International Civil Aviation Organization

Twenty-Ninth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/29)

Bangkok, Thailand, 19 – 22 August 2024

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

MAAR VERTICAL SAFETY REPORT

(Presented by Monitoring Agency for Asia Region)

SUMMARY

This paper presents the results of the 2023 airspace safety oversight for Reduced Vertical Separation Minimum (RVSM) operations in the South Asia/Indian Ocean (SA/IO) region, 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 the South Asia/ Indian Ocean (SA/IO) Airspace, Southeast Asia (SEA) Airspace, and Mongolian Airspace. The full reports of SA/IO, SEA, and Mongolian Airspace are provided in the Attachment. Each report contains:

a) Traffic Sample Data (TSD) and Large Height Deviation (LHD) reports used in risk estimation;

b) summary of LHD occurrences and their associated risk;

c) risk estimation parameters and results;

d) further discussion including geographical location of LHDs, the identification of hot spots; and

e) the hot spot analysis.

2. DISCUSSION

Executive Summary: SA/IO Airspace

2.1 **Table 1** summarizes the vertical collision technical, operational, and total risk estimates in the SA/IO airspace. **Figure 1** presents the risk trends during the period from January 2023 to December 2023.

Table 1: Vertical Collision Risk Estimates for SA/IO Airspace

SA/IO Airspace – estimated annual flying hours = 2,642,401 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 Total Risk	*1.75×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Technical Risk	0.65×10^{-9}	2.5×10^{-9}	Below Technical TLS

SA/IO Airspace – estimated annual flying hours = 2,642,401 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Operational Risk	3.40×10^{-9}	-	-
Total Risk	**4.05×10^{-9}**	5.0×10^{-9}	**Below TLS**

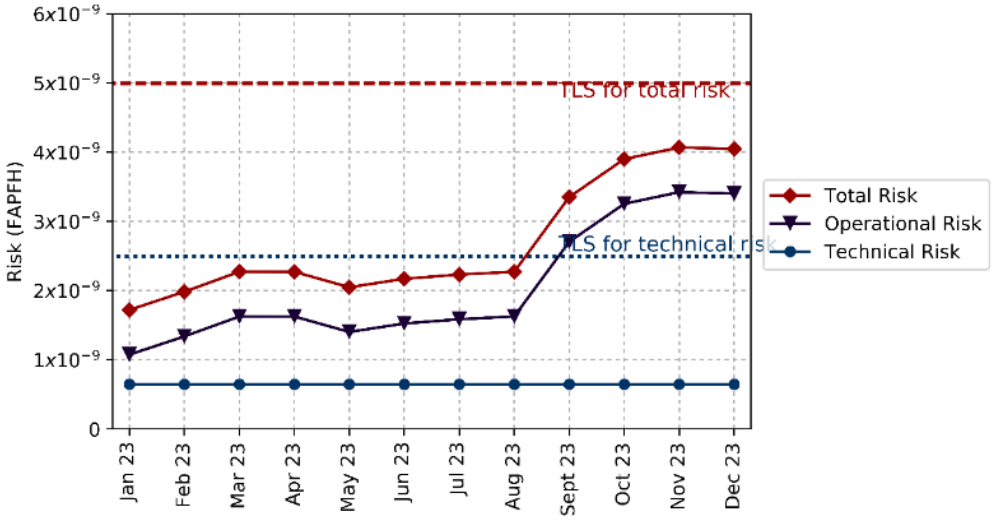


Figure 1: Trends of Risk Estimates for SA/IO Airspace

2.2 **Table 2** presents a summary of the LHD causes in SA/IO airspace from January 2023 until December 2023.

Table 2: Summary of LHD by Categories within SA/IO Airspace

Code	LHD Category Description	No.
A	Flight crew fails to climb or descend the aircraft as cleared	0
B	Flight crew climbing or descending without ATC clearance	0
C	Incorrect operation or interpretation of airborne equipment	1
D	ATC system loop error	4
E	Coordination errors in the ATC -to-ATC transfer of control responsibility as a result of human factors issues	248
F	ATC transfer of control coordination errors due to technical issues	0
G	Aircraft contingency leading to sudden inability to maintain level	0
H	Airborne equipment failure and unintentional or undetected level change	0
I	Turbulence or other weather related cause leading to unintentional or undetected change of flight level	0
J	TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory	1
K	TCAS resolution advisory; flight crew incorrectly climb or descend following the resolution advisory	0
L	An aircraft being provided with RVSM separation is not RVSM approved	0
M	Others	0
Total		254

2.3 **Figure 2** provides the geographic location of 'Non-zero-duration' LHD reports within SA/IO Airspace during the assessment period.

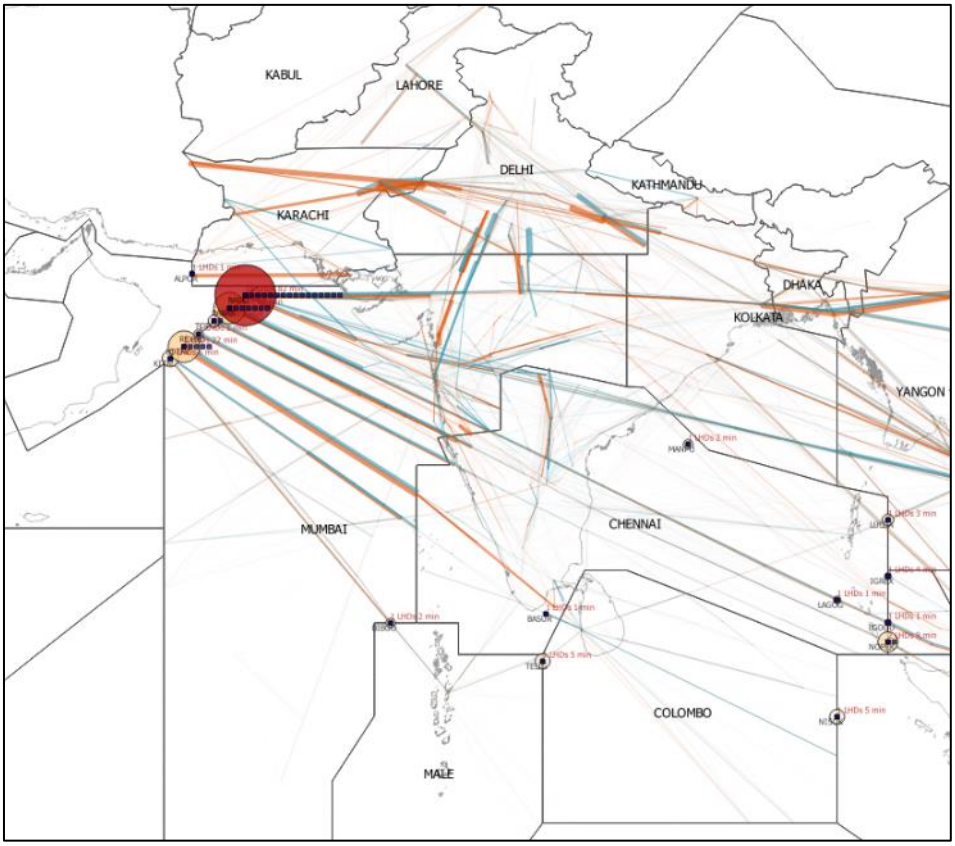


Figure 2: Geographic Locations of **Non-Zero-Duration LHDs** in SA/IO Airspace

2.4 According to the process of identifying hot spots, **Table 3** shows the number of LHDs and operational risk of each cluster, as well as the results of checking against the criteria in SA/IO Airspace.

Table 3: Results of Identifying Hot Spots in SA/IO Airspace

2023 Clusters (SA/IO)	**Mumbai-Muscat (Hot Spot G)**	**Mogadishu-Mumbai (Hot Spot F)**	**Chennai/Kolkata-Yangon (Hot Spot A1)**	**Chennai-Kuala Lumpur (Hot Spot A2)**	**Chennai-Colombo**	**Jakarta-Colombo**	**Karachi-Muscat**
Number of LHDs	138	10	26	13	14	8	10
Check Criteria: Number >= 31.75	Positive	Negative	Negative	Negative	Negative	Negative	Negative
Operational Risk (x 10^{-9} FAPFH)	2.79	0.00	0.06	0.22	0.03	0.10	0.01
Check Criteria: Risk >= 0.43 x 10^{-9} FAPFH	Positive	Negative	Negative	Negative	Negative	Negative	Negative
Check Criteria: Operation Risk	Negative	Negative	Negative	Negative	Negative	Negative	Negative

2023 Clusters (SA/IO)	Mumbai-Muscat (Hot Spot G)	Mogadishu-Mumbai (Hot Spot F)	Chennai/Kolkata-Yangon (Hot Spot A1)	Chennai-Kuala Lumpur (Hot Spot A2)	Chennai-Colombo	Jakarta-Colombo	Karachi-Muscat
>= 5.00 x 10^{-9} FAPFH							

2.5 Regarding the result in **Table 3**, the Mumbai-Muscat boundary (Hotspot G) satisfies both hot spot criteria in 2023.

2.6 On the other hand, the following boundaries are listed as LHD hot spots but do not satisfy the hot spot criteria in 2023:

a) Mogadishu-Mumbai FIR boundary (Hotspot F);

b) Chennai/Kolkata-Yangon FIR boundary (Hot Spot A1); and

c) Chennai- Kuala Lumpur FIR boundary (Hot Spot A2).

2.7 **LHD Hot Spot G (Mumbai – Muscat/Sanaa) and F (Mogadishu – Mumbai)** were identified as LHD hot spot in 2015. **Table 4** summarizes the number of LHDs, the number of non-zero-duration LHDs, and the operational risk at the western boundaries of the Mumbai FIR from 2021 to 2023. **Figure 3** shows the geographic locations of non-zero-duration LHDs and operation risk at these boundaries from 2021 to 2023.

Table 4: Comparison of the Number of LHDs, the Number of Non-Zero-Duration LHDs and Operational Risk at the Western Boundaries of Mumbai FIR from 2021 to 2023

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Mumbai-Muscat	44	43	138	17	10	32	1.35	0.79	2.79
Mumbai-Sanaa	4	2	3	1	0	0	0.07	0.00	0.00
Mumbai-Mogadishu	5	9	10	1	1	0	0.12	0.02	0.00
Total	**53**	**54**	**151**	**19**	**11**	**32**	**1.54**	**0.81**	**2.79**

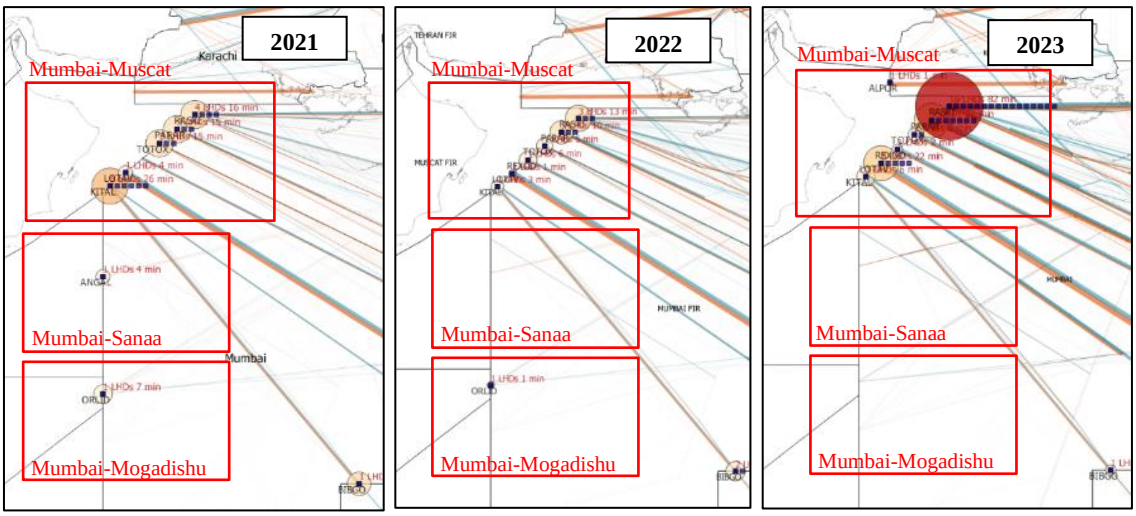


Figure 3: Geographic Locations of Non-Zero-Duration LHDs and Operation Risk at the Western Boundaries of Mumbai FIR from 2021 to 2023

2.8 At the Mumbai-Muscat FIR boundary, the number of LHDs, the number of non-zero-duration LHDs, and the operational risk significantly increased from 2021 to 2023. The 138 LHDs in 2023, 54% of the total number of LHDs in SA/IO Airspace, represent a noticeable climb from to 44 in 2021 and 43 in 2020. Similarly, the number of non-zero-duration LHDs increased from 17 in 2021 and 10 in 2022 to 32 in 2023. In addition, the operational risk, at 2.79 x 10^{-9} FAPFH, accounts for 82% of the operational risk in SA/IO Airspace.

2.9 The number of LHDs in 2023 nearly reached the 143 LHDs recorded in 2019, a year with high traffic levels before the significant reduction during the COVID-19 pandemic. However, the operational risk in 2023 was relatively small compared to 2019, at 24.71 x 10^{-9} FAPFH.

2.10 At the Mumbai-Sanaa and Mogadishu-Mumbai FIR boundaries, the number of LHDs remained similar to the number recorded in 2022 while the number of non-zero-duration LHDs and the operational risk decreased to 0 in 2023.

2.11 Considering the causes of LHDs at these three boundaries, the majority of LHDs were in Category E, similar to the overall picture in the SA/IO Airspace. The most frequent sub-categories were “No or Late FL revision”.

2.12 An increase in the number of LHDs with low level of operational risk and the causes of Category E reflects that coordination errors between the ATS units continue to occur, but these errors have been detected or solved in a short period of time. This is supported by the implementation of Space-Based ADS-B in February 2020, which enhances the surveillance capability. The enhanced surveillance allows controllers to detect LHDs beyond the Transfer of Control (TOC) point, particularly oceanic airspace. Consequently, the duration of LHDs and operational risk decreased significantly starting in 2020.

2.13 To improve the efficiency of coordination and transfer of control between ATS units, which is the cause of LHD Category E, the ATS Inter-Facility Data Communication (AIDC) has been promoted in APAC region. Consequently, the AIDC implementation between Mumbai ACC and Muscat ACC, as well as between Mumbai ACC and Mogadishu ACC, has been initiated. However, the implementation remained in the testing phase, as indicated in the WP/10 of the Eleventh Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/11), held in March 2024.

2.14 In the process of identifying hot spot, the Mumbai-Muscat FIR boundary (Hot Spot G) continues to meet the hot spot criteria in terms of the number of LHDs and the operational risk. In contrast, the Mumbai-Sanaa FIR boundary (Hot Spot G) and Mogadishu-Mumbai FIR boundary (Hot Spot F) have not satisfied any criteria since 2021. However, the AIDC implementation has not been completed yet. Therefore, the western Boundary of Mumbai FIR (Hot Spot G and F) should remain as hotspots and continue to be monitored until further safety improvement initiatives or prevention measures, such as AIDC, are completed and demonstrate their effectiveness.

2.15 **LHD Hot Spot A1 (Chennai/Dhaka/Kolkata - Yangon) and A2 (Chennai – Kuala Lumpur)** were first identified as LHD hot spots in 2015. **Table 5** summarizes the number of LHDs, the number of non-zero-duration LHDs, and the operational risk at Hot Spot A1 and A2 from 2021 to 2023. **Figure 4** shows the geographic locations of non-zero-duration LHDs and operation risk at these boundaries from 2021 to 2023.

Table 5: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and A2 from 2021 to 2023

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Kolkata-Yangon	1	17	11	0	0	0	0.00	0.00	0.00
Chennai-Yangon	8	23	15	0	1	1	0.00	0.02	0.06
Chennai-Kuala Lumpur	21	22	13	1	0	4	0.05	0.00	0.23
Total	**30**	**62**	**39**	**1**	**1**	**5**	**0.05**	**0.02**	**0.29**

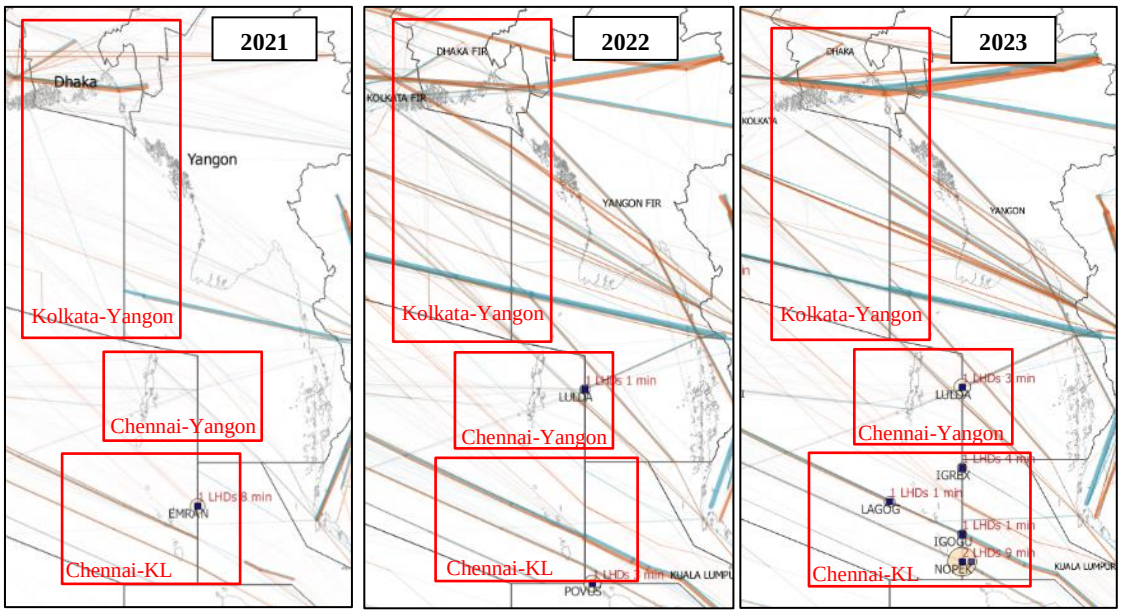


Figure 4: Geographic locations of non-zero-duration LHDs and operation risk at Hot Spot A1 and A2 from 2021 to 2023.

2.16 At the Kolkata-Yangon and Chennai-Yangon FIR boundaries (Hot Spot A1), the number of LHDs decreased from 40 in 2022 to 26 in 2023. All LHDs at these boundaries belonged to Category E. At these two boundaries, there was only one non-zero-duration LHDs, contributed to 0.06 x 10^{-9} FAPFH.

2.17 Considering the results from the process of identifying hot spots, the Kolkata-Yangon and Chennai-Yangon FIR boundaries (Hot Spot A1) did not meet any hot spot identification criteria in 2023. Additionally, The AIDC between Kolkata ACC and Yangon ACC, as well as between Chennai ACC and Yangon ACC, were initiated but remained in the testing phase and have not yet been operated, as mentioned in WP/10 of ACSICG/11. Therefore, Hot Spot A1 should remain on the hot spot list and be monitored until further safety improvement initiatives (specifically AIDC) are implemented and successfully reduce the number of LHDs and the associated risks.

2.18 At Chennai-Kuala Lumpur FIR boundary (Hot Spot A2), the number of LHDs decreased from 22 in 2022 to 13 in 2023. All LHDs were also in Category E. However, the non-zero-duration LHDs significantly increased from 0 in 2022 to 5 in 2023. This led to an increase in operational risk, reaching 0.23 x 10^{-9} FAPFH.

2.19 Considering the results from the process of identifying hot spots, the Chennai-Kuala Lumpur FIR boundary (Hot Spot A2), Hot Spot A2 did not meet the hot spot identification criteria for two consecutive years. Additionally, safety improvement initiatives, including enhanced surveillance by Indian Space-Based ADS-B and the implementation of AIDC between Chennai ACC and Kuala Lumpur ACC, have been successfully operated. Hence, Hot Spot A2 is proposed for removal from the hot spot list.

Executive Summary: SEA Airspace

2.20 **Table 6** summarizes the vertical collision technical, operational, and total risk estimates in the SEA airspace. **Figure 5** presents the risk trends for the period from January 2023 to December 2023.

Table 6: Vertical Collision Risk Estimates for SEA Airspace

SEA Airspace – estimated annual flying hours = 2,969,413 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 Total Risk	*1.83 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
Technical Risk	1.07 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	1.84 x 10^{-9}	-	-
Total Risk	**2.91 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

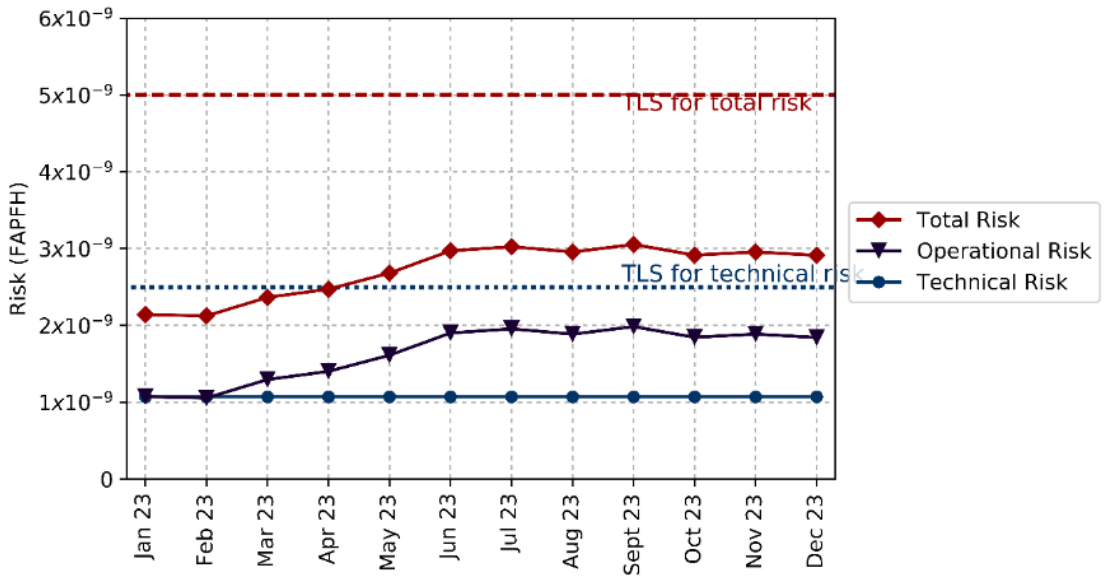


Figure 5: Trends of Risk Estimates for SEA Airspace

2.21 **Table 7** presents a summary of the LHD causes in SEA airspace from January 2023 until December 2023.

Table 7: Summary of LHD Causes within SEA Airspace

Code	LHD Category Description	No.
A	Flight crew fails to climb or descend the aircraft as cleared	0
B	Flight crew climbing or descending without ATC clearance	0
C	Incorrect operation or interpretation of airborne equipment	0
D	ATC system loop error	1
E	Coordination errors in the ATC -to-ATC transfer of control responsibility as a result of human factors issues	85
F	ATC transfer of control coordination errors due to technical issues	6
G	Aircraft contingency leading to sudden inability to maintain level	0
H	Airborne equipment failure and unintentional or undetected level change	0
I	Turbulence or other weather related cause leading to unintentional or undetected change of flight level	2
J	TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory	1
K	TCAS resolution advisory; flight crew incorrectly climb or descend following the resolution advisory	0
L	An aircraft being provided with RVSM separation is not RVSM approved	0
M	Others	0
Total		95

2.22 **Figure 6** provides the geographic location of 'Non-zero-duration' LHD reports within SEA Airspace during the assessment period.

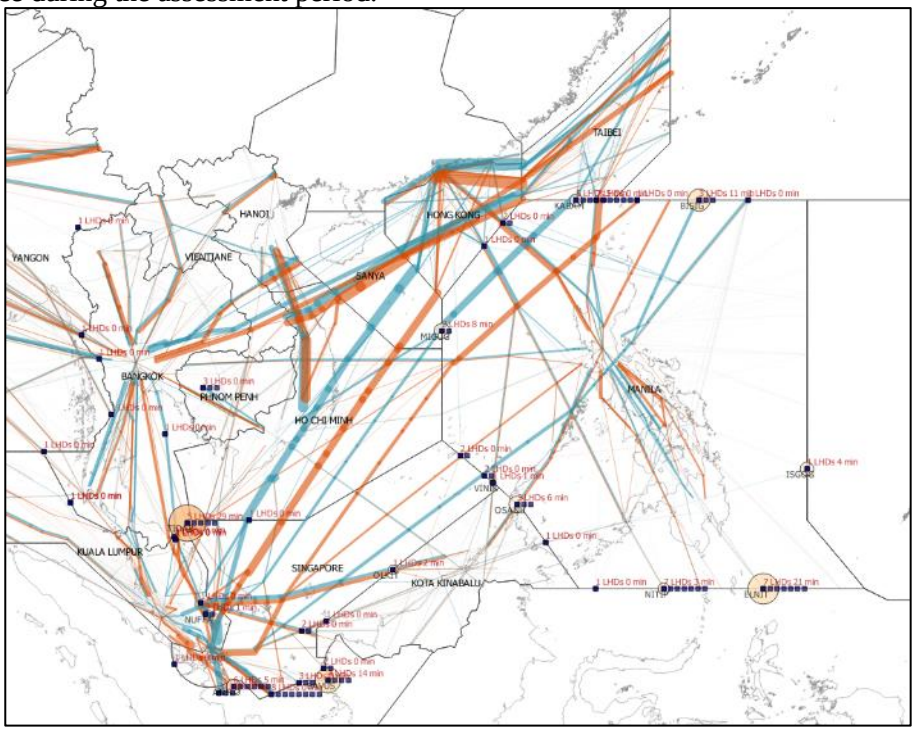


Figure 6: Geographical Locations of **'Non-Zero-Duration' LHDs** in SEA Airspace

2.23 According to the process of identifying hot spots, **Table 8** shows the number of LHDs and operational risk for each cluster, as well as the results of checking against the criteria in SEA Airspace.

Table 8: Results of Identifying Hot Spots in SEA Airspace

2023 Clusters (SEA)	**Bangkok/Ho Chi Minh/ Kuala Lumpur-Singapore (Hot Spot O)**	**Jakarta-Singapore (Hot Spot J)**	**Manila-Taibei (Hot Spot D)**	**Manila-Ujung Pandang (Hot Spot D)**
Number of LHDs	5	27	12	15
Check Criteria: Number >= 19.00	Negative	Positive	Negative	Negative
Operational Risk (x 10^{-9} FAPFH)	0.51	0.33	0.06	0.41
Check Criteria: Operational Risk >= 0.37 x 10^{-9} FAPFH	Positive	Negative	Negative	Positive
Check Criteria: Operational Risk >= 5.00 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative

2.24 According to the result in **Table 8**, the following three (3) clusters satisfy the hot spot criteria:

a) Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore FIR boundaries (Hot Spot O);

b) Jakarta-Singapore FIR boundary (Hot Spot J); and

c) Manila-Ujung Pandang FIR boundary (Hot Spot D).

2.25 On the other hand, the Manila-Taibei FIR boundary is identified as a cluster and is listed as part of Hot Spot D, but it does not meet any hot spot criteria in 2023

2.26 **LHD Hot Spot D (Manila FIR boundaries)** 2015 was identified as LHD hot spots in 2015. **Figure 7** shows the geographic locations of LHDs and operation risk at these boundaries from 2021 to 2023.

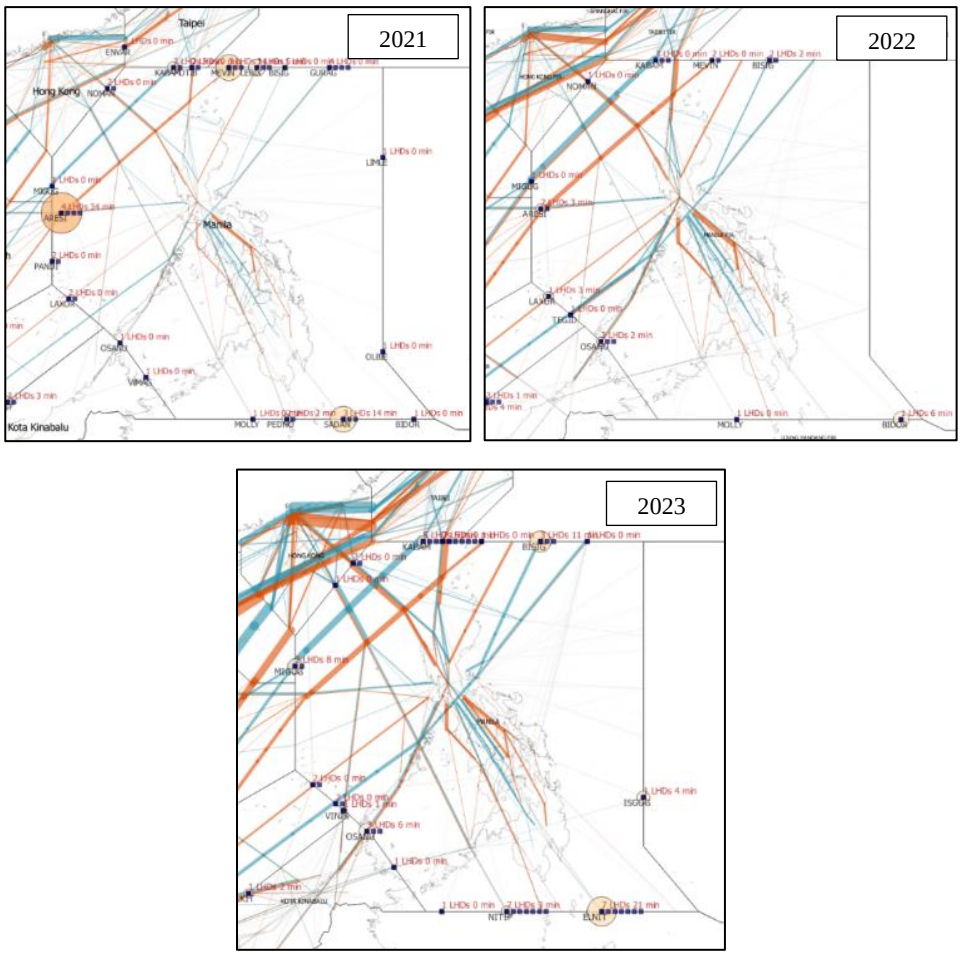


Figure 7: Geographic Locations of LHDs and Operational Risk along Manila FIR Boundaries in 2021, 2022 and 2023

2.27 **Table 9** summarizes the number of LHDs, non-zero-duration LHDs, and associated operational risk along Manila FIR boundaries in 2021, 2022, and 2023.

Table 9: Comparison of the Number of LHDs, Non-Zero-Duration LHDs and Operational Risk along Manila FIR Boundaries from 2021 to 2023

Boundary	**Number of LHDs**			**Number of non-zero-duration LHDs**			**Operational Risk (10^{-9} FAPFH)**		
	2021	**2022**	**2023**	**2021**	**2022**	**2023**	**2021**	**2022**	**2023**
Kobe/Fukuoka-Manila	11	4	4	4	3	2	0.45	0.03	0.19
Ho Chi Minh-Manila	7	3	2	3	2	1	0.77	0.05	0.10
Hong Kong-Manila	2	1	3	0	0	0	0.00	0.00	0.00
Kota Kinabalu-Manila	2	3	5	0	2	2	0.00	0.04	0.13
Manila-Sanya	0	0	0	0	0	0	0.00	0.00	0.00
Manila-Singapore	2	2	4	0	1	0	0.00	0.04	0.00
Manila-Taibei	4	3	12	1	0	1	0.07	0.00	0.06
Manila-Ujung Pandang	7	2	15	2	1	6	0.36	0.11	0.41
Manila-Oakland	2	0	1	0	0	1	0.00	0.00	0.07
Total	**37**	**18**	**46**	**10**	**9**	**13**	**1.65**	**0.27**	**0.96**

2.28 According to **Table 9**, the number of LHDs increased to 46 in 2023, highest over the last three years. The 46 LHDs at Hot Spot D accounted for 48% of the total LHDs in SEA airspace. In addition, the operational risk increased from 0.27 x 10^{-9} FAPFH in 2022 to 0.96 x 10^{-9} FAPFH in 2023. The operational risk at Hot Spot D accounted for 52% of total operational risk in SEA Airspace.

2.29 In 2023, the highest number of LHDs and the highest total operational risk occurred at Manila-Ujung Pandang FIR boundary with 15 LHDs and 0.41 x 10^{-9} FAPFH of the operational risk. Out of 15 LHDs, 10 LHDs were in Category E and 5 LHDs were in Category F. All Category F LHDs were caused by the error from AIDC, leading to the operational risk of 0.17 x 10^{-9} FAPFH.

2.30 According to the decision made by the RASMAG MAWG/11, a hot spot can be subdivided into smaller interfaces between FIR boundaries or ATS sectors, if applicable. Therefore, Hot Spot D is subdivided into nine (9) interfaces as shown in **Figure 8**.

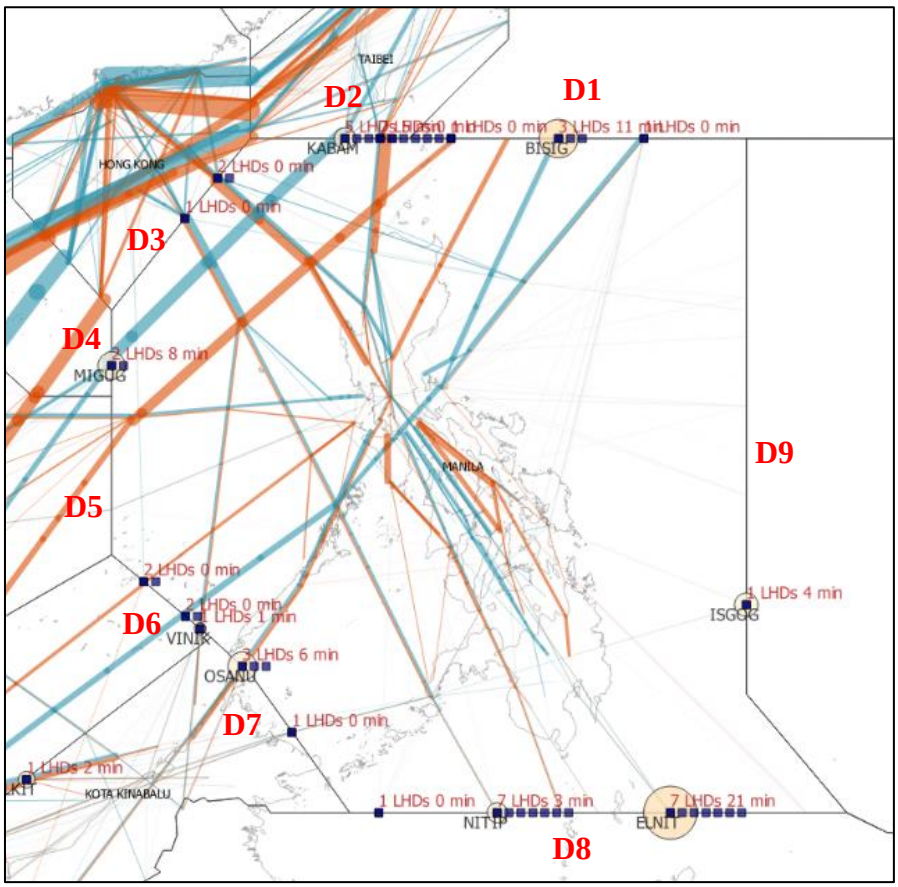


Figure 8: The Subdivision of Hot Spot D

2.31 To analyze these subdivisions, the hot spot identification process was applied to each interface as shown in **Table 10.** Since 2020, four FIR boundaries including Fukuoka-Manila (D1), Ho Chi Minh-Manila (D5), Kota Kinabalu-Manila (D7), and Manila-Ujung Pandang (D8) satisfied the hot spot criteria. However, only the Manila-Ujung Pandang FIR boundary (D8) met the hot spot criteria in the last two years (2022-2023).

Table 10: The result from hot spot identification process for the subdivision of Hot Spot D from 2019 to 2023.

Year	Identification Hot Spot Criteria	D1	D2	D3	D4	D5	D6	D7	D8	D9
2023	Number of LHDs	4	12	3	0	1	4	5	15	1
	Check Number Criteria >= 19.00	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.19	0.06	0.00	0.00	0.10	0.00	0.13	0.41	0.07
	Check Risk Criteria >= 0.37 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Positive	Negative
2022	Number of LHDs	4	3	1	0	3	2	3	2	0
	Check Number Criteria >= 10.50	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.03	0.00	0.00	0.00	0.05	0.04	0.04	0.11	0.00
	Check Risk Criteria >= 0.20 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
2021	Number of LHDs	11	1	2	0	7	1	1	1	2
	Check Number Criteria >= 8.00	Positive	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.45	0.07	0.00	0.00	0.77	0.00	0.00	0.36	0.00
	Check Risk Criteria >= 0.24 x 10^{-9} FAPFH	Positive	Negative	Negative	Negative	Positive	Negative	Negative	Positive	Negative
2020	Number of LHDs	5	3	6	2	4	3	2	0	0
	Check Number Criteria >= 6.50	Negative–	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.49	0.00	0.19	0.00	0.00	0.00	0.37	0.00	0.00
	Check Risk Criteria >= 0.24 x 10^{-9} FAPFH	Positive	Negative	Negative	Negative	Negative	Negative	Positive	Negative	Negative

2.32 Since 2018, the Philippines has promoted safety improvement activities, including implementing a new ATM system, redesigning sectors, enhancing surveillance capabilities, expanding ADS-C/CPDLC coverage to the entire oceanic airspace, conducting safety-related training sessions for controllers, initiating coordination meetings with adjacent ACCs, and implementing AIDC. These efforts support the decrease in LHDs, as noted in RASMAG/27 and RASMAG/28. However, AIDC implementation, which is expected to improve aircraft transfer efficiency across boundaries, is not yet complete with all adjacent ACCs.

2.33 **Table 11** shows the AIDC implementation status between Manila ACC and adjacent units as of August 2024.

Table 11: Status of AIDC Implementation with Manila ACC

ATS Units Adjacent to Manila ACC	AIDC Implementation Status
Hong Kong ACC	Implemented since May 2019
Singapore ACC	Implemented since November 2019
Taibei ACC	Implemented since December 2019
Ujung Pandang ACC	Implemented since December 2020
Oakland ARTCC	Implemented since November 2023
Kota Kinabalu ACC	Trial (April-August 2024)
Ho Chi Minh ACC	Planning
Kobe/Fukuoka ACC	Planning
Japan ATMC	Planning

2.34 Based on the hot spot identification process, analyzed statistics, and existing AIDC implementation, the status of each subdivision of Hot Spot D is as follows:

a) **D1 (Fukuoka and Manila FIR boundary)** should remain on the Hot Spot list because the number of LHDs and operational risk met the 2022 criteria in JASMA's analysis even though it did not met any criteria in MAAR's analysis. The AIDC implementation between Manila ACC and Kobe/Fukuoka ACC has not operated yet.

b) **D2 (Manila and Taibei FIR boundary), D3 (Hong Kong and Manila FIR boundary), D4 (Manila and Sanya FIR boundary), D6 (Manila and Singapore FIR boundary) and D9 (Manila and Oakland FIR boundary)** are proposed for removal from the Hot Spot list because they have not met the hot spot criteria since 2020, and AIDC implementation is completed.

c) **D5 (Ho Chi Minh and Manila FIR boundary)** should remain on the Hot Spot list because AIDC implementation is incomplete, even though it has not met the hot spot criteria since 2022.

d) **D7 (Kota Kinabalu and Manila FIR boundary)** should remain on the Hot Spot list because AIDC implementation is incomplete, even though it has not met the hot spot criteria since 2021.

e) **D8 (Manila and Ujung Pandang FIR boundary)** should remain on the Hot Spot list because it met the hot spot criteria in 2023.

2.35 **LHD Hot Spot J (Singapore-Jakarta)** was identified as LHD hot spot in 2018. In **Table 12**, the number of LHDs at Singapore-Jakarta FIR boundary increased from 14 in 2022 to 27 in 2023. The operational risk also increased from 0.18×10^{-9} FAPFH in 2022 to 0.33×10^{-9} FAPFH in 2023. The increase is approximately double for both the number of LHDs and operational risk. 27 LHDs at Hot Spot J accounted for 28% of the total LHDs in SEA airspace. Additionally, all LHDs at this boundary were in Category E.

Table 12: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Singapore-Jakarta FIR Boundary from 2021 to 2023

Area	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Hot Spot J	16	14	27	2	2	5	0.23	0.18	0.33

2.36 **Figure 9** shows the geographic locations of LHDs and operation risk at Singapore-Jakarta FIR Boundary from 2021 to 2023.

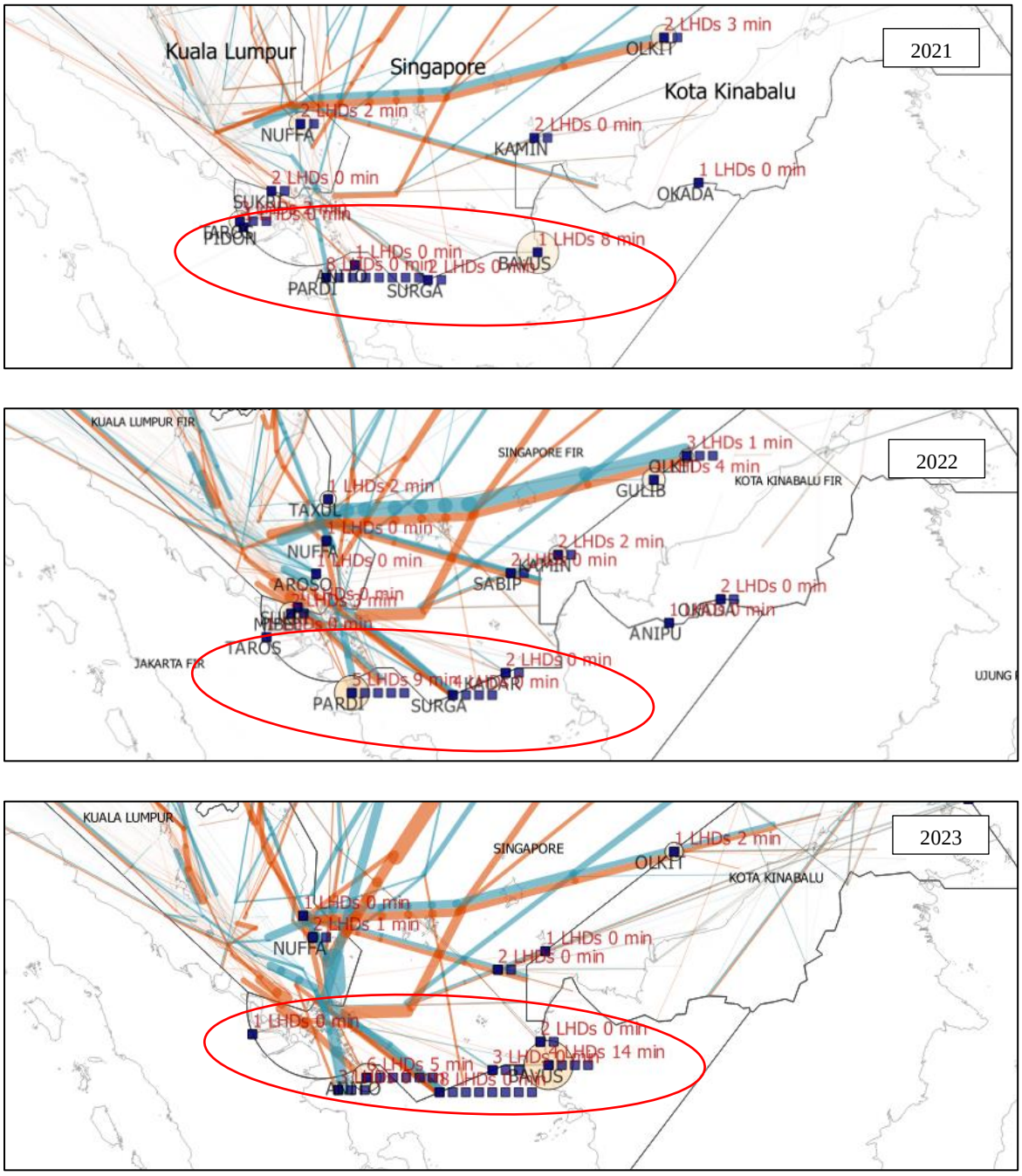


Figure 9: Geographic Location of LHDs and Operation Risk at Singapore-Jakarta FIR Boundary in 2021, 2022 and 2023.

2.37 As detailed in WP/10 of ACSICG/11, the AIDC implementation between Singapore ACC and Jakarta ACC remains in the testing phase. When the AIDC is successfully implemented, the efficiency of coordination is expected to be enhanced and the coordination error, as well as the number of LHDs may be mitigated.

2.38 Regarding the process of identifying hot spots, this boundary was identified as a cluster and met the hot spot criteria in terms of the number of LHDs from 2021 to 2023. Therefore, Singapore-Jakarta boundary (LHD Hot Spot J) should remain on the hot spot list.

2.39 **LHD Hot Spot O (Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore)** was identified as LHD hot spot in 2023. **Table 13** shows the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot O from 2021 to 2023. The number of LHDs and non-zero-duration LHDs, as well as operational risk in 2023 slightly decrease from 2022. However, the operational risk at this area was 28 % of the total operational risk in SEA Airspace. The operational risk of Hot Spot O is contributed by 3 non-zero-duration LHDs, which were the negative transfer from Kuala Lumpur to Singapore at TIDAR waypoint. **Figure 10** shows the geographic locations of LHDs and operation risk at Singapore-Jakarta FIR Boundary from 2021 to 2023.

Table 13: Comparison of the Number of LHDs, the Number of Non-Zero-Duration LHDs and Operational Risk at Hot Spot O from 2021 to 2023

Area	**Number of LHDs**			**Number of non-zero-duration LHDs**			**Operational Risk (10^{-9} FAPFH)**		
	2021	**2022**	**2023**	**2021**	**2022**	**2023**	**2021**	**2022**	**2023**
Hot Spot O	5	7	5	2	4	3	0.14	0.58	0.51

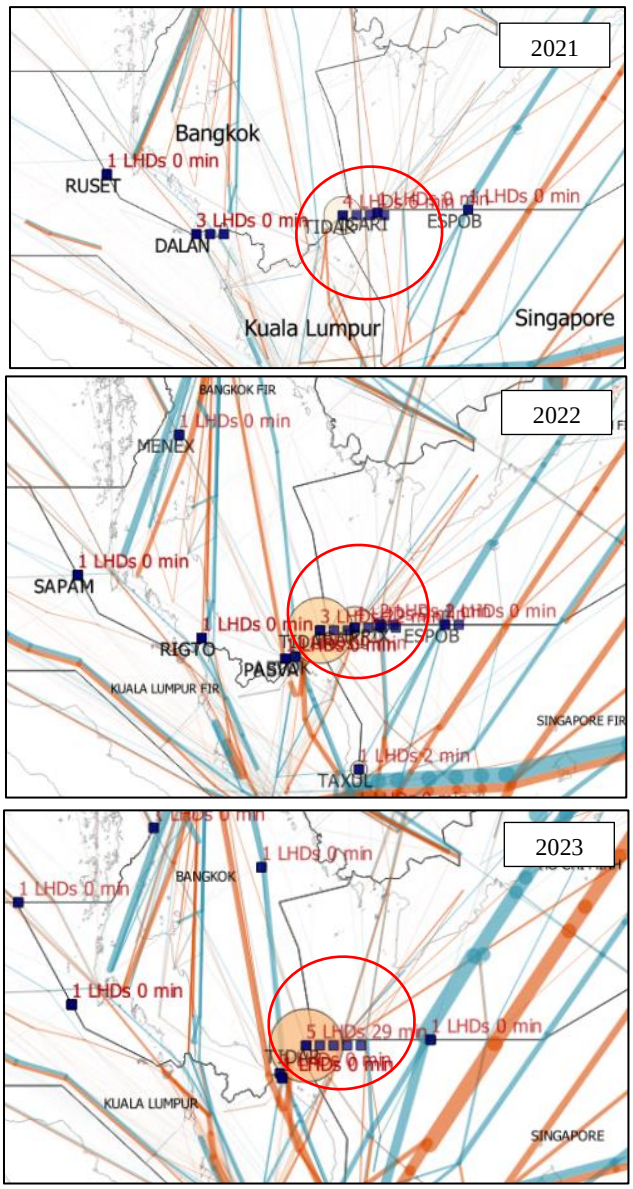


Figure 10: Geographic Location of LHDs and Operation Risk at Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore FIR Boundary in 2021, 2022 and 2023.

2.40 Regarding the process of identifying hot spots, the LHD cluster at Bangkok/ Ho Chi Minh/Kuala Lumpur-Singapore FIR boundary (Hot Spot O) satisfied the hot spot criteria in terms of the operational risk. Consequently, Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore FIR Boundary (Hot Spot O) should remain in the Hot Spot list.

Executive Summary: Mongolian Airspace

2.41 **Table 14** summarizes the vertical collision technical, operational, and total risk estimates in the Mongolian airspace.

Table 14: Vertical Collision Risk Estimates in Mongolian Airspace

Mongolian Airspace – estimated annual flying hours = 83,708 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 Total Risk	*0.33×10^{-9}*	*5.0×10^{-9}*	*Below TLS*

Mongolian Airspace – estimated annual flying hours = 83,708 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
Technical Risk	0.58×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	**0.58×10^{-9}**	5.0×10^{-9}	**Below TLS**

2.42 In 2023, no LHD was reported within or at the boundary of the Mongolian Airspace. Hence, the analysis of operational errors cannot be conducted. As a result, the total risk was estimated as 0.58×10^{-9} FAPFH.

APANPIRG List of Deficiencies

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

2.44 MAAR has not received any data from Afghanistan since the political issue in August 2021. Except Afghanistan, MAAR received the TSD and LHD data from all other States in 2023. The States that submitted the data also provided good cooperation and promptly revised any error when requested.

2.45 As a result, MAAR proposes to **maintain Afghanistan on the APANPIRG List of Deficiencies in the ATM and Airspace Safety, under "Non-Provision of Safety-related Data"**.

Reporting Culture

2.46 Over the past several years, MAAR has observed continuous improvement among the States and ANSPs under its jurisdiction. **Almost all States now regularly submit their LHD reports to MAAR through the Online LHD Submission System and cooperate in addressing LHD-related matters**. Notably, MAAR has seen significant improvement from Sri Lanka, with a rapid increase in the number of LHD reports and LHD-related responses via email in 2023.

2.47 Furthermore, most reported LHDs in SA/IO and SEA Airspace were located at the boundary of FIRs and classified as Category E LHD, which refers to coordination errors in the ATC-to-ATC transfer of control responsibility. There were a small number of other LHD categories observed. Thus, MAAR would like to encourage the LHD POC of the States in SA/IO and SEA Airspace to **expand their focuses on other LHD occurrences in addition to category E while promoting a positive safety reporting culture within their States/organizations.**

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) consider the results from the analysis and the hot spot identification process that;

i) LHD Hot Spot G (Mumbai-Muscat/Sanaa) and F (Mogadishu – Mumbai) remain as hot spots (paragraph 2.14);

ii) LHD Hot Spot A1 (Chennai/Dhaka/Kolkata - Yangon) remains as a hot spot (paragraph 2.17);

iii) LHD Hot Spot A2 (Chennai -Kuala Lumpur) is proposed for removal from the list of hot spot (paragraph 2.19);

iv) LHD Hot Spot D1 (Fukuoka-Manila), D5 (Ho Chi Minh-Manila), D7 (Kota

Kinabalu-Manila) and D8 (Manila-Ujung Pandang) remain as a hot spot (paragraph 2.34);

v) LHD Hot Spot D2 (Manila- Taibei), D3 (Hong Kong-Manila), D4 (Manila-Sanya), D6 (Manila-Singapore) and D9 (Manila-Oakland) are proposed for removal from the list of hot spot (paragraph 2.34);

vi) LHD Hot Spot J (Singapore-Jakarta) remains as a hot spot (paragraph 2.38); and

vii) LHD Hot Spot O (Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore) remains as a hot spot (paragraph 2.40);

b) consider maintaining Afghanistan on the List of Deficiencies in the ATM and Airspace Safety, under "Non-Provision of Safety-related Data" (paragraph 2.45);

c) encourage the LHD POC of the States in SA/IO and SEA Airspace to expand their focuses on other LHD occurrences in addition to category E while promoting a positive safety reporting culture within their States/organizations (paragraph 2.47); and

d) discuss any relevant matters as appropriate.

…….

MONITORING AGENCY FOR ASIA REGION (MAAR)

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

January 2023 to December 2023

AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN THE SOUTH ASIA/INDIAN OCEAN (SA/IO) AIRSPACE
Assessment Period: January 2023 to December 2023

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

1. Introduction

This report provides the result of the airspace safety oversight for the RVSM operation in the **South Asia/Indian Ocean (SA/IO)** airspace. The result is conducted based on one-month traffic sample data (TSD) collected in **December 2023** and monthly Large Height Deviation (LHD) reports between **January 2023 and December 2023** submitted by the States in SA/IO Airspace.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** The TSD covering the month of December 2023 of aircraft operating in SA/IO Airspace is used as required by ICAO regional agreement.

2.2. **Large Height Deviation (LHD).** The cumulative 12-month data set of LHD reports covers January 2023 to December 2023. **Table 1** indicates the FIRs that submitted LHD reports, including NIL reports. MAAR has not received any LHD reports or LHD-related responses from Kabul ACC since 16 August 2021. **Appendix A** provides details of the LHD reports and a brief description of each LHD.

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
May	X	X	X	X	X	X	X	X	X	X	X		X	X
June	X	X	X	X	X	X	X	X	X	X	X		X	X
July	X	X	X	X	X	X	X	X	X	X	X		X	X
August	X	X	X	X	X	X	X	X	X	X	X		X	X
September	X	X	X	X	X	X	X	X	X	X	X		X	X
October	X	X	X	X	X	X	X	X	X	X	X		X	X
November	X	X	X	X	X	X	X	X	X	X	X		X	X
December	X	X	X	X	X	X	X	X	X	X	X		X	X

Table 1: Summary of LHD Reports Submitted by FIRs in 2023. An 'X' indicates that LHD or NIL Reports Are Submitted 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 2023 to December 2023.

Month (2023)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk (x10^{-9} FAPFH)
January	17	1	1	0	0.02
February	10	3	20	0	0.41
March	24	4	19	1	0.42
April	12	1	2	0	0.04
May	24	5	11	1	0.17
June	9	2	6	0	0.12
July	14	2	3	0	0.06
August	36	2	3	0	0.06
September	26	10	60	0	1.22
October	25	9	33	0	0.67
November	29	4	10	0	0.19
December	28	1	1	0	0.02
Total	**254**	**44**	**169**	**2**	**3.40**

Table 2: Monthly Summary of LHD in SA/IO Airspace

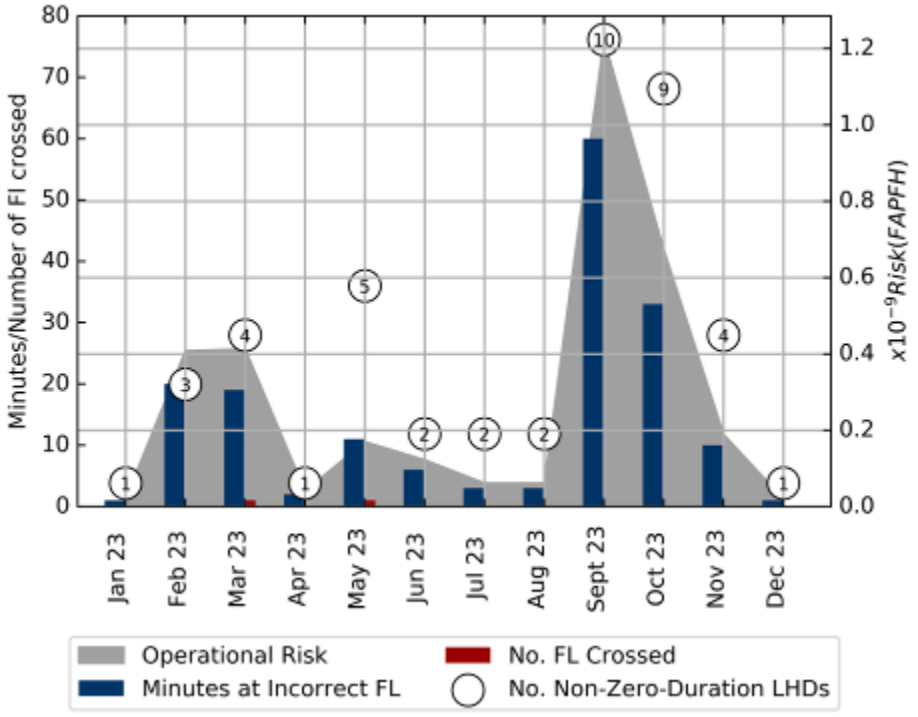


Figure 1: Monthly Summary of Non-Zero-Duration LHDs in SA/IO Airspace

3.2. The number of LHDs significantly increased from 148 in 2022 to 254 in 2023. At the same time, the number of non-zero-duration LHD also increased from 16 in 2022 to 44 in 2023. The

notable rise in the number of non-zero-duration LHDs contributed to a dramatic increase in operational risk, climbing from 1.06 x 10^{-9} FAPFH in 2022 to 3.40 x 10^{-9} FAPFH in 2023.

3.3. **Figure 2** and **Table 3** summarize the number of Non-Zero-Duration LHDs, the associated LHD duration (in minutes), and the number of incorrect flight levels crossed, by LHD category from January 2023 to December 2023.

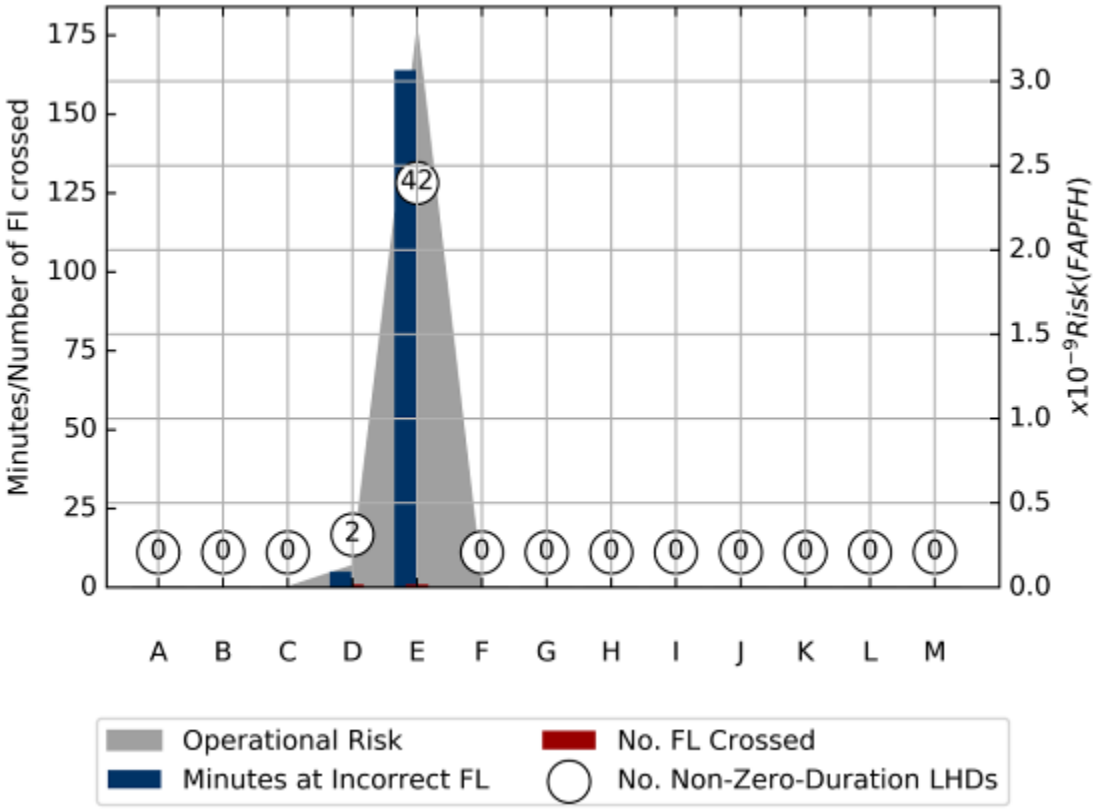


Figure 2: Summary of Non-Zero-Duration LHD by Category in SA/IO Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	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.).	1	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)	4	2	5	1	0.13
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).	248	42	164	1	3.27
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

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)
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		**254**	**44**	**169**	**2**	**3.40**

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

3.4. In 2023, nearly 98% of the total number of LHDs and the operational risk in SA/IO Airspace fell into Category E, which was further divided into sub-categories. **Figure 3** illustrates the contribution of each sub-category in terms of the number of LHDs, while **Figure 4** shows the contribution in terms of risk.

3.5. In **Figure 3**, Category E LHDs in SA/IO Airspace are dominated by two sub-categories. The largest portion, "No or Late Flight Level Revision" accounts for 71%, while "No Transfer Information" accounts for 24%. The remaining 5% is accounted for by other causes.

3.6. In terms of the operational risk, **Figure 4** shows that "No or Late Flight Level Revision" accounts for 73%, with "No Transfer Information" accounting for 27%. Other sub-categories do not account for any operational risk.

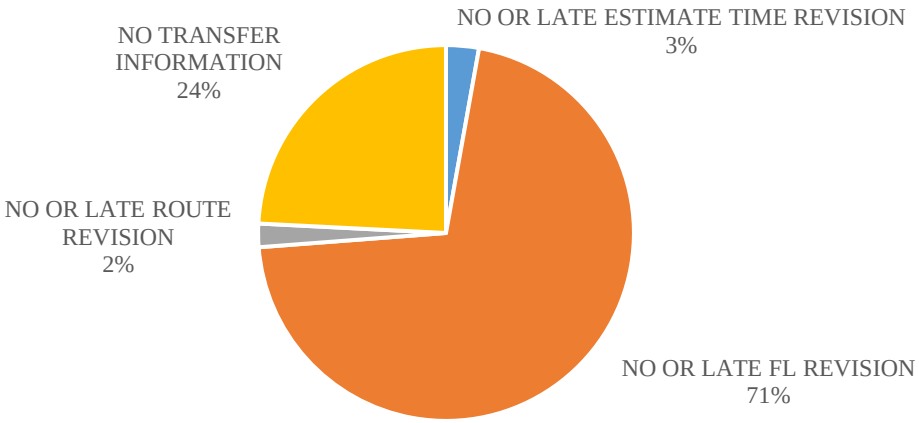


Figure 3: Sub-Categories of Category-E LHDs in SA/IO Airspace
(The Number of LHDs)

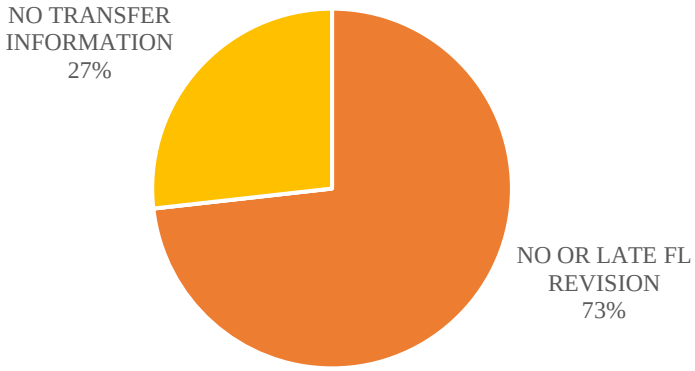


Figure 4: Sub-Categories of Category-E LHDs in SA/IO Airspace
(Operational Risk)

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	2,145,671	496,730	Hour	Dec 2023 TSD
E_z(same)	Same-direction vertical occupancies	0.4188/ 0.0494	0.0833	-	
E_z(opposite)	Opposite-direction vertical occupancies	0.1272	0.0498	-	
λ_x	Average aircraft length	0.02926	0.02557	NM	
λ_y	Average aircraft wingspan	0.02690	0.02343	NM	
λ_z	Average aircraft height	0.00824	0.00744	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.02926	0.02557	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	Conservative value used in previous assessments
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes	33.04	46.18	Knot	Dec 2023 TSD
$\overline{\lvert V\rvert}$	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for SA/IO Airspace

4.2. **Risk Estimation Results**. The results for technical, operational, and total risk are detailed in **Table 5**. The technical risk, defined as the probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft., is estimated at 0.65 x 10^{-9} FAPFH, which is below the target level of safety (TLS) value of 2.5 x 10^{-9} FAPFH. Additionally, the total risk is estimated at 4.05 x 10-9 FAPFH, which is also below the specified TLS value of 5.0 x 10^{-9} FAPFH.

SA/IO Airspace – estimated annual flying hours = 2,642,401 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 Total Risk	*1.75 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
Technical Risk	0.65 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	3.40 x 10^{-9}	-	-
Total Risk	**4.05 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

Table 5: Vertical Collision Risk Estimates for SA/IO Airspace

4.3. **Figure 5** presents the trends in collision risk estimates for each month using the appropriate cumulative 12-month dataset of LHD. The operational and total risk in 2023 showed an upward trend. The total risk increased dramatically by more than 130%, rising from 1.75 x 10^{-9} FAPFH in 2022 to 4.05 x 10^{-9} FAPFH in 2023. Despite this increase, the total risk remains below the specified TLS.

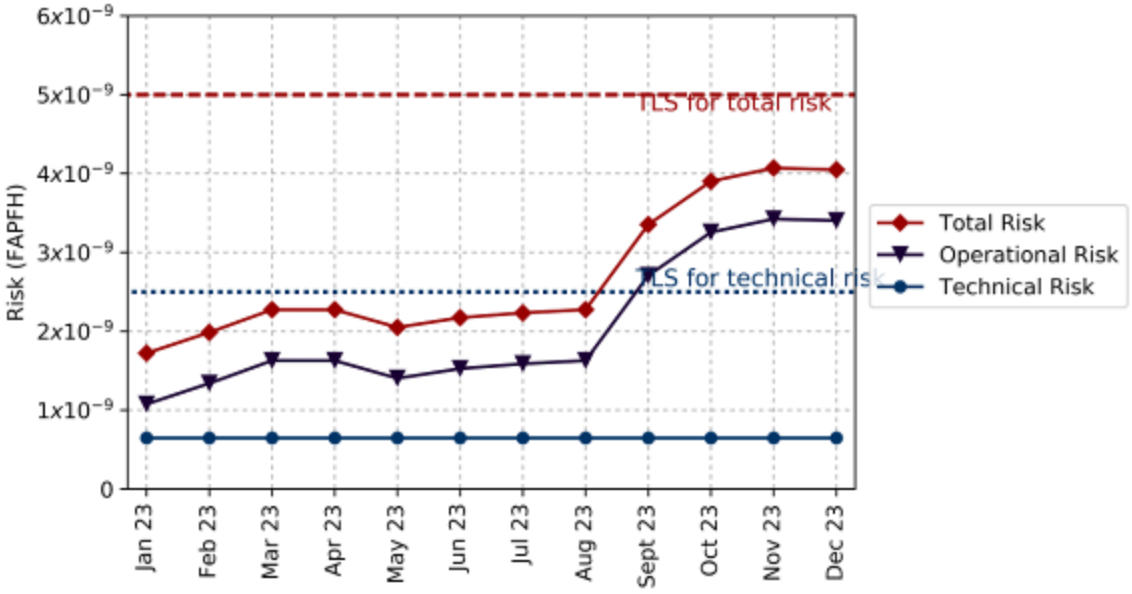


Figure 5: Trends of Risk Estimates for SA/IO Airspace

5. Analysis of Operational Errors

5.1 **Figure 6** depicts geographic locations of all reported LHDs in SA/IO Airspace based on LHD reports from January to December 2023. **Figure 7** 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.

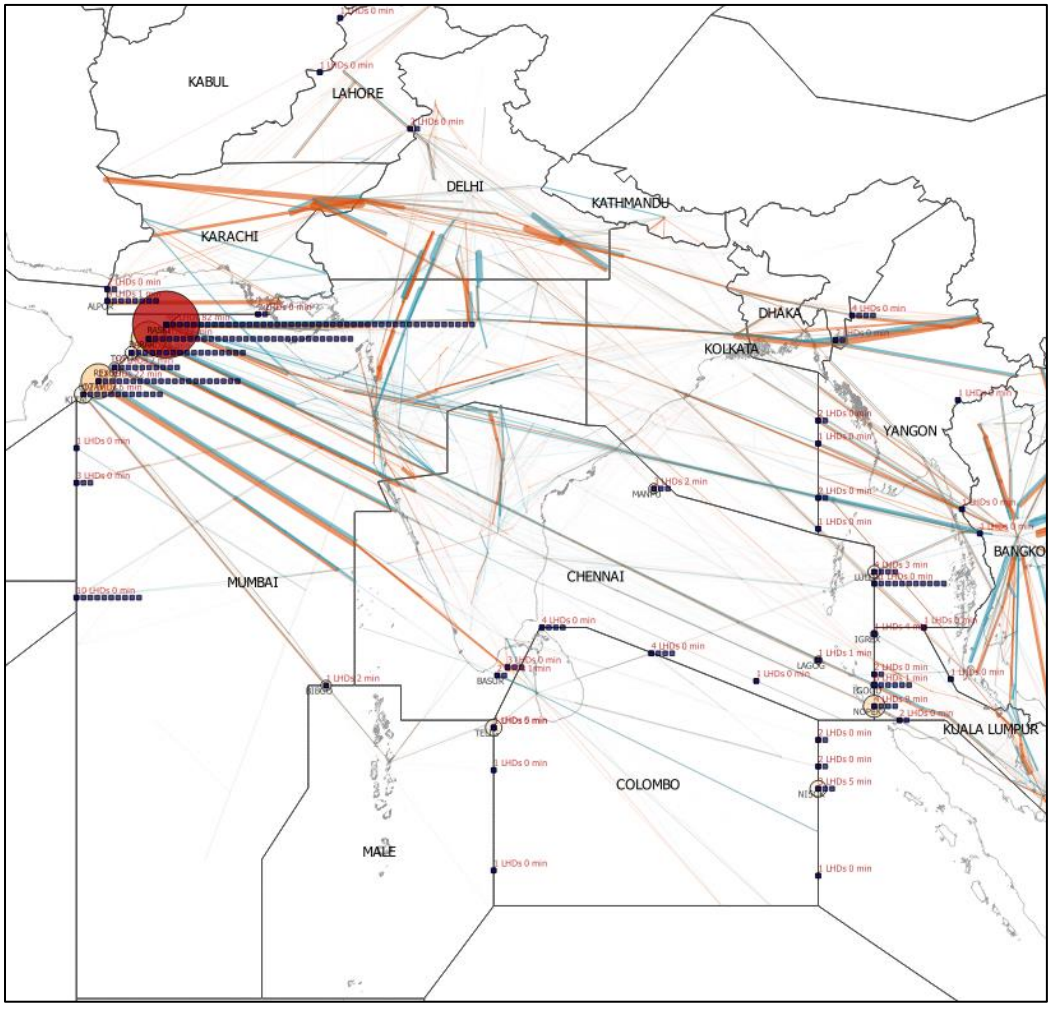


Figure 6: Geographic Locations of **All LHDs** in SA/IO Airspace

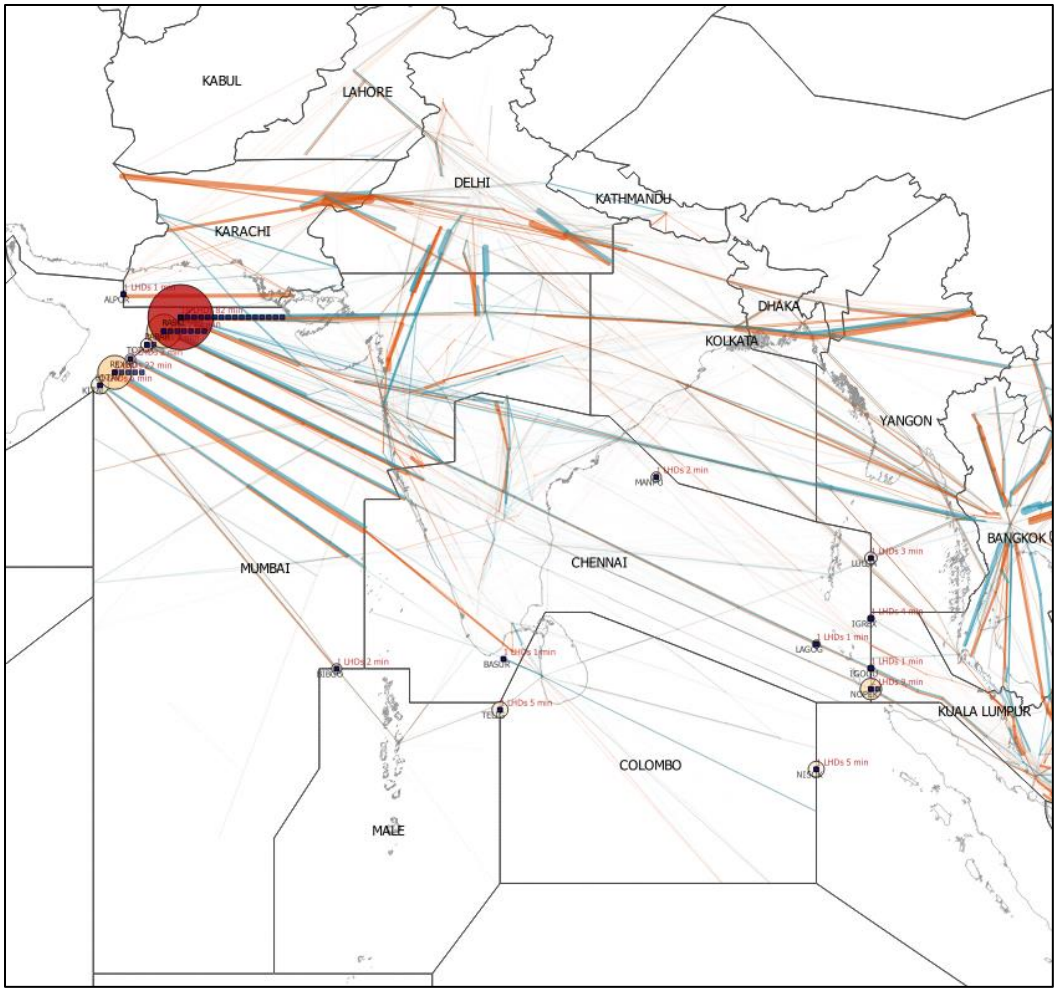


Figure 7: Geographic Locations of **Non-Zero-Duration LHDs** in SA/IO Airspace

LHD Hot Spot identification

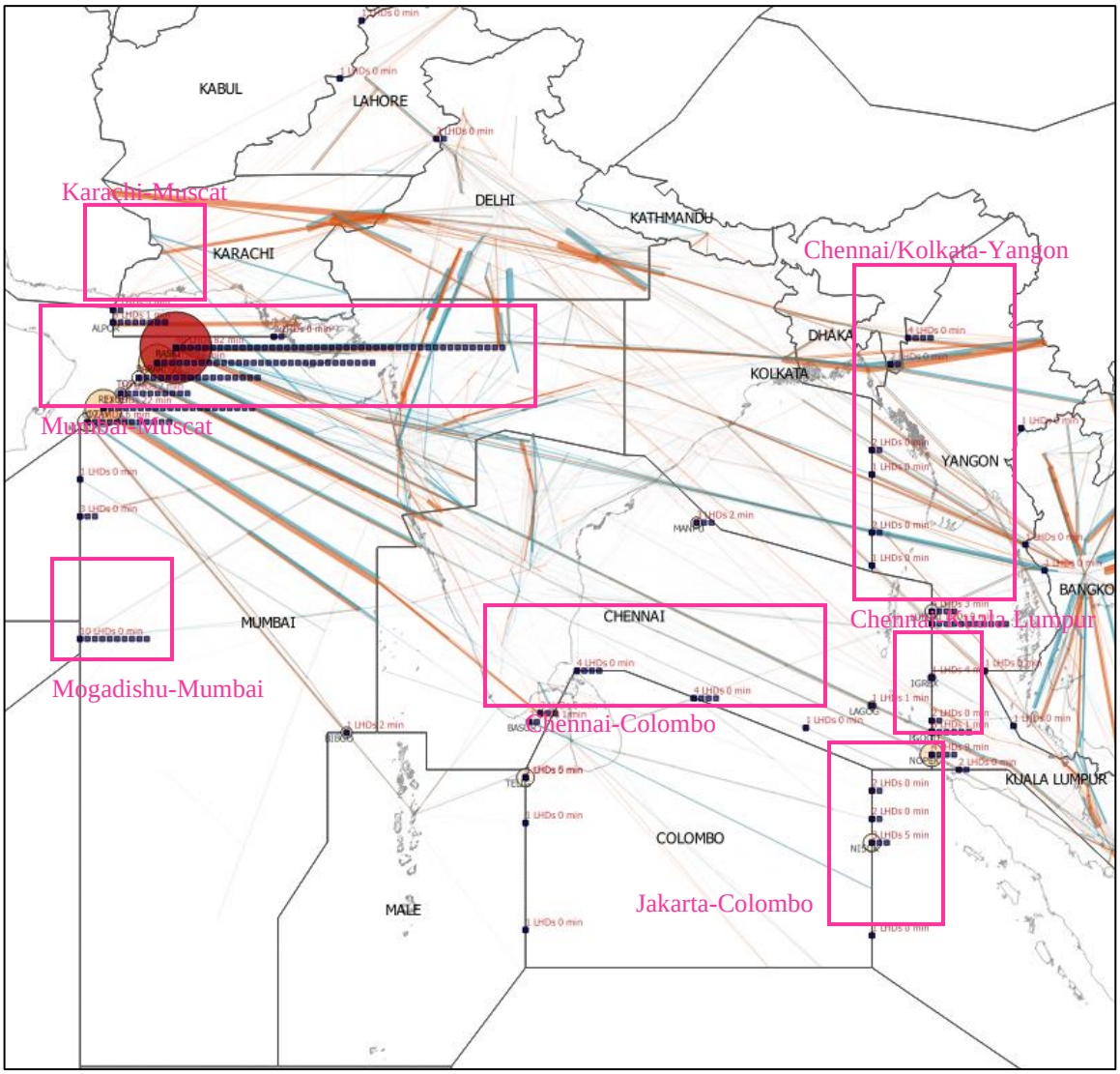


Figure 8: Geographic locations of **LHD Clusters** identified in SA/IO Airspace

5.2 In the process of identifying hot spots in SA/IO Airspace, seven (7) LHD clusters are identified as shown in pink rectangles in **Figure 8**.

5.3 **Table 6** shows the profile of the LHD clusters in SA/IO Airspace and the determining criteria in 2023.

SA/IO	2023
Number of Clusters	**7**
Number of LHDs	**254**
Operational Risk (x 10^{-9} FAPFH)	**3.40**
Criteria: Number of LHDs	**31.75**
Criteria: Risk (x 10^{-9} FAPFH)	**0.43**
Criteria: TLS (x 10^{-9} FAPFH)	**5.00**

Table 6: Profile of LHD Clusters and Determining Criteria for SA/IO Airspace in 2023

5.4 According to the decision in the process of identifying hot spots, a cluster will be identified as a 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 operational risk of each cluster, as well as the results of checking against the criteria. A 'Negative' result indicates that the cluster does not satisfy that particular criterion, while a 'Positive' result indicates that the cluster satisfies that particular criterion and can be identified as a hot spot.

2023 Clusters (SA/IO)	Mumbai-Muscat (Hot Spot G)	Mogadishu-Mumbai (Hot Spot F)	Chennai/Kolkata-Yangon (Hot Spot A1)	Chennai-Kuala Lumpur (Hot Spot A2)	Chennai-Colombo	Jakarta-Colombo	Karachi-Muscat
Number of LHDs	138	10	26	13	14	8	10
Check Criteria: Number >= 31.75	Positive	Negative	Negative	Negative	Negative	Negative	Negative
Operational Risk (x 10^{-9} FAPFH)	2.79	0.00	0.06	0.22	0.03	0.10	0.01
Check Criteria: Risk >= 0.43 x 10^{-9} FAPFH	Positive	Negative	Negative	Negative	Negative	Negative	Negative
Check Criteria: Operation Risk >= 5.00 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Table 7: Results of Identifying Hot Spots in SA/IO Airspace

5.5 Regarding the result in **Table 7**, the Mumbai-Muscat FIR boundary (Hotspot G) satisfies both hot spot criteria in 2023.

5.6 On the other hand, the following FIR boundaries are listed as LHD hot spots but do not satisfy the hot spot criteria in 2023:

- Mogadishu-Mumbai FIR boundary (Hotspot F);
- Chennai/Kolkata-Yangon FIR boundary (Hot Spot A1); and
- Chennai- Kuala Lumpur FIR boundary (Hot Spot A2).

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

5.7 The western boundaries of Mumbai FIR were identified as LHD hot spots G and F in 2015, including the Mumbai-Muscat, Mumbai-Sanaa, and Mogadishu-Mumbai FIR boundaries.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Mumbai-Muscat	44	43	138	17	10	32	1.35	0.79	2.79
Mumbai-Sanaa	4	2	3	1	0	0	0.07	0.00	0.00
Mogadishu-Mumbai	5	9	10	1	1	0	0.12	0.02	0.00
Total	**53**	**54**	**151**	**19**	**11**	**32**	**1.54**	**0.81**	**2.79**

Table 8: Comparison of the Number of LHDs, the Number of Non-Zero-Duration LHDs and Operational Risk at the Western Boundaries of Mumbai FIR from 2021 to 2023

5.8 **Table 8** summarizes the number of LHDs, the number of non-zero-duration LHDs, and the operational risk at the western boundaries of the Mumbai FIR from 2021 to 2023. **Figure 9** shows the geographic locations of non-zero-duration LHDs and operation risk at these boundaries from 2021 to 2023.

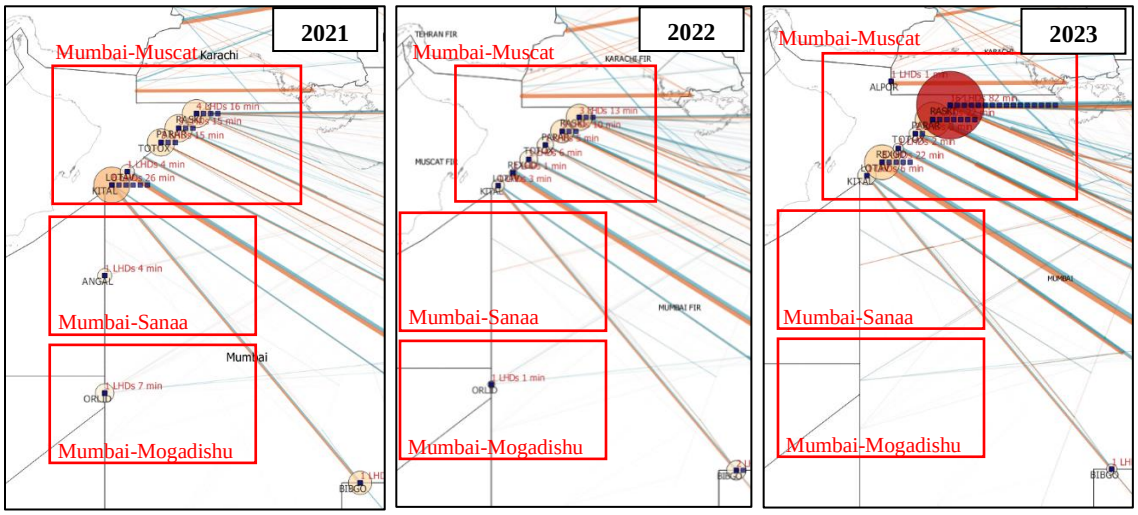


Figure 9: Geographic Locations of Non-Zero-Duration LHDs and Operation Risk at the Western Boundaries of Mumbai FIR from 2021 to 2023

5.9 At the Mumbai-Muscat FIR boundary, the number of LHDs, the number of non-zero-duration LHDs, and the operational risk significantly increased from 2021 to 2023. The 138 LHDs in 2023, 54% of the total number of LHDs in SA/IO Airspace, represented a noticeable climb from 44 in 2021 and 43 in 2022. Similarly, the number of non-zero-duration LHDs increased from 17 in 2021 and 10 in 2022 to 32 in 2023. In addition, the operational risk, at 2.79 x 10^{-9} FAPFH, accounted for 82% of the operational risk in SA/IO Airspace.

5.10 The number of LHDs in 2023 nearly reached the 143 LHDs recorded in 2019, a year with high traffic levels before the significant reduction during the COVID-19 pandemic. However, the operational risk in 2023 was relatively small compared to 2019, at 24.71 x 10^{-9} FAPFH.

5.11 At the Mumbai-Sanaa and Mogadishu-Mumbai FIR boundaries, the number of LHDs remained similar to the number recorded in 2022 while the number of non-zero-duration LHDs and the operational risk decreased to 0 in 2023.

5.12 Considering the causes of LHDs at these three boundaries, the majority of LHDs were in Category E, similar to the overall picture in the SA/IO Airspace. The most frequent sub-categories were “No or Late FL revision”.

5.13 An increase in the number of LHDs with low level of operational risk and the causes of Category E reflects that coordination errors between the ATS units continue to occur, but these errors have been detected or solved in a short period of time. This is supported by the implementation of Space-Based ADS-B in February 2020, which enhances the surveillance capability. Enhanced surveillance allows controllers to detect LHDs beyond the Transfer of Control (TOC) point, particularly in oceanic airspace. Consequently, the duration of LHDs and operational risk decreased significantly starting in 2020.

5.14 To improve the efficiency of coordination and transfer of control between ATS units, which is the cause of LHD Category E, the ATS Inter-Facility Data Communication (AIDC) has been promoted in APAC region. Consequently, the AIDC implementation between Mumbai ACC and Muscat ACC, as well as between Mumbai ACC and Mogadishu ACC, has been initiated. However, the implementation remained in the testing phase, as indicated in the WP/10 of the Eleventh Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/11) held in March 2024.

5.15 In the process of identifying hot spot, the Mumbai-Muscat FIR boundary (Hot Spot G) continues to meet the hot spot criteria in terms of the number of LHDs and the operational risk as shown in **Table 7**. In contrast, the Mumbai-Sanaa FIR boundary (Hot Spot G) and Mogadishu-Mumbai FIR boundary (Hot Spot F) have not satisfied any criteria since 2021. However, the AIDC implementation has not been completed yet. Therefore, the western Boundary of Mumbai FIR (Hot Spot G and F) should remain as hotspots and continue to be monitored until further safety improvement initiatives or prevention measures, such as AIDC, are completed and demonstrate their effectiveness.

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

5.16 Chennai/Dhaka/Kolkata-Yangon FIR boundaries (Hot Spot A1), and Chennai-Kuala Lumpur FIR boundary (Hot Spot A2) were identified as LHD hot spots in 2015.

5.17 **Table 9** summarizes the number of LHDs, the number of non-zero-duration LHDs, and the operational risk at Hot Spot A1 and A2 from 2021 to 2023. **Figure 10** shows the geographic locations of non-zero-duration LHDs and operation risk at these boundaries from 2021 to 2023.

Boundary	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Kolkata-Yangon	1	17	11	0	0	0	0.00	0.00	0.00
Chennai-Yangon	8	23	15	0	1	1	0.00	0.02	0.06
Chennai-Kuala Lumpur	21	22	13	1	0	4	0.05	0.00	0.23
Total	**30**	**62**	**39**	**1**	**1**	**5**	**0.05**	**0.02**	**0.29**

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 2021 to 2023.

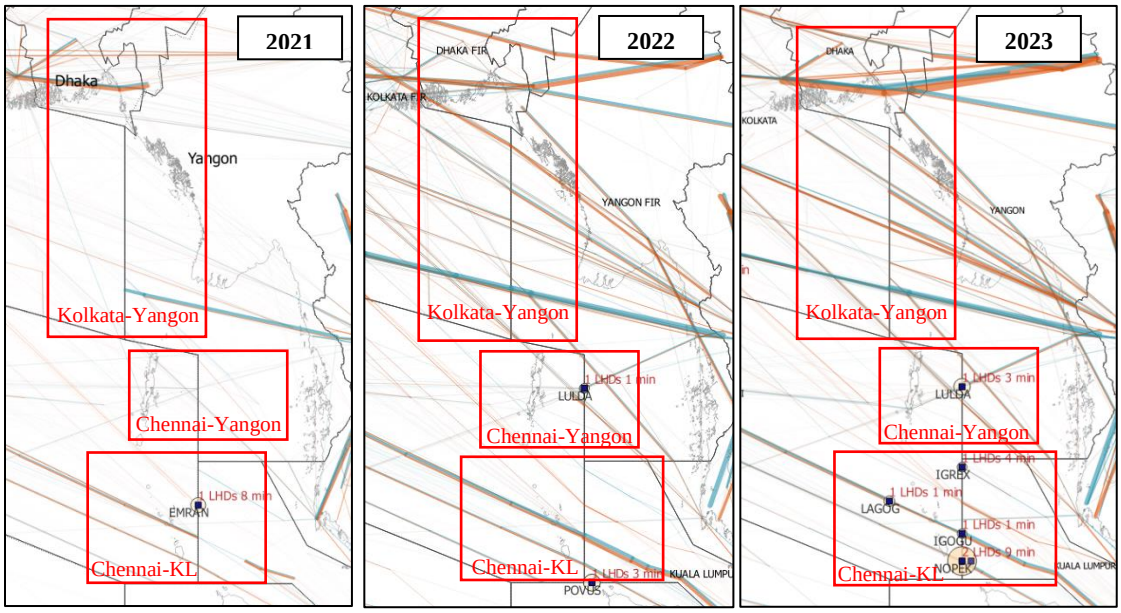


Figure 10: Geographic locations of non-zero-duration LHDs and operation risk at Hot Spot A1 and A2 from 2021 to 2023.

5.18 At the Kolkata-Yangon and Chennai-Yangon FIR boundaries (Hot Spot A1), the number of LHDs decreased from 40 in 2022 to 26 in 2023. All LHDs at these boundaries belonged to Category E. At these two boundaries, there was only one non-zero-duration LHDs, contributed to 0.06 x 10^{-9} FAPFH.

5.19 Considering the results from the process of identifying hot spots, the Kolkata-Yangon and Chennai-Yangon FIR boundaries (Hot Spot A1) did not meet any hot spot identification criteria in 2023. Additionally, the AIDC between Kolkata ACC and Yangon ACC, as well as between Chennai ACC and Yangon ACC, were initiated but remained in the testing phase and have not yet been operated, as mentioned in WP/10 of ACSICG/11. Therefore, Hot Spot A1 should remain on

the hot spot list and be monitored until further safety improvement initiatives (specifically AIDC) are implemented and successfully reduce the number of LHDs and the associated risks.

5.20 At Chennai-Kuala Lumpur FIR boundary (Hot Spot A2), the number of LHDs decreased from 22 in 2022 to 13 in 2023. All LHDs were also in Category E. However, the non-zero-duration LHDs significantly increased from 0 in 2022 to 5 in 2023. This led to an increase in operational risk, reaching 0.23×10^{-9} FAPFH.

5.21 Considering the results from the process of identifying hot spots, the Chennai-Kuala Lumpur FIR boundary (Hot Spot A2), which was proposed as a potential non-hot spot in the RASMAG/28 meeting held in August 2023, continued to not satisfy any criteria in 2023. Hot Spot A2 did not meet the hot spot identification criteria for two consecutive years. Additionally, safety improvement initiatives, including enhanced surveillance by Indian Space-Based ADS-B and the implementation of AIDC between Chennai ACC and Kuala Lumpur ACC, have been successfully operated. Hence, Hot Spot A2 is proposed for removal from the hot spot list.

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	Description
17/8/2023	XHV	FL300	FL323	0	D	None
18/8/2023	XHV	FL300	FL311	0	D	None
9/7/2023	YAQ	FL330	FL350	0	E	NO OR LATE FL REVISION
25/8/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
19/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
19/11/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
16/3/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
24/10/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
24/12/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
2/7/2023	YAQ	FL350	FL370	0	E	NO OR LATE FL REVISION
23/8/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
30/10/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
26/3/2023	QKM	FL390	FL410	0	E	NO OR LATE FL REVISION
17/8/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
15/1/2023	QKM	FL310	FL330	0	E	NO OR LATE FL REVISION
6/1/2023	QKM	FL410	FL410	0	E	NO OR LATE ESTIMATE TIME REVISION
22/10/2023	QKM	FL390	FL410	0	E	NO OR LATE FL REVISION
29/10/2023	XHV	FL390	FL380	0	E	NO OR LATE FL REVISION
4/11/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
24/3/2023	QKM	FL350	FL350	0	E	NO OR LATE ROUTE REVISION
20/11/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION
3/12/2023	QKM	FL310	FL350	0	E	NO OR LATE FL REVISION
19/9/2023	QKM		FL350	6	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/2/2023	QKM	FL350	FL330	12	E	NO OR LATE FL REVISION
3/3/2023	ZMA	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/12/2023	ZMA	FL360	FL340	0	E	NO OR LATE FL REVISION
7/2/2023	BDQ		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/5/2023	FII		FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
19/6/2023	BDQ	FL380	FL380	0	J	None

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
4/9/2023	KOO	FL360	FL380	5	D	ATC ISSUES INCORRECT CLEARANCE TO PILOT
13/5/2023	ZMA		FL270	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
20/9/2023	ZMA		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/5/2023	ZMA		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
20/8/2023	QKM	FL310	FL350	0	E	NO OR LATE FL REVISION
4/10/2023	PEK		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/3/2023	QKM	FL350	FL330	0	E	NO OR LATE FL REVISION
5/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
31/12/2023	QKM	FL310	FL290	0	E	NO OR LATE FL REVISION
20/3/2023	QKM		FL390	1	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/9/2023	QKM	FL270	FL350	0	E	NO OR LATE FL REVISION
26/6/2023	QKM	FL270	FL350	0	E	NO OR LATE FL REVISION
4/7/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
29/8/2023	QKM	FL390	FL370	0	E	NO OR LATE FL REVISION
25/9/2023	QKM	FL370	FL390	4	E	NO OR LATE FL REVISION
16/2/2023	QKM	FL370	FL350	6	E	NO OR LATE FL REVISION
7/12/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
5/9/2023	QKM	FL370	FL350	1	E	NO OR LATE FL REVISION
23/11/2023	PEK	FL360	FL340	4	E	NO OR LATE FL REVISION
28/12/2023	QKM	FL310	FL290	0	E	NO OR LATE FL REVISION
11/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
16/3/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
2/8/2023	PEK		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
16/3/2023	PEK	FL340	FL340	0	C	None
20/2/2023	PBI	FL300	FL280	0	E	NO OR LATE FL REVISION
15/12/2023	QKM	FL350	FL390	1	E	NO OR LATE FL REVISION
14/9/2023	QKM		FL390	30	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/11/2023	QKM	FL410	FL370	0	E	NO OR LATE FL REVISION
11/12/2023	QKM		FL370	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	Description
11/12/2023	QKM		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/10/2023	QKM		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
19/3/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
7/9/2023	QKM	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
23/3/2023	PEK	FL380	FL356	1	D	PILOT MISUNDERSTANDS ATC CLEARANCE
21/1/2023	FII	FL350	FL370	0	E	NO OR LATE FL REVISION
17/8/2023	PEK	FL320	FL360	0	E	NO OR LATE FL REVISION
17/4/2023	QKM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/4/2023	ZMA		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/8/2023	QKM	FL330	FL410	0	E	NO OR LATE FL REVISION
23/1/2023	PBI		FL300	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/9/2023	QKM	FL350	FL370	2	E	NO OR LATE FL REVISION
2/5/2023	PEK		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
2/5/2023	PEK		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
20/10/2023	QKM	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
17/8/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
23/11/2023	QKM	FL410	FL390	0	E	NO OR LATE FL REVISION
14/11/2023	QKM		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
23/8/2023	QKM	FL310	FL330	0	E	NO OR LATE FL REVISION
30/1/2023	AJT	FL390	FL370	0	E	NO OR LATE FL REVISION
2/9/2023	YAQ	FL310	FL330	0	E	NO OR LATE FL REVISION
22/8/2023	QKM		FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/10/2023	PEK		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
16/8/2023	QKM		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
13/11/2023	QKM		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/10/2023	PEK		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	Description
24/8/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
27/9/2023	QKM	FL410	FL370	0	E	NO OR LATE FL REVISION
28/4/2023	ZMA	FL360	FL340	0	E	NO OR LATE FL REVISION
19/11/2023	XHV	FL290	FL300	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/8/2023	QKM	FL350	FL390	0	E	NO OR LATE FL REVISION
30/4/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
23/10/2023	QKM	FL330	FL350	1	E	NO OR LATE FL REVISION
11/1/2023	FII	FL370	FL390	1	E	NO OR LATE FL REVISION
30/12/2023	QKM	FL390	FL370	0	E	NO OR LATE FL REVISION
13/9/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
5/7/2023	QKM	FL310	FL350	0	E	NO OR LATE FL REVISION
31/5/2023	ZMA	FL340	FL320	0	E	NO OR LATE FL REVISION
13/7/2023	ZMA	FL400	FL380	0	E	NO OR LATE FL REVISION
7/3/2023	AJT		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/10/2023	QKM	FL310	FL330	9	E	NO OR LATE FL REVISION
7/3/2023	AJT		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/6/2023	QKM	FL390	FL350	0	E	NO OR LATE FL REVISION
29/10/2023	QKM		FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/5/2023	AJT	FL390	FL350	0	E	NO OR LATE FL REVISION
13/8/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
11/4/2023	ZMA			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/5/2023	ZMA		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
7/11/2023	QKM	FL330	FL310	0	E	NO OR LATE FL REVISION
23/5/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
3/11/2023	QKM	FL390	FL370	0	E	NO OR LATE FL REVISION
8/11/2023	QKM	FL350	FL370	2	E	NO OR LATE FL REVISION
23/8/2023	QKM	FL310	FL370	0	E	NO OR LATE FL REVISION
16/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
8/9/2023	QKM	FL370	FL390	2	E	NO OR LATE FL REVISION
15/3/2023	PEK	FL340	FL320	0	E	NO OR LATE FL REVISION
6/9/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
26/9/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION
3/11/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION
5/11/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
9/5/2023	PEK	FL340	FL300	0	E	NO OR LATE FL REVISION
23/11/2023	PEK	FL360	FL400	3	E	NO OR LATE FL REVISION
11/5/2023	FII		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/9/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
23/12/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
21/7/2023	QKM		FL350	2	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/7/2023	YAQ	FL350	FL370	0	E	NO OR LATE FL REVISION
24/1/2023	BDQ	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
23/4/2023	AJT		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/8/2023	QKM	FL350	FL370	1	E	NO OR LATE FL REVISION
15/8/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
8/8/2023	QKM	FL310	FL350	0	E	NO OR LATE FL REVISION
10/11/2023	AJT		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/12/2023	AJT		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/1/2023	BDQ		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/11/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
18/4/2023	QKM		FL370	2	E	NO OR LATE FL REVISION
26/7/2023	QKM	FL330	FL350	1	E	NO OR LATE FL REVISION
24/8/2023	AJT	FL370	FL390	0	E	NO OR LATE FL REVISION
24/10/2023	BDQ		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
14/2/2023	FII	FL450	FL410	0	E	NO OR LATE FL REVISION
7/12/2023	QKM	FL310	FL370	0	E	NO OR LATE FL REVISION
10/8/2023	QKM	FL290	FL310	0	E	NO OR LATE FL REVISION
25/5/2023	QKM	FL370	FL310	0	E	NO OR LATE FL REVISION
16/3/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION
30/5/2023	QKM	FL370	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	Description
28/10/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION
5/10/2023	QKM	FL310	FL350	1	E	NO OR LATE FL REVISION
24/11/2023	QKM	FL350	FL330	0	E	NO OR LATE FL REVISION
11/12/2023	QKM	FL310	FL330	0	E	NO OR LATE FL REVISION
2/5/2023	YAQ	FL370	FL364	1	E	NO OR LATE FL REVISION
28/11/2023	QKM	FL310	FL270	0	E	NO OR LATE FL REVISION
9/9/2023	QKM	FL350	FL330	3	E	NO OR LATE FL REVISION
22/6/2023	ZMA	FL350	FL370	0	E	NO OR LATE FL REVISION
12/11/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
24/10/2023	QKM	FL350	FL370	1	E	NO OR LATE FL REVISION
27/4/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
5/7/2023	YAQ			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
2/10/2023	QKM	FL350	FL370	2	E	NO OR LATE FL REVISION
24/3/2023	QKM	FL390	FL410	0	E	NO OR LATE FL REVISION
5/7/2023	YAQ	FL310	FL330	0	E	NO OR LATE FL REVISION
19/4/2023	ZMA	FL330	FL370	0	E	NO OR LATE FL REVISION
25/8/2023	QKM	FL370	FL350	0	E	NO OR LATE FL REVISION
31/5/2023	QKM	FL290	FL310	2	E	NO OR LATE FL REVISION
30/12/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
20/8/2023	QKM	FL310	FL330	0	E	NO OR LATE FL REVISION
4/10/2023	QKM	FL350	FL290	0	E	NO OR LATE FL REVISION
23/5/2023	AJT	FL370	FL390	0	E	NO OR LATE FL REVISION
9/10/2023	PEK	FL360	FL320	0	E	NO OR LATE FL REVISION
13/5/2023	QKM	FL390	FL330	3	E	NO OR LATE FL REVISION
5/2/2023	PBI	FL360	FL340	0	E	NO OR LATE FL REVISION
8/9/2023	YAQ	FL310	FL330	0	E	NO OR LATE FL REVISION
29/8/2023	QKM	FL350	FL390	0	E	NO OR LATE FL REVISION
27/8/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
19/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
12/11/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
30/9/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
25/9/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION
14/9/2023	QKM	FL370	FL390	2	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
1/1/2023	ZMA	FL340		0	E	NO OR LATE ESTIMATE TIME REVISION
26/10/2023	QKM	FL290	FL310	13	E	NO OR LATE FL REVISION
3/9/2023	QKM		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/5/2023	QKM	FL410	FL390	0	E	NO OR LATE FL REVISION
29/7/2023	QKM	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
24/8/2023	QKM	FL330	FL370	0	E	NO OR LATE FL REVISION
10/9/2023	QKM	FL350	FL390	0	E	NO OR LATE FL REVISION
23/4/2023	PBI		FL380	0	E	NO OR LATE FL REVISION
13/1/2023	BDQ		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
2/5/2023	PEK		FL410	2	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/1/2023	FII	FL360	FL380	0	E	NO OR LATE FL REVISION
2/2/2023	FII		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/3/2023	QKM	FL350	FL330	0	E	NO OR LATE FL REVISION
30/8/2023	AJT	FL390	FL410	0	E	NO OR LATE FL REVISION
11/3/2023	PEK	FL340	FL340	0	E	NO OR LATE ESTIMATE TIME REVISION
25/5/2023	PEK	FL300	FL380	4	E	NO OR LATE FL REVISION
3/8/2023	ZMA		FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/6/2023	ZMA	FL320	FL360	5	E	NO OR LATE FL REVISION
18/3/2023	FII	FL350	FL330	5	E	NO OR LATE FL REVISION
13/1/2023	ZMA	FL380	FL360	0	E	NO OR LATE FL REVISION
18/7/2023	ZMA	FL340	FL360	0	E	NO OR LATE FL REVISION
12/9/2023	BDQ	FL400	FL380	0	E	NO OR LATE FL REVISION
4/7/2023	YAQ	FL370	FL350	0	E	NO OR LATE FL REVISION
23/5/2023	ZMA		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
7/8/2023	QKM	FL370	FL390	2	E	NO OR LATE FL REVISION
24/3/2023	QKM	FL330	FL310	13	E	NO OR LATE FL REVISION
23/8/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
18/12/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
31/3/2023	QKM	FL310	FL350	0	E	NO OR LATE FL REVISION
8/10/2023	QKM	FL310	FL330	1	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
14/8/2023	QKM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/3/2023	QKM	FL350	FL350	0	E	NO OR LATE ROUTE REVISION
8/5/2023	PEK		FL410	0	E	NO OR LATE ROUTE REVISION
10/12/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
25/12/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
23/6/2023	QKM	FL310	FL330	1	E	NO OR LATE FL REVISION
15/12/2023	QKM	FL290	FL350	0	E	NO OR LATE FL REVISION
4/11/2023	AJT		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/1/2023	PBI	FL280	FL300	0	E	NO OR LATE FL REVISION
22/1/2023	FII		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/5/2023	QKM	FL390	FL370	0	E	NO OR LATE FL REVISION
27/10/2023	PEK	FL380	FL340	0	E	NO OR LATE FL REVISION
27/9/2023	AJT	FL350	FL370	0	E	NO OR LATE FL REVISION
14/1/2023	BDQ		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/11/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
10/11/2023	AJT		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/11/2023	AJT		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/3/2023	QKM	FL350	FL370	0	E	NO OR LATE FL REVISION
4/11/2023	AJT		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/11/2023	AJT		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/1/2023	BDQ		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
23/4/2023	PBI	FL340	FL340	0	E	NO OR LATE ROUTE REVISION
29/10/2023	PEK	FL380	FL400	0	E	NO OR LATE FL REVISION
1/6/2023	ZMA	FL320	FL320	0	E	NO OR LATE ROUTE REVISION
26/11/2023	ZMA	FL400	FL380	1	E	NO OR LATE FL REVISION
26/10/2023	QKM	FL350	FL370	3	E	NO OR LATE FL REVISION
11/9/2023	QKM	FL370	FL350	5	E	NO OR LATE FL REVISION
10/7/2023	YAQ	FL330	FL350	0	E	NO OR LATE FL REVISION
12/12/2023	QKM	FL290	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	Description
2/2/2023	QKM		FL380	2	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
31/3/2023	ZMA	FL360	FL380	0	E	NO OR LATE FL REVISION
4/5/2023	QKM		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
19/6/2023	QKM	FL390	FL350	0	E	NO OR LATE FL REVISION
23/10/2023	QKM	FL370	FL390	2	E	NO OR LATE FL REVISION
23/11/2023	QKM	FL390	FL410	0	E	NO OR LATE FL REVISION
31/8/2023	QKM	FL310	FL390	0	E	NO OR LATE FL REVISION
8/4/2023	QKM	FL330	FL350	0	E	NO OR LATE FL REVISION
23/12/2023	QKM	FL350	FL330	0	E	NO OR LATE FL REVISION
24/8/2023	QKM	FL290	FL310	0	E	NO OR LATE FL REVISION
28/8/2023	PEK	FL320	FL300	0	E	NO OR LATE FL REVISION
31/1/2023	BDQ		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/12/2023	QKM	FL390	FL390	0	E	NO OR LATE ESTIMATE TIME REVISION
5/6/2023	ZMA		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/2/2023	QKM	FL390	FL350	0	E	NO OR LATE FL REVISION
19/2/2023	QKM		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/3/2023	QKM	FL370	FL390	0	E	NO OR LATE FL REVISION

MONITORING AGENCY FOR ASIA REGION (MAAR)

The Airspace Safety Oversight for the RVSM Operation in the Southeast Asia (SEA) Airspace

January 2023 to December 2023

AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN THE SOUTHEAST ASIA AIRSPACE
Assessment Period: January 2023 to December 2023

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

1. Introduction

This report provides the results of the airspace safety oversight for the RVSM operation in the **Southeast Asia (SEA)** airspace. The review is conducted based on one-month traffic sample data (TSD) collected in **December 2023** and monthly Large Height Deviation (LHD) reports between **January 2023** and **December 2023** submitted by the States in the SEA airspace.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2023 of aircraft operating in the SEA 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 2023 to December 2023. **Table 1** indicates those FIRs which submitted LHD reports, including NIL reports. All FIRs in SEA airspace submitted LHD reports in a timely manner. **Appendix A** provides details of LHD reports and brief description of each LHD.

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 2023. An 'X' indicates that the LHD or NIL Reports Are Submitted 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 2023 to December 2023.

Month (2023)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
January	15	2	10	0	0.13
February	5	0	0	0	0.00
March	10	3	16	0	0.28
April	5	1	6	0	0.11
May	5	2	14	0	0.25
June	8	3	18	0	0.29
July	6	3	6	0	0.10
August	8	0	0	0	0.00
September	13	2	8	0	0.14
October	7	2	4	0	0.07
November	7	2	20	0	0.35
December	6	3	8	0	0.12
Total	**95**	**23**	**110**	**0**	**1.84**

Table 2: Monthly Summary of LHD in SEA Airspace

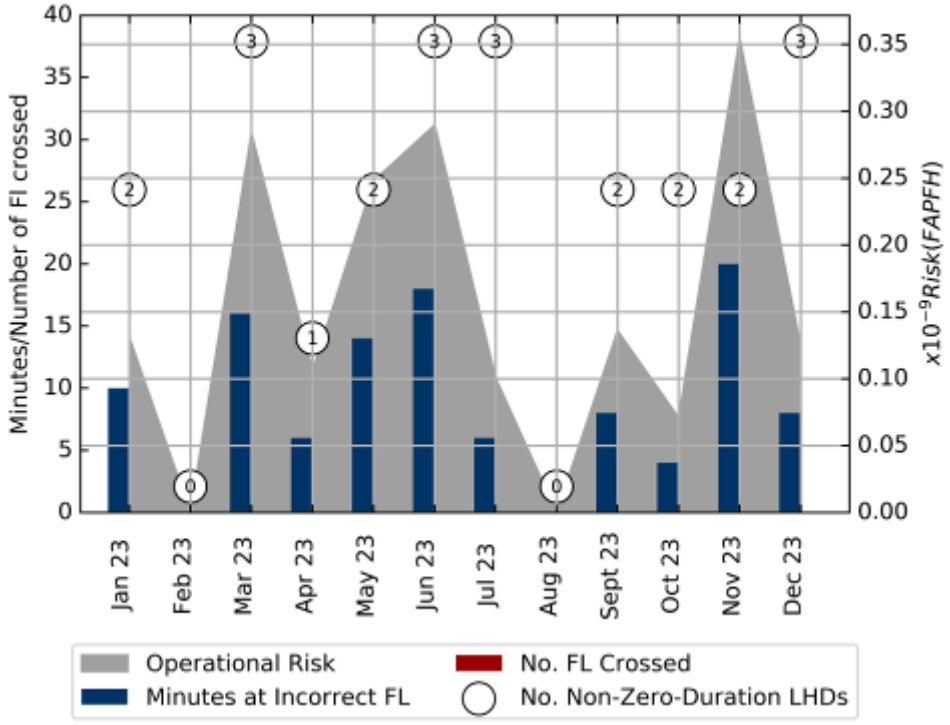


Figure 1: Monthly Summary of Non-Zero-Duration LHDs in SEA Airspace

3.2. The number of LHDs increased from 63 in 2022 to 95 in 2023. At the same time, the number of non-zero-duration LHDs increased from 19 in 2022 to 23 in 2023. This increase in the number of non-zero-duration LHDs led to a rise in the operational risk from 1.18 x 10^{-9} FAPFH in 2022 to 1.84 x 10^{-9} FAPFH in 2023.

3.3. **Figure 2** and **Table 3** summarize the number of Non-Zero-Duration LHDs, the associated LHD duration (in minutes) and the number of incorrect flight levels crossed, by the LHD category from January 2023 to December 2023.

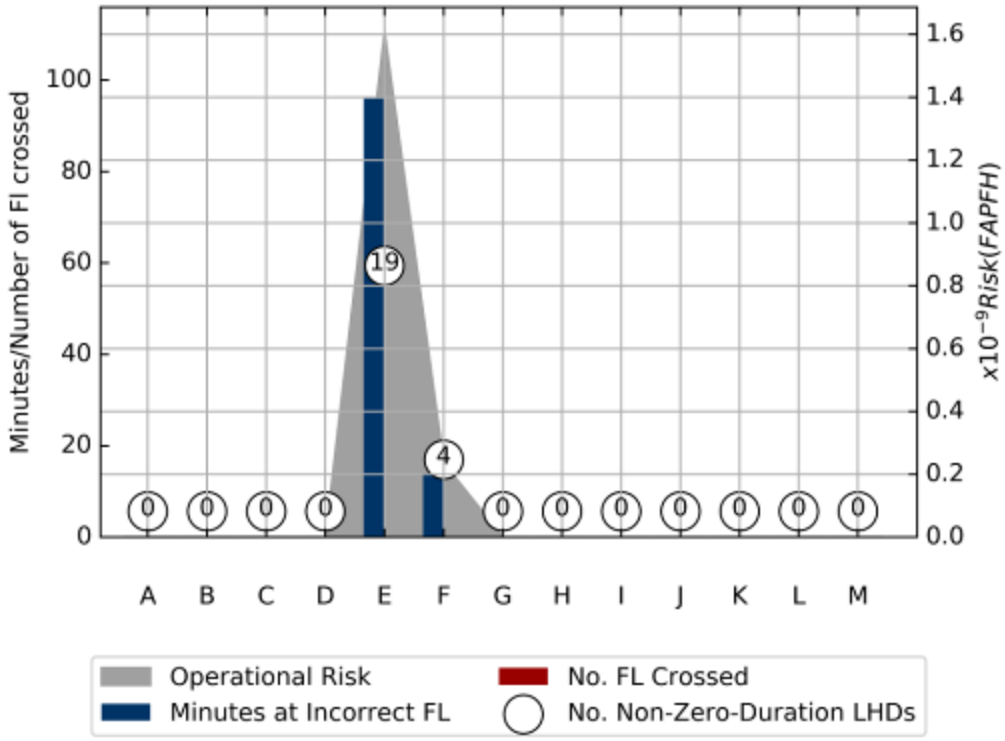


Figure 2: Summary of Non-Zero-Duration LHD by Category in SEA Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10^{-9} FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	0	0	0	0	0
B	Flight crew climbing/descending without ATC Clearance	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,	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)
	original clearance followed instead of re-clearance etc.).					
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	1	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).	85	19	96	0	1.61
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).	6	4	14	0	0.23
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	2	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		**95**	**23**	**110**	**0**	**1.84**

Table 3: Summary of LHD by category in SEA Airspace

3.4. The majority of LHDs, non-zero-duration LHDs, duration, and operational risk in SEA Airspace was in Category E. The second highest number of LHDs was in Category F, accounting for 6% of the total number of LHDs, which led to 0.23 x 10^{-9} FAPFH, or 12.5% of the total operational risk in SEA Airspace.

3.5. In **Figure 3**, Category E LHDs are categorized into four sub-categories. The majority, "No or Late FL Revision", accounts for 54%. This is followed by "No Transfer Information," which accounts for 34%. For smaller portions, 8%, is "No or Late Estimate Time Revision," and 4% is "Readback-Hearback Error."

3.6. In terms of the operational risk due to Category E LHDs, **Figure 4** shows that "No Transfer Information" is the most significant contributor, accounts for 58%. This indicates that "No Transfer Information" poses a higher risk than any other categories.

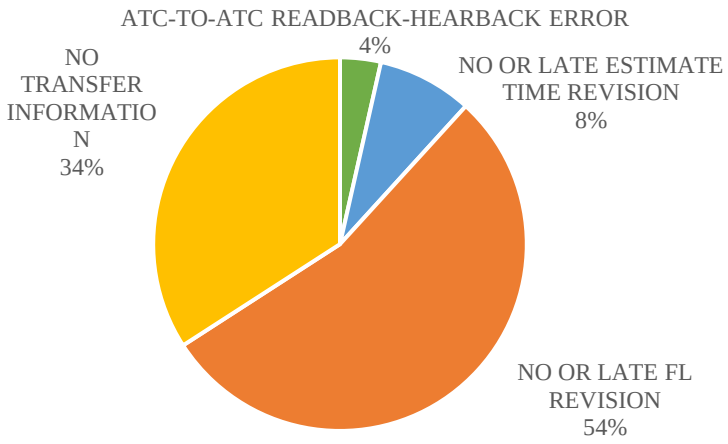


Figure 3: Sub-Categories of Category-E LHDs in SA/IO Airspace

(The Number of LHDs)

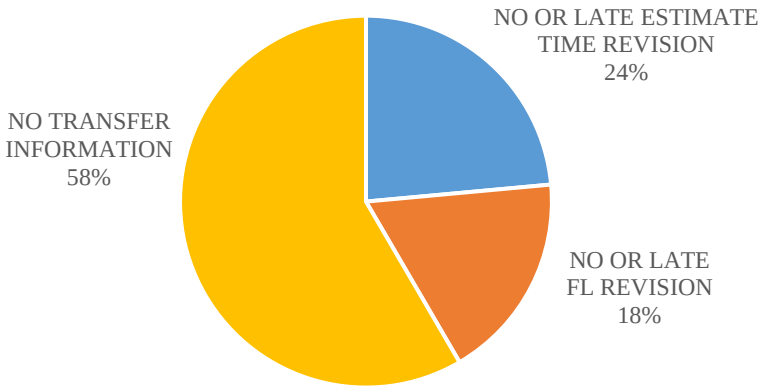


Figure 4: Sub-Categories of Category-E LHDs in SA/IO Airspace
(Operational Risk)

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	2,076,002	893,410	Hour	Dec 2023 TSD
E_z(same)	Same-direction vertical occupancies	0.35255/ 0.05234	0.30756	-	
E_z(opposite)	Opposite-direction vertical occupancies	0.23450	0.06446	-	
λ_x	Average aircraft length	0.02616	0.02864	NM	
λ_y	Average aircraft wingspan	0.02396	0.02645	NM	
λ_z	Average aircraft height	0.00753	0.00803	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.02616	0.02864	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	Conservative value used in previous assessments
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes	39.85	28.71	Knot	Dec 2023 TSD
$\overline{\lvert V\rvert}$	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 4: Estimates of the Parameters in the CRM for SA/IO Airspace

4.2. **Risk Estimation Results.** The results for technical, operational, and total risk are detailed in **Table 5**. The technical risk, defined as the probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft., is estimated at 1.07 x 10^{-9} FAPFH, which is below the target level of safety (TLS) value of 2.5 x 10^{-9} FAPFH. Additionally, the total risk is estimated at 2.91 x 10^{-9} FAPFH, which is below the specified TLS value of 5.0 x 10^{-9} FAPFH.

SEA Airspace – estimated annual flying hours = 2,969,413 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 Total Risk	*1.83 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
Technical Risk	1.07 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	1.84 x 10^{-9}	-	-
Total Risk	**2.91 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

Table 5: Vertical Collision Risk Estimates for SEA Airspace

4.3. **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHDs. The operational and total risk in 2023 showed an upward trend. The total risk increased by 59% from 1.83 x 10^{-9} FAPFH in 2022 to 2.91 x 10^{-9} FAPFH in 2023. Despite this increase, the total risk remains below the specified TLS.

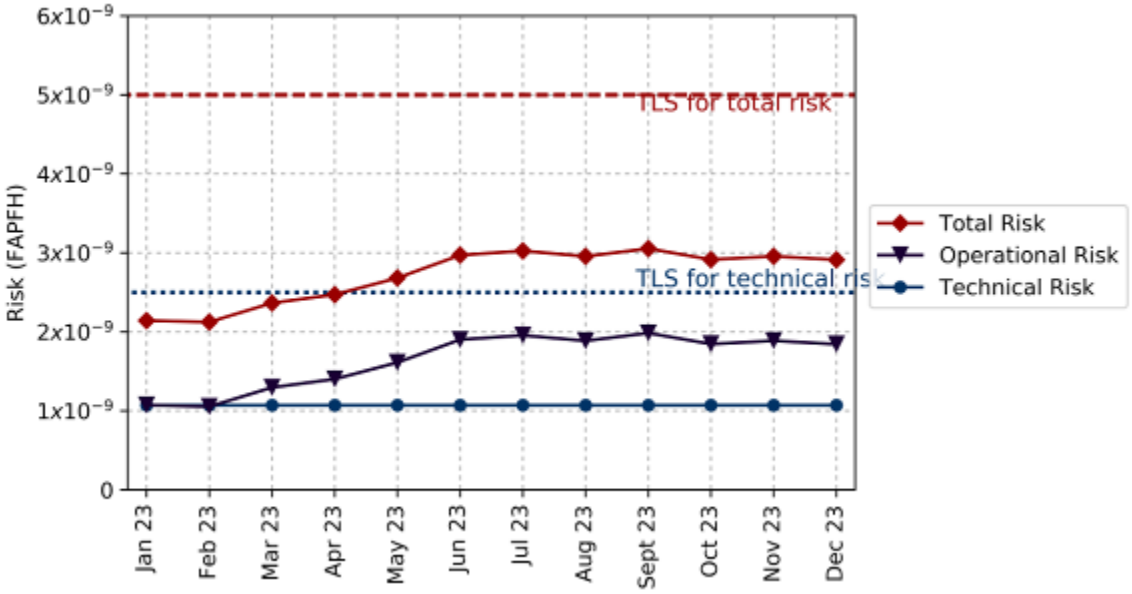


Figure 5: Trends of Risk Estimates for SEA Airspace

5. Analysis of Operational Errors

5.1 **Figure 6** depicts geographical locations of all reported LHDs in SEA airspace based on LHD reports from January to December 2023. **Figure 7** depicts only LHDs which are determined to be non-zero duration. The following are symbols and color 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.

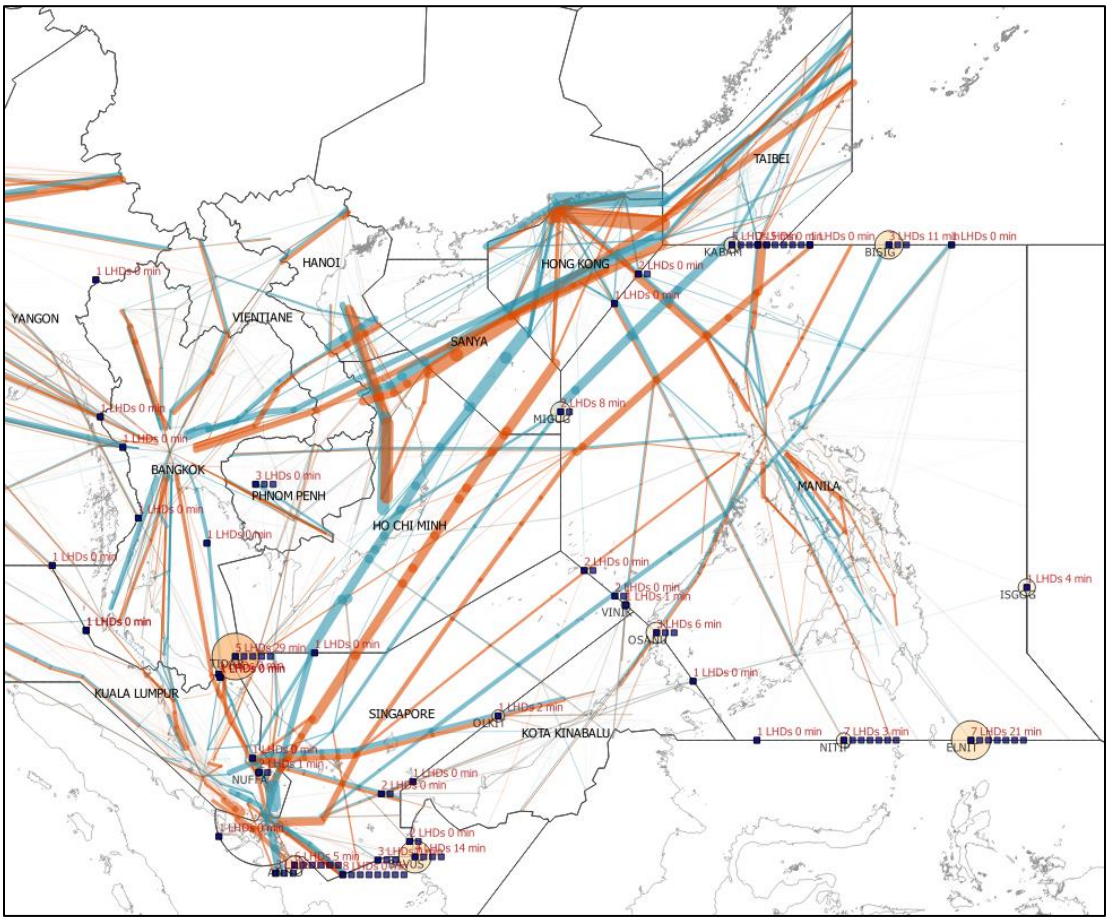


Figure 6: Geographic Locations of **All LHDs** in SEA Airspace

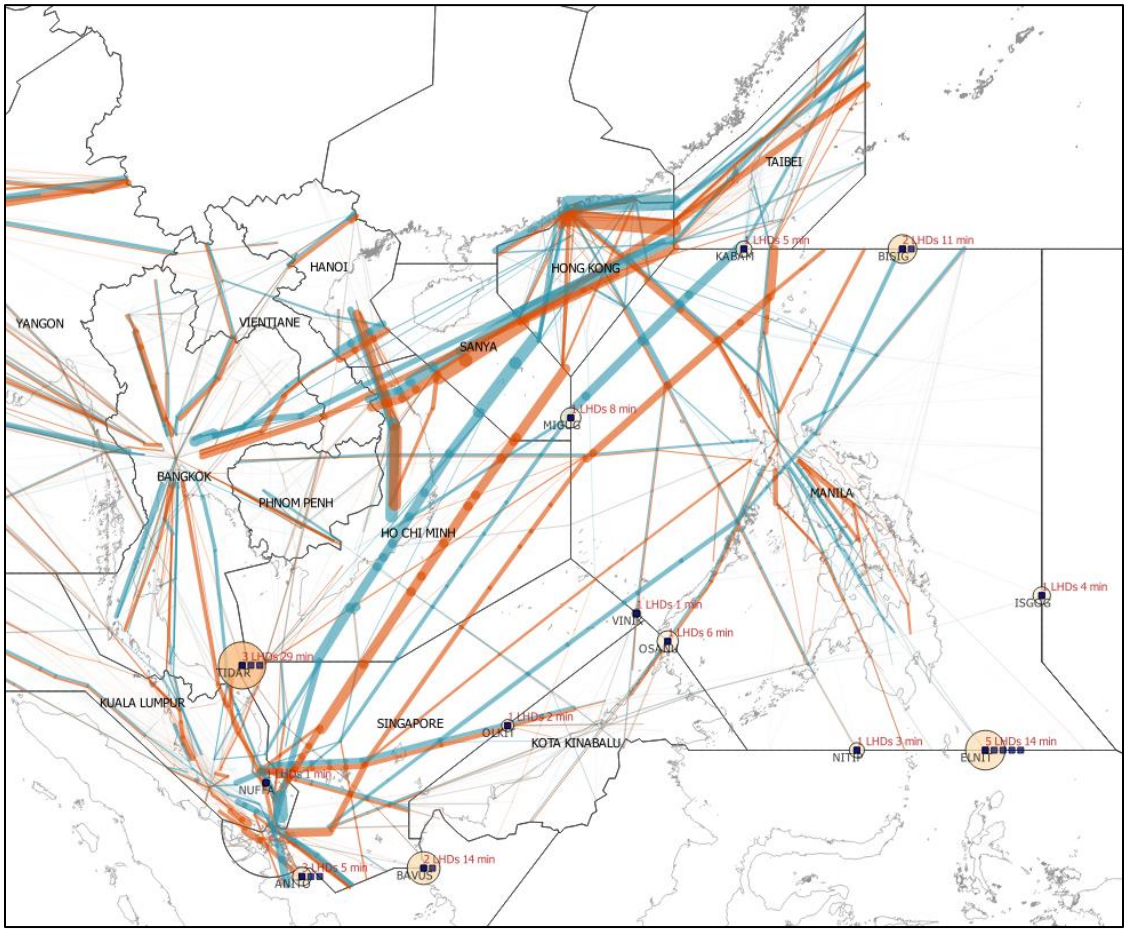


Figure 7: Geographic Locations of **Non-Zero-Duration LHDs** in SEA Airspace

LHD Hot Spot identification

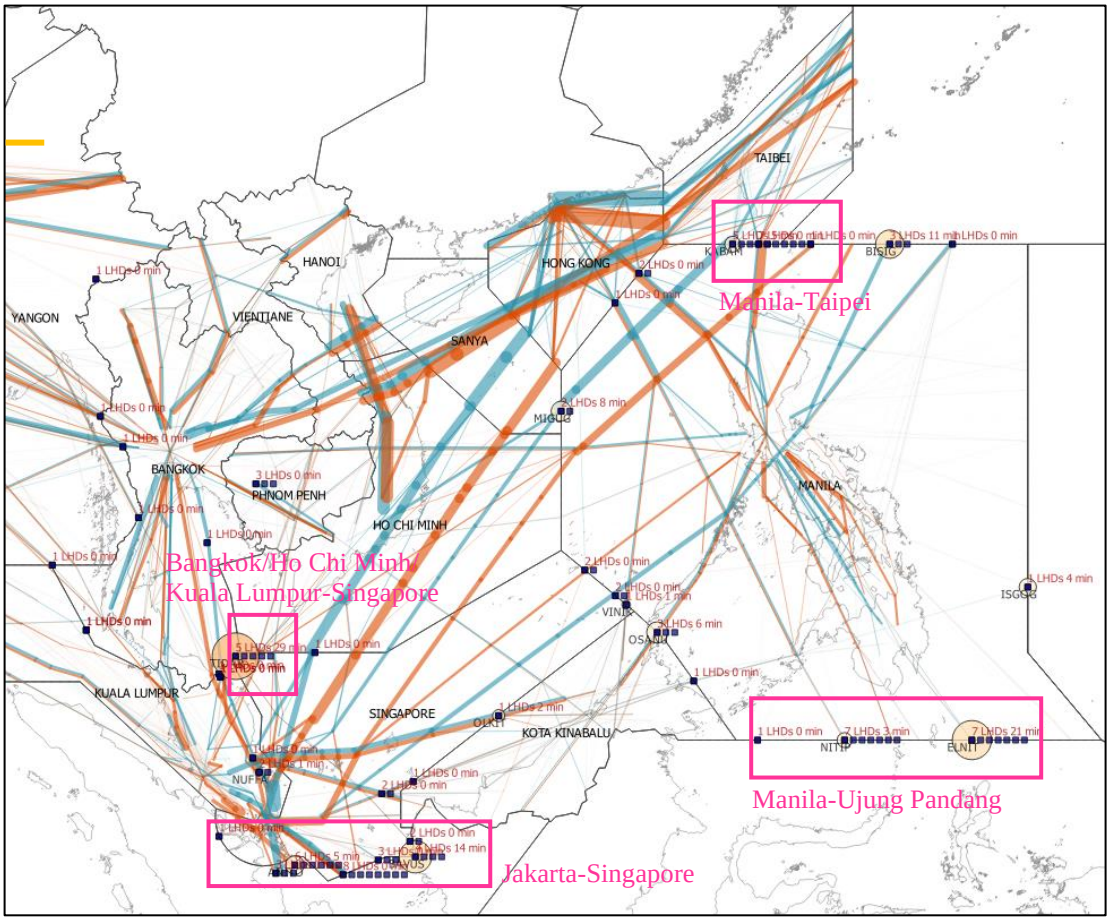


Figure 8: Geographical locations of **LHD clusters** identified in SEA Airspace

5.2 In identifying hot spots for SEA Airspace, four (4) LHD clusters are identified as shown in pink rectangles in **Figure 8**.

5.3 **Table 6** shows the profile of the LHD clusters in SEA Airspace and the determining criteria in 2023.

SEA	2023
Number of Clusters	**4**
Number of LHDs	**95**
Operational Risk (x 10^{-9} FAPFH)	**1.84**
Criteria: Number of LHDs	**19.00**
Criteria: Operational Risk (x 10^{-9} FAPFH)	**0.37**
Criteria: TLS (x 10^{-9} FAPFH)	**5.00**

Table 6: Profile of LHD Clusters and Determining Criteria for SA/IO Airspace in 2023

5.4 According to the decision in the process of identifying hot spots, a cluster will be identified as a 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 operational risk of each cluster, as well as the results of checking against the criteria. A 'Negative' result indicates that the

cluster does not satisfy the criteria, while a 'Positive' result indicates that the cluster satisfies the criteria and can be identified as a hot spot.

2023 Clusters (SEA)	Bangkok/Ho Chi Minh/ Kuala Lumpur-Singapore (Hot Spot O)	Jakarta-Singapore (Hot Spot J)	Manila-Taibei (Hot Spot D)	Manila-Ujung Pandang (Hot Spot D)
Number of LHDs	5	27	12	15
Check Criteria: Number >= 19.00	Negative	Positive	Negative	Negative
Operational Risk (x 10^{-9} FAPFH)	0.51	0.33	0.06	0.41
Check Criteria: Operational Risk >= 0.37 x 10^{-9} FAPFH	Positive	Negative	Negative	Positive
Check Criteria: Operational Risk >= 5.00 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative

Table 7: Results of Identifying Hot Spots in SEA Airspace

5.5 According to the result in **Table 7**, the following three (3) clusters satisfy the hot spot criteria:

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

5.6 On the other hand, the Manila-Taibei FIR boundary is identified as a cluster and is listed as part of Hot Spot D, but it does not meet any hot spot criteria in 2023.

LHD Hot Spot D (Manila FIR boundaries)

5.7 **Figure 9** depicts the geographical locations of LHDs and operational risk along the Manila FIR boundaries from 2019 to 2023. In 2023, traffic movement recovered compared to 2020, 2021, and 2022, as indicated by the thicker turquoise and orange lines. However, the traffic movement level in 2023 still did not reach that observed in 2019. The number of LHDs at the boundaries between Manila and Taipei, Hong Kong, Ho Chi Minh, Singapore, and Kota Kinabalu FIR decreased over the last four years compared to 2019. However, LHDs increased at the Manila-Ujung Pandang FIR and Manila-Taipei FIR boundaries in 2023.

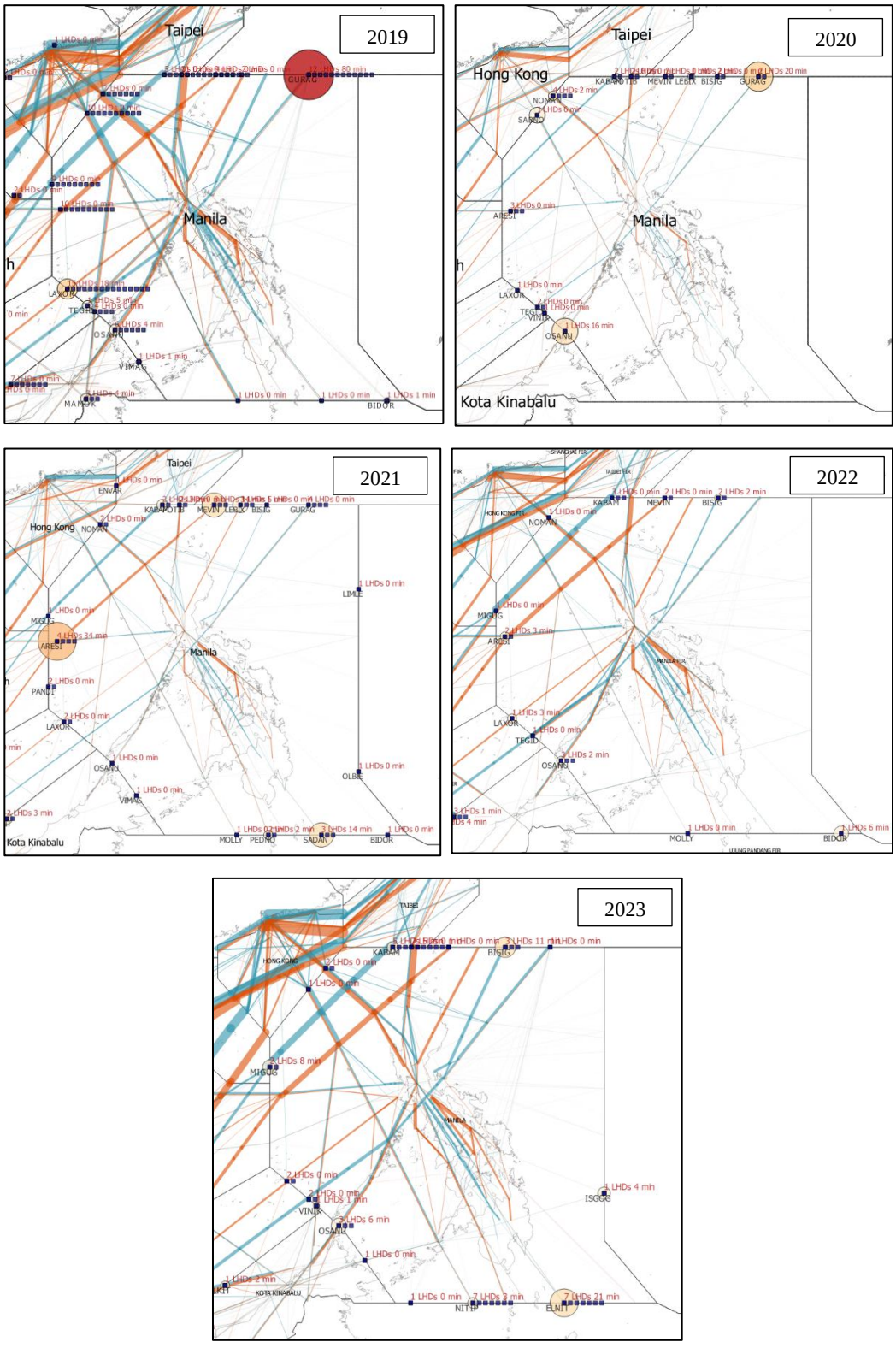


Figure 9: Geographic Locations of LHDs and Operational Risk along Manila FIR Boundaries in 2019, 2020, 2021, 2022 and 2023

5.8 **Table 8** summarizes the number of LHDs, non-zero-duration LHDs, and associated operational risk along Manila FIR boundaries in 2021, 2022, and 2023. The number of LHDs increased to 46 in 2023, highest over the last three years. The 46 LHDs at Hot Spot D accounted for 48% of the total LHDs in SEA airspace. In addition, the operational risk increased from 0.27 x 10^{-9} FAPFH in 2022 to 0.96 x 10^{-9} FAPFH in 2023. The operational risk at Hot Spot D accounted for 52% of total operational risk in SEA Airspace.

Boundary	**Number of LHDs**			**Number of non-zero-duration LHDs**			**Operational Risk (10^{-9} FAPFH)**		
	2021	**2022**	**2023**	**2021**	**2022**	**2023**	**2021**	**2022**	**2023**
Kobe/Fukuoka-Manila	11	4	4	4	3	2	0.45	0.03	0.19
Ho Chi Minh-Manila	7	3	2	3	2	1	0.77	0.05	0.10
Hong Kong-Manila	2	1	3	0	0	0	0.00	0.00	0.00
Kota Kinabalu-Manila	2	3	5	0	2	2	0.00	0.04	0.13
Manila-Sanya	0	0	0	0	0	0	0.00	0.00	0.00
Manila-Singapore	2	2	4	0	1	0	0.00	0.04	0.00
Manila-Taibei	4	3	12	1	0	1	0.07	0.00	0.06
Manila-Ujung Pandang	7	2	15	2	1	6	0.36	0.11	0.41
Manila-Oakland	2	0	1	0	0	1	0.00	0.00	0.07
Total	**37**	**18**	**46**	**10**	**9**	**13**	**1.65**	**0.27**	**0.96**

Table 8: Comparison of the Number of LHDs, Non-Zero-Duration LHDs and Operational Risk along Manila FIR Boundaries from 2021 to 2023

5.9 In 2023, the majority of LHDs and the operational risk occurred at Manila-Ujung Pandang FIR boundary, with 15 LHDs and 0.41 x 10^{-9} FAPFH of the operational risk. Out of 15 LHDs, 10 LHDs were in Category E and 5 LHDs were in Category F. All Category F LHDs were caused by the error from AIDC, leading to the operational risk of 0.17 x 10^{-9} FAPFH.

5.10 According to the decision made by the RASMAG MAWG/11, a hot spot can be subdivided into smaller interfaces between FIR boundaries or ATS sectors, if applicable. Therefore, Hot Spot D is subdivided into nine (9) interfaces as shown in **Figure 10**,

D1 for Fukuoka and Manila FIR boundary;
D2 for Manila and Taibei FIR boundary;
D3 for Hong Kong and Manila FIR boundary;
D4 for Manila and Sanya FIR boundary;
D5 for Ho Chi Minh and Manila FIR boundary;
D6 for Manila and Singapore FIR boundary;
D7 for Kota Kinabalu and Manila FIR boundary;
D8 for Manila and Ujung Pandang FIR boundary; and
D9 for Manila and Oakland FIR boundary.

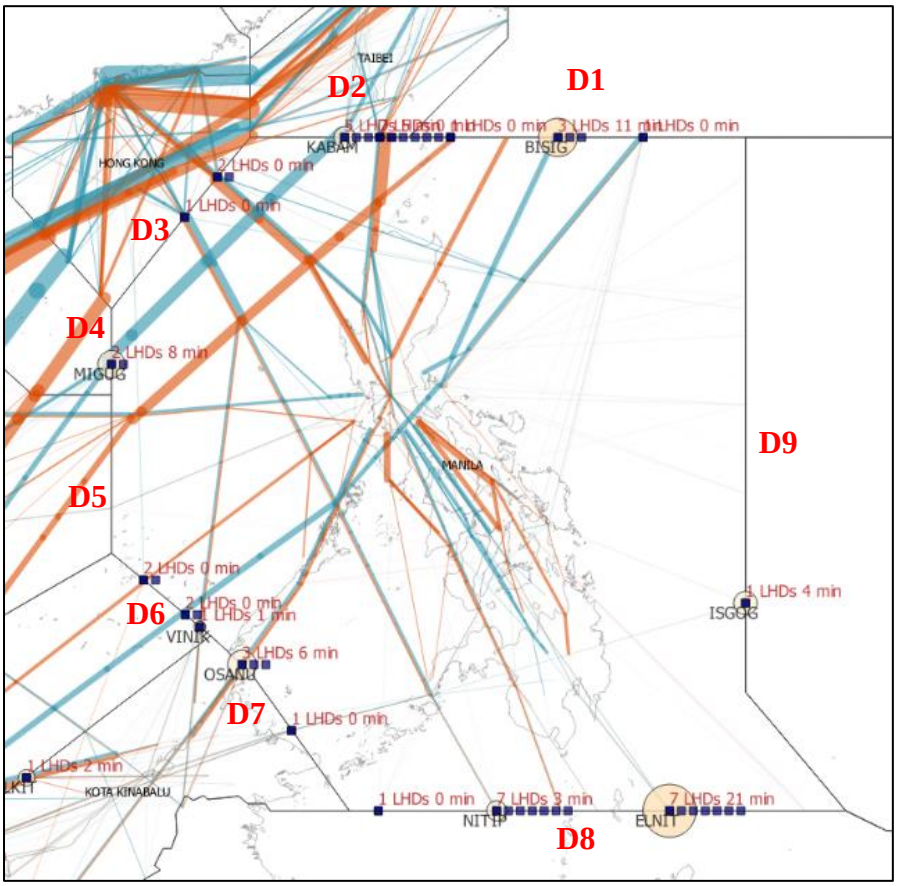


Figure 10: The Subdivision of Hot Spot D

5.11 To analyze these subdivisions, the hot spot identification process was applied to each interface as shown in **Table 9.** Since 2020, four FIR boundaries including Fukuoka-Manila (D1), Ho Chi Minh-Manila (D5), Kota Kinabalu-Manila (D7), and Manila-Ujung Pandang (D8) satisfied the hot spot criteria. However, only the Manila-Ujung Pandang FIR boundary (D8) met the hot spot criteria in the last two years (2022-2023).

Year	Identification Hot Spot Criteria	D1	D2	D3	D4	D5	D6	D7	D8	D9
2023	Number of LHDs	4	12	3	0	1	4	5	15	1
	Check Number Criteria >= 19.00	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.19	0.06	0.00	0.00	0.10	0.00	0.13	0.41	0.07
	Check Risk Criteria >= 0.37 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Positive	Negative
2022	Number of LHDs	4	3	1	0	3	2	3	2	0
	Check Number Criteria >= 10.50	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.03	0.00	0.00	0.00	0.05	0.04	0.04	0.11	0.00
	Check Risk Criteria >= 0.20 x 10^{-9} FAPFH	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
2021	Number of LHDs	11	1	2	0	7	1	1	1	2
	Check Number Criteria >= 8.00	Positive	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.45	0.07	0.00	0.00	0.77	0.00	0.00	0.36	0.00
	Check Risk Criteria >= 0.24 x 10^{-9} FAPFH	Positive	Negative	Negative	Negative	Positive	Negative	Negative	Positive	Negative
2020	Number of LHDs	5	3	6	2	4	3	2	0	0
	Check Number Criteria >= 6.50	Negative–	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
	Operational Risk	0.49	0.00	0.19	0.00	0.00	0.00	0.37	0.00	0.00
	Check Risk Criteria >= 0.24 x 10^{-9} FAPFH	Positive	Negative	Negative	Negative	Negative	Negative	Positive	Negative	Negative

Table 9: The result from hot spot identification process for the subdivision of Hot Spot D from 2020 to 2023.

5.12 Since 2018, the Philippines has promoted safety improvement activities, including implementing a new ATM system, redesigning sectors, enhancing surveillance capabilities, expanding ADS-C/CPDLC coverage to the entire oceanic airspace, conducting safety-related training sessions for controllers, initiating coordination meetings with adjacent ACCs, and implementing AIDC. These efforts support the decrease in LHDs, as noted in RASMAG/27 and RASMAG/28. However, AIDC implementation, which is expected to improve aircraft transfer efficiency across boundaries, is not yet complete with all adjacent ACCs.

5.13 **Table 10** shows the AIDC implementation status between Manila ACC and adjacent units as of August 2024.

ATS Units Adjacent to Manila ACC	AIDC Implementation Status
Hong Kong ACC	Implemented since May 2019
Singapore ACC	Implemented since November 2019
Taibei ACC	Implemented since December 2019
Ujung Pandang ACC	Implemented since December 2020
Oakland ARTCC	Implemented since November 2023
Kota Kinabalu ACC	Trial (April-August 2024)
Ho Chi Minh ACC	Planning
Kobe/Fukuoka ACC	Planning
Japan ATMC	Planning

Table 10: Status of AIDC Implementation with Manila ACC

5.14 Based on the hot spot identification process, analyzed statistics, and existing AIDC implementation, the status of each subdivision of Hot Spot D is as follows:

- **D1 (Fukuoka and Manila FIR boundary)** should remain on the Hot Spot list because the number of LHDs and operational risk met the 2022 criteria in JASMA's analysis even though it did not met any criteria in MAAR's analysis. The AIDC implementation between Manila ACC and Kobe/Fukuoka ACC has not operated yet.
- **D2 (Manila and Taibei FIR boundary), D3 (Hong Kong and Manila FIR boundary), D4 (Manila and Sanya FIR boundary), D6 (Manila and Singapore FIR boundary) and D9 (Manila and Oakland FIR boundary** are proposed for removal from the Hot Spot list because they have not met the hot spot criteria since 2020, and AIDC implementation is completed.
- **D5 (Ho Chi Minh and Manila FIR boundary)** should remain on the Hot Spot list because AIDC implementation is incomplete, even though it has not met the hot spot criteria since 2022.
- **D7 (Kota Kinabalu and Manila FIR boundary)** should remain on the Hot Spot list because AIDC implementation is incomplete, even though it has not met the hot spot criteria since 2021.
- **D8 (Manila and Ujung Pandang FIR boundary)** should remain on the Hot Spot list because it met the hot spot criteria in 2023.

LHD Hot Spot J (Singapore-Jakarta)

5.15 Since 2018 the **Singapore-Jakarta FIR boundary** has been identified as Hot Spots J. In **Table 11**, the number of LHDs at Singapore-Jakarta FIR boundary increased from 14 in 2022 to 27 in 2023. The operational risk also increased from 0.18 x 10^{-9} FAPFH in 2022 to 0.33 x 10^{-9} FAPFH in 2023. The increase is approximately double for both the number of LHDs and operational risk. 27 LHDs at Hot Spot J accounted for 28% of the total LHDs in SEA airspace. Additionally, all LHDs at this boundary were in Category E.

Area	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Hot Spot J	16	14	27	2	2	5	0.23	0.18	0.33

Table 11: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Singapore-Jakarta FIR Boundary from 2021 to 2023

5.16 As detailed in WP/10 of ACSICG/11, the AIDC implementation between Singapore ACC and Jakarta ACC remains in the testing phase. When the AIDC is successfully implemented, the coordination error and the number of LHDs are expected to be mitigated efficiently.

5.17 Regarding the process of identifying hot spots, this boundary was identified as a cluster and met the hot spot criteria in terms of the number of LHDs from 2021 to 2023. Therefore, Singapore-Jakarta boundary (LHD Hot Spot J) should remain on the hot spot list.

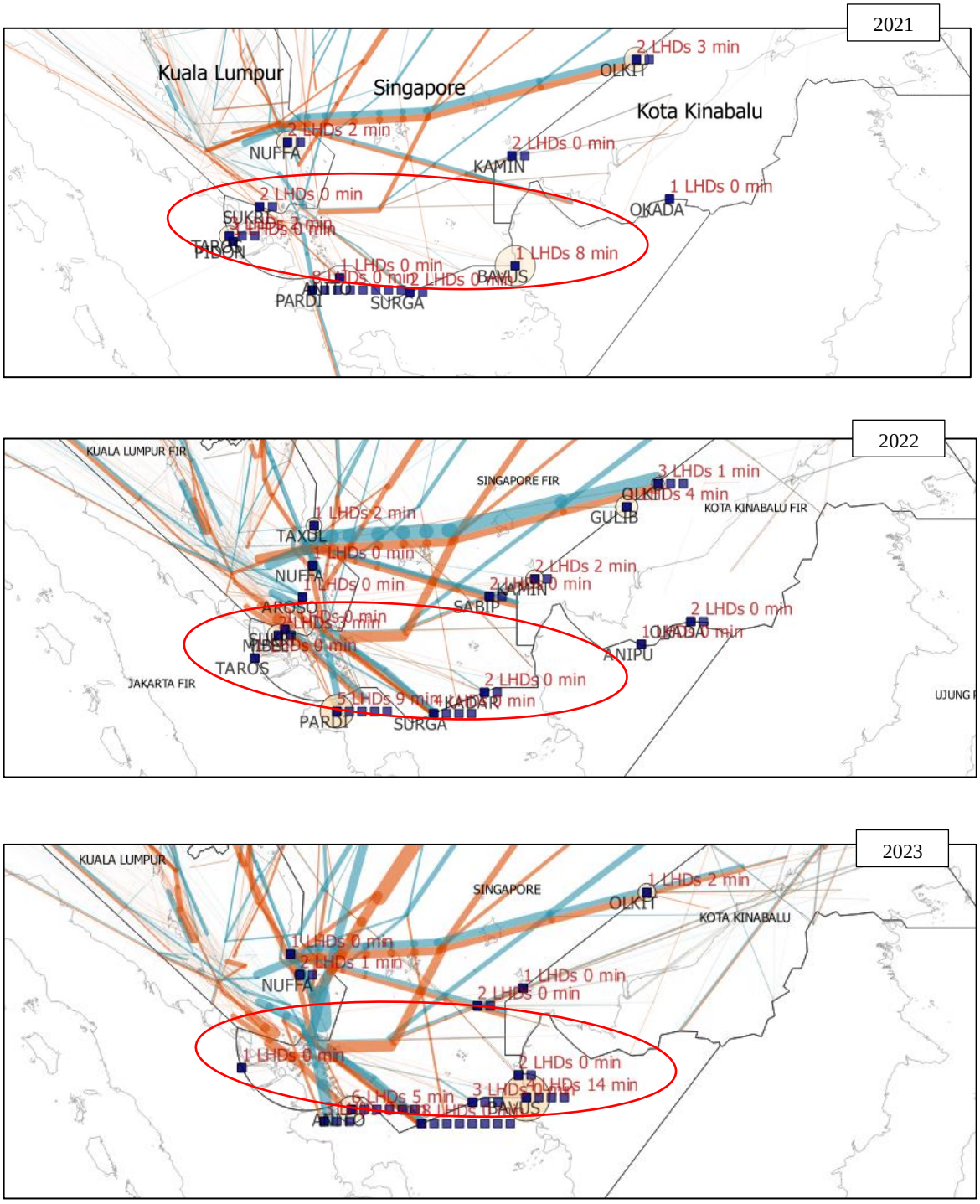


Figure 11: Geographic Location of LHDs and Operation Risk at Singapore-Jakarta FIR Boundary in 2021, 2022 and 2023.

LHD Hot Spot O (Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore)

5.18 This area was identified as Hot Spot O during RASMAG/28 meeting in 2023 due to the operational risk, which met the risk criteria in the process of identifying hot spots.

5.19 **Figure 12** demonstrates the area between Bangkok, Ho Chi Minh, Kuala Lumpur and Singapore FIR, which is considered as Hot Spot O. The route M904 between TIDAR and UPRON is in the Singapore FIR but the communication along this portion of route is with Kuala Lumpur ACC. In addition, the route M765 between VENLI and IGARI is delegated to Kuala Lumpur.

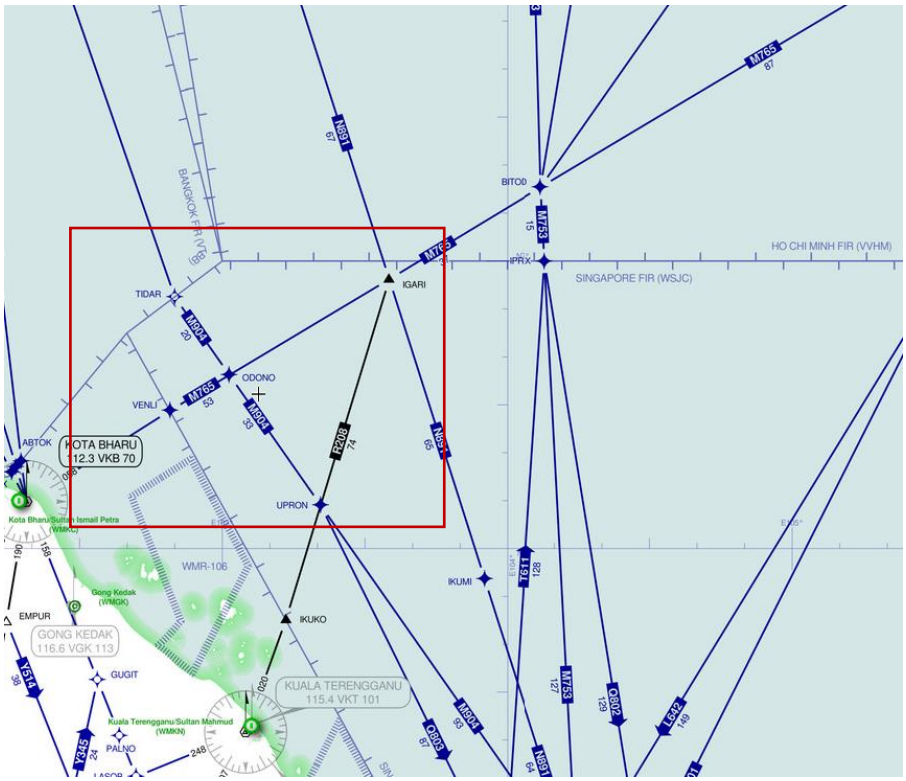


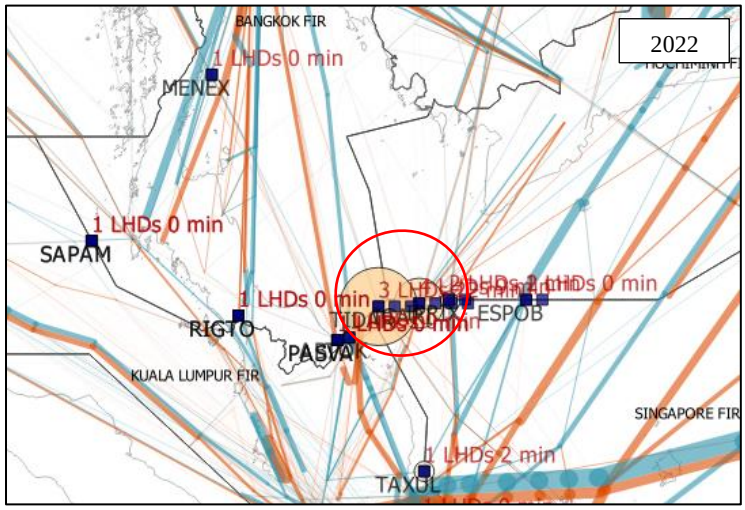
Figure 12: Location of Hot Spot O.

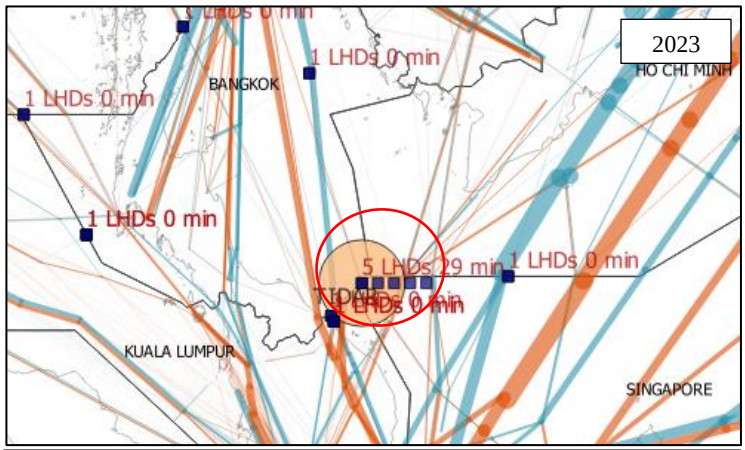
5.20 **Table 12** shows the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot O from 2021 to 2023. The number of LHDs and non-zero-duration LHDs, as well as operational risk in 2023 slightly decrease from 2022. However, the operational risk at this area was 28 % of the total operational risk in SEA Airspace. The operational risk of Hot Spot O is contributed by 3 non-zero-duration LHDs, which were the negative transfer from Kuala Lumpur to Singapore at TIDAR waypoint.

Area	Number of LHDs			Number of non-zero-duration LHDs			Operational Risk (10^{-9} FAPFH)		
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Hot Spot O	5	7	5	2	4	3	0.14	0.58	0.51

Table 12: Comparison of the Number of LHDs, the Number of Non-Zero-Duration LHDs and Operational Risk at Hot Spot O from 2021 to 2023

2021


2022
BANGKOK FIR
1 LHDs 0 min
MENEX
1 LHDs 0 min
SAPAM
1 LHDs 0 min
RIGTO
ESPOB
KUALA LUMPUR FIR
SINGAPORE FIR
1 LHDs 2 min
TAXUL


2023
1 LHDs 0 min
BANGKOK
HO CHI MINH
1 LHDs 0 min
1 LHDs 0 min
5 LHDs 29 min
1 LHDs 0 min
KUALA LUMPUR
SINGAPORE

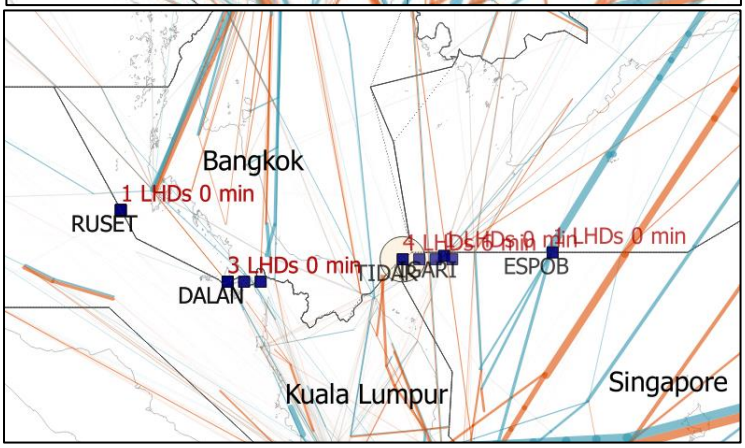

Bangkok
1 LHDs 0 min
RUSET
3 LHDs 0 min
DALAN
ESPOB
Kuala Lumpur
Singapore

Figure 13: Geographic Location of LHDs and Operation Risk
at Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore FIR Boundary in 2021, 2022 and 2023.

5.21 Regarding the process of identifying hot spots, the LHD cluster at Bangkok/Ho Chi Minh/Kuala Lumpur-Singapore FIR boundary (Hot Spot O) satisfied the hot spot criteria in terms of the operational risk. Consequently, this area should remain in the Hot Spot list.

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	Description
12/1/2023	AIG	FL320	FL350	8	E	NO OR LATE FL REVISION
7/2/2023	VST		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/12/2023	ZMV	FL350	FL370	0	E	NO OR LATE FL REVISION
19/6/2023	VST	FL380	FL380	0	J	None
23/9/2023	AIG	FL350	FL390	0	E	NO OR LATE FL REVISION
1/2/2023	XBE	FL340	FL334	0	D	PILOT MISUNDERSTANDS ATC CLEARANCE
8/1/2023	AIG	FL350	FL350	0	F	None
12/10/2023	ZMV	FL350	FL370	3	E	NO OR LATE FL REVISION
10/3/2023	ZMV	FL330	FL350	0	E	NO OR LATE FL REVISION
2/10/2023	ZMV	FL350	FL330	1	E	NO OR LATE FL REVISION
29/11/2023	ZMV		FL380	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
9/3/2023	ZMV		FL330	9	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/11/2023	ZMV		FL330	13	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/4/2023	EIN		FL350	6	E	NO OR LATE ESTIMATE TIME REVISION
25/9/2023	ZMV	FL270	FL290	0	E	NO OR LATE FL REVISION
29/3/2023	ZMV		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
22/1/2023	ZMV	FL360	FL380	0	E	NO OR LATE FL REVISION
31/3/2023	AIG		FL380	6	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/4/2023	AIG	FL380	FL340	0	E	NO OR LATE FL REVISION
10/4/2023	AIG	FL320	FL340	0	E	NO OR LATE FL REVISION
20/9/2023	QSU			0	E	NO OR LATE FL REVISION
18/10/2023	AIG	FL340	FL380	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
1/12/2023	AIG		FL380	5	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
9/9/2023	AIG		FL340	7	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/8/2023	AIG	FL400	FL380	0	E	NO OR LATE FL REVISION
17/7/2023	AIG		FL380	3	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
31/3/2023	AIG	FL340	FL380	1	E	NO OR LATE FL REVISION
6/8/2023	XBE	FL330	FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/3/2023	ZMV	FL340	FL380	0	E	NO OR LATE FL REVISION
9/10/2023	AIG	FL340	FL380	0	E	NO OR LATE FL REVISION
25/6/2023	ZMV	FL380	FL380	12	E	NO OR LATE ESTIMATE TIME REVISION
29/7/2023	ZMV	FL410	FL390	1	E	NO OR LATE FL REVISION
2/1/2023	XBE	FL330	FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/8/2023	AIG	FL350	FL360	0	E	NO OR LATE FL REVISION
15/9/2023	AIG	FL340	FL380	0	E	NO OR LATE FL REVISION
8/8/2023	ZMV	FL340	FL400	0	E	NO OR LATE FL REVISION
25/7/2023	AIG	FL350	FL346	0	I	None
1/2/2023	AIG	FL360	FL350	0	E	NO OR LATE FL REVISION
11/3/2023	QSU	FL390	FL390	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
16/9/2023	ZMV	FL400	FL400	0	E	NO OR LATE ESTIMATE TIME REVISION
24/1/2023	VST	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/5/2023	QSU	FL349	FL360	0	E	NO OR LATE FL REVISION
7/9/2023	AIG	FL360	FL340	1	E	NO OR LATE FL REVISION
17/7/2023	QSU			0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
23/5/2023	AIG		FL370	4	F	None
2/6/2023	AIG		FL300	1	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/12/2023	AIG	FL340	FL320	0	E	NO OR LATE FL REVISION
30/1/2023	VST		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/1/2023	ZMV	FL350	FL330	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
24/10/2023	VST		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
28/9/2023	QSU			0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
20/12/2023	ZMV	FL370	FL350	1	E	NO OR LATE FL REVISION
31/1/2023	EIN		FL370	2	E	NO OR LATE FL REVISION
10/1/2023	ZMV		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/5/2023	ZMV	FL380	FL400	0	E	NO OR LATE FL REVISION
28/5/2023	AIG	FL360	FL363	0	I	None
18/10/2023	AIG	FL400	FL430	0	E	NO OR LATE FL REVISION
1/8/2023	AIG		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/8/2023	AIG	FL350	FL310	0	E	NO OR LATE FL REVISION
11/5/2023	AIG		FL320	10	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/12/2023	AIG			2	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/11/2023	AIG	FL340	FL380	0	E	NO OR LATE FL REVISION
25/6/2023	ZMV		FL300	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
1/11/2023	AIG	FL370	FL390	0	F	NO OR LATE FL REVISION
13/1/2023	VST		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/9/2023	ZMV		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
5/9/2023	ZMV	FL410	FL390	0	E	NO OR LATE FL REVISION
12/9/2023	VST	FL400	FL380	0	E	NO OR LATE FL REVISION
12/4/2023	ZMV		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/1/2023	QSU	FL400	FL390	0	E	NO OR LATE FL REVISION
14/6/2023	AIG	FL400	FL400	5	E	NO OR LATE ESTIMATE TIME REVISION
14/6/2023	AIG	FL400	FL400	0	E	NO OR LATE ESTIMATE TIME REVISION
2/11/2023	ZMV		FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
12/6/2023	ZMV	FL360	FL380	0	E	NO OR LATE FL REVISION
8/2/2023	ZMV	FL340	FL340	0	E	NO OR LATE ESTIMATE TIME REVISION
28/7/2023	ZMV	FL320	FL340	2	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Description
5/6/2023	ZMV	FL360	FL380	0	E	NO OR LATE FL REVISION
10/1/2023	ZMV	FL360	FL340	0	E	NO OR LATE FL REVISION
13/9/2023	ZMV		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/11/2023	EIN	FL330	FL350	0	E	NO OR LATE FL REVISION
29/3/2023	ZMV	FL380	FL400	0	E	NO OR LATE FL REVISION
25/3/2023	ZMV	FL290	FL330	0	E	NO OR LATE FL REVISION
3/11/2023	ZMV		FL330	7	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/1/2023	VST		FL320	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/1/2023	VST		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
20/7/2023	ZMV	FL340	FL360	0	E	NO OR LATE FL REVISION
28/8/2023	ZMV	FL360	FL380	0	E	NO OR LATE FL REVISION
16/9/2023	AIG	FL430	FL380	0	E	NO OR LATE FL REVISION
10/4/2023	ZMV		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/12/2023	AIG		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/3/2023	AIG	FL320	FL350	0	E	NO OR LATE FL REVISION
31/1/2023	VST		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
31/10/2023	AIG	FL350	FL340	0	E	NO OR LATE FL REVISION
1/8/2023	EIN		FL290	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
27/2/2023	ZMV	FL400	FL400	0	E	NO OR LATE ESTIMATE TIME REVISION

MONITORING AGENCY FOR ASIA REGION (MAAR)

Airspace Safety Review of RVSM in Mongolian Airspace

January 2023 to December 2023

AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN THE MONGOLIAN AIRSPACE
Assessment Period: January 2023 to December 2023

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

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1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **Mongolian Airspace**. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2023** and monthly Large Height Deviation (LHD) reports between **January 2023** and **December 2023** submitted by Mongolia.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2023 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 2023 to December 2023. **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 2023. An 'X' indicates that the LHD or NIL Reports Are Submitted Each Month

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 2023 to December 2023 by month and by LHD category, respectively.

Month (2022)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk ($x10^{-9}$ FAPFH)
January	0	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	0	0	0	0	0

Table 2: Monthly Summary of LHD in 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).	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)
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		**0**	**0**	**0**	**0**	**0**

Table 3: Summary of LHD by Category in Mongolian Airspace

4. Risk Assessment and Safety Oversight

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

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	82,944	763	Hour	Dec 2023 TSD
E_z(same)	Same-direction vertical occupancies	0.27871/ 0.00620	0.00000	-	
E_z(opposite)	Opposite-direction vertical occupancies	0.10465	0.00000	-	
λ_x	Average aircraft length	0.0330	0.0360	NM	
λ_y	Average aircraft wingspan	0.0305	0.0323	NM	
λ_z	Average aircraft height	0.0090	0.0093	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0330	0.0360	NM	
Pz(0)	Probability of vertical overlap (with planned vertical separation equal to zero)	0.538	0.538	-	More conservative value used in previous assessments
$\overline{\lvert\Delta V\rvert}$	Average relative along-track speed between aircraft on same direction routes	21.14	0.00	Knot	Dec 2023 TSD NOTE: $\overline{\lvert\Delta V\rvert}$ was calculated based on relative speed of proximate pair on each route type. For uni-dir route, there was no proximate pair.
$\overline{\lvert V\rvert}$	Average absolute aircraft ground speed	480	480	Knot	More conservative value used in previous assessments

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

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. **The technical risk**, defined as probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and to all causes, **meets the TLS** value of 2.5 x 10^{-9} FAPFH. **The total risk** is 0.58 x 10^{-9} FAPFH, which also **meets the specified TLS** value of 5.0 x 10^{-9} FAPFH.

Mongolian Airspace – estimated annual flying hours = 83,708 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 Total Risk	*0.33 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
Technical Risk	0.58 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	0.00 x 10^{-9}	-	-
Total Risk	**0.58 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

Table 5: Risk Estimates for Mongolian Airspace

5. Analysis of Operational Errors

In 2023, no LHD was reported within or at the boundary of the Mongolian Airspace. Hence, the analysis of operational errors cannot be conducted.