



ICAO

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

MAAR SAFETY REPORT

(Presented by the Monitoring Agency for Asia Region)

SUMMARY

This paper presents 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

1.1 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 the **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, the identification of hot spots and the hot spot analysis.

2. DISCUSSION

Executive Summary: South Asia/Indian Ocean Airspace

2.1 **Table 1** summarizes SA/IO airspace RVSM technical, operational, and total risks. **Figure 1** presents collision risk estimate trends during the period from January 2021 to December 2021.

SA/IO Airspace – estimated annual flying hours = 1,201,822 hours (note: estimated hours based on Dec 2021 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 26 Total Risk	15.67×10^{-9}	5.0×10^{-9}	Above TLS
Technical Risk	0.47×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	5.15×10^{-9}	-	-
Total Risk	5.62×10^{-9}	5.0×10^{-9}	Above TLS

Table 1: Risk Estimates for SA/IO RVSM Airspace

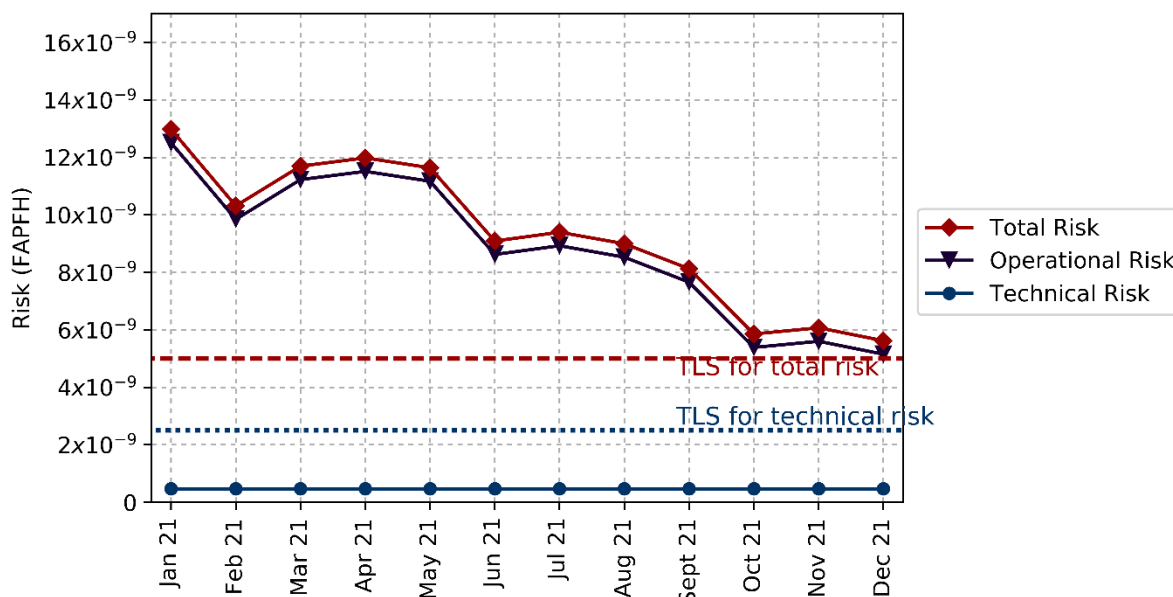


Figure 1: Trends of Risk Estimates for SA/IO RVSM Airspace

2.2 **Table 2** presents a summary of the LHDs by categories within SA/IO airspace from January 2021 to December 2021. Compared to 2020, the number of LHDs decreased from 152 to 134. Out of 134 LHDs, 30 LHDs were non-zero-duration LHDs resulting in the 128 minutes LHD duration and 7 crossed flight levels. The operational risk also decreased from 15.19×10^{-9} FAPFH in 2020 to 5.15×10^{-9} FAPFH in 2021. Furthermore, the total risk decreased 64% from 15.67×10^{-9} FAPFH in 2020 to 5.62×10^{-9} FAPFH in 2021.

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($\times 10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	2	1	0	2	0.374
B	Flight crew climbing/descending without ATC Clearance	2	1	0	1	0.187
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.).	2	2	20	0	1.738
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	4	4	0	4	0.748

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	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).	123	22	108	0	2.1044
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	0	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	1	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
M	Other	0	0	0	0	0
Total		134	30	128	7	5.15

Table 2: Summary of LHDs by Category within SA/IO Airspace

2.3 **Figure 2** provides the geographic locations of non-zero-duration LHDs within SA/IO Airspace during the assessment period.

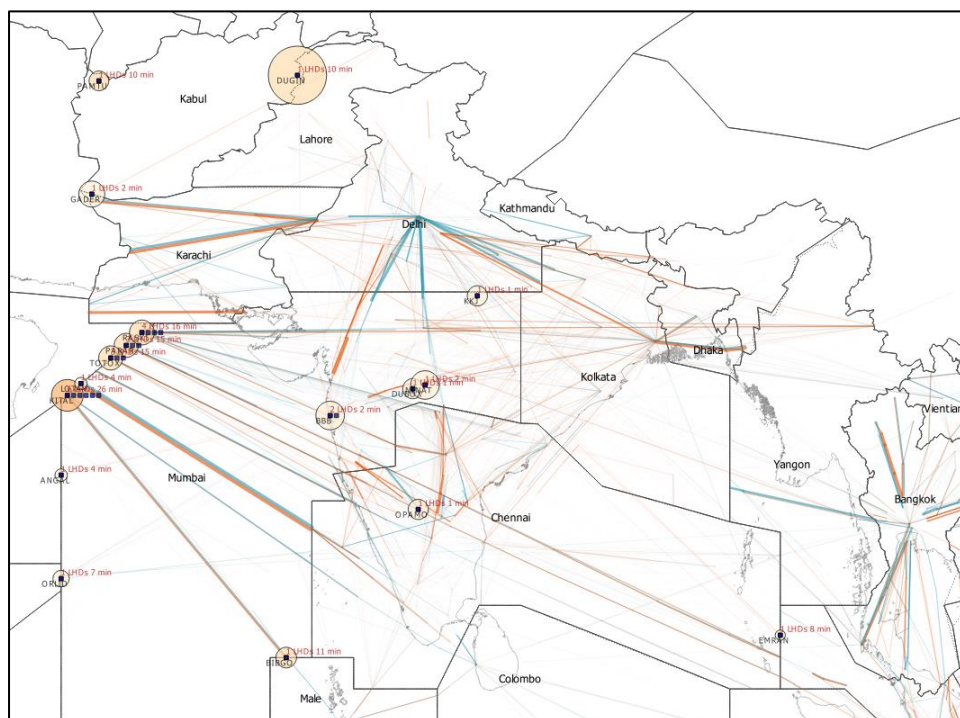


Figure 2: Geographic Locations of ‘Non-zero-duration’ LHDs in SA/IO Airspace

2.4 In RASMAG-MAWG/9, MAAR presented a drafting process of identifying, monitoring and removing APAC hot spots and all monitoring agencies agreed to simulate the process to their safety reports for RASMAG/27. **Table 3** shows the number of LHD and risk of each cluster as well as the results of checking against the criteria.

2021 Clusters (SA/IO)	Chennai-Yangon/ Kuala Lumpur (Hot Spot A2)	Chennai-Mumbai-Delhi	Mumbai-Male	Mumbai-Muscat (Hot Spot G)	Mumbai-Sanaa (Hot Spot G)	Mumbai-Mogadishu (Hot Spot F)	Karachi-Muscat	Western Boundary of Kabul	Kabul-Lahore
Number of LHDs	29	8	7	44	4	5	4	6	13
Check Criteria: Number \geq 13.4	Positive	Negative	Negative	Positive	Negative	Negative	Negative	Negative	Negative
Risk ($\times 10^{-9}$ FAPFH)	0.05	1.31	0.20	1.35	0.07	0.12	0.00	0.49	1.56
Check Criteria: Risk \geq 0.52×10^{-9} FAPFH	Negative	Positive	Negative	Positive	Negative	Negative	Negative	Negative	Positive
Check Criteria: Risk \geq TLS	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Table 3: The results of identifying hot spots in SA/IO Airspace.

2.5 According to the result in **Table 3**, the following clusters satisfy the hot spot criteria:

- Chennai-Yangon/Kuala Lumpur boundary (Hot Spot A2);
- Mumbai-Muscat boundary (Hotspot G);

- Chennai-Mumbai-Delhi (Indian FIRs); and
- The boundary between Kabul FIR and Lahore FIR.

2.6 On the other hand, the following interfaces are listed as LHD hot spots and do not meet the hot spot criteria in 2021:

- Mumbai-Sanaa boundary (Hotspot G);
- Mumbai-Mogadishu boundary (Hotspot F); and
- Kolkata-Yangon boundary (Hot Spot A1).

2.7 **LHD Hot Spot G (Sanaa/Muscat – Mumbai) and LHD Hot Spot F (Mogadishu – Mumbai)** were identified as LHD hot spots since 2015. **Table 4** summarizes the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot G and Hot Spot F from 2019 to 2021.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10 ⁻⁹ FAPFH)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Mumbai-Muscat	143	48	44	76	28	17	24.71	6.37	1.35
Mumbai-Sanaa	5	1	4	2	0	1	0.20	0.00	0.07
Mumbai-Mogadishu	9	8	5	3	4	1	0.74	4.80	0.12
Total	157	57	53	81	32	19	25.65	11.17	1.54

Table 4: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot G and Hot Spot F from 2019 to 2021

2.8 At Mumbai-Muscat boundary, the number of LHDs, the number of non-zero-duration LHDs and the operational risk gradually decreased from 2019 to 2021. In 2021, the operational risk at this boundary was only 1.35 x 10⁻⁹ FAPFH, which decreased by 79% from 6.37 x 10⁻⁹ FAPFH in 2020.

2.9 At Mumbai-Sanaa boundary, the number of LHDs increased from 1 in 2020 to 4 in 2021. The number of non-zero-duration LHDs increased from 0 in 2020 to 1 in 2021, resulting in the risk of 0.07 x 10⁻⁹ FAPFH.

2.10 A Mumbai-Mogadishu boundary, the number of LHDs, the number of non-zero-duration LHDs and the operational risk also decreased in 2021. The operational risk at this boundary was 0.12 x 10⁻⁹ FAPFH.

2.11 In 2020 and 2021, the long-duration LHDs were mitigated and the operational risks at Hot Spot G and F were very low compared to 2019. The decreasing trend of the risk at these hot spots might be due to the increasing awareness of the LHD issue, the traffic reduction during the COVID-19 pandemic and the implementation of the Space Based ADS-B.

2.12 Regarding the process of identifying hot spots, the LHD cluster at the boundary between Mumbai FIR and Muscat FIR (Hot Spot G) satisfies the hot spot criteria in terms of the number and the risk. This should remain as a hot spot. The LHD clusters at the boundary between Mumbai FIR and Sanaa FIR (Hot Spot G) and between Mumbai FIR and Mogadishu FIR (Hot Spot F) do not satisfy any of the 3 hot spot criteria in 2021 as the first year. Some mitigation measures also remain unfinished. Therefore, these two clusters should continue to be hot spots.

2.13 **LHD Hot Spot A1 (Kolkata/Dhaka - Yangon) and LHD Hot Spot A2 (Chennai - Kuala Lumpur)** were first identified as hot spots in 2015. **Table 5** summarizes the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and Hot Spot A2 from 2019 to 2021.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10 ⁻⁹ FAPFH)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Kolkata-Yangon	59	8	1	3	0	0	0.31	0.00	0.00
Chennai-Yangon	16	3	8	4	0	0	0.49	0.00	0.00
Chennai-Kuala Lumpur	88	13	21	15	0	1	1.14	0.00	0.05
Total	163	24	30	22	0	1	1.94	0.00	0.05

Table 5: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and Hot Spot A2 from 2019 to 2021

2.14 At Kolkata-Yangon boundary, there was one LHD report. The operational risk was reduced to zero in 2020 and 2021. At Chennai-Yangon boundary and Chennai-Kuala Lumpur boundary, the number of LHDs increased in 2021. However, there was only one non-zero-duration LHD, contributing to the operational risk of 0.05 x 10⁻⁹ FAPFH. The implementation of ADS-B data sharing between Kolkata ACC and Yangon ACC allows the controllers to detect and resolve any issue before an aircraft passing the transfer-of-control points. However, the situational awareness of LHD occurrences and the implementation of engineering solutions such as AIDC (hard barrier) still need to be considered as the number of LHDs started to increase with the traffic.

2.15 Regarding the process of identifying hot spots, the Hot Spot A1 (the boundaries between Kolkata FIR / Dhaka FIR and Yangon FIR) does not satisfy any of the 3 hot spot criteria in 2020 and 2021. It was reported to RASMAG/26 that the issue of LHDs over waypoint APAGO and CHILA (the Dhaka-Yangon interface) was resolved by implementation of a new procedure since June 2019 to handle traffic among Yangon, Dhaka, and Kolkata ACC. The ADS-B data sharing between Kolkata ACC and Yangon ACC is implemented to allow the controllers to detect and resolve any issue before an aircraft passing the transfer-of-control points. If it can also be confirmed that AIDC is successfully implemented between Kolkata ACC and Yangon ACC, then the Hot Spot A1 (the boundaries between Kolkata FIR / Dhaka FIR and Yangon FIR) should be proposed to be removed from the hot spot list. Hot Spot A2 (the boundaries between Chennai FIR and Yangon FIR / Kuala Lumpur FIR) satisfies hot spot criteria in terms of the number. Therefore, Hot Spot A2 should remain on the hot spot list.

2.16 The **FIR boundaries connecting Chennai, Mumbai and Delhi** are discussed in this paper as result of the hot spot identification process. In 2021, 6 non-zero-duration LHDs in this area contributed to 25% of the total operational risk in SA/IO airspace. This area satisfies the hot spot criteria in terms of the risk, meaning this LHD cluster contributed to a relatively big portion of the operational risk. When considering the causes of these 6 non-zero-duration LHDs, 3 of these were categorized as Category D, 2 as Category A, and 1 as Category B. No pattern could be identified from the reported data in this area. The risk from these LHDs should be individually addressed by the responsible State and ANSP. Therefore, the FIR boundaries connecting Chennai, Mumbai and Delhi is not proposed as a hot spot.

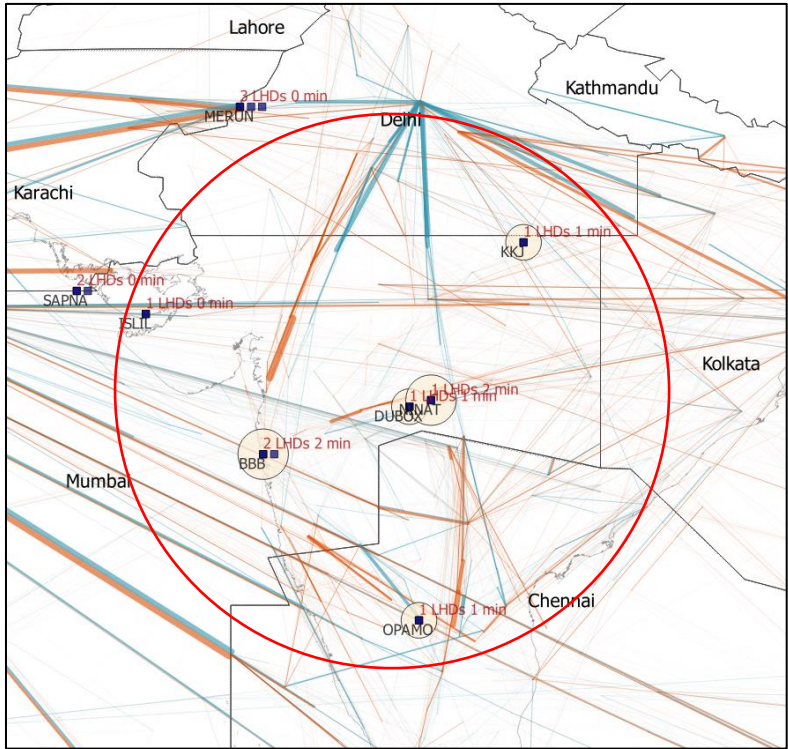


Figure 3: The Visualization of LHDs and operation risk within Chennai FIR, Mumbai FIR and Delhi FIR in 2021

2.17 **The boundary between Kabul FIR and Lahore FIR** is also highlighted in this paper according to the result of the hot spot identification process. In 2021, the number of LHDs was 13 and the operational risk was 30% of the total operational risk in SA/IO airspace. This boundary satisfies the hot spot criteria in terms of the risk. However, the risk was caused by a single LHD occurrence and, therefore, this area is not proposed as a hot spot. The situation at this boundary should be closely monitored regarding the increase in the number of LHDs in 2021.

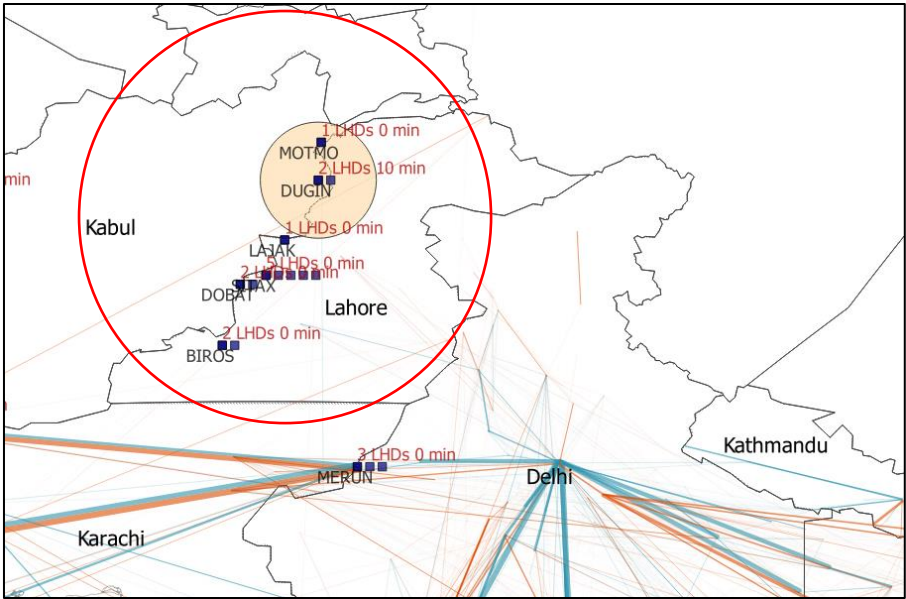


Figure 4: The Visualization of LHDs and operation risk at the boundary between Kabul and Lahore FIR in 2021.

Executive Summary: Southeast Asia Airspace

2.18 **Table 6** summarizes Southeast Asia (SEA) airspace RVSM technical, operational, and total risks. **Figure 5** presents collision risk estimate trends during the period from January 2021 to December 2021.

SEA Airspace – estimated annual flying hours = 1,019,866 hours <i>(note: estimated hours based on Dec 2021 traffic sample data)</i>			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 26 Total Risk	1.82×10^{-9}	5.0×10^{-9}	Below TLS
Technical Risk	0.45×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	2.13×10^{-9}	-	-
Total Risk	2.58×10^{-9}	5.0×10^{-9}	Below TLS

Table 6: Risk Estimates for SEA RVSM Airspace

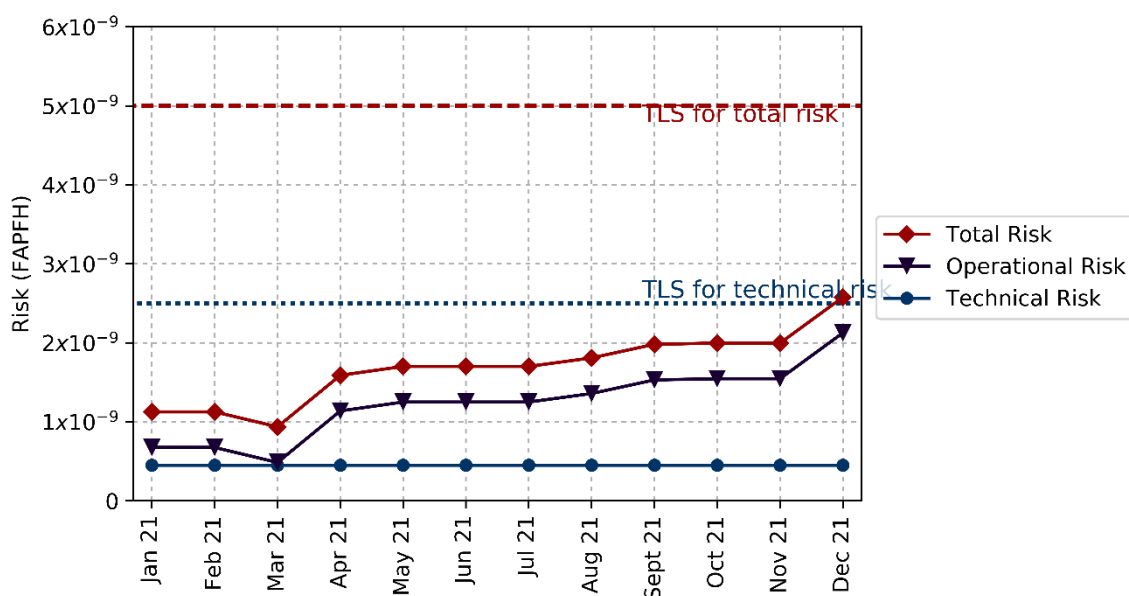


Figure 5: Trends of Risk Estimates for SEA RVSM Airspace

2.19 **Table 7** presents a summary of the LHDs by categories within SEA airspace from January 2021 to December 2021. Compared to 2020, the number of LHDs increased from 39 to 72. Out of 72 LHDs, 16 LHDs were non-zero-duration LHDs, which resulted in the 93 minutes LHD duration and no crossed flight level. The total operational risk also increased from 1.42×10^{-9} FAPFH in 2020 to 2.13×10^{-9} FAPFH in 2021.

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (min)	No. of levels Crossed	Operational Risk ($\times 10^{-9}$ 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	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)
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).	65	16	93	0	2.13
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).	4	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	1	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
M	Other	0	0	0	0	0
Total		72	16	93	0	2.13

Table 7: Summary of LHDs by Category within SEA Airspace

2.20 Regarding the hot spot identification process, **Table 8** shows the number of LHDs and risk of each LHD clusters as well as the results of checking against the hot spot criteria.

2021 Clusters (SEA)	Manila-Kobe/Fukuoka	Manila-Taibei	Manila-Ho Chi Minh	Manila-Ujung Pandang	Singapore-Jakarta	Bangkok-Kuala Lumpur/Singapore	Kuala Lumpur-Singapore	Singapore-Kota Kinabalu
Number of LHDs	11	4	7	7	16	9	4	4
Check Criteria: Number \geq 8	Positive	Negative	Negative	Negative	Positive	Positive	Negative	Negative
Risk ($\times 10^{-9}$ FAPFH)	0.45	0.07	0.77	0.36	0.23	0.14	0.05	0.04
Check Criteria: Risk $\geq 0.24 \times 10^{-9}$ FAPFH	Positive	Negative	Positive	Positive	Negative	Negative	Negative	Negative
Check Criteria: Risk \geq TLS	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Table 8: The results of identifying hot spots in SEA Airspace

2.21 According to the result in **Table 8**, the following clusters satisfy the hot spot criteria:

- Manila-Kobe/Fukuoka boundary (Hot Spot D);
- Manila-Ho Chi Minh boundary (Hot Spot D);
- Manila-Ujung Pandang boundary (Hot Spot D);
- Singapore-Jakarta boundary (Hot Spot J); and
- Bangkok- Kuala Lumpur/Singapore boundary.

2.22 In the process of identifying hot spots, Hot Spot D (Manila FIR boundaries) was broken down into 4 clusters. Out of the 4 clusters, 3 clusters satisfy the hot spot criteria. Some boundaries such as Manila-Singapore boundary had a small number of LHDs and the operational risk was 0×10^{-9} FAPFH, thus it was not considered as a cluster.

2.23 This new process also identifies the LHD clusters at the Singapore-Jakarta FIR boundary and the Bangkok-Kuala Lumpur/Singapore FIR boundary as potential new hot spots from the relatively big number of reported LHDs.

2.24 **LHD Hot Spot D (Manila FIR and adjacent FIRs)** were first identified as hot spots in 2015. The number of LHDs and the operational risk have improved due to several safety enhancement activities including the new ATM system, the enhanced surveillance capability, the implementation of ADS-C/CPDLC and partial implementation of AIDC. However, the number of LHDs and the total operational risk along Manila FIR boundaries increased in 2021. The total operational risk in 2021 was almost as high as the total operational risk in 2019, which was in the normal traffic situation before COVID-19 pandemic. The significant increase in the number of LHDs and the high operational risk were at Manila-Fukuoka, Manila-Ho Chi Minh and Manila-Ujung Pandang boundaries. The distribution of LHDs and operational risk are detailed in **Table 9**.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10 ⁻⁹ FAPFH)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Manila-Kobe/Fukuoka	15	5	11	1	2	4	1.36	0.49	0.45
Manila-Ho Chi Minh	20	4	7	0	0	3	0	0	0.77
Manila-Hong Kong	17	5	2	0	2	0	0	0.19	0
Manila-Kota Kinabalu	11	2	2	3	1	0	0.08	0.37	0
Manila-Sanya	0	2	0	0	0	0	0	0	0
Manila-Singapore	17	3	2	5	0	0	0.28	0	0
Manila-Taibei	16	3	4	0	0	1	0	0	0.07
Manila-Ujung Pandang	3	0	7	1	0	2	0.02	0	0.36
Manila-Oakland	0	0	2	0	0	0	0	0	0
Total	99	24	37	10	5	10	1.74	1.05	1.65

Table 9: The number of LHDs, non-zero-duration LHDs and operational risk in 2019, 2020 and 2021 along Manila FIR boundaries

2.25 Regarding the process of identifying hot spots, this is the first time that the LHDs along Manila FIR boundaries are broken up into different clusters. In 2021, the LHD clusters at Manila FIR boundary interfacing with Kobe/Fukuoka, Ho Chi Minh, and Ujung Pandang satisfy the hot spot criteria, while the other interfaces do not. MAAR suggests to keep watch all Manila FIR boundaries (Hot Spot D) and maintain it on the LHD Hot Spot list because some mitigations still remain. The spikes in the number of LHDs and operational risk in 2021 particularly at Manila-Fukuoka, Manila-Ho Chi Minh and Manila-Ujung Pandang boundaries also need to be monitored

2.26 **LHD Hot Spot J (The boundary between Singapore FIR and Jakarta FIR)** is discussed in this paper according to the result of the hot spot identification process. The number of LHDs at this boundary was significantly higher than the hot spot criteria in terms of the number of LHDs. Even though the operational risk was below the hot spot criteria, the increase in the number of LHDs at this boundary should be managed in order to reduce the workload on the controllers. Therefore, the boundary between Singapore FIR and Jakarta FIR should remain on the hot spot list.

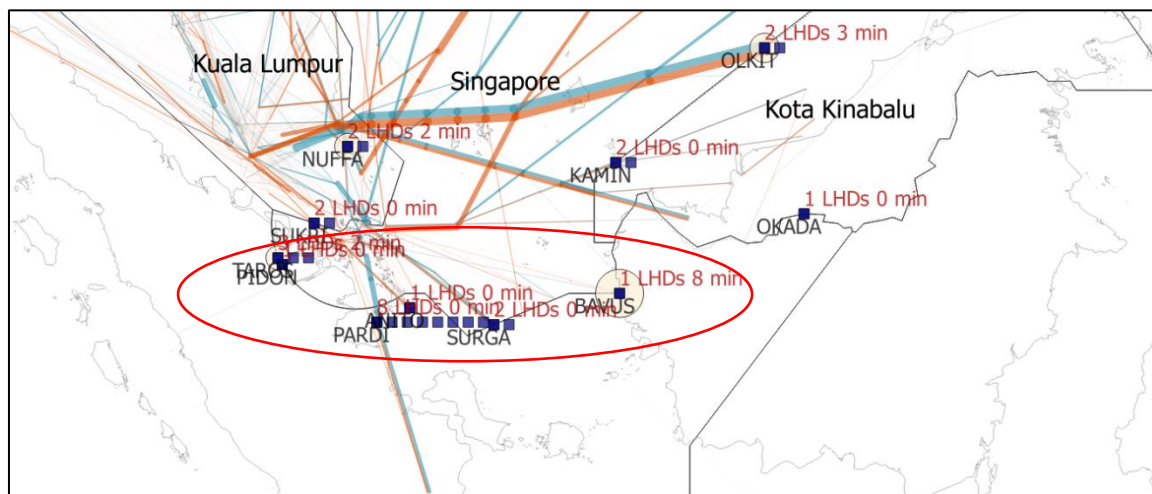


Figure 6: The Visualization of LHDs and operation risk at the boundary between Singapore FIR and Jakarta FIR in 2021

2.27 **The boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR** also meets the criteria of the hot spot identification process in terms of the number of LHDs. The number of LHDs at this boundary was relatively high for the past 3 consecutive years: 13 LHDs in 2019, 9 LHDs in 2020 and 9 LHDs in 2021. As a result, the boundaries between Bangkok FIR and Kuala Lumpur/Singapore FIR are proposed to be included on the hot spot list for monitoring.

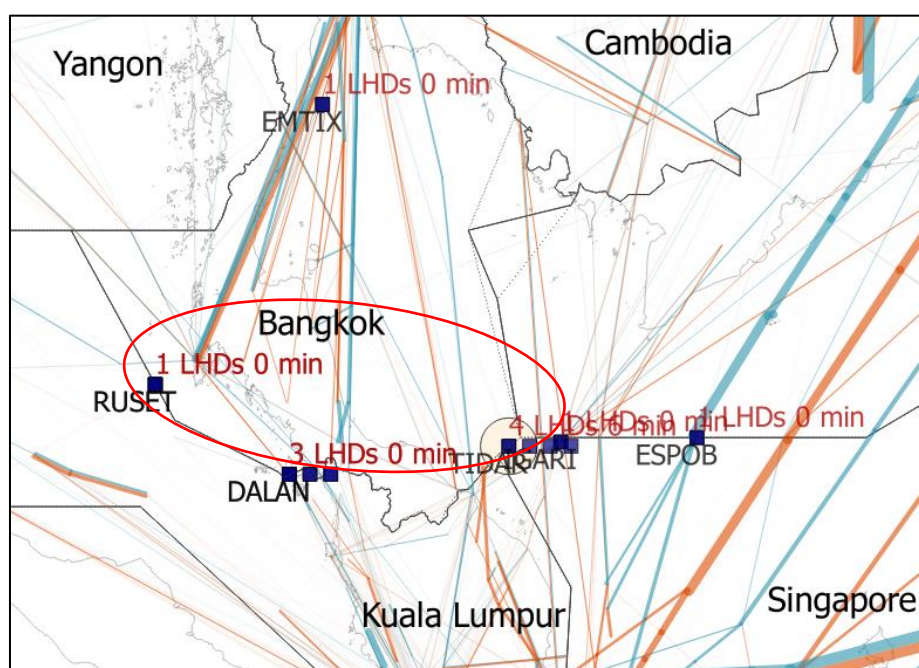


Figure 7: The Visualization of LHDs and operation risk at the boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR in 2021

Executive Summary: Mongolian Airspace

2.28 **Table 10** summarizes Mongolian airspace RVSM technical, operational, and total risks.

Mongolian Airspace – estimated annual flying hours = 121,621 hours (note: estimated hours based on Dec 2021 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
<i>RASMAG 26 Total Risk</i>	0.87×10^{-9}	5.0×10^{-9}	<i>Below TLS</i>
Technical Risk	0.81×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	0.81×10^{-9}	5.0×10^{-9}	Below TLS

Table 10: Mongolian Airspace Horizontal Risk Estimates

2.29 In 2021, there was one LHD reported in Mongolian Airspace. The LHD was the negative transfer from Irkutsk ACC. However, Mongolian ATC detected the aircraft before crossing the transfer of control point. Hence, this LHD contributed to zero operational risk. The hot spot identification process was not needed.

APANPIRG List of Deficiencies

2.30 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 every month to their Regional Monitoring Agencies (RMAs).

2.31 MAAR received 2021 TSD from almost all States except Afghanistan. The States which submitted the 2021 TSD also provided good cooperation in revising TSD if any error was found.

2.32 Regarding the LHD submission, MAAR has not received any LHD report or LHD-related response from Afghanistan since the political issue in August 2021. Furthermore, MAAR received the 2021 LHD reports from Yangon FIR only in June 2022. These LHDs were submitted late and could not be investigated by the adjacent FIRs. Therefore, these LHDs were not included in this report.

2.33 MAAR proposes to maintain Afghanistan on the List of Deficiencies in the ATM and Airspace Safety field, under “Non-Provision of Safety Related Data by States”.

Reporting Culture

2.34 Almost all States regularly submit the LHD reports to the MAAR via the online submission system and provide good cooperation related to LHD. The reports from Kathmandu FIR and Yangon FIR were submitted in the provided template and submitted by email to MAAR.

2.35 MAAR continues to see improvements among the responsible States and ANSPs. The following LHD characteristics that could be indicators of improvement in reporting have been observed since 2018:

2.35.1 **NIL Reports** are regularly submitted to MAAR in certain months to confirm that no LHDs should be reported. Anyhow, the low number of LHDs or several NIL reports can possibly be an indicator of under-reporting rather than the improvement in reporting culture.

2.35.2 **LHDs within FIR** were observed among Indian FIRs in 2021. Even though those LHDs also led to the high percentage of the total operational risk in the airspace, they are signs of positive safety culture by reporting on errors of their ATCOs or within their FIRs.

2.35.3 **Reporting Own Mistakes** shows even stronger and positive safety culture. Such LHDs were normally reported from Hong Kong FIR, Kabul FIR (January 2021 to August 2021), Kuala Lumpur FIR, Manila FIR, Singapore FIR and Taipei FIR. In 2021, the number of LHDs that reported their own mistakes and transferred to adjacent FIRs was 15% of all LHDs.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) consider the results from hot spot identification process that
 - i) the boundaries between Mumbai FIR and Muscat FIR (Hot Spot G), between Mumbai FIR and Sanaa FIR (Hot Spot G), and between Mumbai FIR and Mogadishu FIR (Hot Spot F) remain as hot spots (paragraph 2.12);
 - ii) the boundaries between Kolkata FIR / Dhaka FIR and Yangon FIR (Hot Spot A1) should be removed from the hot spot list if it can be confirmed that AIDC is successfully implemented between Kolkata ACC and Yangon ACC (paragraph 2.15);
 - iii) the boundaries between Chennai FIR and Yangon FIR / Kuala Lumpur FIR (Hot Spot A2) remain as a hot spot (paragraph 2.15);
 - iv) the boundaries along Manila FIR remain and Sanaa FIR remain as Hot Spot D (paragraph 2.25);
 - v) the boundary between Singapore FIR and Jakarta FIR remain as Hot Spot J (paragraph 2.26); and
 - vi) the boundaries between Bangkok FIR and Kuala Lumpur/Singapore FIR should be considered as an LHD hot spot and added to the hot spot list (paragraph 2.27);
- b) consider maintaining Afghanistan on the List of Deficiencies in the ATM/AIS/SAR fields, under “Non-Provision of Safety Related Data by States” (paragraph 2.33);
- c) note the information contained in this paper; and
- d) 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 2021 to December 2021

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE SOUTH ASIA/INDIAN OCEAN (SA/IO) AIRSPACE
Assessment Period: January 2021 to December 2021**

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

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **South Asia/Indian Ocean (SA/IO)** airspace. The review is conducted based on one-month traffic sample data (TSD) collected in **December 2021** and monthly Large Height Deviation (LHD) reports between **January 2021** and **December 2021** submitted by concerning States in the SA/IO airspace.

2. Data Sources

2.1. Traffic Sample Data (TSD). The TSD covering the month of December 2021 of aircraft operating in the SA/IO airspace is used as required by ICAO regional agreement.

2.2. Large Height Deviation (LHD). The accumulative 12-month data set of LHD reports covers January 2021 to December 2021. **Table 1** indicates those FIRs which submitted LHD reports including NIL reports. MAAR has not received any LHD report or LHD-related response from Kabul ACC since 16 August 2021. Yangon FIR submitted LHD reports for the month of April 2021, and later in June 2022 submitted more LHDs which occurred back in 2021. These late submissions made it difficult to investigate by the adjacent FIRs and, hence, they were not included in this report. **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
February	X	X	X	X	X	X	X		X	X	X	X	X	X
March	X	X	X	X	X	X	X		X	X	X	X	X	X
April	X	X	X	X	X	X	X	X	X	X	X	X	X	X
May	X	X	X	X	X	X	X		X	X	X	X	X	X
June	X	X	X	X	X	X	X		X	X	X	X	X	X
July	X	X	X	X	X	X	X		X	X	X		X	X
August	X	X	X	X	X	X	X		X	X	X	X	X	X
September	X	X	X	X	X	X	X		X	X	X		X	X
October	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
December	X	X	X	X	X	X	X		X	X	X		X	X

Table 1: Summary of LHD Reports Submitted by FIRs in 2021. ‘X’ indicates that the LHD or NIL reports are submitted in each month.

3. Summary of LHD Occurrences

3.1. **Table 2** and **Figure 1** summarize the number of LHDs and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2021 to December 2021.

Month (2021)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk ($\times 10^{-9}$ FAPFH)
January	15	3	17	1	0.49
February	13	1	1	0	0.02
March	15	2	18	0	1.7
April	16	3	12	1	0.68
May	6	0	0	0	0
June	7	0	0	0	0
July	9	3	11	2	0.47
August	11	2	7	1	0.31
September	4	1	2	0	0.03
October	14	5	24	0	0.43
November	15	9	36	1	0.83
December	9	1	0	1	0.19
Total	134	30	128	7	5.15

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

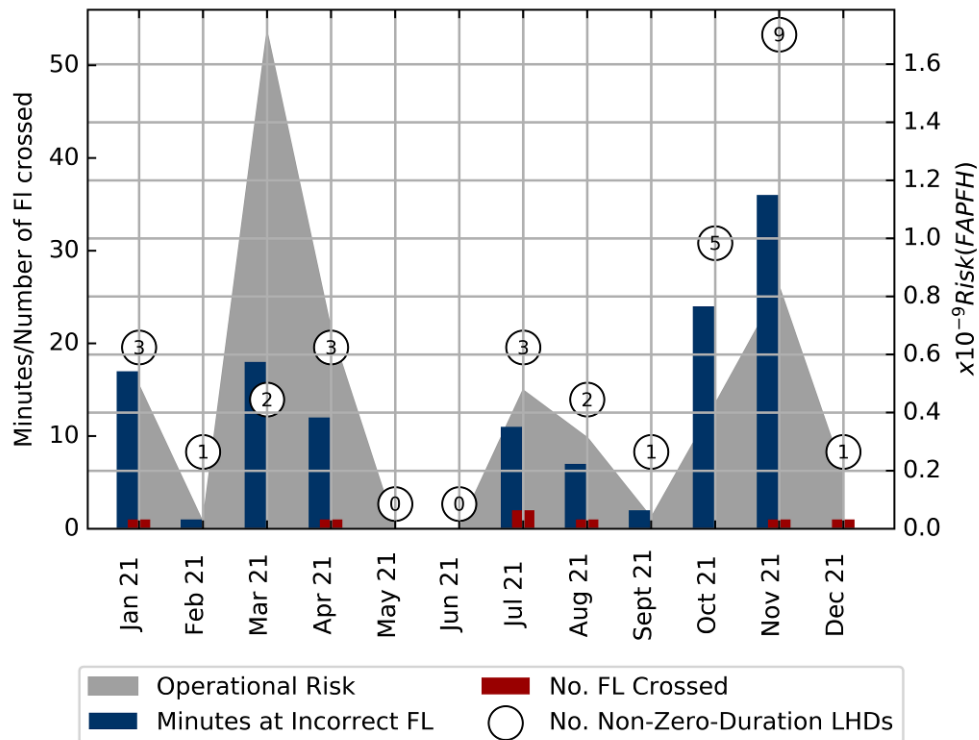


Figure 1: Summary of LHD Occurrences by Month for SA/IO Airspace

3.2. Compared to 2020, the number of LHDs decreased from 152 to 134. Out of 134 LHDs, 30 LHDs were non-zero-duration LHDs resulting in the 128 minutes LHD duration and 7 crossed

flight levels. The operational risk also decreased from 15.19×10^{-9} FAPFH in 2020 to 5.15×10^{-9} FAPFH in 2021.

3.3. **Figure 1** shows that March 2021 had the highest operational risk from 2 non-zero-duration LHDs. While November 2021 had the highest number of non-zero-duration LHDs and LHD duration. More analysis is provided in Section 5.

3.4. **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 2021 to December 2021.

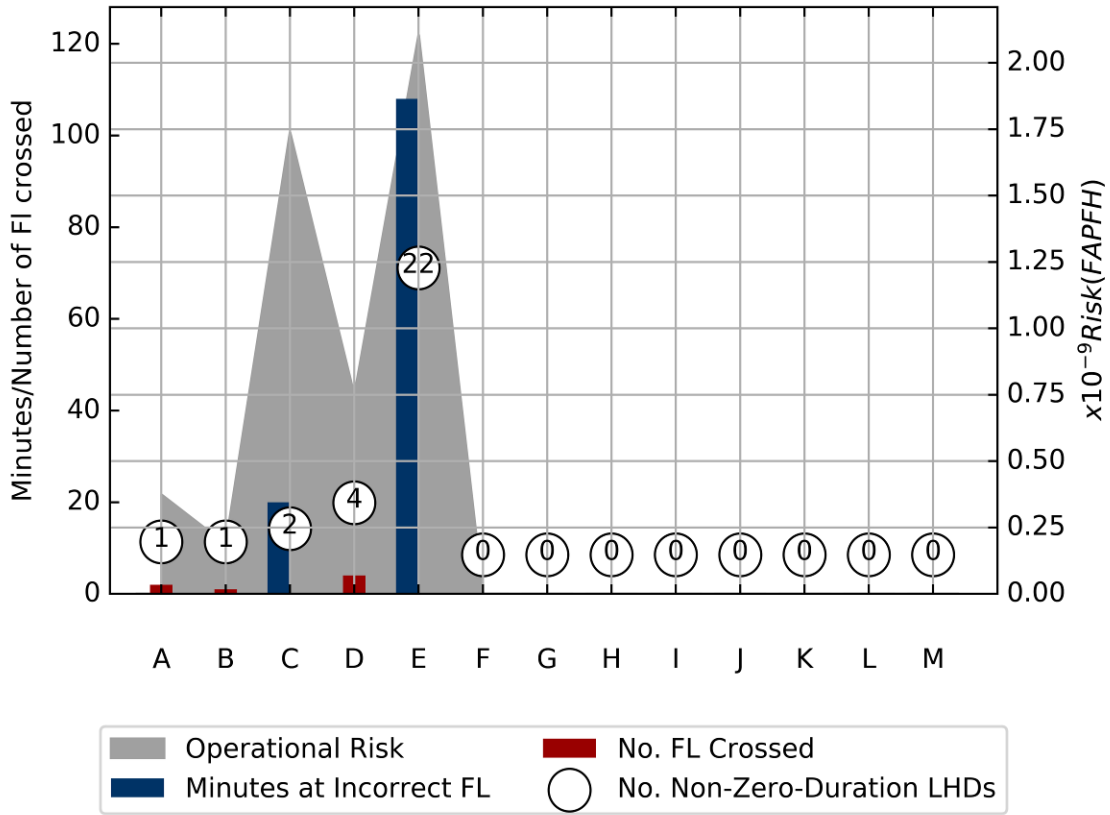


Figure 2: Summary of LHD by LHD Category for SA/IO Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($\times 10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	2	1	0	2	0.374
B	Flight crew climbing/descending without ATC Clearance	2	1	0	1	0.187

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)
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.).	2	2	20	0	1.738
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	4	4	0	4	0.748
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).	123	22	108	0	2.1044
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	0	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	1	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		134	30	128	7	5.15

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

3.5. In 2021, the majority of LHDs and duration in this airspace were in Category E, which can be further categorized into sub-categories. **Figure 3** shows the contribution of each sub-category in terms of the number of LHDs and **Figure 4** shows the contribution in terms of risk.

3.6. Within Category-E, “No or late flight level revision” sub-category was the most frequent sub-category at 49% of the total number of Category E LHDs. “No Transfer Information” sub-category was 39% and other sub-categories were only 12% of the total number of Category E LHDs

3.7. In terms of contribution to the operational risk, “No or late flight level revision” sub-category led to 76% of the total operational risk. “No Transfer Information” sub-category was 23% and other sub-categories was 1% of the total operational risk.

3.8. It should also be noted that the 2 LHDs in Category C (Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment) contributed to a high risk of 1.738 x 10⁻⁹ FAPFH in 2021.

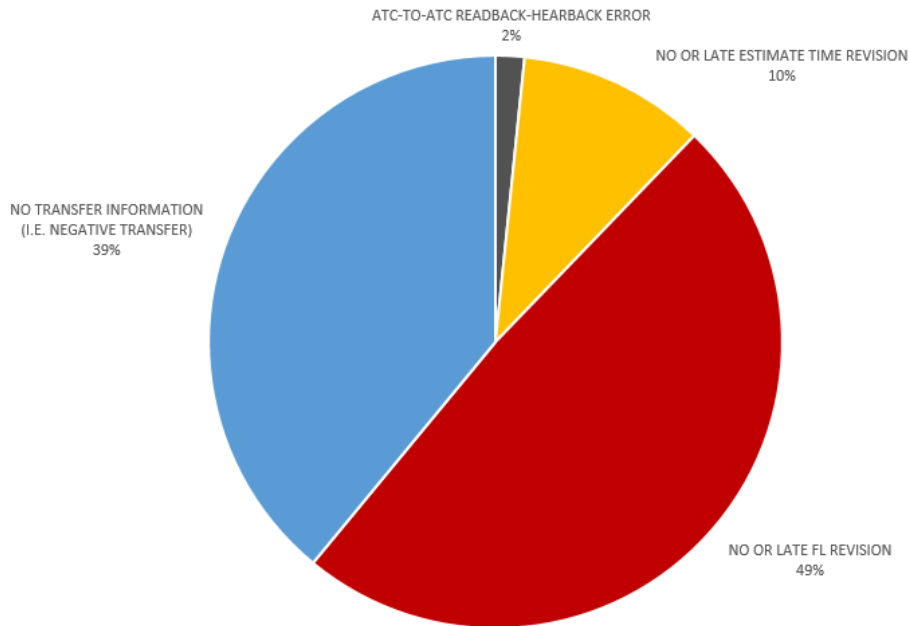


Figure 3: Sub-categories of Category-E LHDs for SA/IO Airspace
(Number of LHDs)

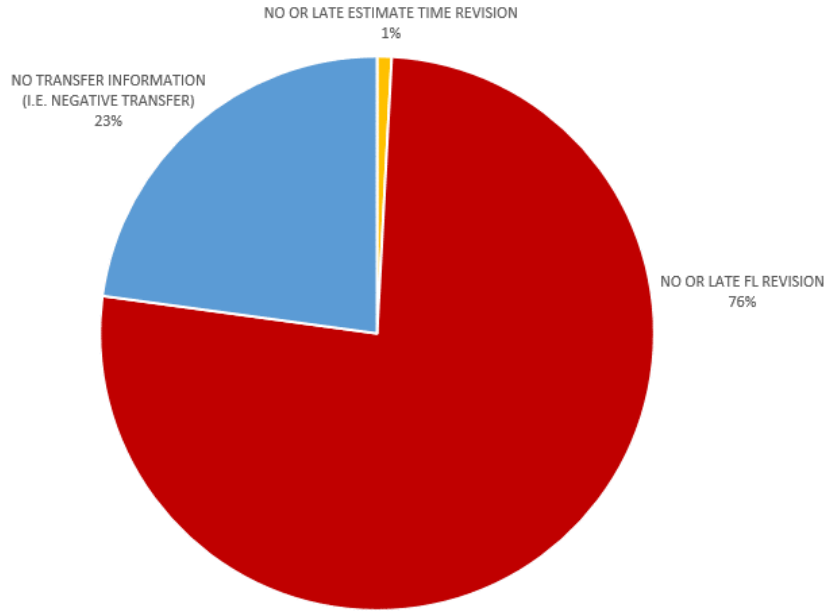


Figure 4: Sub-categories of Category-E LHDs for SA/IO Airspace (Risk)

4. Risk Assessment and Safety Oversight

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

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	1,455,137	508,648	Hour	Dec 2021 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.2852 / 0.0331	0.0720	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.1040	0.0176	-	
λ_x	Average aircraft length	0.0287	0.0239	NM	
λ_y	Average aircraft wingspan	0.0262	0.0217	NM	
λ_z	Average aircraft height	0.0080	0.0070	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0287	0.0239	NM	
$P_z(0)$	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	
$ \overline{\Delta V} $	Average relative along-track speed between aircraft on same direction routes	30.95	44.77	Knot	Dec 2021 TSD
$ \overline{V} $	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for 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 2.5×10^{-9} FAPFH. The total risk is 5.62×10^{-9} FAPFH. Therefore, **the total risk exceeds the specified TLS** value for these components of 5.0×10^{-9} FAPFH.

South Asia/Indian Ocean (SA/IO) RVSM Airspace – estimated annual flying hours = 1,201,822 hours (note: estimated hours based on December 2021 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.47×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	5.15×10^{-9}	-	-
Total Risk	5.62×10^{-9}	5.0×10^{-9}	Above Overall TLS

Table 5: Risk Estimates for SA/IO Airspace

4.3. The total risk decreased 64% from 15.67×10^{-9} FAPFH in 2020 to 5.62×10^{-9} FAPFH in 2021.

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 overall operational and total risk in 2021 showed as the downward trend.

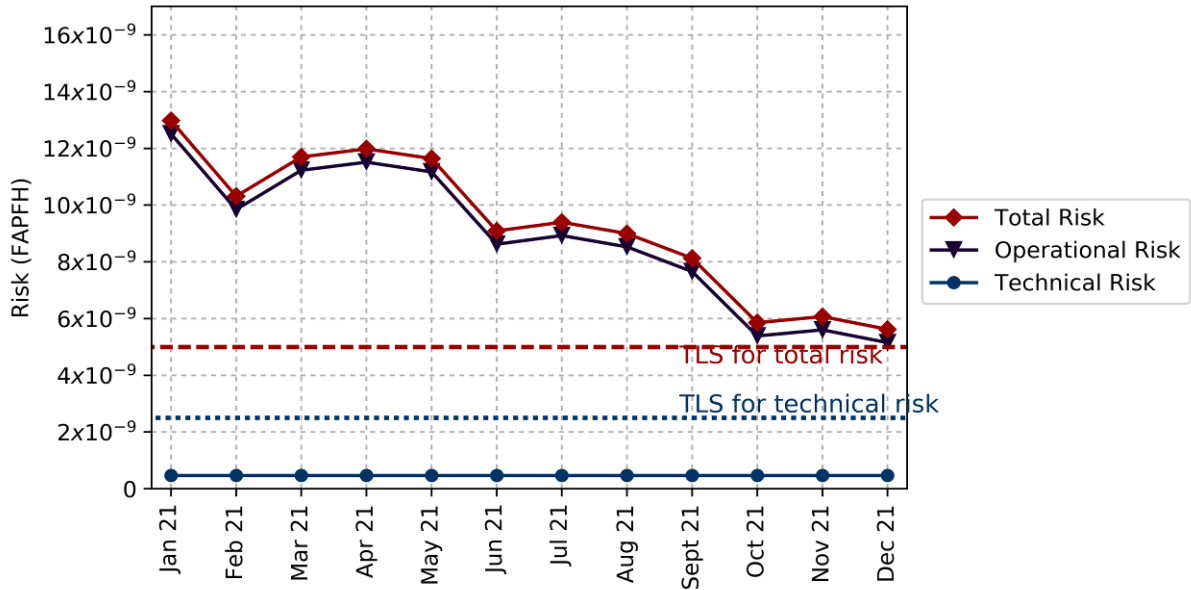


Figure 5: Trends of Risk Estimates for SA/IO Airspace

4.5. 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. Each block represents each LHD and the height of each block corresponds to the operational risk. **Figure 6** shows that the operational risk in **6 out of 12 months are above** the average monthly risk. **The other half of the months are below** the average monthly risk. The average monthly risk is calculated from the annual risk of 5.0×10^{-9} FAPFH (red line in Figure 7 below, which is approximately 0.4167×10^{-9} FAPFH).

4.6. **Figure 6** also shows that there is a very distinctively high-risk LHD in March 2021. This LHD contributed to 1.56×10^{-9} FAPFH, which was almost four times higher than the average monthly risk. Further analysis of the operational risk is presented in Section 5.

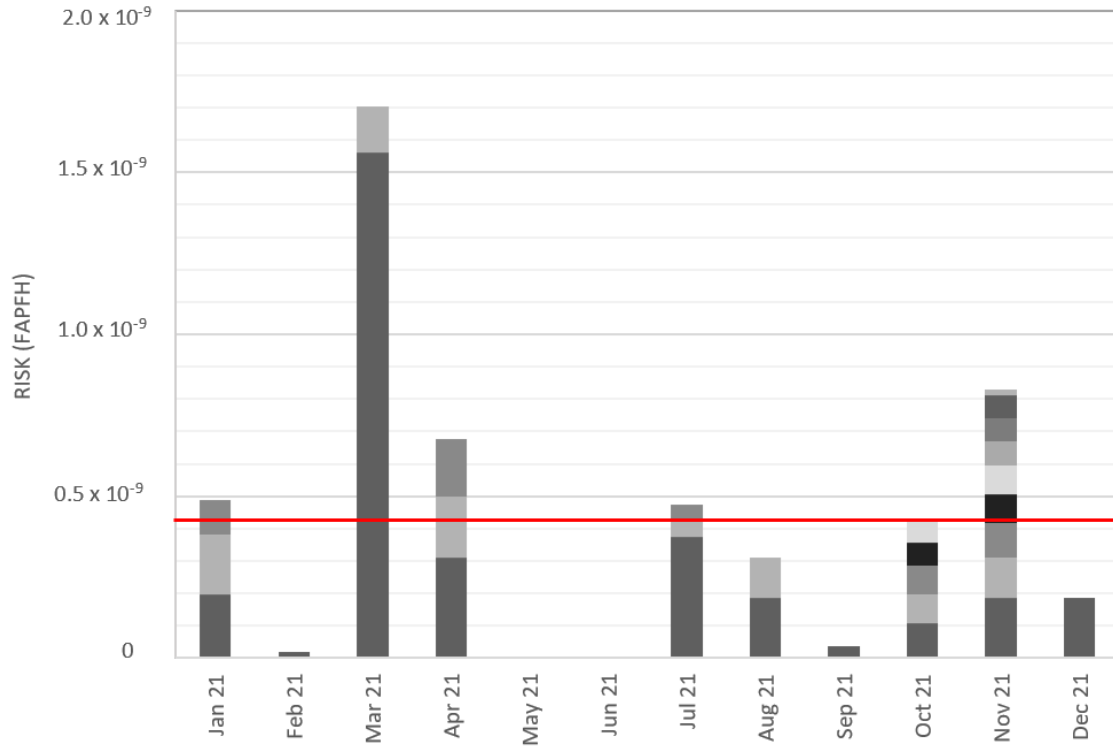


Figure 6: Monthly LHD Risk Estimates for SA/IO Airspace.
Red line is the average monthly value for an annual risk of 5.0×10^{-9} FAPFH. Risk is measured in Fatal Accidents per Flight Hour (FAPFH).

5. Analysis of Operational Errors

5.1 **Figure 7** depicts geographic locations of all reported LHDs in SA/IO airspace based on LHD reports from January to December 2021. **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.

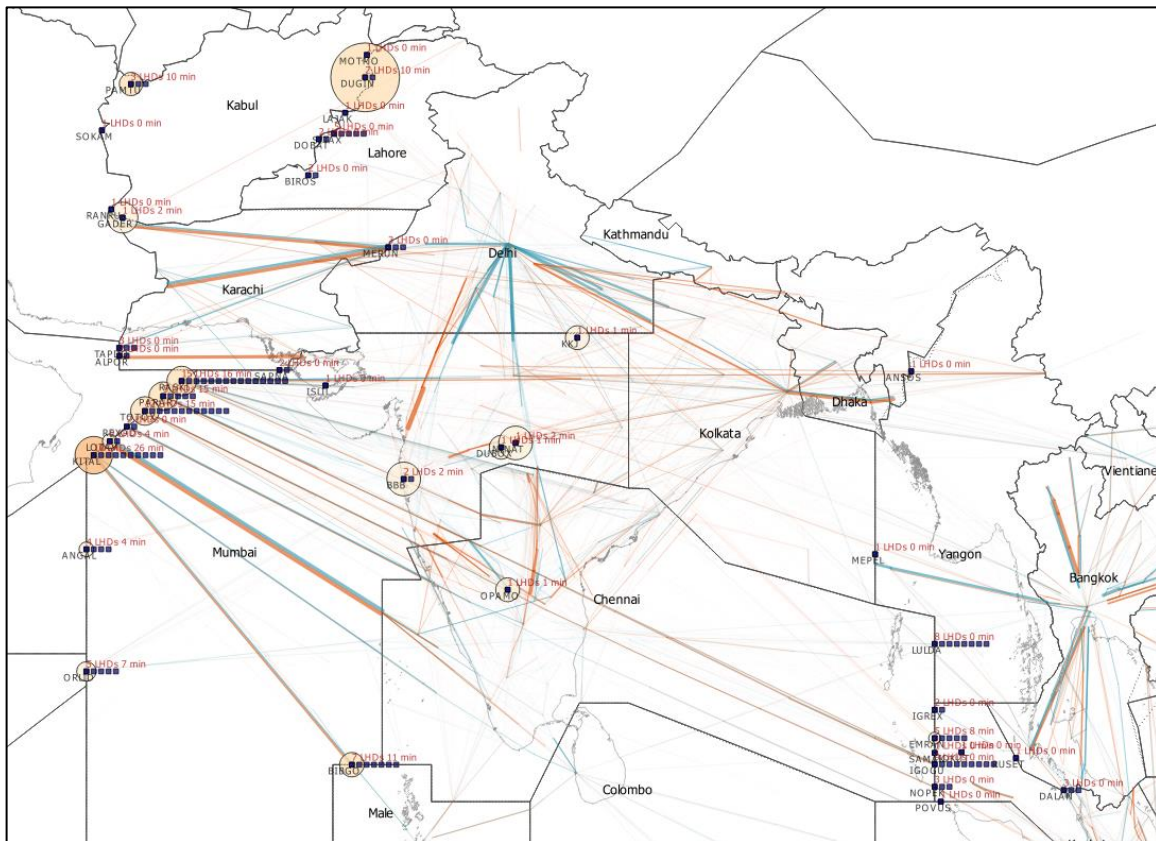


Figure 7: Geographic Locations of All LHD Reports in SA/IO Airspace

5.2 **Figure 8** depicts only LHDs which are determined to be non-zero duration.

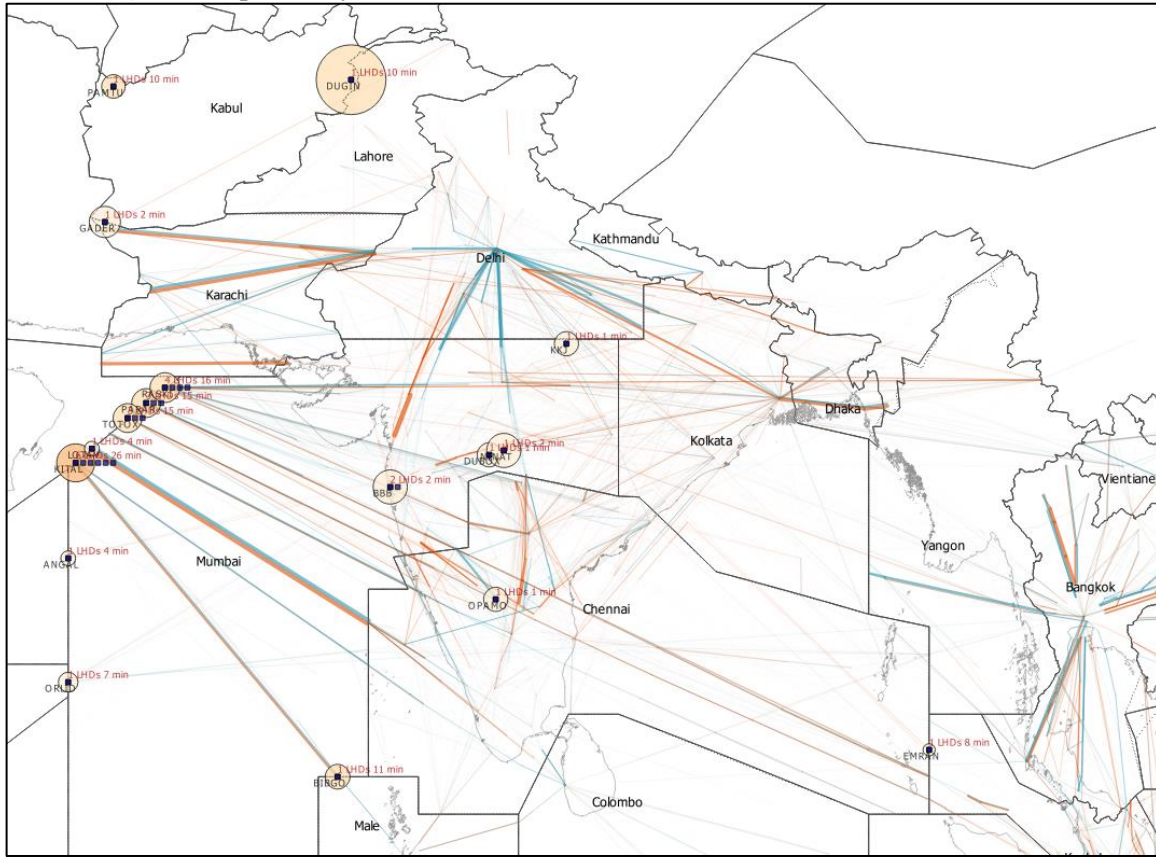


Figure 8: Geographic Locations of 'Non-zero-duration' LHDs in SA/IO Airspace

LHD Hot Spot identification

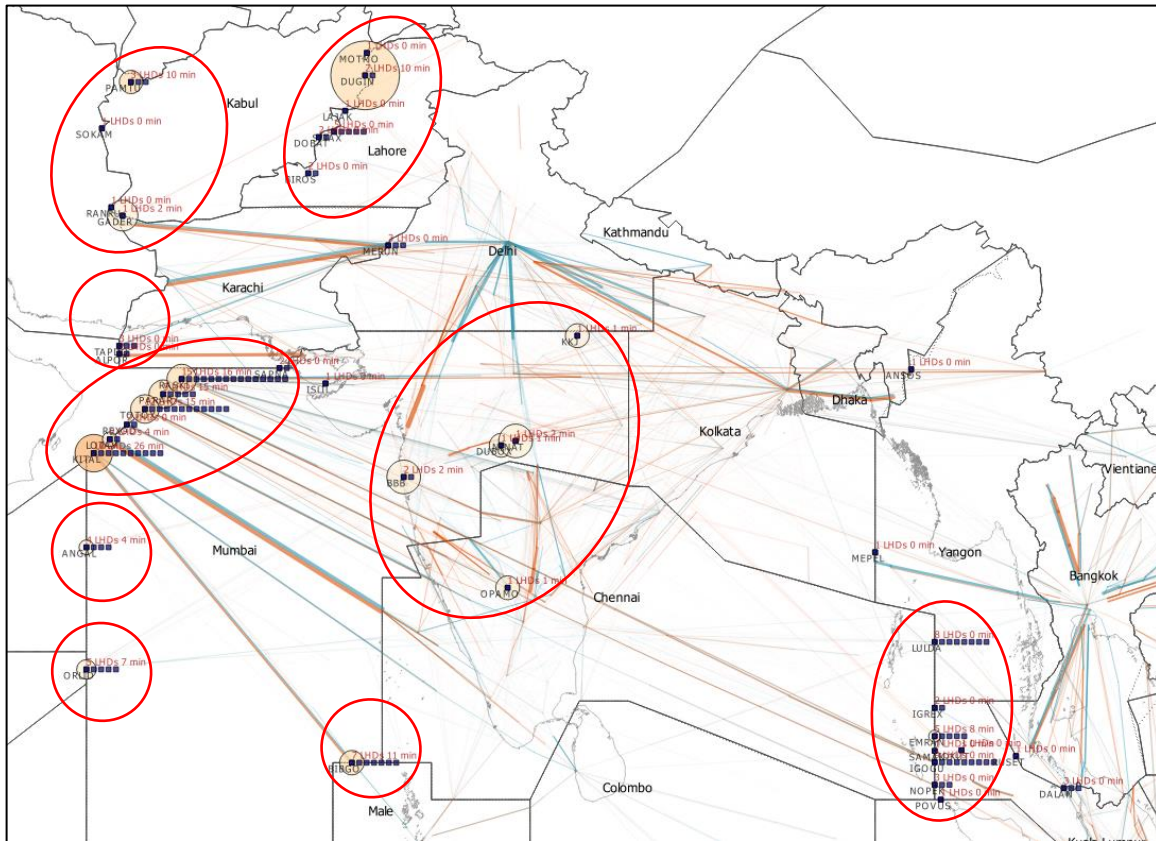


Figure 9: Geographical Locations of **identified LHD clusters** in SA/IO Airspace

5.3 In RASMAG-MAWG/9, MAAR presented a drafting process of identifying, monitoring and removing APAC hot spots and all monitoring agencies agreed to simulate the process to their safety reports for RASMAG/27. To follow the process of identifying hot spots in SA/IO airspace, nine (9) LHD clusters are identified as shown in red ovals in **Figure 9**.

5.4 **Table 6** shows the profile of the LHD clusters in SA/IO airspace and the determining criteria for 2021. The total number of LHDs was 134. The operational risk was 5.15×10^{-9} FAPFH. As a result, the criteria regarding the number of LHDs is 13.40 (calculated from $134 / [9 + 1]$), the criteria regarding the risk is 0.52×10^{-9} FAPFH (calculated from $5.15 / [9 + 1]$) and the criteria regarding the TLS is 5×10^{-9} FAPFH.

SA/IO	2021
Number of Clusters	9
Number of LHDs	134
Risk ($\times 10^{-9}$ FAPFH)	5.15
Criteria: Number of LHDs	13.40
Criteria: Risk ($\times 10^{-9}$ FAPFH)	0.52
Criteria: TLS ($\times 10^{-9}$ FAPFH)	5.00

Table 6: The profile of the LHD clusters in SA/IO airspace and the determining criteria for 2021

5.5 In the process of identifying hot spots, a cluster will be identified as an LHD hot spot if the number of LHDs or the operational risk equals to or exceeds at least one of the three criteria. **Table 7** shows the number of LHD and risk of each cluster as well as the results of checking against the criteria. A ‘Negative’ result means that the cluster does not satisfy that particular criterion. Conversely, a ‘Positive’ result means that the cluster satisfies that particular criterion and can be identified as a hot spot.

2021 Clusters (SA/IO)	Chennai-Yangon/ Kuala Lumpur (Hot Spot A2)	Chennai-Mumbai-Delhi	Mumbai-Male	Mumbai-Muscat (Hot Spot G)	Mumbai-Sanaa (Hot Spot G)	Mumbai-Mogadishu (Hot Spot F)	Karachi-Muscat	Western Boundary of Kabul	Kabul-Lahore
Number of LHDs	29	8	7	44	4	5	4	6	13
Check Criteria: Number >= 13.4	Positive	Negative	Negative	Positive	Negative	Negative	Negative	Negative	Negative
Risk (x 10 ⁻⁹ FAPFH)	0.05	1.31	0.20	1.35	0.07	0.12	0.00	0.49	1.56
Check Criteria: Risk >= 0.52 x 10 ⁻⁹ FAPFH	Negative	Positive	Negative	Positive	Negative	Negative	Negative	Negative	Positive
Check Criteria: Risk >= TLS	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Table 7: The results of identifying hot spots in SA/IO Airspace

5.6 According to the result in **Table 7**, the following clusters satisfy the hot spot criteria:

- Chennai-Yangon/Kuala Lumpur boundary (Hot Spot A2);
- Mumbai-Muscat boundary (Hotspot G);
- Chennai-Mumbai-Delhi (Indian FIRs); and
- the boundary between Kabul FIR and Lahore FIR.

5.7 On the other hand, the following interfaces are listed as LHD hot spots but do not meet the hot spot criteria in 2021:

- Mumbai-Sanaa boundary (Hotspot G);
- Mumbai-Mogadishu boundary (Hotspot F); and
- Kolkata-Yangon boundary (Hot Spot A1).

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

5.8 Since 2015 the **Western boundaries of Mumbai FIR** has been identified as LHD hot spots G and F at three interfaces. The first interface is 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.

5.9 **Table 8** summarizes the number of LHDs, the number of non-zero-duration LHDs and operational risk at the western boundary of Mumbai FIR from 2019 to 2021. In 2020, the number of LHDs, the number of non-zero-duration LHDs and the operational risk dramatically decreased from 2019. In 2021, the number of LHDs further decreased from 57 in 2020 to 53. The non-zero-duration LHDs significantly decreased from 32 in 2020 to 19 in 2021. All non-zero-duration LHDs led to the risk of 1.54 x 10⁻⁹ FAPFH, accounting for 30% of the operational risk in SA/IO airspace.

5.10 At Mumbai-Muscat boundary, the number of LHDs, the number of non-zero-duration LHDs and the operational risk gradually decreased from 2019 to 2021. In 2021, the operational risk at this boundary was only 1.35×10^{-9} FAPFH, which decreased by 79% from 6.37×10^{-9} FAPFH in 2020.

5.11 At Mumbai-Sanaa boundary, the number of LHDs increased from 1 in 2020 to 4 in 2021. The number of non-zero-duration LHDs increased from 0 in 2020 to 1 in 2021, resulting in risk of 0.07×10^{-9} FAPFH.

5.12 At Mumbai-Mogadishu boundary, the number of LHDs, the number of non-zero-duration LHDs and the operational risk also decreased in 2021. The operational risk at this boundary was 0.12×10^{-9} FAPFH.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Mumbai-Muscat	143	48	44	76	28	17	24.71	6.37	1.35
Mumbai-Sanaa	5	1	4	2	0	1	0.20	0.00	0.07
Mumbai-Mogadishu	9	8	5	3	4	1	0.74	4.80	0.12
Total	157	57	53	81	32	19	25.65	11.17	1.54

Table 8: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at the Western Boundary of Mumbai FIR from 2019 to 2021

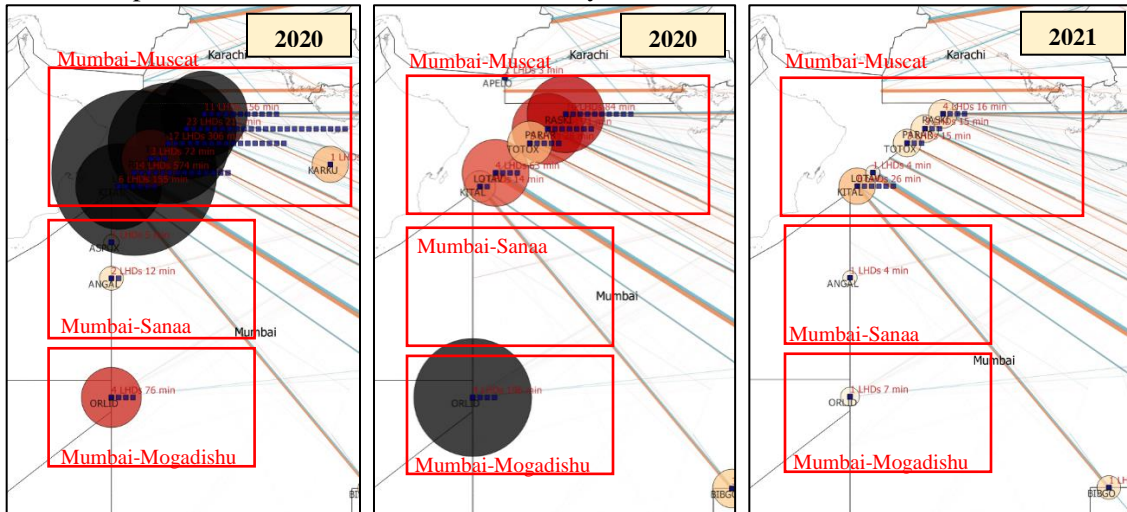


Figure 10: The Visualization of non-zero-duration LHDs and operation risk at Hot Spot G and F in 2019, 2020 and 2021.

5.13 Similar to the picture of the SA/IO airspace, the majority of LHDs at the western boundary of Mumbai FIR were in Category E. The most frequently reported sub-categories were “No or Late FL revision” and “Negative Transfer”.

5.14 From 2015 to 2019, the poor communication services and lack of surveillance coverage at these boundaries contributed to the high number of long-duration LHDs and operational risk. In 2020 and 2021, the long-duration LHDs were mitigated and the operational risks were very low compared to 2019.

5.15 The decreasing trend of the risk at these hot spots might be due to the increasing awareness (soft barrier) of the issue and the traffic reduction during the COVID-19 pandemic. However, it is strongly recommended that an engineering solution such as AIDC (hard barrier) is implemented with Mumbai FIR to be the long-term mitigation.

5.16 According to the final report of Ninth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/9) held in April 2022, the AIDC trials between Mumbai ACC and Muscat ACC, and between Mumbai ACC and Mogadishu ACC had been conducted in March 2021. However, some minor system issues with Muscat's and Mogadishu's automation systems were found and remained to be resolved before the AIDC implementation could proceed to the next phase.

5.17 According to IP2 of The Combined Tenth Meeting of the South Asia/Indian Ocean ATM Coordination Group (SAIOACG/10) and Twenty Seventh Meeting of the South-East Asia ATS Coordination Group (SEACG/27) held in April 2021, Airports Authority of India has implemented the Space Based ADS-B since February 2020 to enhance the surveillance capability, particularly in the oceanic airspace. The Space-Based ADS-B could enable the controller to identify an LHD occurrence beyond the Transfer of Control (TOC) point. This technology may potentially reduce the LHDs and the operational risk at these Hot Spots.

5.18 Regarding the process of identifying hot spots, the LHD cluster at the boundary between Mumbai FIR and Muscat (Hot Spot G) satisfies the hot spot criteria in terms of the number and the risk. This should remain as a hot spot. The LHD clusters at the boundary between Mumbai FIR and Sanaa FIR (Hot Spot G) and between Mumbai FIR and Mogadishu FIR (Hot Spot F) do not satisfy any of the 3 hot spot criteria in 2021 as the first year. Some mitigation measures also remain unfinished. Therefore, these two clusters should continue to be hot spots.

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

5.19 The boundaries between Kolkata FIR / Dhaka FIR and Yangon FIR (Hot Spot A1), and between Chennai FIR and Yangon FIR / Kuala Lumpur FIR (Hot Spot A2) were first identified as LHD hot spots in 2015.

5.20 **Table 9** provides the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and A2 from 2019 to 2021. In 2020, the number of LHDs dramatically decreased from 2019, while the number of non-zero-duration LHDs and the operational risk dropped to 0. In 2021, the number of LHDs increased from 24 in 2020 to 30 and there was one non-zero-duration LHD, accounting for 0.05×10^{-9} FAPFH. **Figure 11** provides the geographical visualization of the non-zero-duration LHDs and their associated operational risk grouped at the three boundaries in 2019, 2020 and 2021.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Kolkata-Yangon	59	8	1	3	0	0	0.31	0.00	0.00
Chennai-Yangon	16	3	8	4	0	0	0.49	0.00	0.00
Chennai-Kuala Lumpur	88	13	21	15	0	1	1.14	0.00	0.05
Total	163	24	30	22	0	1	1.94	0.00	0.05

Table 9: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and A2 from 2019 to 2021.

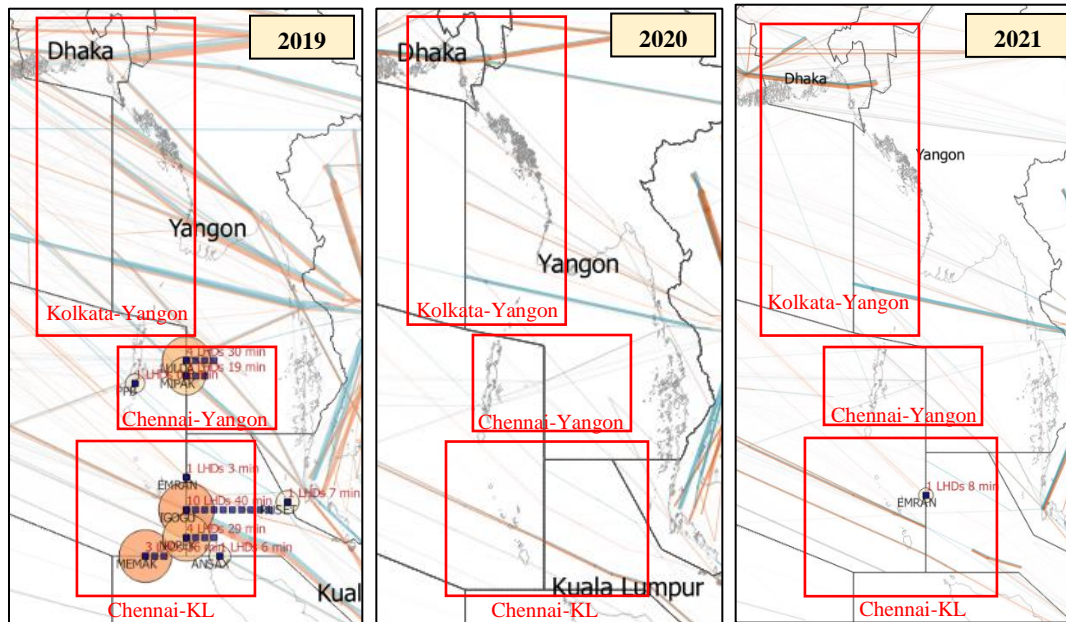


Figure 11: The Visualization of Non-zero-duration LHDs and operation risk at Hot Spot A1 and A2 in 2019, 2020 and 2021.

5.21 As previously mentioned in RASMAG/26, the implementation of ADS-B data sharing between Kolkata ACC and Yangon ACC allowed the controllers to detect and resolve any issue before an aircraft passing the transfer-of-control points. Thus, there were a small number of LHDs

at the boundary between Kolkata FIR and Yangon FIR, and the operational risk reduced to zero in 2020 and 2021.

5.22 At Chennai-Yangon boundary, the number of LHDs increased from 3 in 2020 to 8 in 2021. At Chennai-Kuala Lumpur boundary, the number of LHDs increased from 13 in 2020 to 21 in 2021. With the increase in the number of LHDs, there was only one non-zero-duration LHD at Chennai-Kuala Lumpur boundary. This LHD contributed to the operational risk of 0.05×10^{-9} FAPFH, which was the total operational risk of Hot Spot A in 2021. However, the situational awareness of LHD occurrences and the implementation of engineering solutions such as AIDC (hard barrier) still need to be considered as the number of LHDs started to increase with the traffic.

5.23 As detailed in the final report of ACSICG/9, the operational implementation of AIDC between Chennai OCC and Kuala Lumpur ACC commenced in January 2021 and the updated LOA was signed on 26 May 2021. The AIDC trial between Chennai OCC and Yangon ACC commenced in January 2018 and encountered an issue from Yangon ACC side. Yangon ACC would contact Chennai OCC for further testing when ready. The AIDC implementation trial between Kolkata ACC and Yangon ACC in the 1st quarter of 2020 was successful and the LOA would be negotiated and signed.

5.24 Regarding the process of identifying hot spots, the Hot Spot A1 (the boundaries between Kolkata FIR / Dhaka FIR and Yangon FIR) does not satisfy any of the 3 hot spot criteria in 2020 and 2021. It was reported to RASMAG/26 that the issue of LHDs over waypoint APAGO and CHILA (the Dhaka-Yangon interface) was resolved by implementation of a new procedure since June 2019 to handle traffic among Yangon, Dhaka, and Kolkata ACC. The ADS-B data sharing between Kolkata ACC and Yangon ACC is implemented to allow the controllers to detect and resolve any issue before an aircraft passing the transfer-of-control points. If it can also be confirmed that AIDC is successfully implemented between Kolkata ACC and Yangon ACC, then the Hot Spot A1 (the boundaries between Kolkata FIR / Dhaka FIR and Yangon FIR) should be proposed to be removed from the hot spot list.

5.25 Hot Spot A2 (the boundaries between Chennai FIR and Yangon FIR / Kuala Lumpur FIR) satisfies hot spot criteria in terms of the number. Therefore, Hot Spot A2 should remain on the hot spot list.

The boundary between Kabul FIR and Lahore FIR

5.29 In 2021, the number of reported LHDs was 13 at the boundary between Kabul FIR and Lahore FIR. But the only one non-zero duration LHD resulted in the operational risk of 1.56×10^{-9} FAPFH, accounting for 30% of the operational risk in SA/IO airspace.

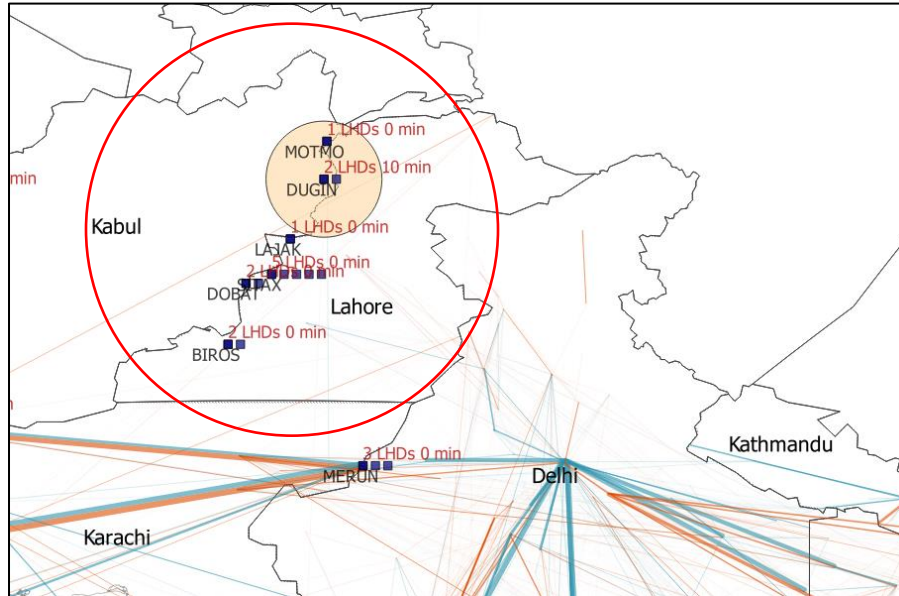


Figure 13: The Visualization of LHDs and operation risk at the boundary between Kabul FIR and Lahore FIR in 2021

5.30 In the process of identifying hot spots, the cluster of 13 LHDs at this boundary does not satisfy the hot spot criteria in terms of the number, but satisfies the hot spot criteria in terms of the risk. However, the risk was caused by a single LHD occurrence and, therefore, this area is not proposed as a hot spot. The situation at this boundary should be closely monitored regarding the increase in the number of LHDs in 2021.

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

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
4/1/2021	AGU	FL370	FL380	0	E	NO OR LATE FL REVISION
5/1/2021	AGU	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
2/1/2021	CJG	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
7/1/2021	AGU	FL280	FL340	0	B	PILOT MISUNDERSTANDS ATC CLEARANCE
28/1/2021	AGU	FL310	FL330	0	E	NO OR LATE FL REVISION
28/1/2021	AGU		FL290	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/2/2021	CJG	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/2/2021	CJG	FL390	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/1/2021	CJG	FL410	FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/1/2021	CJG	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
2/1/2021	FSV	FL340	FL360	0	A	FLIGHT CREW CLIMBING/DESCENDING WITHOUT ATC CLEARANCE
8/1/2021	FSV	FL370	FL350	6	E	NO OR LATE FL REVISION
28/1/2021	FSV		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/1/2021	WYI		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/1/2021	WYI	FL340	FL360	0	E	NO OR LATE FL REVISION
18/2/2021	CJG	FL390	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/2/2021	CJG	FL350	FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/2/2021	CJG	FL390	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/2/2021	HOC	FL310	FL370	0	E	NO OR LATE FL REVISION
18/2/2021	HOC		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/2/2021	CJG	FL350	FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
27/2/2021	CJG	FL390	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)

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Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
7/3/2021	CJG	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
7/3/2021	CJG	FL360	FL360	0	E	NO OR LATE ESTIMATE TIME REVISION
7/3/2021	CJG	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
19/2/2021	FSV	FL330	FL350	1	E	NO OR LATE FL REVISION
5/2/2021	WYI		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/2/2021	WYI		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/2/2021	WYI		FL380	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/3/2021	AGU	FL350	FL360	10	C	ATC ISSUES INCORRECT CLEARANCE TO PILOT
2/4/2021	AGU	FL280	FL330	10	C	PILOT MISUNDERSTANDS ATC CLEARANCE
10/3/2021	EAV	FL370	FL390	0	E	NO OR LATE FL REVISION
10/3/2021	EAV	FL410	FL370	0	E	NO OR LATE FL REVISION
9/4/2021	AGU	FL330	FL350	2	E	NO OR LATE FL REVISION
5/3/2021	FSV	FL330	FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/3/2021	FSV	FL350	FL370	0	E	NO OR LATE FL REVISION
19/3/2021	FSV		FL350	8	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/3/2021	FSV	FL370	FL390	0	E	NO OR LATE FL REVISION
14/3/2021	WYI	FL360	FL380	0	E	NO OR LATE FL REVISION
5/3/2021	WYI	FL360	FL360	0	E	NO OR LATE ESTIMATE TIME REVISION
15/3/2021	WYI	FL300	FL320	0	E	NO OR LATE FL REVISION
28/4/2021	TPH		FL321	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/4/2021	TPH		FL280	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/4/2021	CJG	FL320	FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/4/2021	QBL	FL390	FL350	0	E	NO OR LATE FL REVISION
24/4/2021	HOC	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
28/4/2021	TPH		FL321	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/4/2021	WYI	FL300	FL340	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
27/1/2021	YDZ	FL450	FL450	11	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/3/2021	YDZ		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
23/3/2021	YDZ		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/4/2021	YDZ	FL370	FL390	0	E	NO OR LATE FL REVISION
12/5/2021	HOC		FL300	0	E	NO OR LATE ESTIMATE TIME REVISION
1/4/2021	FSV	FL390	FL330	0	E	NO OR LATE FL REVISION
15/4/2021	FSV	FL330	FL390	0	E	NO OR LATE FL REVISION
15/4/2021	FSV	FL350	FL370	0	E	NO OR LATE FL REVISION
17/4/2021	FSV	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
22/4/2021	HOC	FL360	FL360	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
22/5/2021	HOC	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
31/5/2021	HOC		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
2/5/2021	FSV	FL330	FL350	0	E	NO OR LATE FL REVISION
8/5/2021	FSV		FL450	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/5/2021	FSV	FL330	FL350	0	E	NO OR LATE FL REVISION
10/6/2021	HOC	FL350	FL390	0	E	NO OR LATE FL REVISION
20/6/2021	HOC		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
22/6/2021	HOC	FL350	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/6/2021	FSV	FL330	FL350	0	E	NO OR LATE FL REVISION
6/6/2021	FSV	FL310	FL410	0	E	NO OR LATE FL REVISION
29/6/2021	FSV		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/7/2021	HOC	FL410	FL410	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
25/6/2021	WYI	FL300	FL340	0	E	NO OR LATE FL REVISION
25/7/2021	HOC	FL390	FL410	8	E	NO OR LATE FL REVISION
27/7/2021	HOC		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/7/2021	FSV	FL330	FL350	3	E	NO OR LATE FL REVISION

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Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
16/7/2021	NSQ	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/7/2021	WYI		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/7/2021	WYI		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/8/2021	HOC		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
31/7/2021	WYI		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/8/2021	WYI	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
13/8/2021	WYI	FL300	FL300	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/8/2021	WYI	FL340	FL400	0	E	NO OR LATE FL REVISION
1/8/2021	FSV	FL330	FL350	7	E	NO OR LATE FL REVISION
2/8/2021	FSV	FL350	FL370	0	E	NO OR LATE FL REVISION
5/8/2021	FSV		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
9/8/2021	FSV	FL330	FL350	0	E	NO OR LATE FL REVISION
17/8/2021	FSV	FL410	FL370	0	E	NO OR LATE FL REVISION
17/8/2021	FSV		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/9/2021	FSV	FL310	FL370	2	E	NO OR LATE FL REVISION
15/9/2021	FSV		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/9/2021	WYI		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/9/2021	HOC	FL410	FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/10/2021	FSV	FL390	FL410	0	E	NO OR LATE FL REVISION
30/10/2021	FSV	FL410	FL310	0	E	NO OR LATE FL REVISION
26/10/2021	FSV	FL310	FL330	0	E	NO OR LATE FL REVISION
26/10/2021	FSV	FL330	FL350	0	E	NO OR LATE FL REVISION
25/10/2021	FSV	FL370	FL390	0	E	NO OR LATE FL REVISION
25/10/2021	FSV	FL350	FL370	0	E	NO OR LATE FL REVISION
23/10/2021	FSV	FL330	FL350	0	E	NO OR LATE FL REVISION
21/10/2021	FSV	FL410	FL450	4	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
18/10/2021	FSV	FL410	FL390	5	E	NO OR LATE FL REVISION
17/10/2021	FSV	FL370	FL410	0	E	NO OR LATE FL REVISION
17/10/2021	FSV	FL350	FL370	5	E	NO OR LATE FL REVISION
17/10/2021	FSV	FL350	FL370	6	E	NO OR LATE FL REVISION
15/10/2021	FSV		FL390	4	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/10/2021	FSV	FL410	FL350	0	E	NO OR LATE FL REVISION
25/11/2021	HOC		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/12/2021	HOC		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/12/2021	HOC	FL370	FL390	0	E	NO OR LATE FL REVISION
9/11/2021	TPH	FL350	FL350	0	J	None
9/11/2021	FSV	FL370	FL390	0	E	NO OR LATE FL REVISION
11/11/2021	FSV	FL310	FL350	0	E	NO OR LATE FL REVISION
11/11/2021	FSV	FL330	FL350	4	E	NO OR LATE FL REVISION
12/11/2021	FSV	FL330	FL330	1	E	NO OR LATE ESTIMATE TIME REVISION
29/12/2021	HOC	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
12/11/2021	FSV	FL410	FL390	4	E	NO OR LATE FL REVISION
13/11/2021	FSV		FL390	4	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/11/2021	FSV	FL350	FL330	6	E	NO OR LATE FL REVISION
14/11/2021	FSV	FL390	FL290	5	E	NO OR LATE FL REVISION
15/11/2021	FSV	FL370	FL350	0	E	NO OR LATE FL REVISION
18/11/2021	FSV	FL390	FL370	7	E	NO OR LATE FL REVISION
21/11/2021	FSV	FL390	FL410	0	E	NO OR LATE FL REVISION
30/11/2021	FSV	FL350	FL390	5	E	NO OR LATE FL REVISION
1/12/2021	FSV	FL350	FL370	0	E	NO OR LATE FL REVISION
2/12/2021	FSV	FL350	FL310	0	E	NO OR LATE FL REVISION
6/12/2021	FSV		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/12/2021	FSV	FL380	FL360	0	E	NO OR LATE FL REVISION
21/12/2021	FSV		FL380	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/1/2021	FSV	FL390	FL390	1	D	None

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Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
15/8/2021	FSV	FL350	FL350	1	D	None
22/11/2021	FSV	FL390	FL390	1	D	None
20/7/2021	FSV	FL400	FL250	2	A	FLIGHT CREW CLIMBING/DESCENDING WITHOUT ATC CLEARANCE
2/4/2021	OBP	FL370	FL360	1	B	None
10/12/2021	WYI	FL260	FL260	1	D	None

MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2021 to December 2021

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE SOUTHEAST ASIA AIRSPACE**

Assessment Period: January 2021 to December 2021

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

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **Southeast Asia (SEA)** airspace. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2021** and monthly Large Height Deviation (LHD) reports between **January 2021** and **December 2021** submitted by concerning States in the SEA airspace.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2021 of aircraft operating in the SEA airspace is used as required by ICAO regional agreement.

2.2. **Large Height Deviation (LHD).** A cumulative 12-month data set of LHD reports covers January 2021 to December 2021. **Table 1** indicates those FIRs, which submitted LHD reports including NIL reports. All FIRs submitted LHD reports in a timely manner. **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	Taibei
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 2021

3. Summary of LHD Occurrences

3.1. **Table 2** and **Figure 1** summarize the number of LHDs and associated LHD duration (in minutes) or number of levels crossed, and their associated operational risk by month from January 2021 to December 2021.

Month (2021)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk (x10 ⁻⁹ FAPFH)
January	6	3	7	0	0.17
February	4	0	0	0	0
March	5	2	4	0	0.09
April	9	2	29	0	0.65
May	4	1	5	0	0.11
June	2	0	0	0	0
July	4	0	0	0	0
August	4	2	11	0	0.25
September	3	2	7	0	0.17
October	13	2	3	0	0.08
November	8	0	0	0	0
December	10	2	27	0	0.61
Total	72	16	93	0	2.13

Table 2: Summary of LHD by Month for SEA Airspace

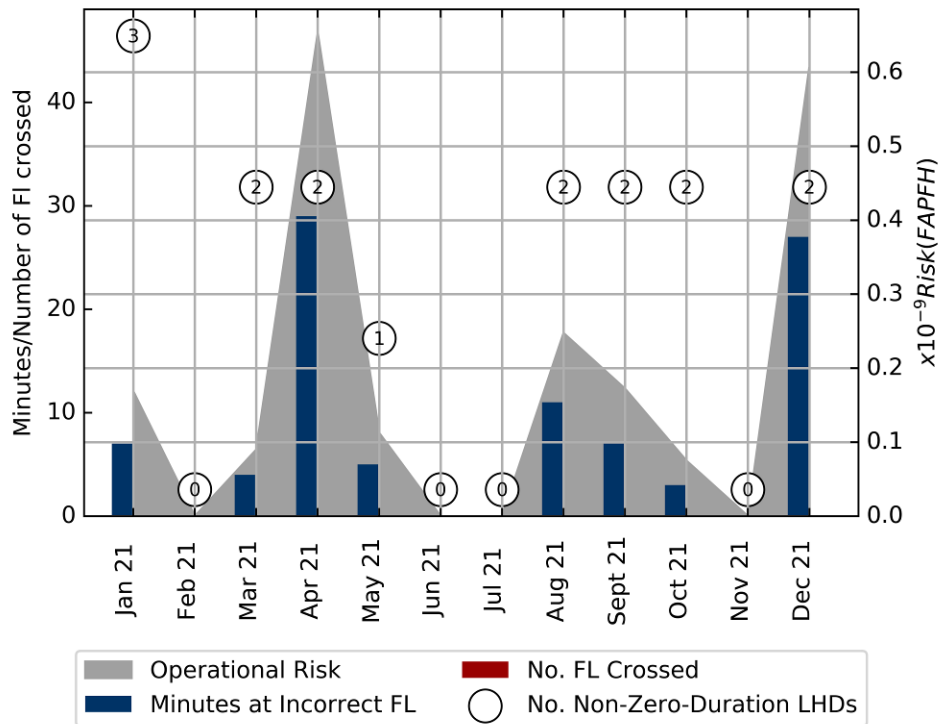


Figure 1: Summary of LHDs by Month for SEA Airspace

3.2. Compared to 2020, the number of LHDs increased from 39 to 72. Out of 72 LHDs, sixteen (16) were non-zero-duration LHDs, which resulted in the LHD duration of 93 minutes and no

crossed flight level. The total operational risk also increased from 1.42×10^{-9} FAPFH in 2020 to 2.13×10^{-9} FAPFH in 2021.

3.3. **Figure 1** shows that the LHD duration and the operational risk were relatively high in April and December with 2 non-zero-duration LHDs in each month. More analysis would be provided in Section 5.

3.4. **Figure 2** and **Table 3** summarize the number of LHDs, the associated LHD duration (in minutes) and the number of flight levels crossed, by the LHD category from January 2021 to December 2021.

3.5. In 2021, Category E LHDs remained the most frequent occurrences in the SEA airspace. Out of all 72 LHDs, 65 were classified as Category E. And 16 of these were Category E non-zero-duration LHDs, contributing to the operational risk of 2.13×10^{-9} FAPFH which was the total operational risk in SEA airspace.

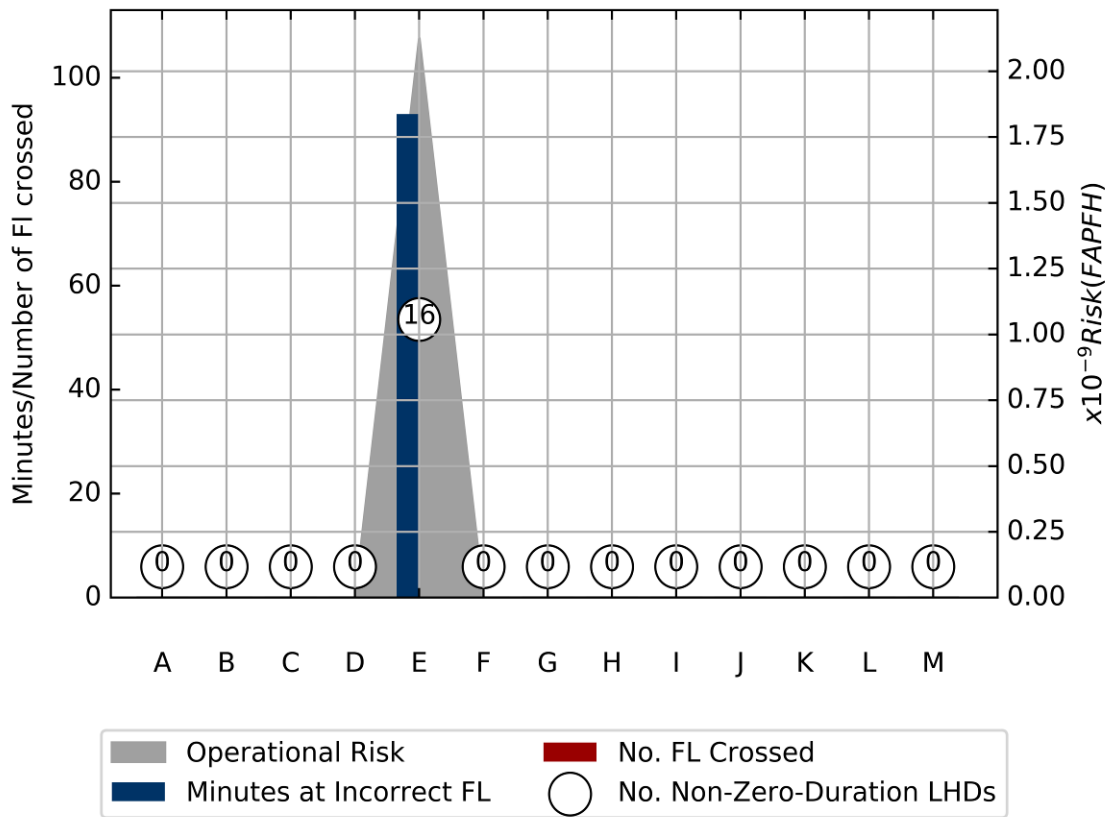


Figure 2: Summary of LHD by LHD Category for SEA Airspace

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

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)
B	Flight crew climbing/descending without ATC Clearance	1	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).	65	16	93	0	2.13
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).	4	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	1	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 ($\times 10^{-9}$ FAPFH)
M	Other	0	0	0	0	0
Total		72	16	93	0	2.13

Table 3: Summary of LHD by Category for SEA Airspace

3.6. The Category E LHDs can be further categorized into sub-categories. **Figure 3** shows the contribution of each sub-category in terms of the number of LHDs and **Figure 4** shows the contribution in terms of risk.

3.7. Within Category-E, “No Transfer Information” sub-category was 43%, “No or late flight level revision” sub-category was 32%, “No or late time level revision” sub-category was 20% and “Readback-Hearback Error” sub-categories was 5% of the total number of Category E LHDs as shown in **Figure 3**.

3.8. In terms of contribution to the operational risk as shown in **Figure 4**, a few LHDs in “No or late time revision” sub-categories led to 49% of the total operational risk of the SEA airspace.

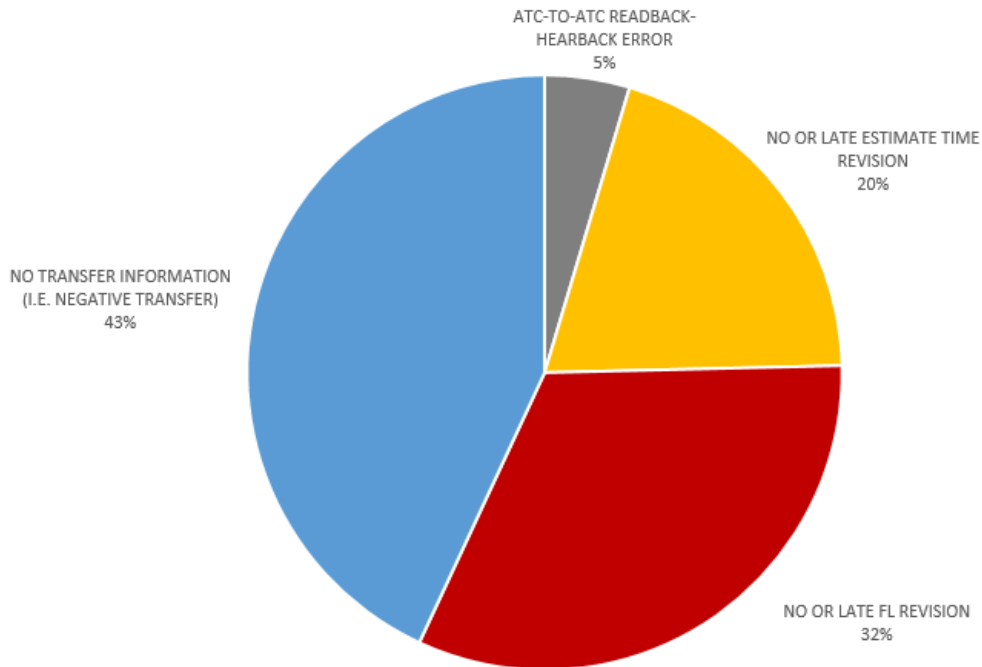


Figure 3: Sub-categories of Category-E LHDs for SEA Airspace
(Number of LHDs)

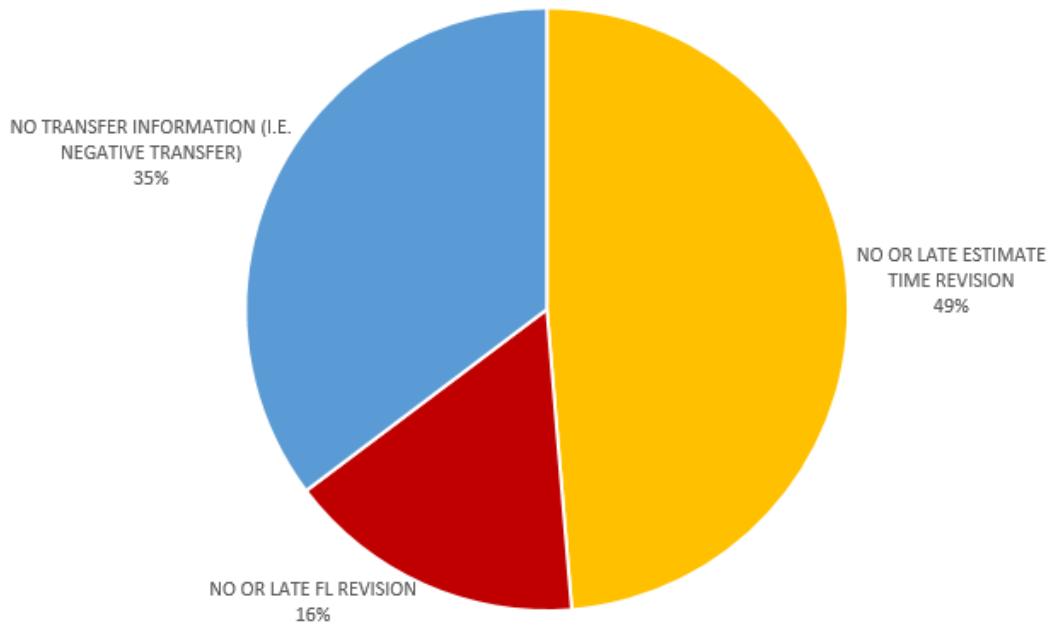


Figure 4: Sub-categories of Category-E LHDs for SEA Airspace (Risk)

4. Risk Assessment and Safety Oversight

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

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	709,967	309,899	Hour	Dec 2021 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.1785/ 0.0129	0.1710	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.1013	0.0211	-	
λ_x	Average aircraft length	0.0297	0.0321	NM	
λ_y	Average aircraft wingspan	0.0272	0.0293	NM	
λ_z	Average aircraft height	0.0082	0.0087	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0297	0.0321	NM	
$P_z(0)$	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	
$ \overline{\Delta V} $	Average relative along-track speed between aircraft on same direction routes	33.00	41.93	Knot	Dec 2021 TSD
$ \overline{V} $	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for 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 2.5×10^{-9} FAPFH. **The total risk** is 2.58×10^{-9} FAPFH, which also **meets the specified TLS** value for these components of 5.0×10^{-9} FAPFH.

Southeast Asia (SEA) RVSM Airspace – estimated annual flying hours = 1,019,866 hours (note: estimated hours based on December 2021 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.45×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	2.13×10^{-9}	-	-
Total Risk	2.58×10^{-9}	5.0×10^{-9}	Below Technical TLS

Table 5: Risk Estimates for SEA Airspace

4.3. The total risk in SEA airspace increased from 1.82×10^{-9} FAPFH in 2020 to 2.58×10^{-9} FAPFH in 2021, accounting for 42% increase.

4.4. **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHDs. The overall trends of operational and total risk increased from January 2021 to December 2021.

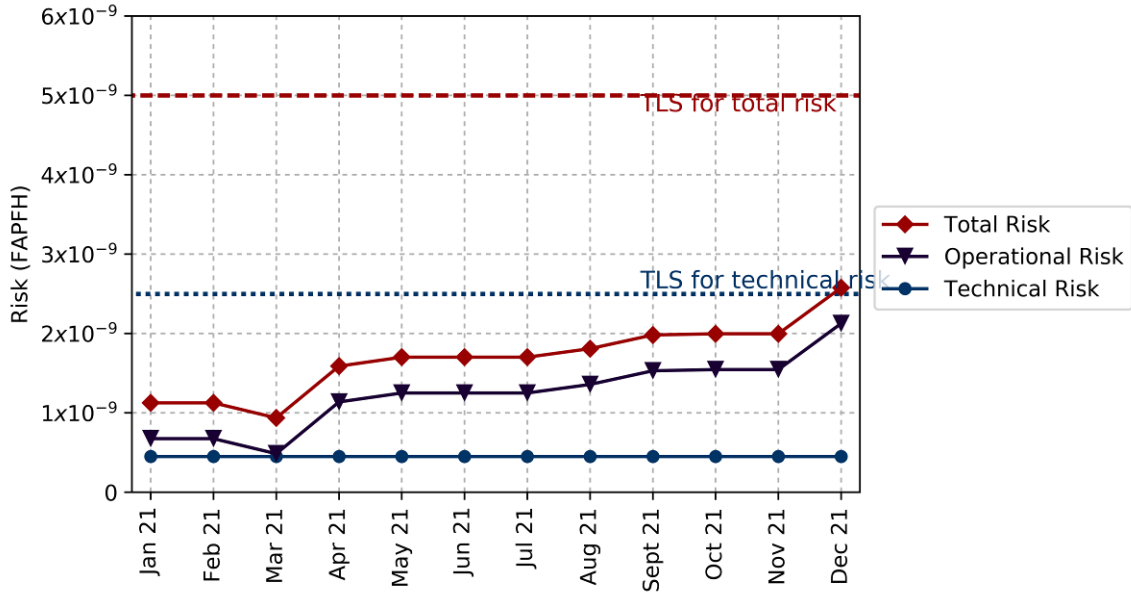


Figure 5: Trends of Risk Estimates for SEA Airspace

4.5. 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).

4.6. As depicted in **Figure 6**, the operational risk was over the average monthly risk in April and December 2021. The 4 non-zero-duration LHDs in April and December 2021 resulted in the operational risk of 1.26×10^{-9} FAPFH, accounting for 59% of the total operational risk in SEA airspace. More details is provided in Section 5.

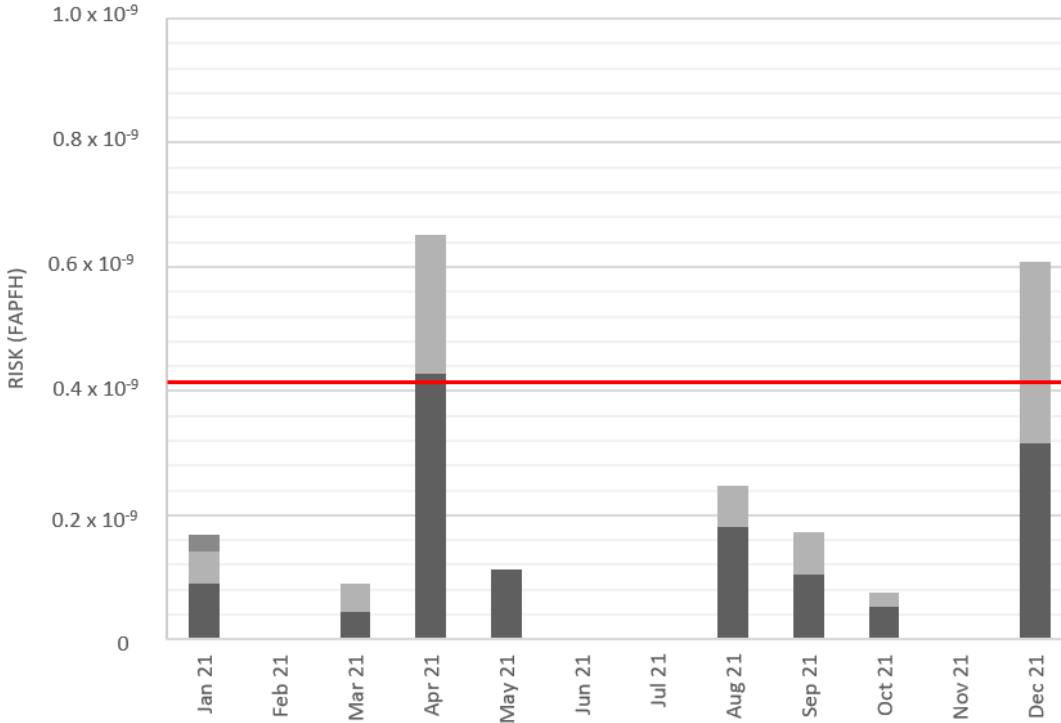


Figure 6: Monthly LHD Risk Estimates for SEA Airspace.

Red line is the average monthly risk for an annual risk of 5.0×10^{-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 2021. **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.

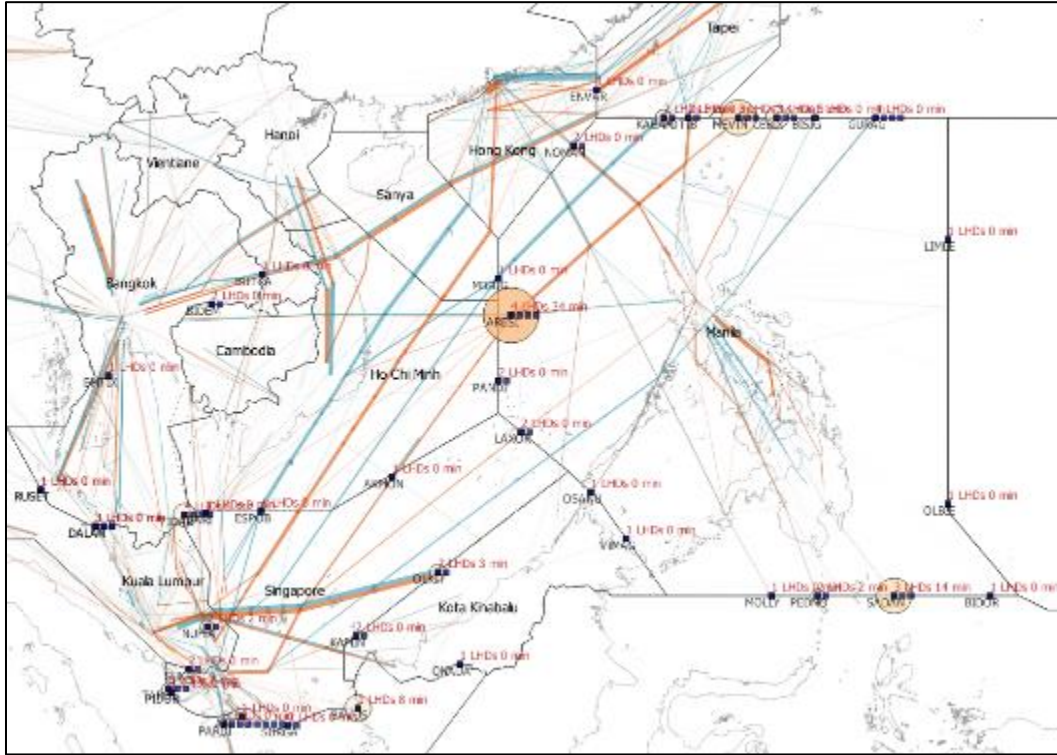


Figure 7: Geographical Locations of All LHDs in SEA Airspace

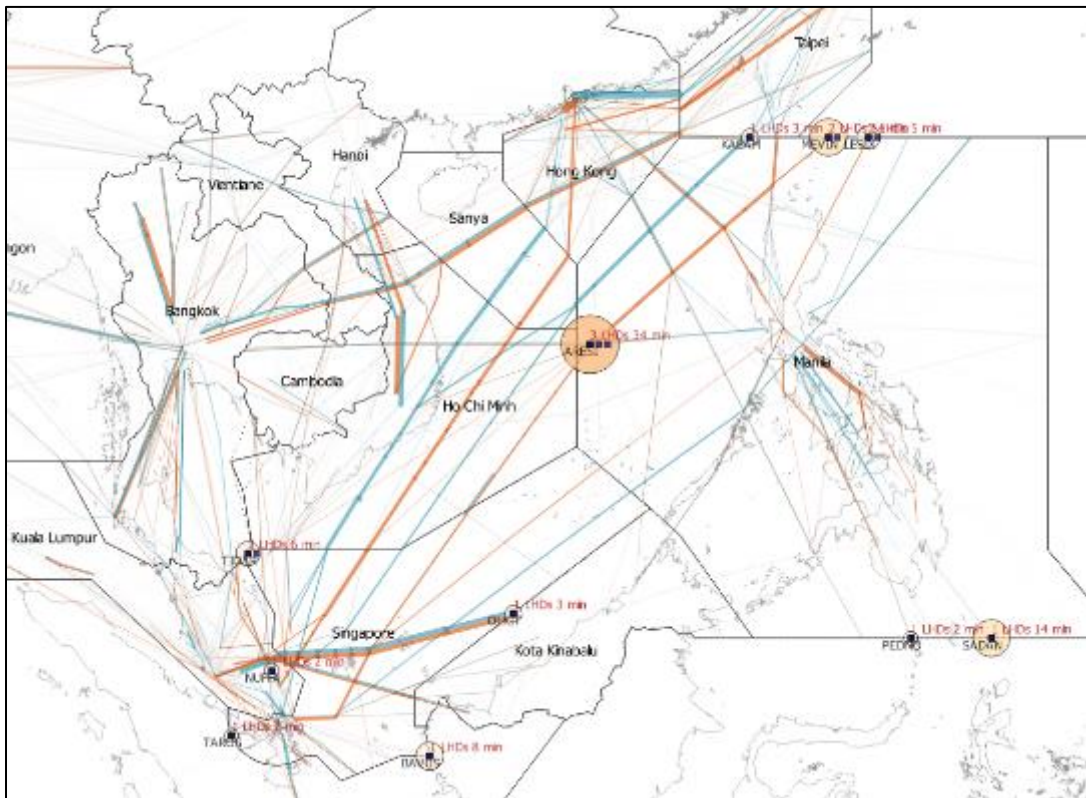


Figure 8: Geographical Locations of 'Non-zero-duration' LHDs in SEA Airspace

LHD Hot Spot identification

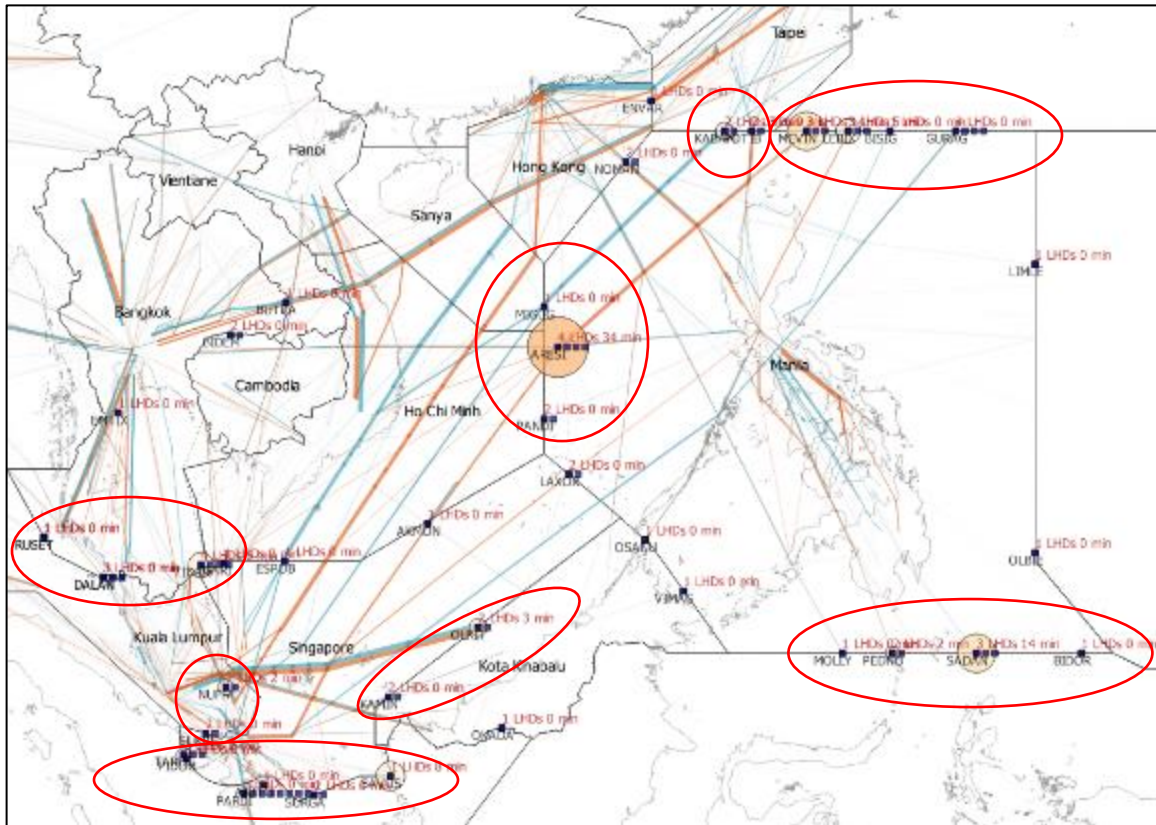


Figure 9: Geographical Locations of **identified LHD clusters** in SEA Airspace

5.2 In RASMAG-MAWG/9, MAAR presented a drafting process of identifying, monitoring and removing APAC hot spots and all monitoring agencies agreed to simulate the process to their safety reports for RASMAG/27. To follow the process of identifying hot spots in SEA airspace, eight (8) LHD clusters are identified as shown in **Figure 9**.

5.3 **Table 6** shows the profile of the LHD clusters in SEA airspace and the determining criteria in 2021. The total number of LHDs was 72. The operational risk was 2.13×10^{-9} FAPFH. As a result, the criteria regarding the number of LHDs is 8.00 (calculated from $72 / [8 + 1]$), the criteria regarding the risk is 0.24×10^{-9} FAPFH (calculated from $2.13 / [8 + 1]$) and the criteria regarding the TLS is 5×10^{-9} FAPFH.

SEA	2021
Number of Clusters	8
Number of LHDs	72
Risk ($\times 10^{-9}$ FAPFH)	2.13
Criteria: Number of LHDs	8.00
Criteria: Risk ($\times 10^{-9}$ FAPFH)	0.24
Criteria: TLS ($\times 10^{-9}$ FAPFH)	5.00

Table 6: The profile of the LHD clusters in SEA airspace and the determining criteria for 2021

5.4 In the process of identifying hot spots, a cluster will be identified as an LHD hot spot if the number of LHDs or operational risk equals to or exceeds at least one of the three criteria . **Table 7**

shows the number of LHDs and the operational risk of each cluster as well as the results of checking against the criteria. A ‘Negative’ result means that the cluster does not satisfy that particular criterion. Conversely, a ‘Positive’ result means that the cluster satisfies that particular criterion and can be identified as a hot spot.

2021 Clusters (SEA)	Manila-Kobe/Fukuoka	Manila-Taibei	Manila-Ho Chi Minh	Manila-Ujung Pandang	Singapore-Jakarta	Bangkok-Kuala Lumpur/Singapore	Kuala Lumpur-Singapore	Singapore-Kota Kinabalu
Number of LHDs	11	4	7	7	16	9	4	4
Check Criteria: Number \geq 8	Positive	Negative	Negative	Negative	Positive	Positive	Negative	Negative
Risk ($\times 10^{-9}$ FAPFH)	0.45	0.07	0.77	0.36	0.23	0.14	0.05	0.04
Check Criteria: Risk $\geq 0.24 \times 10^{-9}$ FAPFH	Positive	Negative	Positive	Positive	Negative	Negative	Negative	Negative
Check Criteria: Risk \geq TLS	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Table 7: The results of identifying hot spots in SEA Airspace

5.5 According to the result in **Table 7**, the following clusters satisfy the hot spot criteria:

- Manila-Kobe/Fukuoka boundary (Hot Spot D);
- Manila-Ho Chi Minh boundary (Hot Spot D);
- Manila-Ujung Pandang boundary (Hot Spot D);
- Singapore-Jakarta boundary (Hot Spot J); and
- Bangkok-Kuala Lumpur/Singapore boundary.

5.6 In the process of identifying hot spots, Hot Spot D (Manila FIR boundaries) was broken down into 4 clusters. Out of the 4 clusters, 3 clusters satisfy the hot spot criteria. Some boundaries such as Manila-Singapore boundary had a small number of LHDs and the operational risk was 0×10^{-9} FAPFH, thus it was not considered as a cluster.

5.7 This new process also identifies the LHD clusters at the Singapore-Jakarta FIR boundary and the Bangkok-Kuala Lumpur/Singapore FIR boundary as potential new hot spots from the relatively big number of reported LHDs.

LHD Hot Spot D (Manila)

5.8 **Figure 10** depicts the geolocation of the number of LHDs and operational risk along Manila FIR boundaries from 2019 to 2021. Due to the spread of the COVID-19 pandemic, the traffic movement in 2020 dramatically decreased from 2019 as indicated by the thinner turquoise and orange lines. However, the traffic movement in 2021 slightly increased from 2020 as the turquoise and orange lines were a little thicker.

5.9 **Table 8** summarizes the number of LHDs, the number of non-zero-duration LHDs and the associated operational risk along Manila FIR boundaries in 2019, 2020 and 2021. In 2021, the number of LHDs along Manila FIR boundaries increased from 24 in 2020 to 37 in 2021, accounting for approximately half of the number of LHDs in SEA airspace. The operational risk also increased from 1.05×10^{-9} FAPFH in 2020 to 1.65×10^{-9} FAPFH in 2021, accounting for 78% of the total operational risk in SEA airspace. Similar to the previous years, the majority of the reported LHDs and the operational risk of the SEA airspace still remained along Manila FIR boundaries.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Manila-Kobe/Fukuoka	15	5	11	1	2	4	1.36	0.49	0.45
Manila-Ho Chi Minh	20	4	7	0	0	3	0	0	0.77
Manila-Hong Kong	17	5	2	0	2	0	0	0.19	0
Manila-Kota Kinabalu	11	2	2	3	1	0	0.08	0.37	0
Manila-Sanya	0	2	0	0	0	0	0	0	0
Manila-Singapore	17	3	2	5	0	0	0.28	0	0
Manila Taipei	16	3	4	0	0	1	0	0	0.07
Manila-Ujung Pandang	3	0	7	1	0	2	0.02	0	0.36
Manila-Oakland	0	0	2	0	0	0	0	0	0
Total	99	24	37	10	5	10	1.74	1.05	1.65

Table 8: The number of LHDs, non-zero-duration LHDs and operational risk in 2019, 2020 and 2021 along Manila FIR boundaries.

5.10 The total operational risk in 2021 was almost comparable to the normal traffic situation in 2019. The significant increase in the number of LHDs and the high operational risk were at the Manila FIR boundaries interfacing with Fukuoka, Ho Chi Minh and Ujung Pandang FIRs. All of the 4 high-risk LHDs mentioned in Section 4 were at Hot Spot D: two were reported at the Manila-Fukuoka FIR boundary, one at the Manila-Ho Chi Minh FIR boundary and another one at the Manila-Ujung Pandang FIR boundary.

5.11 Several of safety improvement activities led to a significant decrease in the number of LHDs and operational risk since 2018 as shown in **Figure 11**. With the commission of the new ATM system at Manila ATMC, Manila ACC can be partitioned into 9 sectors from the previous limit of 4 sectors. The surveillance capability is enhanced to cover the whole FIR and beyond their boundaries with 10 new radar sites. ADS-C/CPDLC is successfully integrated in the controller’s workstations and covered the whole oceanic airspace as shown in **Table 9**.

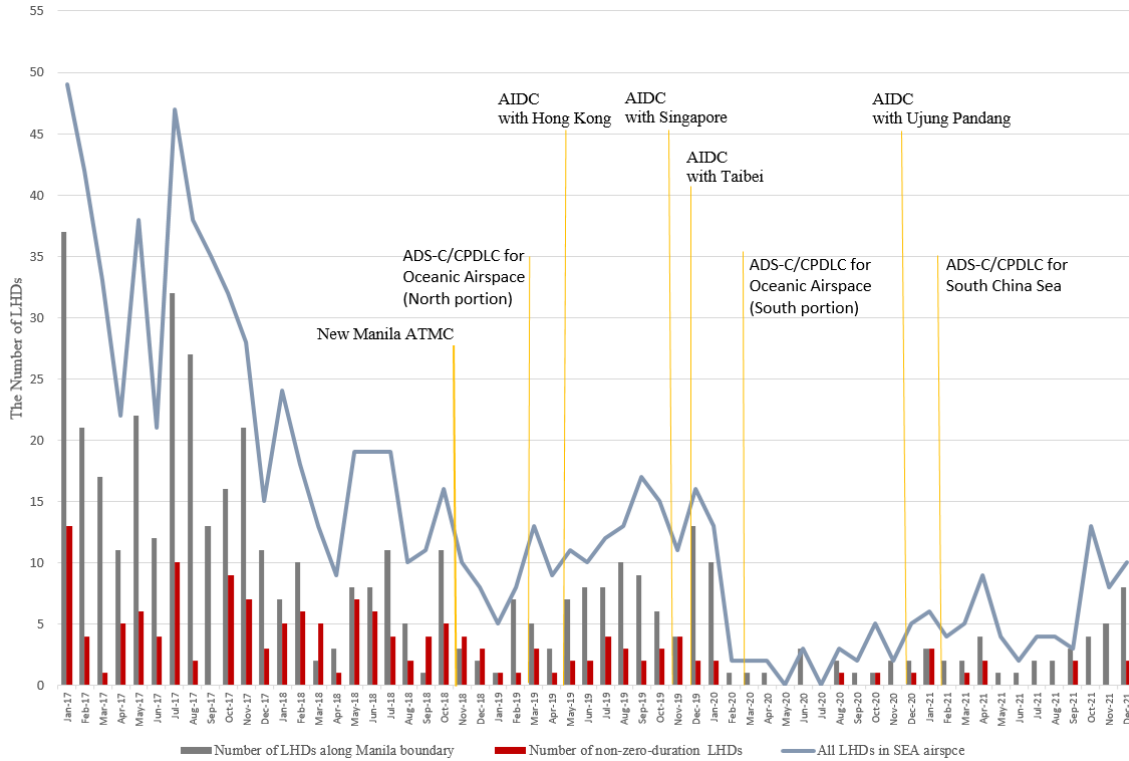


Figure 11: Number of LHDs and non-zero-duration LHDs along Manila Boundary Compared to all LHDs in SEA from 2017 to 2021.

Area with ADS-C/CPDLC Capability	ADS-C/CPDLC Implementation Status
The north portion of West Pacific Oceanic Airspace (Category R)	Implemented since March 2019
The south portion of West Pacific Oceanic Airspace (Category R)	Implemented since March 2020
The South China Sea Category R Airspace	Implemented since February 2021

Table 9: Status of ADS-C/CPDLC in the Manila FIR

5.12 **Table 10** shows the AIDC implementation status between Manila ACC and the adjacent units. Manila ACC successfully implemented AIDC with Hong Kong, Singapore and Taipei in 2019. The number of LHDs and the operational risk at these boundaries decreased in 2020 and 2021. Manila ACC also completed AIDC integration with Ujung Pandang ACC in December 2020. However, the number of LHDs and the operational risk at Manila-Ujung Pandang boundary still increased in 2021. At Manila-Ujung Pandang boundary, 7 LHDs were classified as Category E and the other 2 LHDs were Category F, caused by the AIDC error. The AIDC implementation between Manila ACC and other adjacent units are planned as detailed in **Table 10**.

ATS Units Adjacent to Manila ACC	AIDC Implementation Status
Hong Kong ACC	Implemented since May 2019
Singapore ACC	Implemented since November 2019
Taipei ACC	Implemented since December 2019
Ujung Pandang ACC	Implemented since December 2020
Ho Chi Minh ACC	Technical test in November 2021
Oakland ARTCC	Technical test in November 2021
Kota Kinabalu ACC	Awaiting the time table of Kota Kinabalu
Kobe/Fukuoka ACC	Initiated correspondence, awaiting response
Japan ATMC	Initiated correspondence, awaiting response

Table 10: Status of AIDC Implementation with Manila FIR

5.13 Regarding the process of identifying hot spots, this is the first time that the LHDs along Manila FIR boundaries are broken up into different clusters. In 2021, the LHD clusters at Manila FIR boundary interfacing with Kobe/Fukuoka, Ho Chi Minh, and Ujung Pandang satisfy the hot spot criteria, while the other interfaces do not. MAAR suggests to keep watch all Manila FIR boundaries (Hot Spot D) and maintain it on the LHD Hot Spot list because some mitigations still remain. The spikes in the number of LHDs and operational risk in 2021 particularly at Manila-Fukuoka, Manila-Ho Chi Minh and Manila-Ujung Pandang boundaries also need to be monitored.

LHD Hot Spot J (Singapore-Jakarta boundary)

5.14 In 2021, there were 16 LHD reports at the boundary between Singapore and Jakarta FIR. Out of 16 LHDs, there were 8 LHDs reported at PARDI waypoint. The operational risk at this boundary was of 0.23×10^{-9} FAPFH, accounting for 11% of the operational risk in SEA airspace, caused by 2 non-zero-duration LHDs. And all LHDs at this boundary were in Category E.

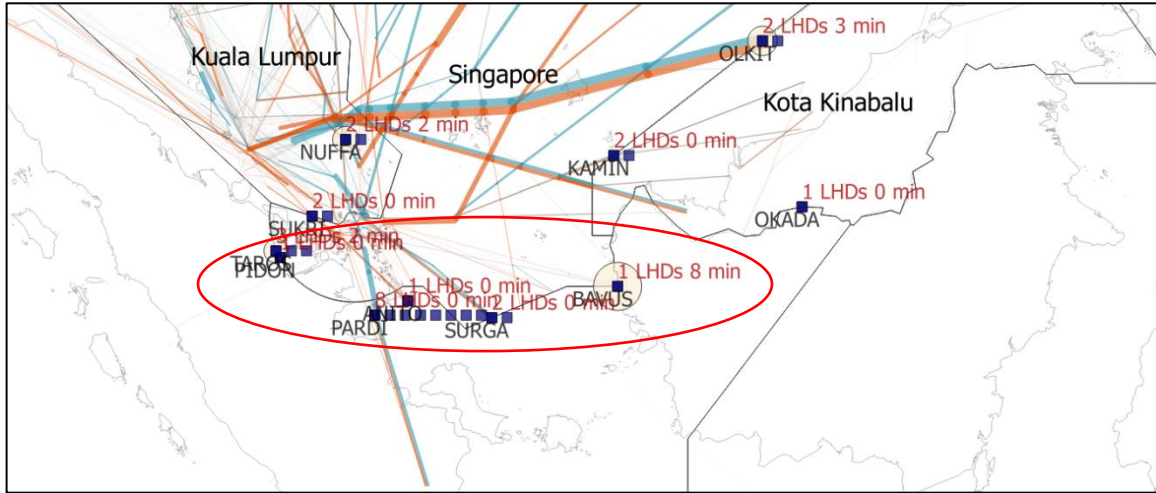


Figure 12: The Visualization of LHDs and operation risk at the boundary between Singapore and Jakarta FIR in 2021.

5.15 As detailed in the final report of ACSICG/9, Singapore ACC and Jakarta ACC indicated their plan to implement AIDC at this boundary. The technical trials would be initiated once the Jakarta ACC ATMS renewal is completed.

5.16 Regarding the process of identifying hot spots, the number of LHDs at this boundary was significantly higher than the criteria in terms of the number of LHDs. Even though the operational risk was below the hot spot criteria, the increase in the number of LHDs at this boundary should be managed in order to reduce the workload on the controllers. Therefore, the boundary between Singapore FIR and Jakarta FIR should remain on the hot spot list.

Bangkok- Kuala Lumpur/Singapore boundary

5.17 In 2021, there were 9 LHD reports at the boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR. 2 non-zero duration LHDs resulted in the operational risk of 0.14×10^{-9} FAPFH, accounting for 7 % of the operational risk in SEA airspace. The number of LHDs at this boundary was relatively high for the past 3 consecutive years: 13 LHDs in 2019, 9 LHDs in 2020 and 9 LHDs in 2021.

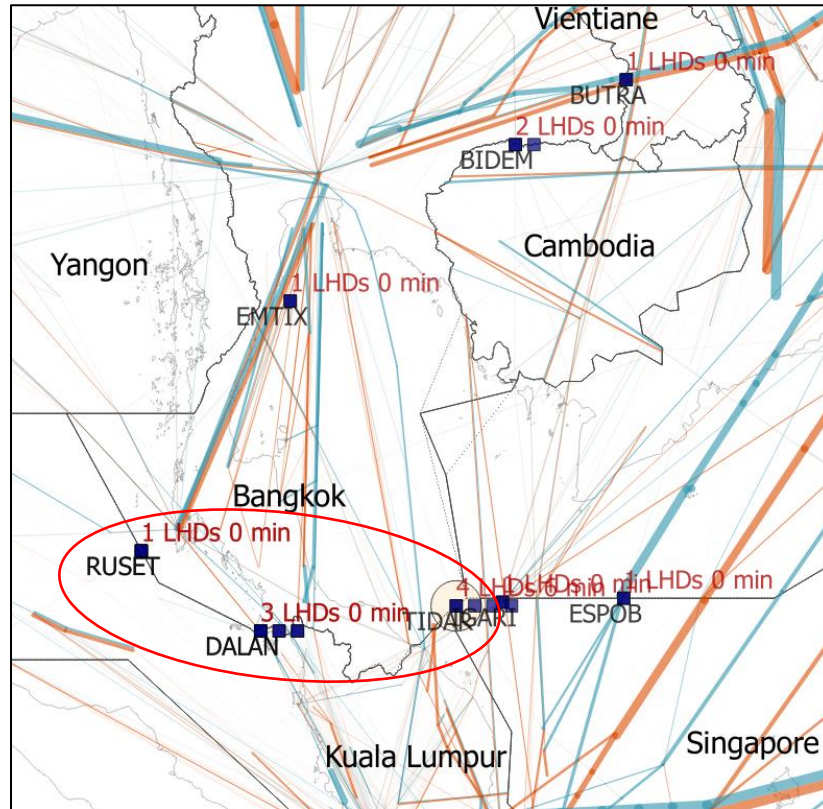


Figure 13: The Visualization of LHDs and operation risk at the boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR.

5.18 Regarding the process of identifying hot spots, the LHD cluster at the Bangkok FIR boundaries interfacing with Kuala Lumpur FIR and Singapore FIR satisfies the hot spot criteria in terms of the number of LHDs in 2021. This area is proposed to be included on the hot spot list for monitoring.

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

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
2/1/2021	UOF		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/1/2021	UOF		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/1/2021	UOF	FL320	FL280	0	E	NO OR LATE FL REVISION
30/1/2021	VCG	FL390	FL400	2	E	NO OR LATE FL REVISION
6/1/2021	VCG			4	E	NO OR LATE ESTIMATE TIME REVISION
19/1/2021	VCG	FL350	FL370	1	E	NO OR LATE FL REVISION
9/2/2021	UOF	FL302	FL302	0	E	NO OR LATE ESTIMATE TIME REVISION
26/2/2021	UOF	FL360	FL360	0	E	NO OR LATE ESTIMATE TIME REVISION
1/2/2021	VCG	FL320	FL350	0	E	NO OR LATE FL REVISION
19/2/2021	VCG	FL390	FL410	0	E	NO OR LATE FL REVISION
2/3/2021	UOF		FL340	2	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/3/2021	UOF	FL400	FL300	0	E	NO OR LATE FL REVISION
16/3/2021	UOF	FL410	FL370	0	I	None
30/3/2021	VCG	FL380	FL380	2	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/3/2021	VCG	FL390	FL410	0	E	NO OR LATE FL REVISION
28/4/2021	GYN		FL321	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/4/2021	GYN		FL280	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/4/2021	UOF	FL380	FL371	0	E	NO OR LATE FL REVISION
30/4/2021	UOF	FL369	FL360	0	E	NO OR LATE ESTIMATE TIME REVISION
11/4/2021	VCG	FL360	FL360	10	E	NO OR LATE ESTIMATE TIME REVISION
13/4/2021	VCG	FL330	FL330	19	E	NO OR LATE ESTIMATE TIME REVISION
28/4/2021	GYN		FL321	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/5/2021	UOF	FL360	FL350	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
10/5/2021	UOF	FL360	FL350	0	E	NO OR LATE FL REVISION
20/5/2021	UOF		FL419	5	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/5/2021	VCG			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/6/2021	UOF		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/6/2021	VCG	FL380	FL380	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/7/2021	UOF	FL340	FL380	0	E	NO OR LATE FL REVISION
26/7/2021	UOF	FL350	FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
23/7/2021	VCG	FL390	FL400	0	E	NO OR LATE FL REVISION
1/8/2021	UOF		FL320	8	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/8/2021	UOF	FL300	FL340	3	E	NO OR LATE FL REVISION
23/7/2021	UOF	FL390	FL400	0	E	NO OR LATE FL REVISION
28/8/2021	PXO	FL390	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/8/2021	VCG	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
24/9/2021	VCG	FL390	FL360	0	E	NO OR LATE FL REVISION
17/9/2021	VCG	FL350	FL370	4	E	NO OR LATE FL REVISION
13/10/2021	XMK	FL320	FL360	0	E	NO OR LATE FL REVISION
12/10/2021	UOF	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
12/10/2021	UOF		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
13/10/2021	UOF		FL370	2	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
13/10/2021	UOF		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
20/10/2021	UOF	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
22/10/2021	UOF	FL330	FL350	1	E	NO OR LATE FL REVISION
28/10/2021	UOF		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
28/10/2021	UOF		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/10/2021	VCG	FL360	FL350	0	B	NO OR LATE FL REVISION
13/10/2021	VCG	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
27/10/2021	XMK	FL350	FL390	0	E	NO OR LATE FL REVISION
5/4/2021	HIB	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/4/2021	HIB	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/11/2021	UOF		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/12/2021	UOF	FL410	FL400	0	E	NO OR LATE FL REVISION
23/12/2021	UOF		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
9/11/2021	GYN	FL350	FL350	0	J	None
3/11/2021	VCG	FL380	FL360	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
11/11/2021	VCG	FL380	FL380	0	F	No AIDC TRANSFER PASSED DUE TO EQUIPMENT OUTAGE OR TECHNICAL ISSUE.
8/11/2021	VCG	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
15/11/2021	VCG		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/11/2021	VCG		FL370	0	F	No AIDC TRANSFER PASSED DUE TO EQUIPMENT OUTAGE OR TECHNICAL ISSUE.
6/12/2021	VCG	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/12/2021	VCG	FL340	FL340	14	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
13/12/2021	VCG	FL410	FL410	0	F	No AIDC TRANSFER PASSED DUE TO EQUIPMENT OUTAGE OR TECHNICAL ISSUE.
7/12/2021	VCG	FL430	FL430	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
11/12/2021	VCG	FL340	FL340	0	F	No AIDC TRANSFER PASSED DUE TO EQUIPMENT OUTAGE OR TEHNICAL ISSUE.
14/12/2021	VCG	FL330	FL330	13	E	NO OR LATE ESTIMATE TIME REVISION
27/12/2021	VCG	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
19/12/2021	VCG	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
24/9/2021	NDL	FL390	FL360	3	E	NO OR LATE FL REVISION
23/10/2021	NDL	FL390	FL390	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
1/11/2021	NDL	FL330	FL330	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR

MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2021 to December 2021

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE MONGOLIAN AIRSPACE**

Assessment Period: January 2021 to December 2021

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

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **Mongolian Airspace**. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2021** and monthly Large Height Deviation (LHD) reports between **January 2021** and **December 2021** submitted by Mongolia.

2. Data Sources

2.1. **Traffic Sample Data (TSD)**. A TSD covering the month of December 2021 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 covers January 2021 to December 2021. **Table 1** indicates the months in which Ulaanbaatar FIR submitted LHD reports including NIL 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 2021

3. Summary of LHD Occurrences

3.1. **Table 2** and **Table 3** summarize the number of LHDs, the associated LHD duration (in minutes), number of flight levels crossed, and their associated operational risk from January 2021 to December 2021 by month and by LHD category, respectively.

Month (2021)	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	0	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	1	0	0	0	0

Table 2: Summary of LHD by Month for Mongolian 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	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).	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)
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	0	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
M	Other	0	0	0	0	0
Total		1	0	0	0	0

Table 3: Summary of LHD by Category for Mongolian Airspace

3.2. In 2021, there was one Category E LHD submitted by Ulaanbaatar FIR. The LHD was zero-duration and zero operational risk.

4. Risk Assessment and Safety Oversight

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

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	116,946	4,675	Hour	Dec 2021 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.3134/ 0.0005	0.0000	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.1478	0.0715	-	
λ_x	Average aircraft length	0.0342	0.0336	NM	
λ_y	Average aircraft wingspan	0.0316	0.0309	NM	
λ_z	Average aircraft height	0.0092	0.0091	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0342	0.0367	NM	
$P_z(0)$	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	More conservative value used in previous assessments
$ \overline{\Delta V} $	Average relative along-track speed between aircraft on same direction routes	21.44	0.00	Knot	Dec 2021 TSD NOTE : $ \overline{\Delta V} $ was calculated based on relative speed of proximate pair on each route type. For uni-dir route, there was no proximate pair.
$ \overline{V} $	Average absolute aircraft ground speed	480	480	Knot	More conservative value used in previous assessments

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

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. **The technical risk**, 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 2.5×10^{-9} FAPFH. **The total risk** is 0.81×10^{-9} FAPFH, which also **meets the specified TLS** value for these components of 5.0×10^{-9} FAPFH.

Mongolian RVSM Airspace – estimated annual flying hours = 121,621 hours <i>(note: estimated hours based on December 2021 traffic sample data)</i>			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.81×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	0.81×10^{-9}	5.0×10^{-9}	Below Overall TLS

Table 5: Risk Estimates for Mongolian Airspace

5. Analysis of Operational Errors

There was one LHD reported in Mongolian Airspace. The LHD was the negative transfer from Irkutsk ACC. However, Mongolian ATC detected the aircraft before crossing the transfer of control point. Hence, this LHD contributed to zero operational risk. The hot spot identification process was not needed.