennai FIR and Kuala Lumpur FIR in 2017, 2018 and 2019

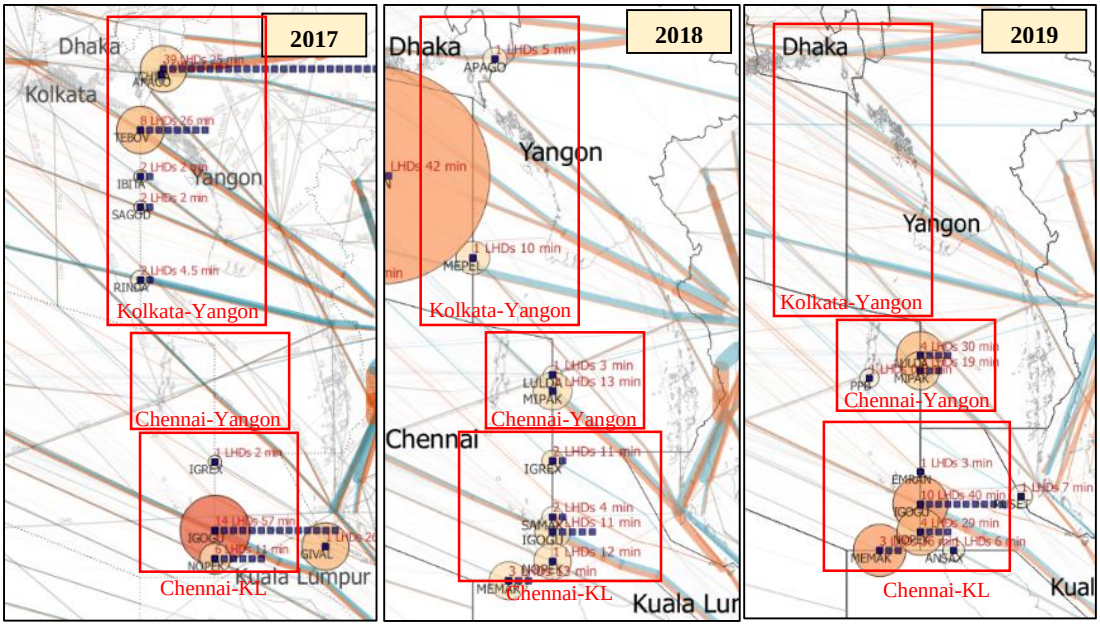

Figure 14: The Visualization of Non-zero-duration LHDs in 2017, 2018 and 2019 between Kolkata FIR, Chennai FIR, Yangon FIR and Kuala Lumpur FIR.

5.11 The LHDs over waypoint APAGO and CHILA involved Dhaka, Kolkata and Yangon FIR where an aircraft would pass through Kolkata for a very brief moment before leaving to Dhaka or Yangon FIR. The ambiguity on handling of eastbound traffic between Dhaka FIR and Kolkata FIR (as well as coordination with Yangon FIR) in this area was resolved by the implementation of a new procedure. A new Letter of Agreement (LOA) was signed between Bangladesh and India with effective date in June 2019.

5.12 Yangon ACC enhanced its surveillance coverage with ADS-B technology to cover the Kolkata-Yangon interface, including waypoint TEBOV and AVLED. The ADS-B data sharing between Kolkata ACC and Yangon ACC was also in place in June 2018. As reported at Bangladesh-India-Myanmar-Thailand ATM Coordination Meeting (BIMT) in Feb 2020, Kolkata ACC successfully integrated ADS-B data shared by Yangon ACC into their ATM system. On the Yangon side, their engineering team was working with the supplier on integrating ADS-B from Kolkata ACC into their system.

5.13 The ADS-B data sharing allowed the controllers to detect and resolve any issues before an aircraft passing the transfer-of-control points. This successfully mitigated the risk at the interface between Kolkata FIR and Yangon FIR where the operational risk decreased from 2.04 x 10^{-9} FAPFH in 2017, to 0.6 x 10^{-9} FAPFH in 2018, and to 0.31 x 10^{-9} FAPFH in 2019 as detailed in **Table 7**. **Figure 14** also showed the reduced number of non-zero-duration LHDs and, hence, the reduced operational risk at the Kolkata-Yangon interface.

5.14 In addition to the surveillance capability enhancement mentioned above, Kolkata ACC and Yangon ACC also discussed communication improvement initatives as reported during BIMT in Feb 2020. The AIDC implementation between the 2 ACCs was in the testing phase. An LOA regarding the use AIDC was planned as the next step. A direct communication enhancement between ATC-to-ATC was under discussion to ensure that each sector combination would have their dedicate line. Other alternatives such as a landline was being considered as the ATS Direct Speech Circuit which relied on undersea cables would require 1 - 2 months to fix any issues with the cables.

5.15 On the other hand, the operational risk in 2019 increased at Chennai-Yangon and Chennai-Kuala Lumpur interfaces (LULDA, MEPAK, IGOGU, NOPEK and MEMAK). At these interfaces, ADS-B data sharing was not implemented. The AIDC implementation between Chennai ACC and Yangon ACC was tested in 2018 but unsuccessful as reported at BIMT in Aug 2018. The AIDC implementation between Chennai ACC and Kuala Lumpur ACC is fully operational from 1st April 2020; however, the surveillance data sharing has not yet implemented, but planned for 2021 (from SEA/BOB ADS-B WG/15 in December 2019).

LHD Hot Spot I (Karachi – Kabul)

5.16 The route segment of A453 between GADER and PIRAN is a very short segment over Karachi FIR, which lies between Tehran and Kabul FIR. Thus, the transfer of aircraft on this route segment is rather complicated. However, the number of LHDs and the risk estimate at the interface between Karachi FIR and Kabul FIR significantly decreased since it was identified as an LHD Hot Spot in 2018 as depicted in **Figure 16**. The new route Z627, as shown in **Figure 17**, was established between Tehran FIR and Kabul FIR in July 2019. Since then, the number of aircraft flying on A453 route through GADER had dropped and there was no LHD reported. Therefore, it was suspected that both the awareness (soft barrier) and the route establishment of Z627 (hard barrier) helped improve the situation at this interface among Iran, Pakistan, and Afghanistan.

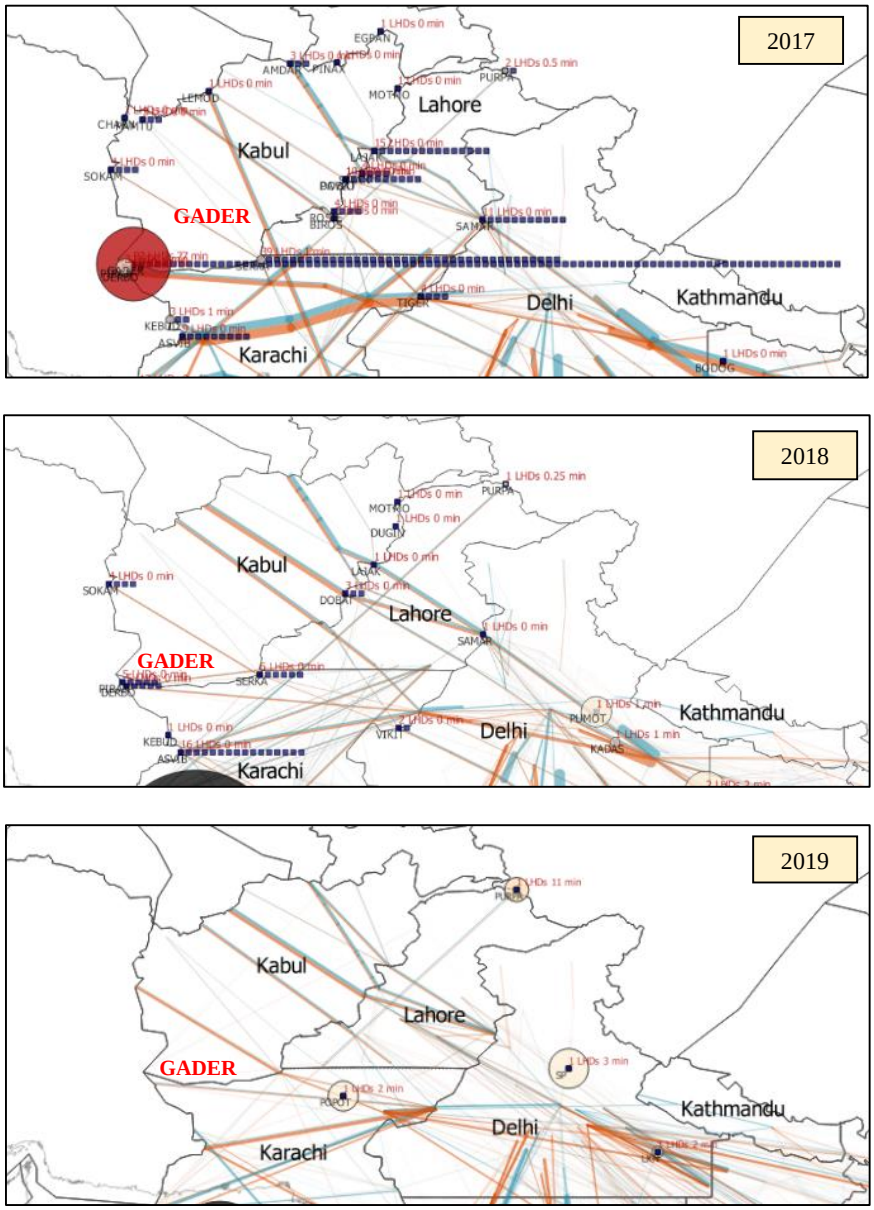

Figure 16: The Visualization of LHDs between Kabul and Karachi in 2017, 2018 and 2019

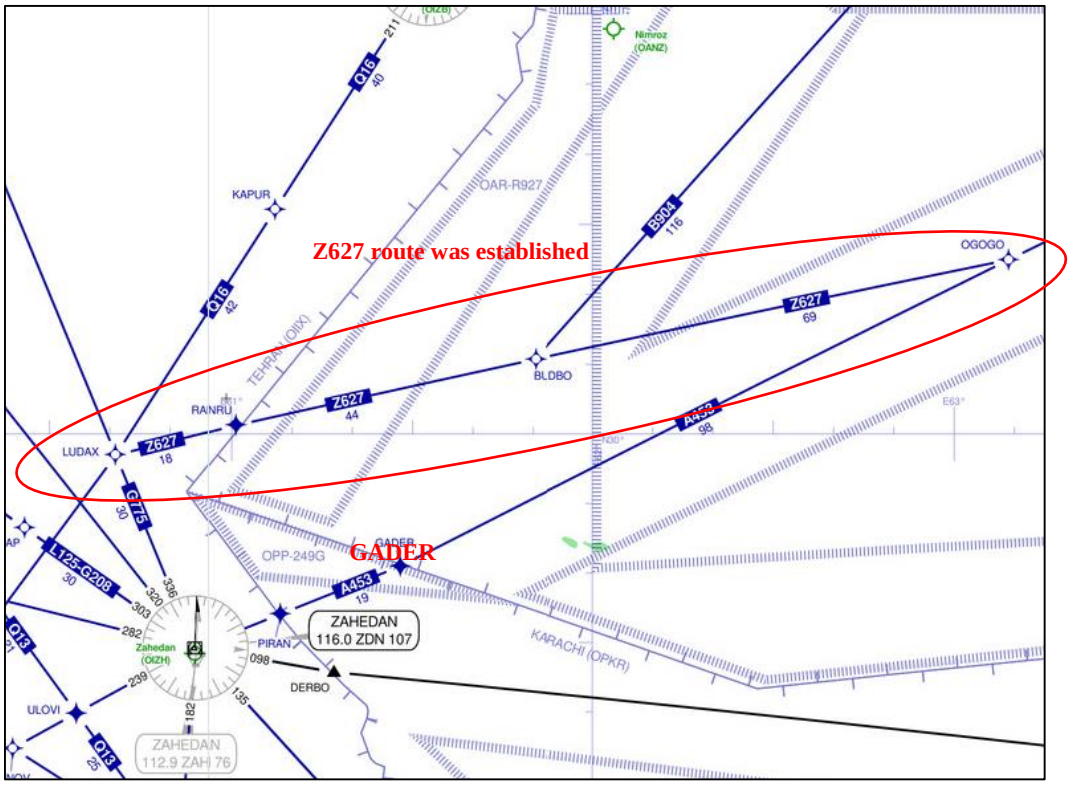

Figure 17: The Visualization of the New Route, Z627, between Tehran FIR and Kabul FIR.

Other LHD Observations in the SA/IO Airspace

5.17 The number of LHDs and risk estimate within Indians FIRs increased in 2019 particularly between Mumbai FIR and Chennai FIR. It may be contributed to the improved reporting culture within Indian airspace.

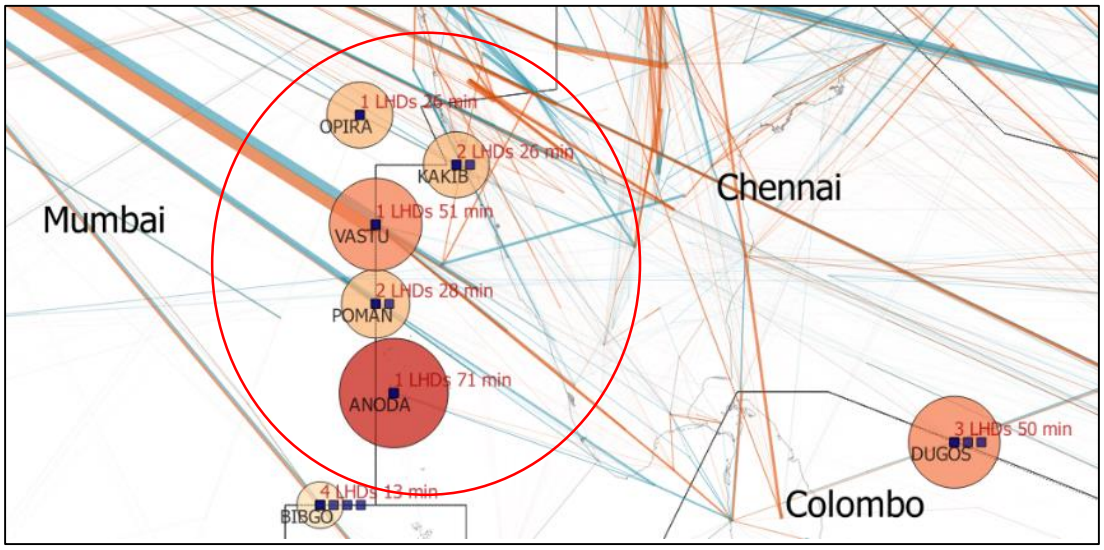

Figure 18: The Visualization of the LHDs between Mumbai FIR and Chennai FIR in 2019**.**

Appendix A: Details of the Reported LHD Occurrences in the SA/IO Airspace

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
10/1/2019	MBA		FL370	3	E	NEGATIVE TRANSFER
29/1/2019	IXN		FL350	0	E	NEGATIVE TRANSFER
12/1/2019	IXN		FL350	0	E	NEGATIVE TRANSFER
3/1/2019	AWP			0	E	NEGATIVE TRANSFER
3/1/2019	AWP			0	E	NO OR LATE FL REVISION
4/1/2019	AWP			0	E	NO OR LATE FL REVISION
5/1/2019	AWP			9	E	NO OR LATE FL REVISION
5/1/2019	AWP			0	E	NO OR LATE FL REVISION
10/1/2019	AWP			0	E	NO OR LATE FL REVISION
11/1/2019	AWP			0	E	NO OR LATE FL REVISION
21/1/2019	AWP			0	E	NO OR LATE FL REVISION
28/1/2019	AWP			1	E	NEGATIVE TRANSFER
29/1/2019	AWP			0	E	NEGATIVE TRANSFER
8/1/2019	AWP			0	E	NEGATIVE TRANSFER
4/1/2019	AWP			6	E	NEGATIVE TRANSFER
29/1/2019	AWP			0	E	NEGATIVE TRANSFER
1/1/2019	DTQ			4	E	NO OR LATE FL REVISION
2/1/2019	DTQ			28	E	NO OR LATE FL REVISION
3/1/2019	DTQ			0	E	NO OR LATE FL REVISION
8/1/2019	DTQ			41	E	NO OR LATE FL REVISION
11/1/2019	DTQ			0	E	NEGATIVE TRANSFER
13/1/2019	DTQ			51	E	NEGATIVE TRANSFER
14/1/2019	DTQ			5	E	NEGATIVE TRANSFER
16/1/2019	DTQ			14	E	NO OR LATE FL REVISION
16/1/2019	DTQ			0	E	NO OR LATE FL

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
						REVISION
16/1/2019	DTQ			10	E	NEGATIVE TRANSFER
17/1/2019	DTQ			0	E	NO OR LATE FL REVISION
17/1/2019	DTQ			7	E	NO OR LATE FL REVISION
18/1/2019	DTQ			14	E	NO OR LATE FL REVISION
20/1/2019	DTQ			0	E	NO OR LATE FL REVISION
21/1/2019	DTQ			1	E	NO OR LATE FL REVISION
21/1/2019	DTQ			0	E	NO OR LATE FL REVISION
25/1/2019	DTQ			0	E	NO OR LATE FL REVISION
25/1/2019	DTQ			5	E	NO OR LATE FL REVISION
25/1/2019	DTQ			1	E	NEGATIVE TRANSFER
27/1/2019	DTQ			71	E	NO OR LATE FL REVISION
27/1/2019	DTQ			27	E	NO OR LATE FL REVISION
23/2/2019	MBA			6	E	NO OR LATE FL REVISION
2/2/2019	BJB	FL340	FL340	0	E	NEGATIVE TRANSFER
2/2/2019	BJB	FL300	FL300	0	E	NEGATIVE TRANSFER
2/3/2019	MBA			6	E	NEGATIVE TRANSFER
9/2/2019	UYM			0	E	NO OR LATE FL REVISION
25/2/2019	UYM			0	E	NO OR LATE FL REVISION
28/2/2019	AWP			0	E	NEGATIVE TRANSFER
26/2/2019	AWP			6	E	NO OR LATE FL REVISION
21/2/2019	AWP			0	E	NO OR LATE FL REVISION
11/2/2019	AWP			0	E	NO OR LATE FL REVISION
20/2/2019	AWP			0	E	NO OR LATE FL

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
						REVISION
17/2/2019	AWP			13	E	NEGATIVE TRANSFER
17/2/2019	AWP			14	E	NEGATIVE TRANSFER
16/2/2019	AWP			2	E	NO OR LATE FL REVISION
16/2/2019	AWP			7	E	NEGATIVE TRANSFER
16/2/2019	AWP			0	E	NO OR LATE FL REVISION
15/2/2019	AWP			2	E	NEGATIVE TRANSFER
18/2/2019	AWP			0	E	NO OR LATE FL REVISION
14/2/2019	AWP			0	E	NO OR LATE FL REVISION
12/2/2019	AWP			0	E	NEGATIVE TRANSFER
8/2/2019	AWP			9	E	NEGATIVE TRANSFER
9/2/2019	AWP			0	E	NO OR LATE FL REVISION
8/2/2019	AWP			0	E	NO OR LATE FL REVISION
7/2/2019	AWP			0	E	NO OR LATE FL REVISION
4/2/2019	AWP			1	E	NO OR LATE FL REVISION
2/2/2019	AWP			0	E	NO OR LATE FL REVISION
1/2/2019	AWP			1	E	NO OR LATE FL REVISION
7/2/2019	DTQ			3	E	NO OR LATE FL REVISION
9/2/2019	DTQ			2	E	NO OR LATE FL REVISION
10/2/2019	DTQ			0	E	NO OR LATE FL REVISION
17/2/2019	DTQ			26	E	NO OR LATE FL REVISION
17/2/2019	DTQ			0	E	NO OR LATE FL REVISION
17/2/2019	DTQ			0	E	NO OR LATE FL REVISION
20/2/2019	DTQ			0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
21/2/2019	DTQ			1	E	NO OR LATE FL REVISION
23/2/2019	DTQ			18	E	NEGATIVE TRANSFER
23/2/2019	DTQ			0	E	NO OR LATE FL REVISION
24/2/2019	DTQ			6	E	NO OR LATE FL REVISION
25/2/2019	DTQ			26	E	NO OR LATE FL REVISION
28/2/2019	DTQ			2	E	NO OR LATE FL REVISION
6/1/2019	BPS			0	E	NO OR LATE FL REVISION
9/1/2019	BPS			0	E	NO OR LATE FL REVISION
22/1/2019	BPS			1	E	NO OR LATE FL REVISION
7/2/2019	BPS			0	E	NO OR LATE FL REVISION
10/2/2019	BPS			0	E	NO OR LATE FL REVISION
25/2/2019	BPS			0	E	NEGATIVE TRANSFER
25/2/2019	BPS			0	E	NO OR LATE FL REVISION
24/3/2019	MBA			0	E	NEGATIVE TRANSFER
7/2/2019	IXN		FL350	0	E	NEGATIVE TRANSFER
22/3/2019	ZMU		FL350	0	E	NEGATIVE TRANSFER
22/3/2019	ZMU		FL370	0	E	NEGATIVE TRANSFER
6/3/2019	BPS			0	E	NO OR LATE FL REVISION
16/3/2019	BPS			0	E	NO OR LATE FL REVISION
24/3/2019	BPS			0	E	NO OR LATE FL REVISION
12/3/2019	BPS			0	E	NO OR LATE FL REVISION
12/3/2019	BPS			0	E	NO OR LATE FL REVISION
2/3/2019	DTQ			0	E	NEGATIVE TRANSFER

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
4/3/2019	DTQ			0	E	NO OR LATE FL REVISION
4/3/2019	DTQ			0	E	NO OR LATE FL REVISION
4/3/2019	DTQ			0	E	NO OR LATE FL REVISION
5/3/2019	DTQ			32	E	NEGATIVE TRANSFER
6/3/2019	DTQ			0	E	NEGATIVE TRANSFER
8/3/2019	DTQ			92	E	NO OR LATE FL REVISION
10/3/2019	DTQ			24	E	NEGATIVE TRANSFER
11/3/2019	DTQ			28	E	NEGATIVE TRANSFER
11/3/2019	DTQ			6	E	NEGATIVE TRANSFER
11/3/2019	DTQ			0	E	NO OR LATE FL REVISION
17/3/2019	DTQ			0	E	NO OR LATE FL REVISION
17/3/2019	DTQ			0	E	NO OR LATE FL REVISION
17/3/2019	DTQ			2	E	NEGATIVE TRANSFER
17/3/2019	DTQ			12	E	NO OR LATE FL REVISION
18/3/2019	DTQ			11	E	NEGATIVE TRANSFER
22/3/2019	DTQ			0	E	NEGATIVE TRANSFER
26/3/2019	DTQ			0	E	NO OR LATE FL REVISION
27/3/2019	DTQ			0	E	NO OR LATE FL REVISION
30/3/2019	DTQ			0	E	NEGATIVE TRANSFER
31/3/2019	DTQ			6	E	NO OR LATE FL REVISION
31/3/2019	DTQ			0	E	NO OR LATE FL REVISION
31/3/2019	DTQ			0	E	NO OR LATE FL REVISION
31/3/2019	DTQ			0	E	NEGATIVE TRANSFER
7/3/2019	DTQ			91	E	NEGATIVE TRANSFER
7/3/2019	DTQ			90	E	NEGATIVE TRANSFER
4/3/2019	AWP			0	E	NO OR LATE FL REVISION
6/3/2019	AWP			10	E	NO OR LATE FL

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
						REVISION
11/3/2019	AWP			0	E	NO OR LATE FL REVISION
13/3/2019	AWP			0	E	NO OR LATE FL REVISION
18/3/2019	AWP			9	E	NO OR LATE FL REVISION
20/3/2019	AWP			0	E	NO OR LATE FL REVISION
20/3/2019	AWP			0	E	NO OR LATE FL REVISION
29/4/2019	DTQ			29	E	NO OR LATE ESTIMATE TIME REVISION
22/3/2019	AWP			0	E	NO OR LATE FL REVISION
22/3/2019	AWP			0	E	NO OR LATE FL REVISION
29/3/2019	AWP			0	E	NO OR LATE FL REVISION
1/4/2019	AWP			2	E	NO OR LATE FL REVISION
1/4/2019	AWP			0	E	NO OR LATE FL REVISION
2/4/2019	AWP			0	E	NO OR LATE FL REVISION
5/4/2019	AWP			0	E	NEGATIVE TRANSFER
10/4/2019	AWP			28	E	NO OR LATE ESTIMATE TIME REVISION
10/4/2019	AWP			9	E	NO OR LATE ESTIMATE TIME REVISION
26/4/2019	AWP			6	E	NO OR LATE FL REVISION
29/4/2019	BPS			0	E	NO OR LATE FL REVISION
28/4/2019	BPS			0	E	NO OR LATE FL REVISION
29/4/2019	DTQ			3	E	NO OR LATE FL REVISION
29/4/2019	DTQ			0	E	NO OR LATE FL

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
						REVISION
17/4/2019	DTQ			0	E	NO OR LATE FL REVISION
17/4/2019	DTQ			0	E	NO OR LATE FL REVISION
17/4/2019	DTQ			14	E	NO OR LATE FL REVISION
18/4/2019	DTQ			41	E	NO OR LATE FL REVISION
18/4/2019	DTQ			0	E	NO OR LATE FL REVISION
18/4/2019	DTQ			28	E	NO OR LATE ESTIMATE TIME REVISION
28/3/2019	UYM			0	E	NO OR LATE FL REVISION
19/4/2019	UYM			0	E	NO OR LATE FL REVISION
21/4/2019	UYM			0	E	NO OR LATE FL REVISION
19/4/2019	UYM			0	E	NO OR LATE FL REVISION
1/4/2019	ZMU	FL370	FL390	0	E	NO OR LATE FL REVISION
30/4/2019	ZMU	FL390	FL410	0	E	NO OR LATE FL REVISION
15/4/2019	ZMU	FL330	FL350	0	E	NO OR LATE FL REVISION
8/4/2019	ZMU	FL330	FL350	0	E	NO OR LATE FL REVISION
14/4/2019	ZMU	FL330	FL350	0	E	NO OR LATE FL REVISION
1/4/2019	ZMU		FL350	0	E	NEGATIVE TRANSFER
27/4/2019	BPS			6	E	NEGATIVE TRANSFER
5/5/2019	BPS			0	E	NEGATIVE TRANSFER
29/5/2019	BPS			10	E	NO OR LATE FL REVISION
20/5/2019	AWP			0	E	NO OR LATE FL REVISION
2/5/2019	UYM			0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
8/5/2019	UYM			0	E	NO OR LATE FL REVISION
22/5/2019	UYM			0	E	NO OR LATE FL REVISION
20/5/2019	BPS			3	E	NEGATIVE TRANSFER
1/5/2019	DTQ			93	E	NO OR LATE FL REVISION
2/5/2019	DTQ			0	E	NO OR LATE FL REVISION
3/5/2019	DTQ			5	E	NO OR LATE FL REVISION
4/5/2019	DTQ			0	E	NO OR LATE FL REVISION
4/5/2019	DTQ			9	E	NO OR LATE FL REVISION
4/5/2019	DTQ			10	E	NO OR LATE FL REVISION
4/5/2019	DTQ			0	E	NEGATIVE TRANSFER
4/5/2019	DTQ			0	E	NEGATIVE TRANSFER
10/5/2019	DTQ			8	E	NO OR LATE FL REVISION
10/5/2019	DTQ			21	E	NO OR LATE FL REVISION
11/5/2019	DTQ			0	E	NO OR LATE FL REVISION
12/5/2019	DTQ			0	E	NO OR LATE FL REVISION
13/5/2019	DTQ			0	E	NO OR LATE FL REVISION
13/5/2019	DTQ			0	E	NO OR LATE FL REVISION
16/5/2019	DTQ			22	E	NO OR LATE FL REVISION
17/5/2019	DTQ			0	E	NO OR LATE FL REVISION
18/5/2019	DTQ			0	E	NO OR LATE FL REVISION
18/5/2019	DTQ			4	E	NO OR LATE FL REVISION
19/5/2019	DTQ			0	E	NO OR LATE FL REVISION
21/5/2019	DTQ			0	E	NO OR LATE FL

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
						REVISION
21/5/2019	DTQ			0	E	NEGATIVE TRANSFER
23/5/2019	DTQ			0	E	NO OR LATE FL REVISION
18/5/2019	DTQ			31	E	NEGATIVE TRANSFER
24/5/2019	DTQ			7	E	NO OR LATE FL REVISION
25/5/2019	DTQ			35	E	NEGATIVE TRANSFER
27/5/2019	DTQ			1	E	NO OR LATE FL REVISION
27/5/2019	DTQ			2	E	NEGATIVE TRANSFER
28/5/2019	DTQ			0	E	NO OR LATE FL REVISION
28/5/2019	DTQ			20	E	NO OR LATE FL REVISION
31/5/2019	DTQ			7	E	NO OR LATE FL REVISION
29/5/2019	DTQ			22	E	NO OR LATE FL REVISION
9/6/2019	BPS			2	E	NO OR LATE ESTIMATE TIME REVISION
9/6/2019	BPS			0	E	NO OR LATE FL REVISION
25/6/2019	BPS			0	E	NEGATIVE TRANSFER
10/6/2019	ZMU	FL370	FL350	0	E	NO OR LATE FL REVISION
28/6/2019	ZMU	FL350	FL370	0	E	NO OR LATE FL REVISION
13/6/2019	ZMU		FL410	0	E	NEGATIVE TRANSFER
27/6/2019	ZMU	FL370	FL350	0	E	NO OR LATE FL REVISION
12/6/2019	ZMU		FL390	0	E	NEGATIVE TRANSFER
18/6/2019	ZMU	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
13/7/2019	MBA		FL350	0	E	NEGATIVE TRANSFER
1/6/2019	DTQ			9	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
2/6/2019	DTQ			0	E	NO OR LATE ROUTE REVISION
4/6/2019	DTQ			49	E	NO OR LATE FL REVISION
5/6/2019	DTQ			7	E	NO OR LATE FL REVISION
6/6/2019	DTQ			0	E	NO OR LATE FL REVISION
8/6/2019	DTQ			15	E	NO OR LATE FL REVISION
8/6/2019	DTQ			0	E	NO OR LATE FL REVISION
10/6/2019	DTQ			12	E	NO OR LATE FL REVISION
14/6/2019	DTQ			120	E	NEGATIVE TRANSFER
18/6/2019	DTQ			53	E	NEGATIVE TRANSFER
20/6/2019	DTQ			7	E	NEGATIVE TRANSFER
22/6/2019	DTQ			15	E	NO OR LATE FL REVISION
22/6/2019	DTQ			11	E	NO OR LATE FL REVISION
22/6/2019	DTQ			2	E	NO OR LATE FL REVISION
22/6/2019	DTQ			9	E	NO OR LATE FL REVISION
23/6/2019	DTQ			3	E	NO OR LATE FL REVISION
25/6/2019	DTQ			5	E	NO OR LATE FL REVISION
26/6/2019	DTQ			6	E	NO OR LATE FL REVISION
4/6/2019	AWP			32	E	NO OR LATE FL REVISION
6/6/2019	AWP			8	E	NO OR LATE FL REVISION
8/6/2019	AWP			0	E	NO OR LATE FL REVISION
9/6/2019	AWP			2	E	NO OR LATE FL REVISION
20/6/2019	AWP			0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
23/6/2019	AWP			0	E	NO OR LATE FL REVISION
25/6/2019	AWP			0	E	NO OR LATE FL REVISION
27/6/2019	AWP			0	E	NO OR LATE FL REVISION
28/6/2019	AWP			0	E	NO OR LATE FL REVISION
28/6/2019	AWP			0	E	NEGATIVE TRANSFER
24/7/2019	MBA			0	E	NO OR LATE FL REVISION
24/7/2019	MBA			0	E	NO OR LATE FL REVISION
7/7/2019	BPS			0	E	NO OR LATE FL REVISION
7/7/2019	BPS			0	E	NO OR LATE ESTIMATE TIME REVISION
24/7/2019	BPS			0	E	NO OR LATE ESTIMATE TIME REVISION
27/7/2019	BPS			0	E	NO OR LATE FL REVISION
17/7/2019	AWP			0	E	NEGATIVE TRANSFER
14/7/2019	AWP			0	E	NEGATIVE TRANSFER
12/7/2019	AWP			0	E	NO OR LATE FL REVISION
5/7/2019	AWP			0	E	NEGATIVE TRANSFER
3/7/2019	AWP			0	E	NO OR LATE FL REVISION
25/7/2019	AWP			0	E	NO OR LATE FL REVISION
13/7/2019	UYM			0	E	NO OR LATE FL REVISION
27/7/2019	UYM			0	E	NO OR LATE FL REVISION
1/7/2019	DTQ			0	E	NO OR LATE FL REVISION
5/7/2019	DTQ			8	E	NO OR LATE FL REVISION
5/7/2019	DTQ			0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
5/7/2019	DTQ			3	E	NEGATIVE TRANSFER
9/7/2019	DTQ			29	E	NO OR LATE FL REVISION
12/7/2019	DTQ			1	E	NO OR LATE FL REVISION
13/7/2019	DTQ			1	E	NO OR LATE FL REVISION
14/7/2019	DTQ			1	E	NO OR LATE FL REVISION
15/7/2019	DTQ			7	E	NO OR LATE FL REVISION
16/7/2019	DTQ			0	E	NO OR LATE FL REVISION
18/7/2019	DTQ			0	E	NEGATIVE TRANSFER
23/7/2019	DTQ			0	E	NO OR LATE FL REVISION
30/7/2019	DTQ			96	E	NO OR LATE FL REVISION
19/7/2019	IXN		FL310	0	E	NEGATIVE TRANSFER
27/7/2019	IXN		FL310	0	E	NEGATIVE TRANSFER
28/7/2019	BPS			1.5	B	UNAUTHORIZED CLIMB IN LUMPUR FIR
23/8/2019	HHN			3	J	
8/7/2019	ZMU		FL390	0	E	NEGATIVE TRANSFER
14/7/2019	ZMU	FL330	FL310	0	E	NO OR LATE FL REVISION
31/7/2019	ZMU	FL370	FL330	0	E	NO OR LATE FL REVISION
12/8/2019	ZMU	FL390	FL410	0	E	NO OR LATE FL REVISION
2/8/2019	ZMU		FL350	0	E	NEGATIVE TRANSFER
6/8/2019	ZMU	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
25/8/2019	ZMU	FL410	FL410	0	E	NO OR LATE ESTIMATE TIME REVISION
24/8/2019	ZMU		FL37	0	E	NEGATIVE TRANSFER

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
			0			
5/8/2019	ZMU	FL350	FL390	0	E	NO OR LATE FL REVISION
25/8/2019	ZMU	FL410	FL410	0	E	NO OR LATE ESTIMATE TIME REVISION
24/8/2019	ZMU		FL410	0	E	NEGATIVE TRANSFER
1/8/2019	BPS			7	E	NO OR LATE ESTIMATE TIME REVISION
1/8/2019	BPS			0	E	NO OR LATE FL REVISION
2/8/2019	BPS			0	E	NO OR LATE ESTIMATE TIME REVISION
5/8/2019	BPS			1	E	NO OR LATE ESTIMATE TIME REVISION
9/8/2019	BPS			0	E	NO OR LATE ESTIMATE TIME REVISION
22/8/2019	BPS			0	E	NO OR LATE FL REVISION
27/8/2019	BPS			0	E	NEGATIVE TRANSFER
27/8/2019	BPS			0	E	NEGATIVE TRANSFER
27/8/2019	BPS			0	E	NEGATIVE TRANSFER
28/8/2019	BPS			0	E	NEGATIVE TRANSFER
30/8/2019	BPS			0	E	NEGATIVE TRANSFER
31/8/2019	BPS			0	E	NEGATIVE TRANSFER
30/8/2019	AWP			0	E	NO OR LATE FL REVISION
25/8/2019	AWP			0	B	
19/8/2019	AWP			0	E	NO OR LATE FL REVISION
12/8/2019	AWP			0	E	NO OR LATE FL REVISION
18/8/2019	AWP			0	E	NEGATIVE TRANSFER
4/8/2019	DTQ			0	E	NEGATIVE TRANSFER
6/8/2019	DTQ			0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
9/8/2019	DTQ			0	E	NO OR LATE FL REVISION
10/8/2019	DTQ			0	E	NO OR LATE FL REVISION
12/8/2019	DTQ			24	E	NO OR LATE FL REVISION
6/8/2019	ZMU		FL350	0	E	NEGATIVE TRANSFER
6/10/2019	MBA		FL370	1	E	NEGATIVE TRANSFER
8/10/2019	MBA	FL290	FL350	0	E	NO OR LATE FL REVISION
23/9/2019	YRT	FL400	FL400	11	E	NEGATIVE TRANSFER
1/9/2019	DTQ	FL370	FL330	8	E	NO OR LATE FL REVISION
9/9/2019	DTQ	FL310	FL350	0	E	NO OR LATE FL REVISION
14/9/2019	DTQ		FL340	0	E	NEGATIVE TRANSFER
12/9/2019	DTQ	FL350	FL370	0	E	NO OR LATE FL REVISION
27/9/2019	DTQ		FL330	0	E	NEGATIVE TRANSFER
27/9/2019	DTQ	FL360	FL380	0	E	NO OR LATE FL REVISION
23/9/2019	DTQ	FL370	FL390	0	E	NO OR LATE FL REVISION
4/9/2019	UYM	FL340	FL300	0	E	NO OR LATE FL REVISION
5/9/2019	UYM	FL380	FL400	0	E	NO OR LATE FL REVISION
10/9/2019	UYM	FL320	FL360	0	E	NO OR LATE FL REVISION
25/9/2019	UYM	FL380	FL340	10	E	NO OR LATE FL REVISION
20/9/2019	UYM	FL300	FL320	0	E	NO OR LATE FL REVISION
1/9/2019	BPS	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
5/9/2019	BPS			0	E	NEGATIVE TRANSFER

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
10/9/2019	BPS	FL330	FL350	0	E	NO OR LATE FL REVISION
16/9/2019	BPS	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
20/9/2019	BPS	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
4/9/2019	AWP	FL400	FL380	0	E	NO OR LATE FL REVISION
15/9/2019	AWP	FL300	FL340	0	E	NO OR LATE FL REVISION
18/9/2019	AWP	FL330	FL350	0	E	NO OR LATE FL REVISION
23/9/2019	AWP	FL360	FL380	0	E	NO OR LATE FL REVISION
28/9/2019	AWP	FL280	FL300	0	E	NO OR LATE FL REVISION
11/8/2019	BPS		FL410	0	E	NEGATIVE TRANSFER
23/9/2019	ZMU	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
18/9/2019	ZMU		FL390	0	E	NEGATIVE TRANSFER
5/9/2019	ZMU		FL350	0	E	NEGATIVE TRANSFER
7/9/2019	ZMU	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
7/9/2019	ZMU		FL350	0	E	NEGATIVE TRANSFER
5/9/2019	ZMU	FL350	FL350	0	E	NEGATIVE TRANSFER
24/10/2019	QVI	FL310	FL310	0	E	NO OR LATE ESTIMATE TIME REVISION
24/10/2019	QVI	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
10/10/2019	BPS	FL330	FL390	3	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
15/10/2019	BPS	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
19/10/2019	BPS	FL330	FL370	0	E	NO OR LATE FL REVISION
19/10/2019	BPS		FL370	0	E	NEGATIVE TRANSFER
23/10/2019	BPS		FL320	0	E	NEGATIVE TRANSFER
8/10/2019	AWP	FL340	FL380	0	E	NO OR LATE FL REVISION
15/10/2019	AWP	FL400	FL380	0	E	NO OR LATE FL REVISION
16/10/2019	AWP	FL400	FL380	0	E	NO OR LATE FL REVISION
26/10/2019	AWP	FL380	FL340	0	E	NO OR LATE FL REVISION
28/10/2019	AWP	FL280	FL360	0	E	NO OR LATE FL REVISION
16/10/2019	UYM	FL360	FL380	0	E	NO OR LATE FL REVISION
29/10/2019	UYM		FL400	0	E	NEGATIVE TRANSFER
28/10/2019	UYM	FL380	FL360	0	E	NO OR LATE FL REVISION
6/11/2019	QVI	FL310	FL290	0	E	NO OR LATE ESTIMATE TIME REVISION
9/11/2019	MBA	FL360	FL360	5	E	NO OR LATE ESTIMATE TIME REVISION
1/11/2019	IXN	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
3/10/2019	DTQ	FL370	FL390	0	E	NO OR LATE FL REVISION
6/10/2019	DTQ	FL350	FL390	0	E	NO OR LATE FL REVISION
16/10/2019	DTQ	FL350	FL330	0	E	NO OR LATE FL REVISION
17/10/2019	DTQ	FL350	FL310	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
25/10/2019	DTQ	FL350	FL330	0	E	NO OR LATE FL REVISION
11/10/2019	DTQ	FL350	FL370	22	E	NO OR LATE FL REVISION
26/10/2019	DTQ	FL370	FL390	0	E	NO OR LATE FL REVISION
14/10/2019	DTQ		FL350	22	E	NEGATIVE TRANSFER
20/11/2019	BJB	FL390	FL397	2	I	
23/10/2019	ZMU		FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
4/10/2019	ZMU	FL370	FL390	0	E	NO OR LATE FL REVISION
31/10/2019	ZMU	FL330	FL350	0	E	NO OR LATE FL REVISION
23/10/2019	ZMU	FL310	FL350	0	E	NO OR LATE FL REVISION
31/10/2019	ZMU	FL390	FL410	0	E	NO OR LATE FL REVISION
23/10/2019	ZMU	FL370	FL350	0	E	NO OR LATE FL REVISION
8/11/2019	BPS		FL390	0	E	NEGATIVE TRANSFER
21/11/2019	BPS		FL410	0	E	NEGATIVE TRANSFER
20/11/2019	BPS		FL400	0	E	NEGATIVE TRANSFER
1/11/2019	AWP	FL370	FL350	0	E	NO OR LATE FL REVISION
4/11/2019	AWP	FL370	FL390	0	E	NO OR LATE FL REVISION
19/11/2019	AWP	FL340	FL360	0	E	NO OR LATE FL REVISION
14/11/2019	AWP	FL350	FL390	0	E	NO OR LATE FL REVISION
11/11/2019	AWP		FL360	0	E	NEGATIVE TRANSFER
11/11/2019	AWP		FL300	0	E	NEGATIVE TRANSFER
11/11/201	AWP	FL34	FL32	0	E	NO OR LATE FL

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
9		0	0			REVISION
9/11/2019	AWP	FL320	FL300	0	E	NO OR LATE FL REVISION
1/11/2019	DTQ	FL310	FL370	22	E	NO OR LATE FL REVISION
3/11/2019	DTQ	FL350	FL390	4	E	NO OR LATE FL REVISION
3/11/2019	DTQ	FL350	FL370	0	E	NO OR LATE FL REVISION
10/11/2019	DTQ	FL390	FL370	13	E	NO OR LATE FL REVISION
11/11/2019	DTQ	FL330	FL350	0	E	NO OR LATE FL REVISION
18/11/2019	DTQ		FL330	0	E	NEGATIVE TRANSFER
30/11/2019	DTQ	FL350	FL370	11	E	NO OR LATE FL REVISION
24/11/2019	DTQ	FL390	FL410	0	E	NO OR LATE FL REVISION
27/11/2019	DTQ	FL350	FL390	11	E	NO OR LATE FL REVISION
12/11/2019	DTQ	FL350	FL390	0	E	NEGATIVE TRANSFER
10/10/2019	BPS	FL350	FL390	0	E	NO OR LATE FL REVISION
30/11/2019	IXN	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
2/12/2019	BPS	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
11/12/2019	BPS	FL330	FL370	0	E	NO OR LATE FL REVISION
30/12/2019	BPS	FL340	FL300	0	E	NO OR LATE FL REVISION
6/12/2019	UYM	FL340	FL360	0	E	NO OR LATE FL REVISION
3/11/2019	UYM	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
3/12/2019	DTQ	FL330	FL350	9	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
4/12/2019	DTQ	FL390	FL410	0	E	NO OR LATE FL REVISION
8/12/2019	DTQ	FL360	FL400	0	E	NO OR LATE FL REVISION
11/12/2019	DTQ		FL390	15	E	NEGATIVE TRANSFER
12/12/2019	DTQ		FL330	20	E	NO OR LATE FL REVISION
15/12/2019	DTQ	FL270	FL310	0	E	NO OR LATE FL REVISION
20/12/2019	DTQ	FL370	FL390	0	E	NO OR LATE FL REVISION
23/12/2019	DTQ	FL330	FL310	10	E	
24/12/2019	DTQ	FL330	FL330	2	E	NO OR LATE ESTIMATE TIME REVISION
29/12/2019	DTQ	FL410	FL390	0	E	NO OR LATE FL REVISION
29/12/2019	AWP	FL340	FL300	0	E	NO OR LATE FL REVISION
26/12/2019	AWP	FL360	FL340	0	E	NO OR LATE FL REVISION
18/12/2019	AWP	FL380	FL400	0	E	NO OR LATE FL REVISION
17/12/2019	AWP	FL380	FL340	0	E	NO OR LATE FL REVISION
10/12/2019	AWP	FL280	FL340	0	E	NO OR LATE FL REVISION
8/1/2019	DTQ	FL300	FL350	3	D	
12/2/2019	DTQ	FL310	FL310	0	E	
15/3/2019	DTQ	FL310	FL330	1	D	
8/6/2019	DTQ	FL360	FL360	0	D	
5/9/2019	DTQ	FL380	FL370	0.5	D	
20/10/2019	DTQ	FL380	FL370	0.5	D	
4/9/2019	DTQ	FL37	FL36	0.5	M	

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
		0	0			
27/9/2019	DTQ	FL350	FL350	0	I	
1/11/2019	DTQ	FL350	FL353	0	J	
23/8/2019	HHN	FL340	FL357	0	D	
17/7/2019	HHN	FL330	FL370	2	B	
18/10/2019	AWP	FL360	FL330	0.5	D	
4/12/2019	AWP	FL390	FL390	0	E	
12/4/2019	MBA	FL380	FL350	3	B	LOA VIOLATION
17/4/2019	MBA		FL370	3	E	NEGATIVE TRANSFER
22/5/2019	MBA	FL360	FL340	0	E	NO OR LATE FL REVISION
26/5/2019	MBA			0	E	NO OR LATE ROUTE REVISION
29/11/2019	MBA			0	M	LOA VIOLATION
17/12/2019	MBA		FL350	0	E	NEGATIVE TRANSFER
25/12/2019	MBA		FL390	0	E	NEGATIVE TRANSFER
30/12/2019	MBA	FL350	FL350	0	F	TIME ESTIMATE FROM ATC SYSTEM IS NOT ACCURATE ENOUGH
30/12/2019	MBA	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION

MONITORING AGENCY FOR ASIA REGION (MAAR)

Airspace Safety Review of RVSM in Southeast Asia (SEA) Airspace

January 2019 to December 2019

AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN THE SOUTHEAST ASIA AIRSPACE
Assessment Period: January 2019 to December 2019

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

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1. Introduction

This report provides an airspace safety review of RVSM airspace risk in **Southeast Asia (SEA)** airspace. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2019** and monthly Large Height Deviation (LHD) reports between **January 2019** and **December 2019** submitted by concerning States in the SEA region.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2019 of aircraft operating in SEA 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 2019 to December 2019. **Table 1** indicates those FIRs, which submitted LHD reports including NIL reports. **Appendix A** provides details of LHD reports, including full description of some uncommon LHDs and LHDs with large duration.

FIR/ Month	Phnom Penh	Hong Kong	Vientiane	Kota Kinabalu	Kuala Lumpur	Manila	Singapore	Bangkok	Hanoi	Ho Chi Minh	Taipei
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 in 2019

3. Summary of LHD Occurrences

3.1. **Table 2** and **Figure 1** summarize the number of LHDs assessed and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2019 to December 2019. In this report, the number of LHDs included the LHDs that had zero duration, unless indicated otherwise.

Month (2019)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk (x10^{-9} FAPFH)
January	7	0	0	0	0.00
February	8	1	1	0	0.02
March	13	1	0	4	0.07
April	9	0	0	0	0.00
May	11	4	8	0	0.11
June	10	2	7	0	0.12
July	12	0	0	0	0.00
August	13	3	18	0	0.22
September	19	3	1	2.5	0.06
October	15	0	0	0	0.00
November	11	2	8	0	0.13
December	17	1	80	0	1.36
Total	145	17	123	6.5	2.09

Table 2: Summary of LHD by Month for SEA Airspace

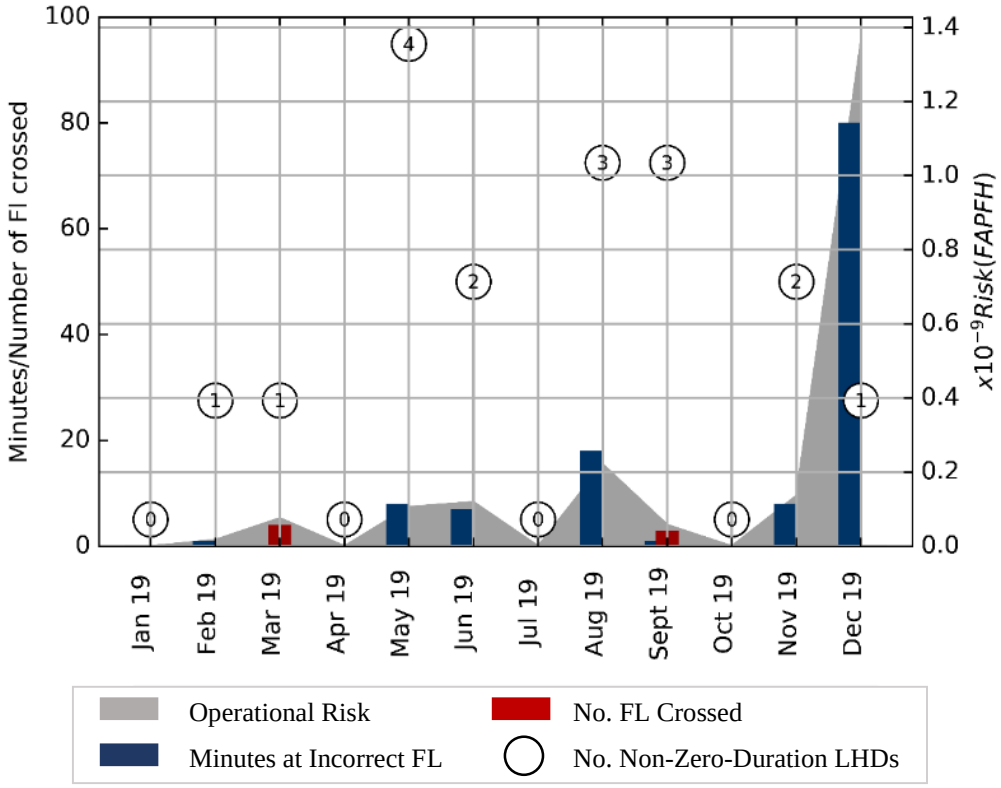

Figure 1: Summary of LHDs by Month for SEA Airspace

3.2. The number of LHDs decreased from 177 in 2018 to 145 in 2019. The number of non-zero-duration LHDs decreased from 53 in 2018 to 17 in 2019. The total LHD duration also decreased from 224 minutes to 123 minutes. As a result, the total operational risk decreased from 3.92 x 10^{-9} Fatal Acccident per Flight Hour (FAPFH) to 2.09 x 10^{-9} FAPFH.

3.3. **Figure 2** and **Table 3** summarize the number of LHDs, the associated LHD duration (in minutes) and number of flight levels crossed, by LHD category from January 2019 to December 2019.

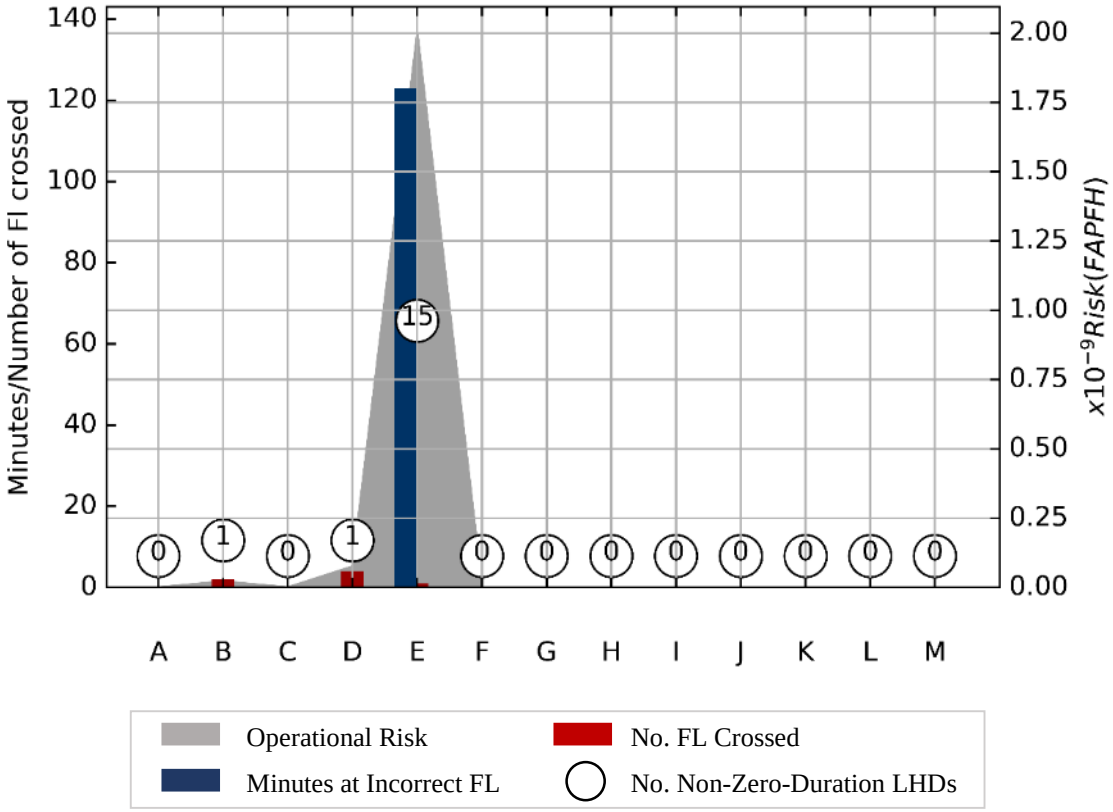

Figure 2: Summary of LHD by LHD Category for SEA Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	1	1	0	1.5	0.02
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	5	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	3	1	0	4	0.08
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	120	15	123	1	1.99
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level).	9	0	0	0	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	1	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	5	0	0	0	0
K	TCAS resolution advisory, flight crew incorrectly climb or descend following the resolution advisory.	0	0	0	0	0
L	An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight	0	0	0	0	0

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
	plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan).					
M	Other	1	0	0	0	0
Total		145	17	123	6.5	2.09

Table 3: Summary of LHD by Category for SEA Airspace

3.4. Category E LHDs remained the most frequent occurrences in the region. These occurrences could be further categorized into the sub-categories as shown in **Figure 3** in terms of the number and **Figure 4** in terms of risk.

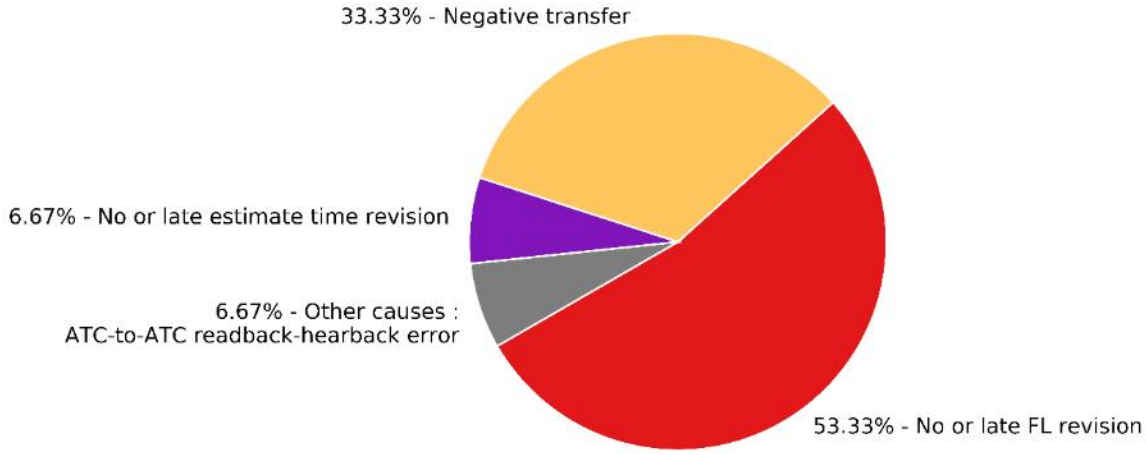

Figure 3: Sub-categories of Category-E LHDs for SEA Airspace
(Number of Non-zero-duration Occurrences)

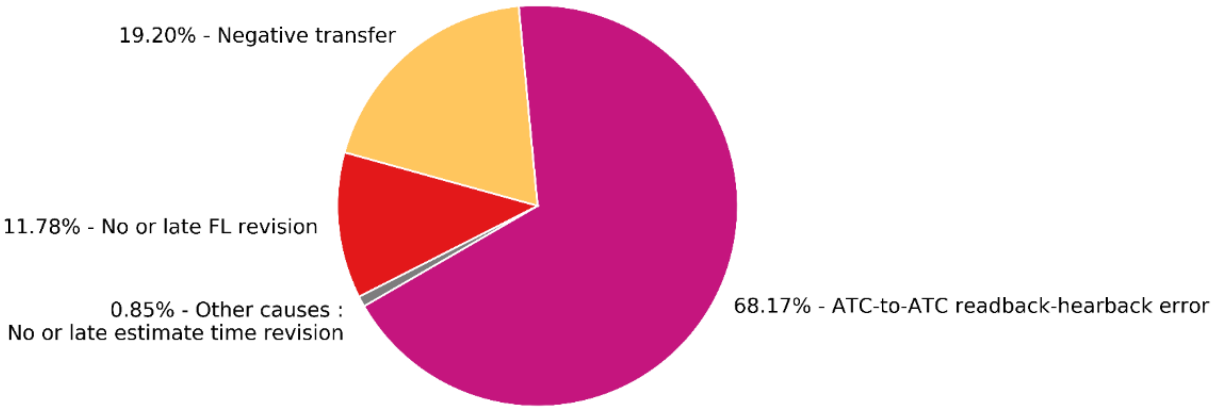

Figure 4: Sub-categories of Category-E LHDs for SEA Airspace Airspace (Risk)

3.5. In term of the number of LHDs, “No or late flight level revision” and “Negative transfer” were most frequent sub-categories, which contributed to 53.33% and 33.33% of Category-E LHDs respectively. However, the “ATC-to-ATC readback-hearback error” sub-category caused 68.17% of risk of Category-E LHDs. The detail would be described in Section 5.

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	2,358,190	1,027,576	Hour	Dec 2018 TSD
E_z(same)	Same-direction vertical occupancies	0.3957/ 0.0387	0.3313	-	
E_z(opposite)	Opposite-direction vertical occupancies	0.3482	0.0599	-	
λ_x	Average aircraft length	0.0258	0.0286	NM	
λ_y	Average aircraft wingspan	0.0237	0.0262	NM	
λ_z	Average aircraft height	0.0075	0.0080	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0258	0.0286	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	Conservative value used in previous assessments
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes	38.65	31.16	Knot	Dec 2019 TSD
$\overline{\lvert V\rvert}$	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for SEA 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**, defined as probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and to all causes, **meets the TLS** value of 2.5 x 10^{-9} FAPFH. **The total risk** is 3.59 x 10^{-9} FAPFH, which also **meets the specified TLS** value for these components of 5.0 x 10^{-9} FAPFH.

Southeast Asia (SEA) RVSM Airspace – estimated annual flying hours = 3,385,767 hours *(note: estimated hours based on December 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	1.50×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	2.09×10^{-9}	-	-
Total Risk	**3.59×10^{-9}**	**5.0×10^{-9}**	**Below Technical TLS**

Table 5: Risk Estimates for SEA Airspace

4.3. **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHDs. The operational and total risk steadily declined from January to November. However, the long duration LHD mentioned in paragraph 3.6 swung up the risk in December.

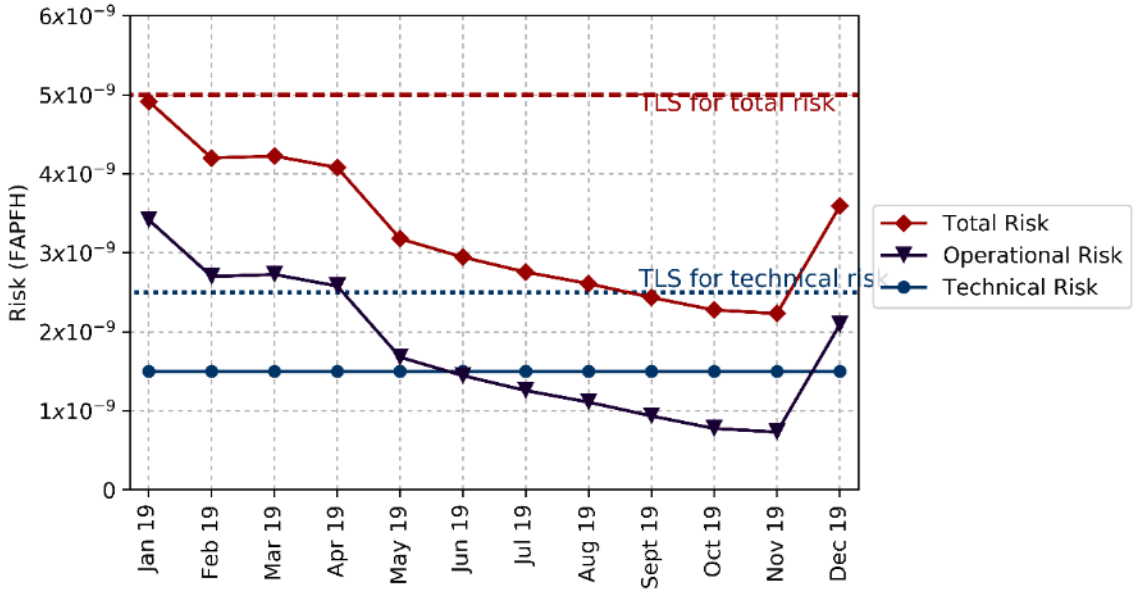

Figure 5: Trends of Risk Estimates for SEA Airspace

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 height of each block corresponds to risk of each LHD. The red horizontal line represents 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).

4.5. The majority of LHDs in the region had zero or low risk. Only 17 out of 145 LHDs in the region were non-zero duration and, hence, bore vertical collision risk. A single long duration occurrence drove the risk of December above the average monthly value of TLS (the red line).

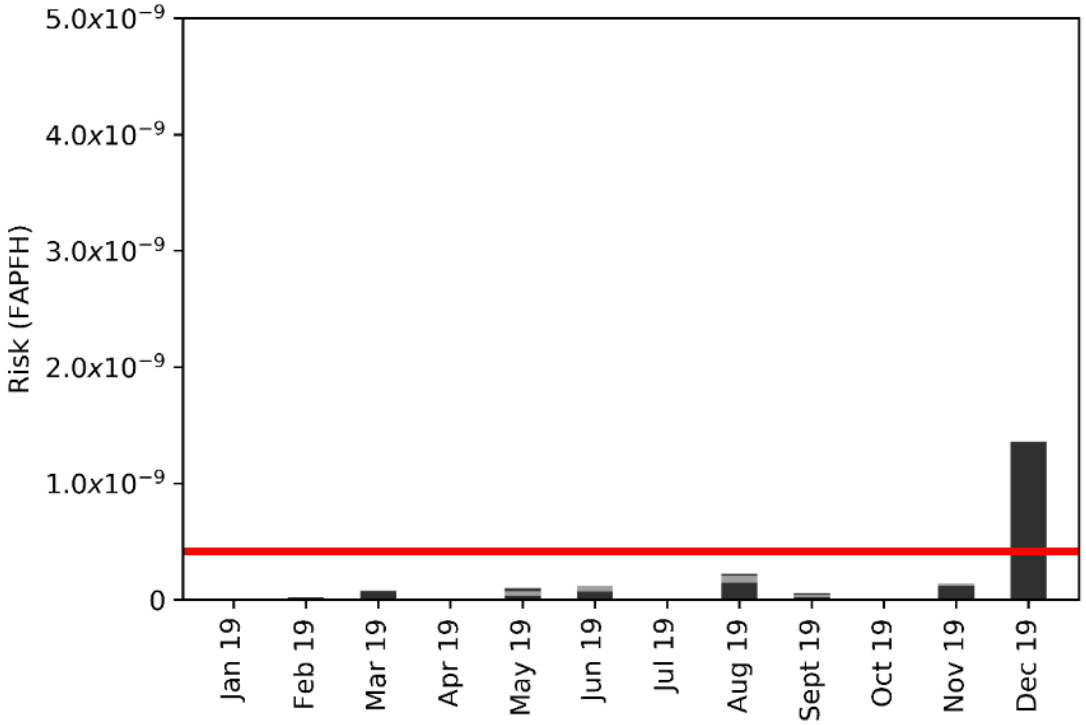

Figure 6: Monthly LHD Risk Estimates for SEA Airspace.
Red line is the average monthly value for an annual risk of 5.0 x 10^{-9} FAPFH. Risk is measured in Fatal Accidents per Flight Hour (FAPFH).

5. Analysis of Operational Errors

5.1 **Figure 7** depicts geographical locations of all reported LHDs in SEA airspace based on LHD reports from January to December 2019. **Figure 8** depicts only LHDs which are determined to be non-zero duration. The following are symbols and color codes used in the visualizations:

- 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.

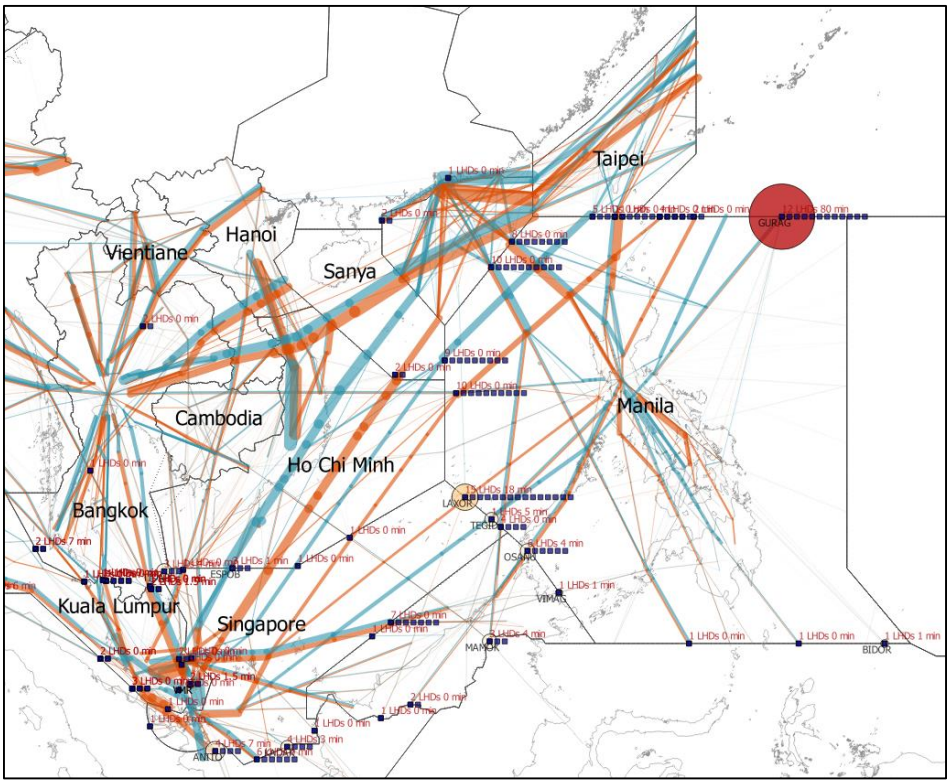

Figure 7: Geographical Locations of **All LHDs** in SEA Airspace

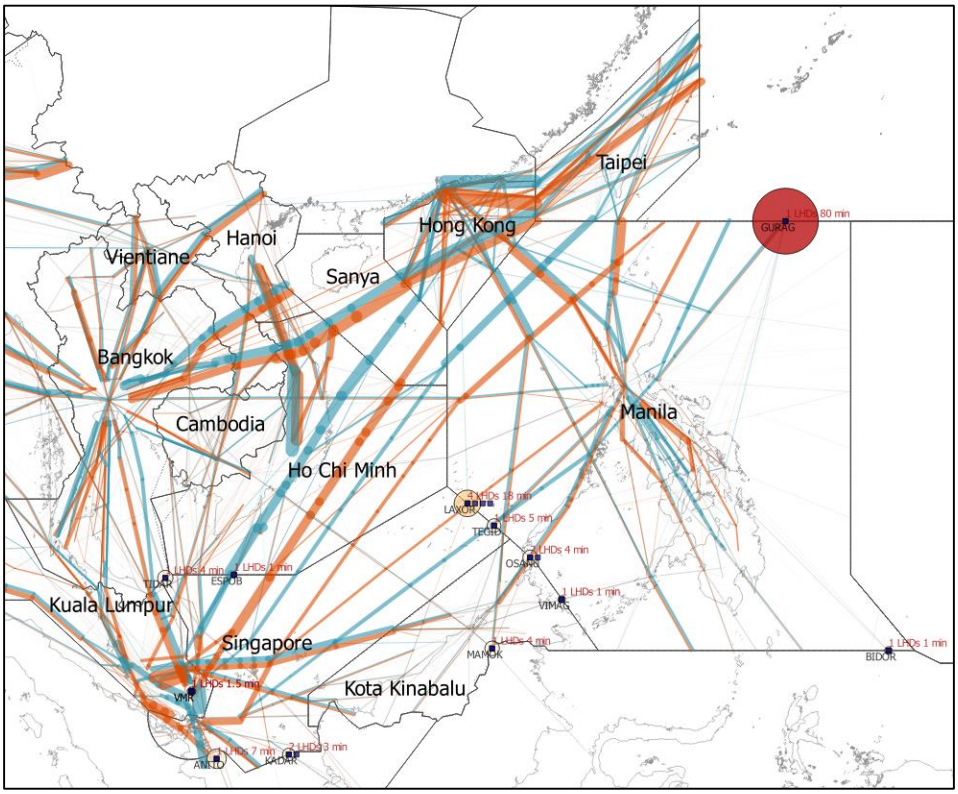

Figure 8: Geographical Locations of **'Non-zero-duration' LHDs** in SEA Airspace

LHD Hot Spot D (Manila)

5.2 As stated in Section 3, both the number of LHDs and operational risk of SEA airspace continued to decline from 2018 to 2019. However, the most number of LHDs and the operational risk located along the boundaries of Manila FIR. Within and along Manila FIR boundaries, a total of 99 LHDs were reported, accounting for 68% of SEA airspace. The operational risk was 1.74 x 10^{-9} FAPFH, accounting for 83% of the SEA airspace risk.

5.3 From the **Table 6**, LHDs were mostly reported, in terms of the number, at the interfaces with Ho Chi Minh, Singapore, Hong Kong, Taipei and Fukuoka FIR. In terms of risk, the single long duration LHD at Manila-Fukuoka interface contributed to the highest operational risk of 1.36 x 10^{-9} FAPFH, 78% of risk along Manila's boundaries and 83% of SEA airspace.

Interface	Number of LHD	Number of non-zero-duration LHD	Operational Risk (FAPFH)
Manila-Kobe/Fukuoka	15	1	1.36 x 10^{-9}
Manila-Ho Chi Minh	20	0	0
Manila-Hong Kong*	17	0	0
Manila-Kota Kinabalu	11	3	0.08 x 10^{-9}
Manila-Singapore*	17	5	0.28 x 10^{-9}
Manila Taipei*	16	0	0
Manila-Ujung Pandang	3	1	0.02 x 10^{-9}
Manila-Oakland	0	0	0
Total	**99**	**10**	**1.74 x 10^{-9}**

Table 6: The Number of LHDs, Non-zero-duration LHD and Operational Risk in 2019 Along Manila FIR Boundaries.

* Interfaces with fully operational AIDC since last quarter of 2019

5.4 The long duration LHD was at waypoint GURAG on route A590 as depicted in **Figure 9**. This occurrence was categorized as Category E LHD. The transfer time from Manila ACCs was 1456 UTC, while Fukuoka's readback was 1556 UTC, and then controller detected the aircraft at 1628 UTC. This LHD led to 80 minutes deviation and was estimated as 1.36 x 10^{-9} FAPFH of the operational risk. This single LHD contributed to 68.17% of all Category E LHDs in SEA Airspace as shown in **Figure 4**.

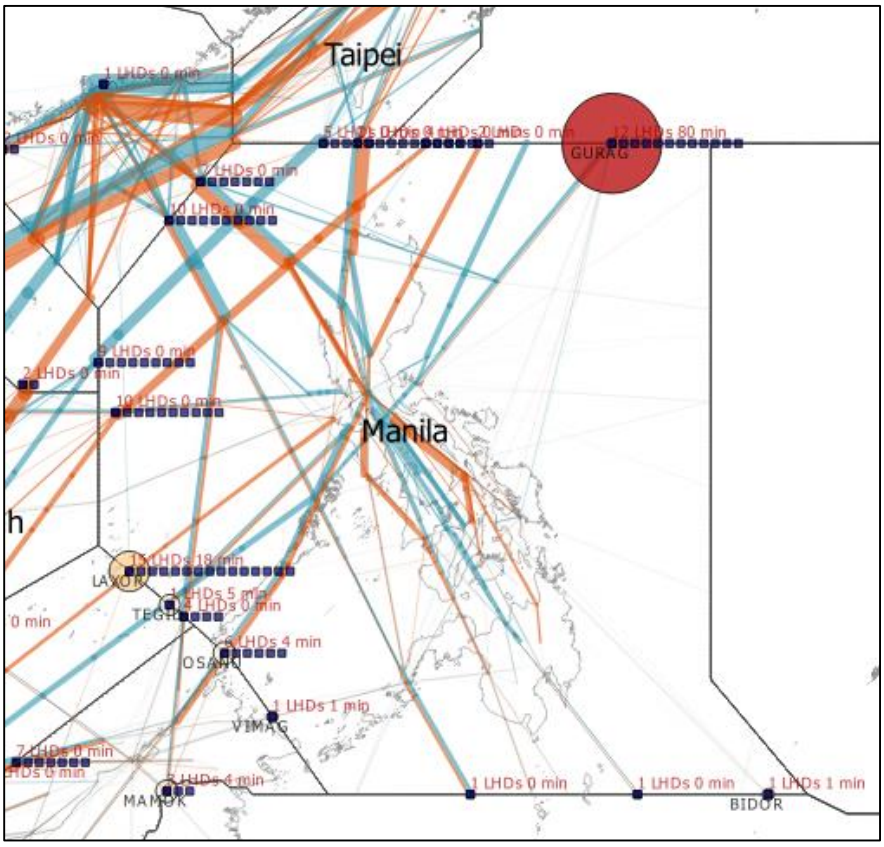

Figure 9: Number of LHDs and risk along Manila Boundary in 2019

5.5 **Figure 10** depicted the number of LHDs reported along Manila boundaries together with the timeline of major safety improvement implementation by Philippines and their neighboring States. The Philippines successfully implemented the new ATM system at Manila ATMC in November 2018. It was expected to help reduce the ATC workload and, hence, reduce human errors and communication difficulties by resecterization from 4 sectors to 7 sectors. Later in July 2019, Manila ACC split into 8 sectors after the the takeover of Mactan ACC. During the first quarter of 2020, Manila ACC was expected to further split into 9 sectors.

5.6 With the new ATM system, Manila ACC obtained a new set of VHF radios with a total of 8 frequencies (as reported during RASMAG/24 in July 2019) with better quality and wider coverage. Six (6) additional NDD/IDD commercial phones were obtained, making a total of 9 circuits. Since the transfer to the new ATM system, no international direct speech circuit outage was reported and only minimal domestic speech circuit outages were experienced.

5.7 ADS-C/CPDLC were integrated in the controller's workstations and expected to cover the whole FIR. ADS-C/CPDLC was implemented in the oceanic airspace in January 2019, for airway A583 segment between SABNO and AKOTA in August 2019. But the implementation target over the South China Sea was modified from the 1st quarter of 2020 to the 2nd quarter of 2021.

5.8 The surveillance capability was also enhanced to cover the whole FIR and beyond their boundaries with 10 new radar sites which were operational together with the new ATM system in November 2018. The ADS-B expansion project was also planned to cover the remaining surveillance gaps. In 2020, the ADS-B coverage over Manila-Singapore interface and the ADS-B

data sharing between the 2 FIRs were expected (as reported in IP04 during RASMAG/24 in July 2019).

5.9 Manila ACC implemented ATS Inter-Facility Datalink Communication (AIDC) with **Hong Kong ACC** in May 2019, **Singapore ACC** in November 2019, and **Taipei ACC** in December 2019 as indicated in **Figure 10**. AIDC operational trial was conducted with Ujung Pandang ACC in October 2019. Manila ACC also planned and initiated AIDC implementation projects with other adjacent units: Kota Kinabalu ACC, Ho Chi Minh ACC, Kobe ACC, Fukuoka ATMC, and Oakland ACC.

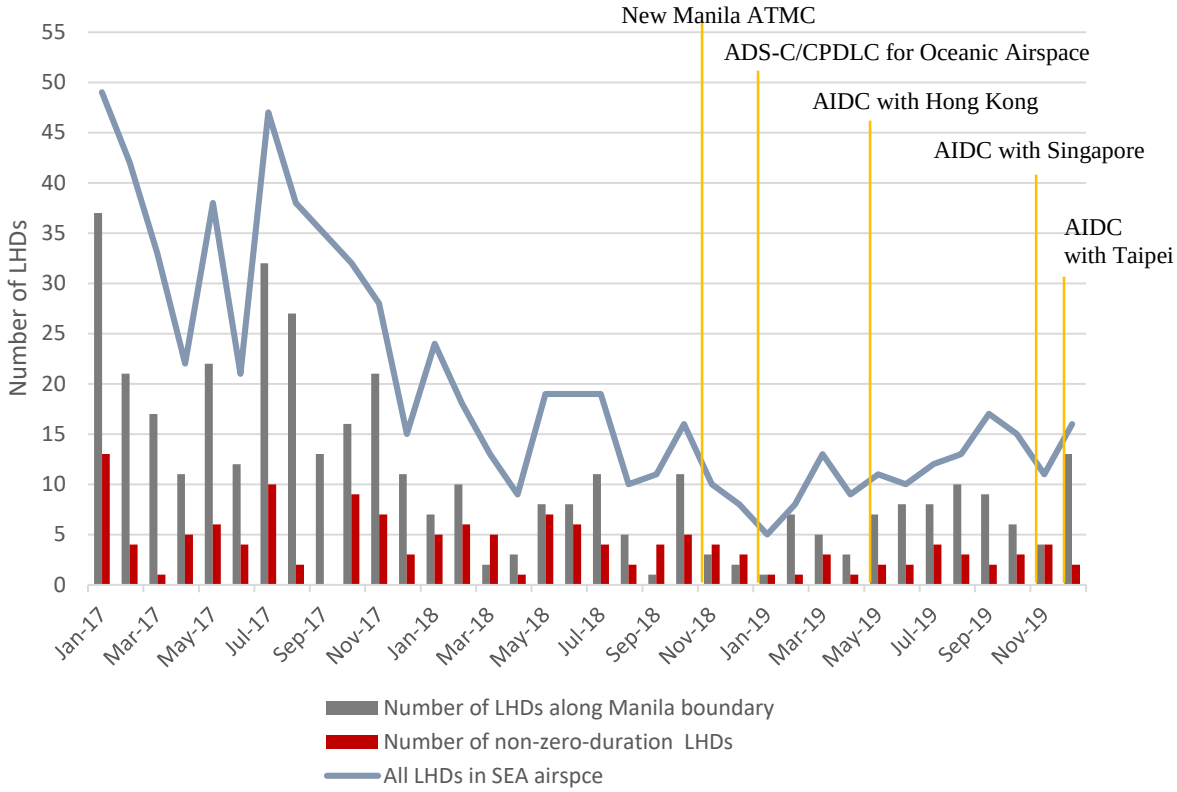

Figure 10: Number of LHDs and non-zero-duration LHDs along Manila Boundary Compared to all LHDs in SEA from 2017 to 2019

5.10 Since the transfer to the new ATM system in November 2018, the decrease in the number of LHDs, the number of non-zero-duration LHDs and the operational risk could be observed due to the reduced ATC workload in a sector and the enhanced communication and surveillance capabilities.

5.11 Category F LHD is defined as 'Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues. There were a total of 9 Category F LHDs reported in 2019. All were involved with Manila FIR, in which 7 out of 9 were due to AIDC errors. This could be the fact that the system failed to alert the controller in case of unsuccessful AIDC transfer. Manila ACC was made aware of the problem and working the system provider to have the system provide visual cues for the controllers to see whether an AIDC stransfer was successful, or not. In case of unsuccessful AIDC transfer, the controller would transfer the aircraft through voice communication.

Appendix A: Details of the Reported LHD Occurrences in the SEA Airspace

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
8/1/2019	JXP	FL390	FL400	0	E	NO OR LATE FL REVISION
13/1/2019	IGR	FL390	FL400	0	E	NO OR LATE FL REVISION
27/1/2019	IGR	FL380	FL340	0	E	NO OR LATE FL REVISION
1/1/2019	KIC			0	E	NO OR LATE FL REVISION
8/2/2019	IGR	FL380	FL360	0	E	NO OR LATE FL REVISION
21/3/2019	WIR	FL350	FL390	0	E	NEGATIVE TRANSFER
23/3/2019	IGR			4	D	UNAUTHORIZED CLIMB NEAR TCP
7/4/2019	KIC			0	E	NO LEVEL AND ESTIMATE TIME REVISION
9/4/2019	KIC			0	E	NO OR LATE FL REVISION
14/4/2019	KIC			0	E	NEGATIVE TRANSFER
4/3/2019	IGR	FL350	FL350	0	E	NEGATIVE TRANSFER
14/3/2019	IGR	FL340	FL370	0	E	NO OR LATE FL REVISION
18/3/2019	IGR	FL350	FL350	0	E	NEGATIVE TRANSFER
22/3/2019	IGR	FL370	FL350	0	E	NO OR LATE FL REVISION
13/4/2019	IGR	FL290	FL290	0	E	NEGATIVE TRANSFER
18/4/2019	IGR	FL300	FL300	0	E	NEGATIVE TRANSFER
2/5/2019	IGR	FL390	FL390	2	E	NEGATIVE TRANSFER
2/5/2019	IGR	FL330	FL310	2	E	NO OR LATE FL REVISION
3/5/2019	IGR	FL330	FL290	0	E	NO OR LATE FL REVISION
17/5/2019	IGR	FL320	FL320	3	E	NEGATIVE TRANSFER
23/5/2019	IGR	FL320	FL360	1	E	NO OR LATE FL REVISION
23/5/2019	IGR	FL320	FL350	0	E	NO OR LATE FL REVISION
21/3/2019	MWV		FL340	0	E	NEGATIVE TRANSFER
7/4/2019	MWV	FL331	FL371	0	E	NO OR LATE FL REVISION
9/1/2019	MWV		FL331	0	E	NEGATIVE TRANSFER
2/3/2019	MWV		FL311	0	E	NEGATIVE TRANSFER
17/7/2019	WIR	FL350	FL350	0	E	NEGATIVE TRANSFER
17/7/2019	WIR	FL360	FL360	0	E	NEGATIVE TRANSFER
6/6/2019	KIC			0	E	NO OR LATE FL REVISION
14/6/2019	KIC			3	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
20/6/2019	KIC			4	E	NO OR LATE FL REVISION
6/8/2019	KIC			1	E	NO OR LATE FL REVISION
1/2/2019	JXP	FL280	FL280	0	E	NO OR LATE ESTIMATE TIME REVISION
1/2/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
8/2/2019	JXP			0	E	
9/2/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
11/2/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
19/2/2019	JXP			1	E	NO OR LATE ESTIMATE TIME REVISION
20/10/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
22/2/2019	JXP			0	E	NEGATIVE TRANSFER
3/3/2019	JXP	FL400	FL380	0	E	NO OR LATE FL REVISION
20/3/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
26/3/2019	JXP			0	E	NEGATIVE TRANSFER
25/3/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
22/3/2019	JXP			0	E	NEGATIVE TRANSFER
4/4/2019	JXP			0	E	NEGATIVE TRANSFER
20/4/2019	JXP	FL340	FL350	0	E	NO OR LATE FL REVISION
11/4/2019	JXP			0	E	NO OR LATE FL REVISION
2/5/2019	JXP			0	E	NEGATIVE TRANSFER
17/5/2019	JXP			0	F	
21/5/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
24/5/2019	JXP			0	E	NEGATIVE TRANSFER
24/5/2019	JXP	FL310	FL300	0	E	NO OR LATE FL REVISION
9/6/2019	JXP	FL280	FL300	0	E	NO OR LATE FL REVISION
10/6/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
6/6/2019	JXP	FL320	FL400	0	F	
6/6/2019	JXP	FL310	FL350	0	F	
14/6/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
27/6/2019	JXP	FL400	FL390	0	E	NO OR LATE FL REVISION
5/6/2019	JXP			0	F	
2/7/2019	JXP			0	C	
7/7/2019	JXP			0	F	
17/7/2019	JXP			0	C	
17/7/2019	JXP			0	E	NEGATIVE TRANSFER
19/7/2019	JXP	FL380	FL360	0	E	NO OR LATE FL REVISION
23/7/2019	JXP			0	E	NEGATIVE TRANSFER
26/7/2019	JXP			0	E	NEGATIVE TRANSFER
17/7/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
1/8/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
2/8/2019	JXP			0	D	
6/8/2019	JXP			0	E	NEGATIVE TRANSFER
18/8/2019	JXP			0	E	NEGATIVE TRANSFER
20/8/2019	JXP			0	E	NEGATIVE TRANSFER
11/8/2019	JXP			0	E	NEGATIVE TRANSFER
11/8/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
29/8/2019	JXP			12	E	NEGATIVE TRANSFER
4/9/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
3/9/2019	JXP			0	E	NEGATIVE TRANSFER
9/9/2019	JXP			0	E	NEGATIVE TRANSFER
5/7/2019	IGR	FL360	FL360	0	E	NEGATIVE TRANSFER
11/7/2019	IGR	FL350	FL350	0	E	NO OR LATE FL REVISION
3/8/2019	IGR	FL280	FL300	0	E	NO OR LATE FL REVISION
4/8/2019	IGR		FL360	5	E	NEGATIVE TRANSFER
10/8/2019	IGR	FL300	FL340	0	E	NO OR LATE FL REVISION
17/8/2019	IGR		FL340	0	E	NEGATIVE TRANSFER
8/9/2019	IGR	FL410	FL380	1.5	B	
12/9/2019	IGR	FL360	FL350	0	E	NO OR LATE FL REVISION
19/9/2019	IGR	FL360	FL400	0	E	NO OR LATE FL REVISION
20/9/2019	IGR	FL340	FL300	0	E	NO OR LATE FL REVISION
25/9/2019	IGR	FL380	FL340	0	E	NO OR LATE FL REVISION
3/10/2019	IGR	FL300	FL320	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
7/10/2019	IGR	FL340	FL337	0	I	
9/10/2019	IGR	FL350	FL370	0	E	NO OR LATE FL REVISION
15/10/2019	IGR	FL390	FL390	0	F	NEGATIVE TRANSFER
16/10/2019	IGR	FL360	FL350	0	E	NO OR LATE FL REVISION
18/10/2019	IGR	FL320	FL360	0	E	NO OR LATE FL REVISION
13/9/2019	KIC	FL290	FL310	1	E	NO OR LATE FL REVISION
18/9/2019	KIC	FL330	FL370	0	E	NO OR LATE FL REVISION
26/9/2019	KIC	FL390	FL410	0	E	NO OR LATE FL REVISION
29/9/2019	KIC	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
21/11/2019	MWV			0	E	NEGATIVE TRANSFER
30/11/2019	MWV	FL370	FL290	0	E	NO OR LATE FL REVISION
5/9/2019	JXP			0	E	NEGATIVE TRANSFER
13/9/2019	JXP			0	E	NEGATIVE TRANSFER
14/9/2019	JXP	FL380	FL360	1	E	NO OR LATE FL REVISION
25/9/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
30/9/2019	JXP			0	E	NEGATIVE TRANSFER
11/11/2019	WIR	FL390	FL400	0	E	NO OR LATE FL REVISION
1/12/2019	WIR	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
14/11/2019	IGR	FL310	FL310	7	E	NEGATIVE TRANSFER
23/11/2019	IGR	FL360	FL340	1	E	NO OR LATE FL REVISION
27/10/2019	KIC		FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
12/11/2019	KIC		FL380	0	E	NEGATIVE TRANSFER
27/12/2019	KIC	FL380	FL340	0	E	NO OR LATE FL REVISION
19/10/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
24/10/2019	JXP			0	E	NO OR LATE ESTIMATE TIME REVISION
1/10/2019	JXP	FL430	FL430	0	E	NEGATIVE TRANSFER
8/10/2019	JXP			0	E	LOA VIOLATION
4/10/2019	JXP	FL330	FL330	0	E	
3/11/2019	JXP			0	M	
3/11/2019	JXP			0	E	NEGATIVE TRANSFER

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
6/11/2019	JXP			0	E	LOA VIOLATION
8/11/2019	JXP			0	E	NEGATIVE TRANSFER
3/10/2019	AIX	FL330	FL330	0	E	NEGATIVE TRANSFER
4/10/2019	AIX	FL330	FL350	0	E	NO OR LATE FL REVISION
22/11/2019	AIX	FL370	FL370	0	E	NO OR LATE FL REVISION
15/12/2019	IGR	FL370	FL370	0	E	NEGATIVE TRANSFER
1/12/2019	JXP			0	C	TIME ESTIMATE FROM PILOT (AIRCRAFT AVIONICS) IS NOT ACCURATE ENOUGH
16/12/2019	JXP	FL310	FL310	80	E	ATC-TO-ATC READBACK-HEARBACK ERROR
6/12/2019	JXP			0	D	
8/12/2019	JXP			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
9/12/2019	JXP			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/12/2019	JXP	FL400	FL410	0	F	NO OR LATE FL REVISION
17/12/2019	JXP			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/12/2019	JXP			0	F	LOA VIOLATION
18/12/2019	JXP			0	F	LOA VIOLATION
12/12/2019	JXP			0	C	TIME ESTIMATE FROM PILOT (AIRCRAFT AVIONICS) IS NOT ACCURATE ENOUGH
19/12/2019	JXP			0	C	TIME ESTIMATE FROM PILOT (AIRCRAFT AVIONICS) IS NOT ACCURATE ENOUGH
29/12/2019	JXP	FL340	FL300	0	E	NO OR LATE FL REVISION
29/12/2019	JXP			0	E	NEGATIVE TRANSFER

MONITORING AGENCY FOR ASIA REGION (MAAR)

Airspace Safety Review of RVSM in Mongolian Airspace

January 2019 to December 2019

AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN THE MONGOLIAN AIRSPACE
Assessment Period: January 2019 to December 2019

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

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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 2019** and monthly Large Height Deviation (LHD) reports between **January 2019** and **December 2019** submitted by Mongolia.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2019 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 2019 to December 2019. **Table 1** indicates the months in which Ulaanbaatar FIR submitted LHD reports including NIL reports. **Appendix A** provides details of the 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 Ulaanbaatar FIR in 2019

3. Summary of LHD Occurrences

3.1. **Table 2** summarizes the number of LHDs assessed and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2019 to December 2019. In this report, the number of LHDs included the LHDs that had zero duration, unless indicated otherwise.

Month (2019)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
January	1	0	0	0	0
February	0	0	0	0	0
March	0	0	0	0	0
April	0	0	0	0	0
May	0	0	0	0	0
June	0	0	0	0	0
July	0	0	0	0	0
August	1	0	0	0	0
September	0	0	0	0	0
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
Total	2	0	0	0	0

Table 2: Summary of LHD by Month for Mongolia Airspace.

3.2. **Table 3** summarizes the number of LHDs, the associated LHD duration (in minutes), number of flight levels crossed, and their associated operational risk by LHD category from January 2019 to December 2019.

3.3. There were 2 LHDs reported by Ulaanbaatar FIR in 2019. One was Category A and another was Category I. Both occurrenes were zero-duration LHDs. Hence, they were analysed as bearing no risk.

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	1	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	0	0	0	0	0
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	0	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	0	0	0	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	0	0	0	0	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level).	0	0	0	0	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	1	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	0	0	0	0	0
K	TCAS resolution advisory, flight crew incorrectly climb or descend following the resolution advisory.	0	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	0

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
M	Other	0	0	0	0	0
Total		**2**	0	0	0	0

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

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	161,948	2,328	Hour	Dec 2019 TSD
E_z(same)	Same-direction vertical occupancies	0.5080/ 0.0017	0.01635	-	
E_z(opposite)	Opposite-direction vertical occupancies	0.1916	0.1199	-	
λ_x	Average aircraft length	0.0335	0.0313	NM	
λ_y	Average aircraft wingspan	0.0310	0.0295	NM	
λ_z	Average aircraft height	0.0092	0.0087	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0335	0.0340	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	More conservative value used in previous assessments
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes	21.93	47.79	Knot	Dec 2019 TSD NOTE : $\overline{\lvert\Delta V\rvert}$ was calculated based on relative speed of proximate pair on each route type. For uni-dir route, there was no proximate pair.
$\overline{\lvert V\rvert}$	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**, defined as probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and to all causes, **meets the TLS** value of 2.5 x 10^{-9} FAPFH. **The total risk** also **meets the specified TLS** value for these components of 5.0 x 10^{-9} FAPFH.

Mongolia RVSM Airspace – estimated annual flying hours = 164,276 hours *(note: estimated hours based on December 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	1.07 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	0.00 x 10^{-9}	-	-
Total Risk	**1.07 x 10^{-9}**	**5.0 x 10^{-9}**	**Below Overall TLS**

Table 5: Risk Estimates for Mongolian Airspace

5. Analysis of Operational Errors

There were a total of two LHDs reported in 2019. One Category-A LHD occurred at waypoint NIGOR, a transfer-of-control point between Ulaanbaatra FIR and Krasnoyarsk FIR. Another LHD was Category I, reported at waypoint HATGA located within Ulaanbaatar FIR. None of them resulted in operational risk.

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

Date	Source	Assigned FL	Observed/ Reported FL	Duration at Incorrect FL	Category	Cause
30/1/2019	FTN	FL371	FL367	0	I	
27/8/2019	FTN	FL351	FL371	0	A	