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ICAO Twenty-Eighth Meeting of the Regional Airspace Safety
Monitoring Advisory Group (RASMAG/28)

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

MAAR SAFETY REPORT

(Presented by the Monitoring Agency for Asia Region)

SUMMARY

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

1. INTRODUCTION

1.1 This paper provides the executive summary of airspace safety oversight for the RVSM operation in 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:

- Traffic Sample Data (TSD) and Large Height Deviation (LHD) reports used in risk estimation;
- summary of LHD occurrences and their associated risk;
- risk estimation parameters and results;
- further discussion including geographical location of LHDs, the identification of hot spots; and
- the hot spot analysis.

2. DISCUSSION

Executive Summary: SA/IO Airspace

2.1 **Table 1** summarizes the SA/IO Airspace RVSM technical, operational, and total risks. **Figure 1** presents collision risk estimate trends during the period from January 2022 to December 2022.

| SA/IO Airspace – estimated annual flying hours = 3,005,641 hours (note: estimated hours based on Dec 2022 traffic sample data) | | | |
|---|-----------------------|----------------------|---------------------|
| Source of Risk | Risk Estimation | TLS | Remarks |
| RASMAG 27 Total Risk | 5.62×10^{-9} | 5.0×10^{-9} | Above TLS |
| Technical Risk | 0.69×10^{-9} | 2.5×10^{-9} | Below Technical TLS |
| Operational Risk | 1.06×10^{-9} | - | - |
| Total Risk | 1.75×10^{-9} | 5.0×10^{-9} | Below TLS |

Table 1: SA/IO Airspace RVSM Risk Estimates

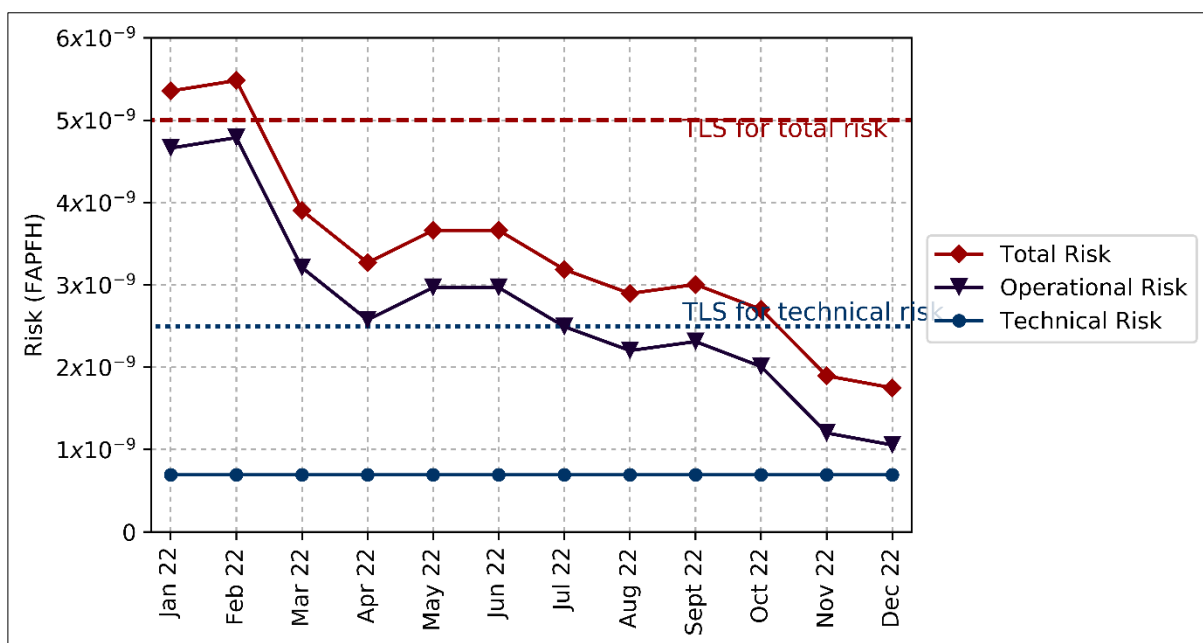


Figure 1: SA/IO Airspace RVSM Risk Estimate Trends

2.2 **Table 2** presents a summary of the LHD causes within SA/IO Airspace from January 2022 until December 2022. The total number of LHDs slightly increased from 134 in 2021 to 148 in 2022. Out of 148 LHDs in 2022, 141 were categorized as Category E LHDs, accounting for approximately 95% of the total number of LHDs in the SA/IO Airspace.

| Code | LHD Category Description | No. |
|-------|---|-----|
| A | Flight crew fails to climb or descend the aircraft as cleared | 2 |
| B | Flight crew climbing or descending without ATC clearance | 1 |
| 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 | 141 |
| 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 | 1 |
| 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 | 0 |
| 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 | 2 |
| Total | | 148 |

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

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

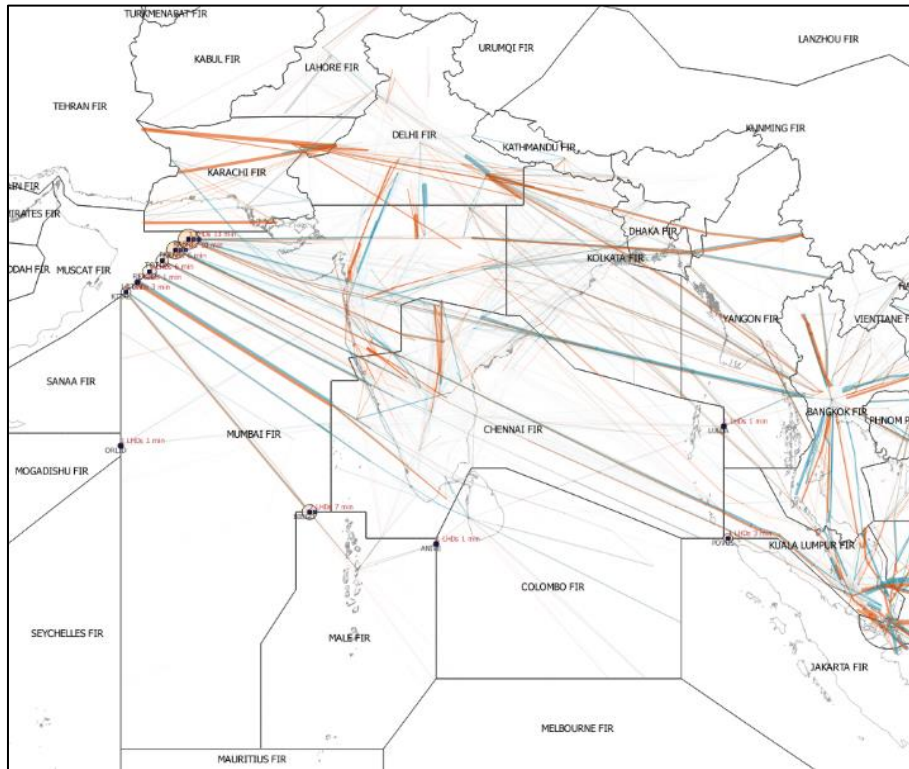


Figure 2: Geographic Locations of ‘Non-zero-duration’ LHDs in SA/IO Airspace

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

| 2022 Clusters (SA/IO) | Mumbai-Muscat (Hot Spot G) | Mumbai-Mogadishu (Hot Spot F) | Chennai/Kolkata-Yangon (Hot Spot A1) | Chennai-Kuala Lumpur (Hot Spot A2) | Chennai-Kolkata |
|---|----------------------------|-------------------------------|--------------------------------------|------------------------------------|-----------------|
| Number of LHDs | 43 | 9 | 40 | 22 | 9 |
| Check Criteria: Number ≥ 24.67 | Positive | Negative | Positive | Negative | Negative |
| Operation Risk ($\times 10^{-9}$ FAPFH) | 0.79 | 0.02 | 0.02 | 0.00 | 0.00 |
| Check Criteria: Operation Risk $\geq 0.18 \times 10^{-9}$ FAPFH | Positive | Negative | Negative | Negative | Negative |
| Check Criteria: Operation Risk $\geq 5 \times 10^{-9}$ FAPFH | Negative | Negative | Negative | Negative | Negative |

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

2.5 Regarding the result in **Table 7**, the following clusters satisfy the hot spot criteria in 2022:

- Mumbai-Muscat boundary (Hotspot G); and
- Chennai/Kolkata-Yangon boundary (Hot Spot A1).

2.6 On the other hand, the following boundaries are listed as LHD hot spots but do not meet the hot spot criteria in 2022:

- Mumbai-Mogadishu boundary (Hotspot F); and
- Chennai- Kuala Lumpur boundary (Hot Spot A2).

2.7 **LHD Hot Spot G (Sanaa/Muscat – Mumbai) and LHD Hot Spot F (Mogadishu – Mumbai)** were identified as LHD hot spots since 2015. **Table 4** summarizes the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot G and Hot Spot F from 2020 to 2022. **Figure 3** shows the visualization of non-zero-duration LHDs and operation risk at Hot Spot and Hot Spot F from 2020 to 2022.

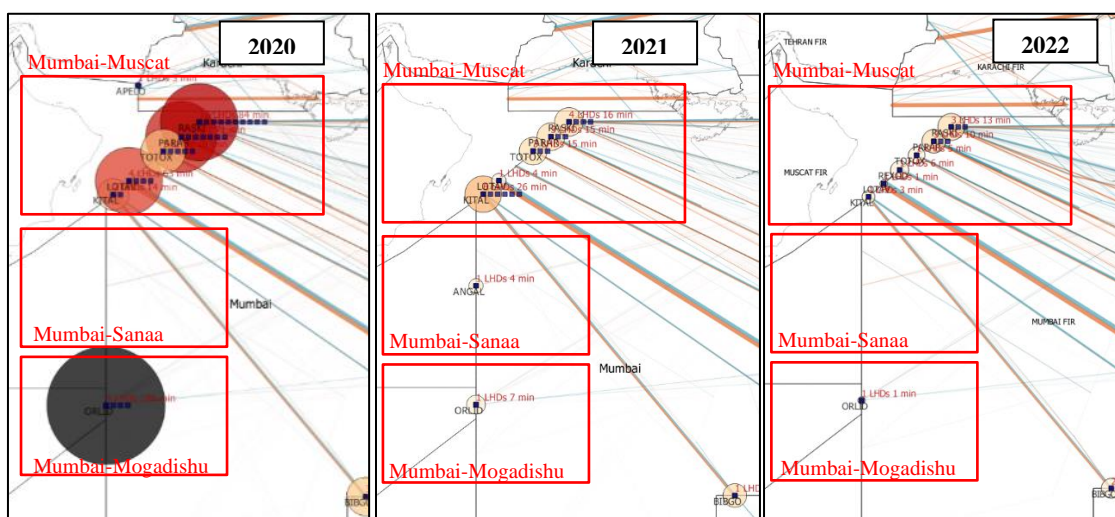


Figure 3: Geographic Locations of ‘Non-zero-duration’ LHDs and Operation Risk at Hot Spot G and Hot Spot F from 2020 to 2022.

| Boundary | Number of LHDs | | | Number of non-zero-duration LHDs | | | Operational Risk (10 ⁻⁹ FAPFH) | | |
|------------------|----------------|-----------|-----------|----------------------------------|-----------|-----------|--|-------------|-------------|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Mumbai-Muscat | 48 | 44 | 43 | 28 | 17 | 10 | 6.37 | 1.35 | 0.79 |
| Mumbai-Sanaa | 1 | 4 | 2 | 0 | 1 | 0 | 0.00 | 0.07 | 0.00 |
| Mumbai-Mogadishu | 8 | 5 | 9 | 4 | 1 | 1 | 4.80 | 0.12 | 0.02 |
| Total | 57 | 53 | 54 | 32 | 19 | 11 | 11.17 | 1.54 | 0.81 |

Table 4: Comparison of the Number of LHDs, the number of ‘Non-zero-duration’ LHDs and Operational Risk at Hot Spot G and Hot Spot F from 2020 to 2022.

2.8 At Mumbai-Muscat boundary, the number of LHDs slightly decreased from 44 in 2021 to 43 in 2022. However, there was a significant reduction in both the number of non-zero-duration LHDs and the operational risk from 2020 to 2022. In 2022, the non-zero-duration LHDs reduced to 10, resulting in the operational risk of 0.79 x 10⁻⁹ FAPFH.

2.9 At Mumbai-Sanaa boundary, the number of LHDs decreased from 4 in 2021 to 2 in 2022. However, there was no non-zero-duration LHDs, resulting in zero operational risk in 2022.

2.10 At Mumbai-Mogadishu boundary, the number of LHDs increased from 5 in 2021 to 9 in 2022. On the other hand, the number of non-zero-duration LHDs was only 1 and the operational risk at this boundary was only 0.02 x 10⁻⁹ FAPFH.

2.11 Despite a partial recovery in traffic, the total number of LHDs at Hot Spot G and F in 2022 closely resembled the figures from 2020 and 2021. However, both the total duration and the associated operational risk consistently decreased. The decreasing trend was potentially due to the traffic reduction during the COVID-19 pandemic and the implementation of Space-Based ADS-B in February 2020. This implementation enhanced surveillance capability, allowing controllers to detect LHDs beyond the Transfer of Control (TOC) point. Consequently, the duration of LHDs and operational risk decreased significantly starting in 2020.

2.12 However, the ATS Inter-Facility Data Communication (AIDC) implementation between Mumbai ACC and Muscat ACC, as well as Mumbai ACC and Mogadishu ACC, remained in the testing phase, as indicated in the final report of the Tenth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/10) held in May 2023.

2.13 In the process of identifying hot spot, Mumbai-Muscat boundary (Hot Spot G) continues to meet the criteria in terms of both the number of LHDs and the operational risk. Mumbai-Mogadishu boundary (Hot Spot F) does not meet any hot spot identification criteria. However, the number of LHDs at Mumbai-Mogadishu boundary (Hot Spot F) slightly increased in 2022. Therefore, **the western boundaries of Mumbai FIR (Hot Spot G and F) should remain as hot spots** and continue to be monitored until further safety improvement initiatives or prevention measures such as AIDC are completed and demonstrate their effectiveness.

2.14 **LHD Hot Spot A1 (Kolkata FIR / Dhaka FIR - Yangon FIR) and LHD Hot Spot A2 (Chennai FIR and Kuala Lumpur FIR)** were first identified as LHD hot spots in 2015. **Table 5** summarizes the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and Hot Spot A2 from 2020 to 2022. **Figure 4** shows the visualization of non-zero-duration LHDs and operation risk at Hot Spot A1 and A2 from 2020 to 2022.

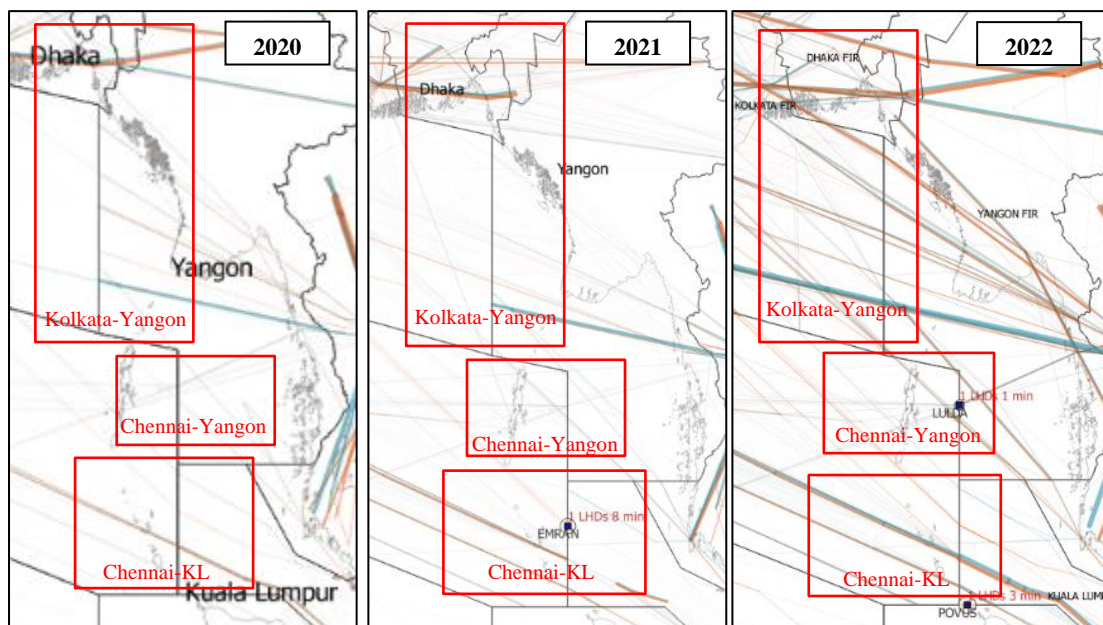


Figure 4: Geographic Locations of ‘Non-zero-duration’ LHDs and Operation Risk at Hot Spot A1 and A2 from 2020 to 2022.

| Boundary | Number of LHDs | | | Number of non-zero-duration LHDs | | | Operational Risk (10 ⁻⁹ FAPFH) | | |
|----------------------|----------------|-----------|-----------|----------------------------------|----------|----------|---|-------------|-------------|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Kolkata-Yangon | 8 | 1 | 17 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 |
| Chennai-Yangon | 3 | 8 | 23 | 0 | 0 | 1 | 0.00 | 0.00 | 0.02 |
| Chennai-Kuala Lumpur | 13 | 21 | 22 | 0 | 1 | 0 | 0.00 | 0.05 | 0.00 |
| Total | 24 | 30 | 62 | 0 | 1 | 1 | 0.00 | 0.05 | 0.02 |

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 2020 to 2022

2.15 At the Kolkata-Yangon and Chennai-Yangon boundaries, the number of LHDs significantly increased in 2022. All LHDs at these two boundaries were in Category E. The increase in the number of LHDs can be attributed by the recovery of traffic. Thus, controllers might face the rapid increase in workload, which easily leads to human errors. At these two boundaries, there was no non-zero-duration LHDs in 2020 and 2021. However, there was one non-zero-duration LHD in 2022. As a result, the operational risk was 0.02×10^{-9} FAPFH, which was the total operational risk at Hot Spot A1 and A2.

2.16 At Chennai-Kuala Lumpur boundary, the number of LHDs slightly increased from 21 in 2021 to 22 in 2022. Nonetheless, there was no non-zero-duration LHD or operational risk.

2.17 As mentioned in RASMAG/26 and RASMAG/27, the implementation of Space-Based ADS-B among Indian FIRs, along with ADS-B data sharing between Kolkata ACC and Yangon ACC, minimized the number of non-zero-duration LHDs and led to the low level of operational risk throughout 2020, 2021, and 2022.

2.18 Furthermore, the AIDC operation has been successfully implemented between Chennai OCC and Kuala Lumpur ACC since January 2021. However, the AIDC between Kolkata and Yangon together with between Chennai and Yangon have not been operated yet as mentioned in the final report of the ACSICG/10 held in May 2023.

2.19 Regarding the process of identifying hot spots, the Hot Spot A1 (the boundaries between Kolkata /Dhaka/Chennai FIR and Yangon FIR) satisfies the criteria in terms of the number of LHD in 2022. Thus, **Hot Spot A1 should remain on the hot spot list** and should be monitored until further safety improvement initiatives are implemented and successfully reduce the number of LHDs and the associated risks.

2.20 On the other hand, Hot Spot A2 (the boundary between Chennai FIR and Kuala Lumpur FIR) does not satisfy any hot spot identification criteria. Hence, **Hot Spot A2 is proposed as the potential non-hot spot**. If this boundary does not satisfy the hot spot criteria again in 2023, Hot Spot A2 can be proposed for removal from the list of hot spots.

Executive Summary: SEA Airspace

2.21 **Table 6** summarizes SEA Airspace RVSM technical, operational, and total risks. **Figure 5** presents collision risk estimate trends during the period from January 2022 to December 2022.

| SEA Airspace – estimated annual flying hours = 1,975,746 hours (note: estimated hours based on Dec 2022 traffic sample data) | | | |
|---|---|----------------------|---------------------|
| Source of Risk | Risk Estimation | TLS | Remarks |
| RASMAG 27 Total Risk | 2.58×10^{-9} | 5.0×10^{-9} | Below TLS |
| Technical Risk | 0.65×10^{-9} | 2.5×10^{-9} | Below Technical TLS |
| Operational Risk | 1.18×10^{-9} | - | - |
| Total Risk | 1.83×10^{-9} | 5.0×10^{-9} | Below TLS |

Table 6: SEA Airspace RVSM Risk Estimates

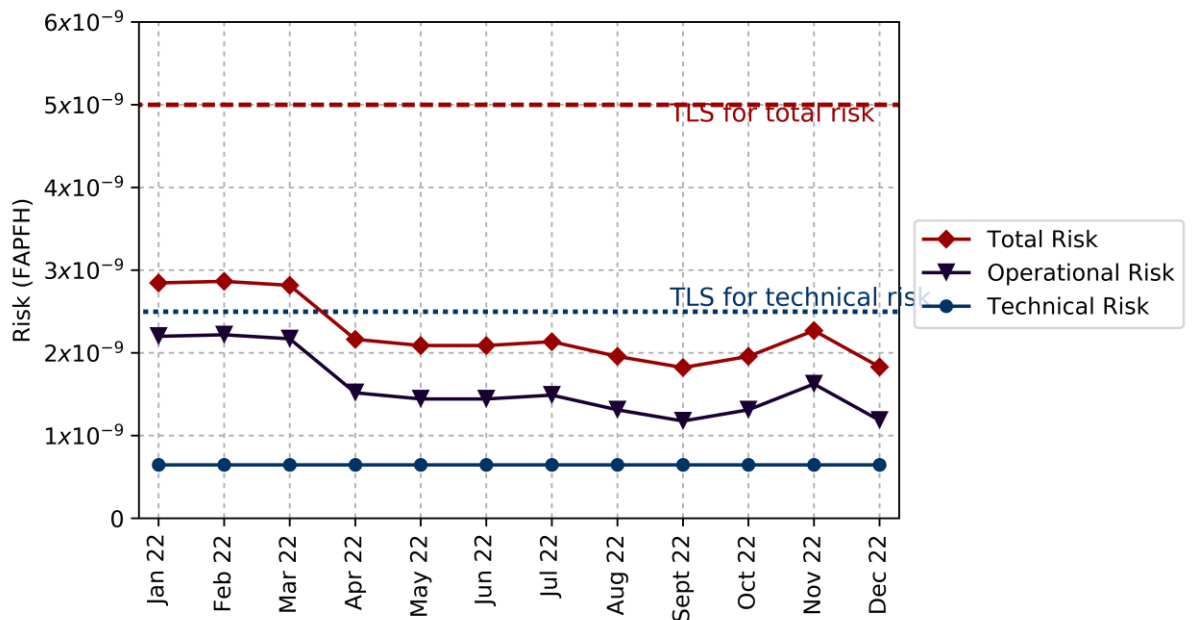


Figure 5: SEA Airspace RVSM Risk Estimates

2.22 **Table 7** presents a summary of the LHD causes within SEA Airspace from January 2022 until December 2022. The total number of LHDs in SEA Airspace slightly decreased from 72 in 2021 to 63 in 2022. Out of 63 LHDs in 2022, 57 were categorized as Category E LHDs, accounting for approximately 91% of the total number of LHDs in SEA Airspace.

| Code | LHD Category Description | No. |
|--------------|---|-----------|
| A | Flight crew fails to climb or descend the aircraft as cleared | 1 |
| B | Flight crew climbing or descending without ATC clearance | 1 |
| 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 | 57 |
| F | ATC transfer of control coordination errors due to technical issues | 1 |
| G | Aircraft contingency leading to sudden inability to maintain level | 0 |
| H | Airborne equipment failure and unintentional or undetected level change | 1 |
| I | Turbulence or other weather related cause leading to unintentional or undetected change of flight level | 1 |
| J | TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory | 0 |
| 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 | | 63 |

Table 7: Summary of LHD by Category within SEA Airspace

2.23 **Figure 5** provides the geographic location of ‘Non-zero-duration’ LHD reports within SEA Airspace during the assessment period.

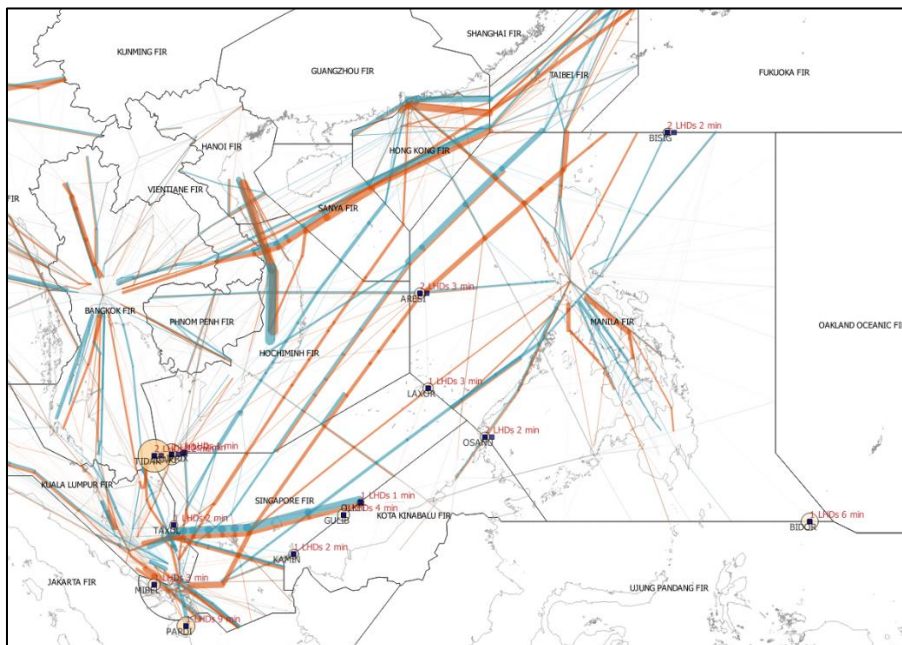


Figure 5: Geographical Locations of ‘Non-zero-duration’ LHDs in SEA Airspace

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

| 2022 Clusters (SEA) | Manila-Kobe/ Fukuoka (Hot Spot D) | Singapore- Jakarta (Hot Spot J) | Singapore- Bangkok/ Ho Chi Minh/ Kuala Lumpur | Singapore-Kota Kinabalu |
|---|---|---------------------------------------|--|----------------------------|
| Number of LHDs | 4 | 14 | 11 | 8 |
| Check Criteria: Number \geq 12.60 | Negative | Positive | Negative | Negative |
| Operational Risk (x 10^{-9} FAPFH) | 0.03 | 0.18 | 0.60 | 0.11 |
| Check Criteria: Operation Risk \geq 0.24×10^{-9} FAPFH | Negative | Negative | Positive | Negative |
| Check Criteria: Operation Risk \geq 5.00×10^{-9} FAPFH | Negative | Negative | Negative | Negative |

Table 8: The Results of Identifying Hot Spots in SEA Airspace

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

- Singapore-Jakarta boundary (Hot Spot J); and
- Singapore-Bangkok/Ho Chi Minh/Kuala Lumpur boundary.

2.26 At the boundaries of Manila FIR (Hot Spot D), no LHD cluster satisfies the hot spot criteria in 2022.

2.27 **LHD Hot Spot D (Manila FIR and adjacent FIRs)** was first identified as a hot spot in 2015. The number of LHDs along Manila FIR boundaries significantly decreased from 37 LHDs in 2021 to 18 LHDs in 2022. Similarly, the operational risk dramatically decreased from 1.65×10^{-9} FAPFH in 2021 to 0.27×10^{-9} FAPFH in 2022, which accounted for 23% of the total operational risk in SEA Airspace. **Figure 6** shows the geographic location of the LHDs and operation risk at Hot Spot D from 2020 to 2022. **Table 9** shows the number of LHDs, non-zero-duration LHDs and operational risk along Manila FIR boundaries from 2020 to 2022.

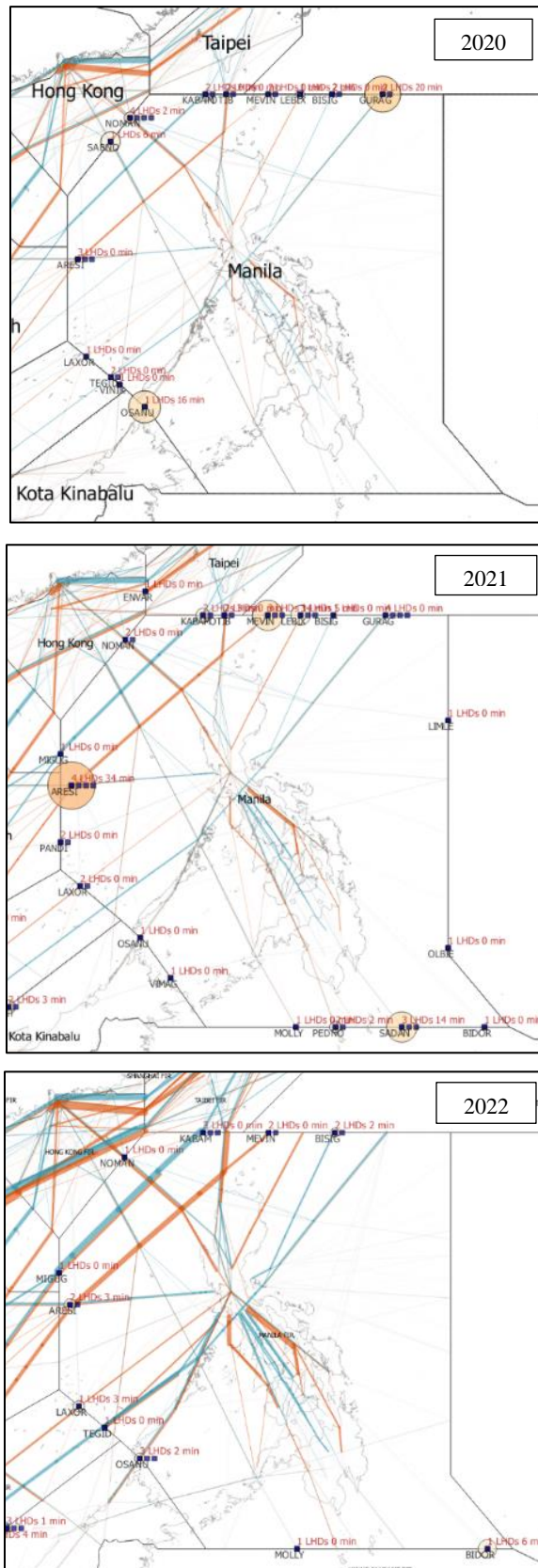


Figure 6: Geographic Location of LHDs and Operational Risk along Manila FIR Boundaries from 2020 to 2022

| Boundary | Number of LHDs | | | Number of non-zero-duration LHDs | | | Operational Risk (10 ⁻⁹ FAPFH) | | |
|----------------------|---------------------|-----------|-----------|----------------------------------|-----------|----------|--|-------------|-------------|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| | Manila-Kobe/Fukuoka | 5 | 11 | 4 | 2 | 4 | 2 | 0.49 | 0.45 |
| Manila-Ho Chi Minh | 4 | 7 | 3 | 0 | 3 | 2 | 0 | 0.77 | 0.05 |
| Manila-Hong Kong | 5 | 2 | 1 | 2 | 0 | 0 | 0.19 | 0 | 0 |
| Manila-Kota Kinabalu | 2 | 2 | 3 | 1 | 0 | 2 | 0.37 | 0 | 0.04 |
| Manila-Sanya | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manila-Singapore | 3 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 0.04 |
| Manila Taibei | 3 | 4 | 3 | 0 | 1 | 0 | 0 | 0.07 | 0 |
| Manila-Ujung Pandang | 0 | 7 | 2 | 0 | 2 | 1 | 0 | 0.36 | 0.11 |
| Manila-Oakland | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 24 | 37 | 18 | 5 | 10 | 8 | 1.05 | 1.65 | 0.27 |

Table 9: The Number of LHDs, Non-zero-duration LHDs and Operational Risk along Manila FIR Boundaries from 2020 to 2022

2.28 In 2022, the highest number of LHDs occurred at Manila-Kobe/Fukuoka boundary with 4 LHDs. The operational risk at this boundary was 0.03 x 10⁻⁹ FAPFH. On the other hand, the highest operational risk of 0.11 x 10⁻⁹ FAPFH was at Manila-Ujung Pandang boundary, but it was attributed by only one LHD containing 6 minutes in duration.

2.29 After the RASMAG/27 scrutiny group discussion, the Civil Aviation Authority of the Philippines (CAAP) revealed that they conducted multiple training sessions in 2022. These sessions aimed to enhance controller proficiency and review new procedures introduced during the COVID-19 pandemic. Additionally, briefing sessions before shift duty and safety-related discussions were held to improve safety awareness and reduce errors among controllers.

2.30 Furthermore, several safety improvement activities such as the new ATM system, restructured sectors, enhanced surveillance, ADS-C/CPDL and AIDC have been implemented and led to a significant reduction in the number of LHDs and operational risk. However, the implementation of AIDC with Ho Chi Minh, Oakland, Kota Kinabalu and Kobe/Fukuoka ACC is expected to further improve the efficiency of aircraft transfer across the boundaries.

2.31 Regarding the process of identifying hot spots, the Manila-Kobe/Fukuoka boundary satisfied the hot spot criteria in 2021, but not in 2022. **Subject to the assessment result from JASMA who is also shared the responsibility of this hot spot, all Manila FIR boundaries (Hot Spot D) may be proposed as the potential non-hot spot.** If none of Manila FIR boundaries satisfy the hot spot criteria in 2022 and 2023 for both SEA and Japan Airspaces, Hot Spot D can be proposed for removal from Hot Spot list. But it should be noted that the AIDC implementation between Manila ACC and Kobe/Fukuoka ACC is yet to begin.

2.32 **LHD Hot Spot J (Singapore-Jakarta boundary)** has been identified as an LHD hot spot since 2018. The number of LHDs at Singapore-Jakarta boundary slightly decreased from 16 LHDs in 2021 to 14 LHDs in 2022. The operational risk also decreased from 0.23 x 10⁻⁹ FAPFH in 2021 to 0.18 x 10⁻⁹ FAPFH in 2022. All LHDs at this boundary were in Category E. **Figure 7** shows the geographic location of the LHDs and operation risk at Hot Spot J from 2020 to 2022.

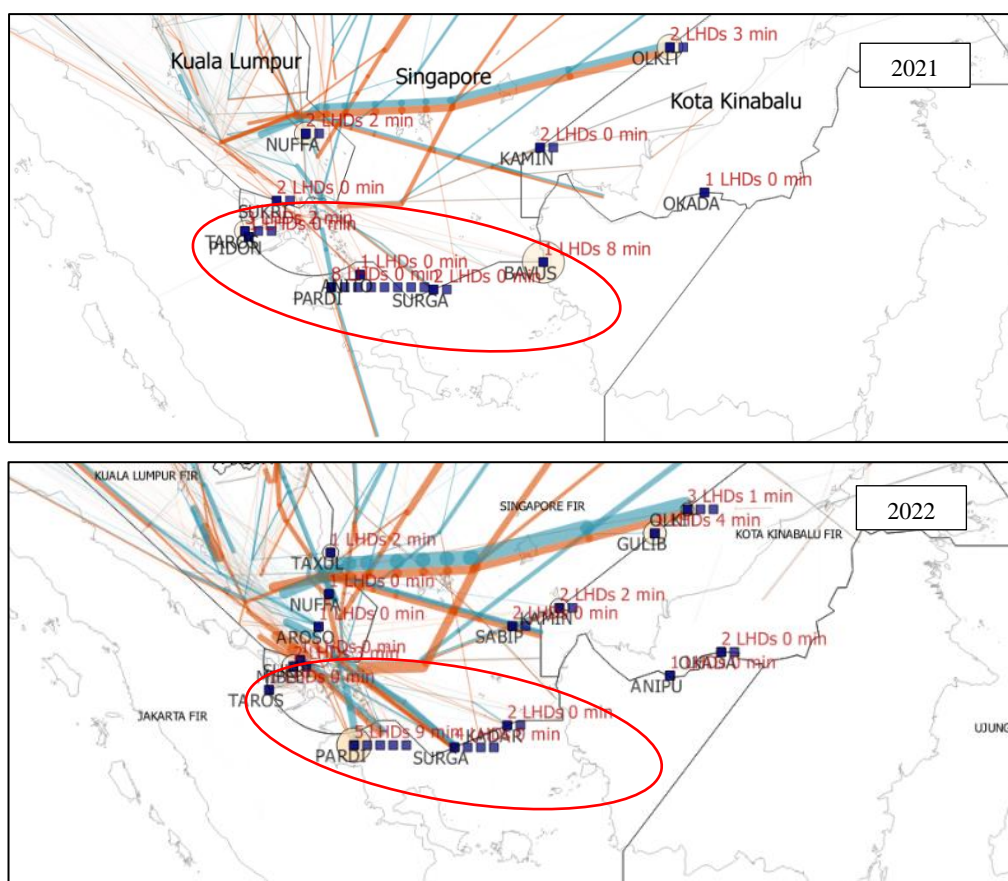


Figure 7: Geographic Locations of the Number of LHDs and Operation Risk at the Boundary between Singapore and Jakarta FIR in 2021 and 2022.

2.33 As detailed in the final report of ACSICG/10, 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.

2.34 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 for 2 consecutive years (2021 and 2022). Therefore, **the boundary between Singapore FIR and Jakarta FIR should remain on the hot spot list.**

2.35 **The boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR** has never been in the LHD hot spot list. In 2022, the number of LHDs at the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR (Waypoint TIDAR, IGARI, IPRIX and ESPOB) increased from 6 in 2021 to 11 in 2022. All LHDs were categorized as Category E. Out of these, there were 5 non-zero-duration LHDs, contributing to 0.60×10^{-9} FAPFH, which was 51 % of the total operational risk in SEA Airspace. **Figure 8** shows the geographic location of the LHDs and operation risk at the boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR from 2020 to 2022.

- At TIDAR, two (2) non-zero-duration LHDs were caused by aircrafts entering the FIR earlier than expected without the time revision and undetected for 10 and 12 minutes.
- At IGARI, two (2) non-zero-duration LHDs were caused by aircrafts entering the FIR without prior transfer information (Negative Transfer), and undetected for 1 and 8 minutes.

- At IPRIX, one (1) non-zero-duration LHD was caused by an aircraft entering the FIR without prior transfer information (Negative Transfer), and undetected for 1 minute.

2.36 The route segments of M904 between TIDAR and abeam IKUMI and M765 between IGARI and VENLI over Singapore FIR are very short. The route structure and ATC procedures of handling crossing traffic over this area can be complex between Singapore ACC and the other three (3) adjacent ATS units.

2.37 Regarding the process of identifying hot spots, the LHD cluster at the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR satisfied the hot spot criteria in terms of the operational risk. Consequently, **MAAR suggests proposing the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR to be included on the hot spot list as a new Hot Spot.**

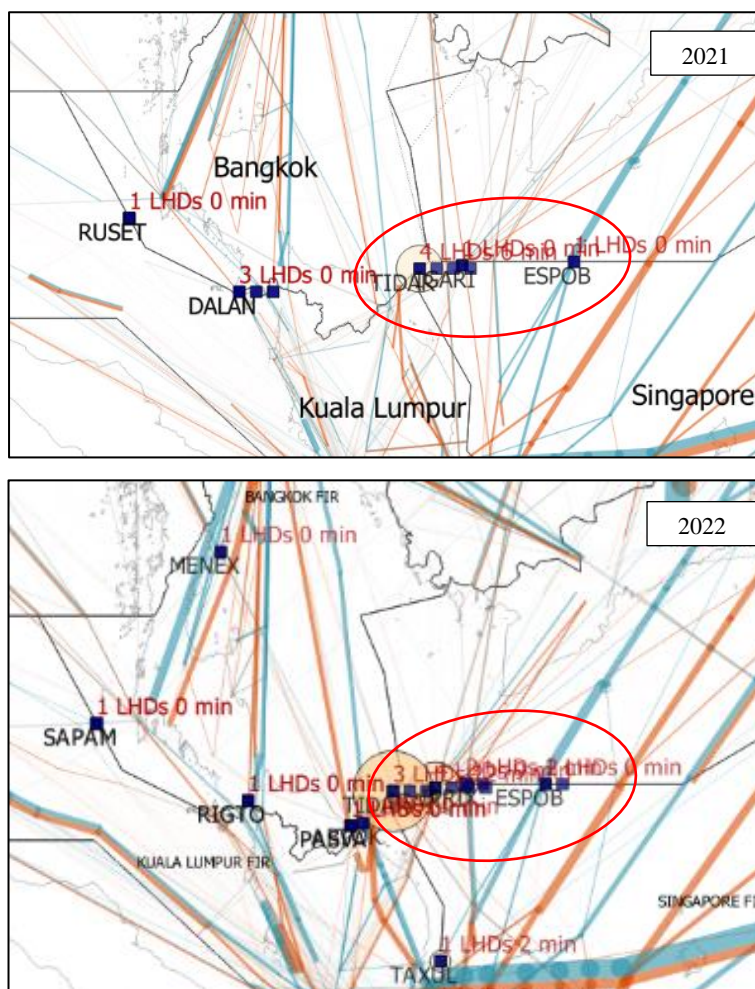


Figure 8: The Visualization of LHDs and Operation Risk at the Boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR in 2021 and 2022.

2.38 During the 31st Aviation Consultative Committee (ACC) Meeting between Malaysia and Thailand held in December 2022, participants discussed the LHD occurrences, the causes, and the coordination procedures between Bangkok FIR and Kuala Lumpur FIR/Singapore FIR. MAAR had a chance to present the LHD reporting process and the recommended Cross-Boundary LHD Coordination Procedure. The meeting agreed to adopt and implement the recommended coordination procedure for facilitating an effective coordination between the Bangkok and Kuala Lumpur ACCs.

Executive Summary: Mongolian Airspace

2.39 **Table 10** summarizes Mongolian Airspace RVSM technical, operational, and total risks

| Mongolian Airspace – estimated annual flying hours = 44,732hours <i>(note: estimated hours based on Dec 2022 traffic sample data)</i> | | | |
|---|---|----------------------|---------------------|
| Source of Risk | Risk Estimation | TLS | Remarks |
| <i>RASMAG 27 Total Risk</i> | 0.81×10^{-9} | 5.0×10^{-9} | <i>Below TLS</i> |
| Technical Risk | 0.33×10^{-9} | 2.5×10^{-9} | Below Technical TLS |
| Operational Risk | 0.00×10^{-9} | - | - |
| Total Risk | 0.33×10^{-9} | 5.0×10^{-9} | Below TLS |

Table 10: Mongolian Airspace RVSM Risk Estimates

2.40 In 2022, 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 0.33×10^{-9} FAPFH.

APANPIRG List of Deficiencies

2.41 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.

2.42 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 2022. The States that submitted the data also provided good cooperation and promptly revised any error when requested.

2.43 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

2.44 Over the past several years, MAAR has observed continuous improvement among the States and ANSPs under MAAR’s responsibility. **Almost all States now regularly submit their LHD reports to MAAR through the Online LHD Submission System.** With the exception of Nepal and Myanmar, they continue to use the LHD reporting template and submit their reports via email. Furthermore, MAAR has not received any data from Afghanistan as mentioned in paragraph 2.39. Nonetheless, all States that submitted LHD reports have shown good cooperation in addressing LHD-related matters.

2.45 The LHD Point of Contacts also monitor the LHD dashboard in MAAR’s Online LHD Submission System and receive notification emails. When there is mismatched information, they usually inform MAAR or discuss with each other within the email loop.

2.46 **The positive safety culture is demonstrated by the reporting one’s own mistakes.** Approximately 15% of all reports involved the States who reported their own mistakes and transferred aircraft to adjacent States. These reports are predominantly submitted by **Singapore, Philippines, Malaysia and Vietnam.**

2.47 In 2022, most LHDs 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 in both SA/IO and SEA Airspace. Additionally, the NIL reports are regularly submitted to MAAR in certain months to confirm no LHDs. However, it's important to note that a significant number of NIL (Nothing to Report) reports could potentially indicate under-reporting rather than an improvement in safety. Therefore, 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) the western boundaries of Mumbai FIR (Hot Spot G and F) remain as hot spots (paragraph 2.13);
 - ii) the boundaries between Kolkata/Dhaka/Chennai FIR and Yangon FIR (Hot Spot A1) remain as a hot spot (paragraph 2.19);
 - iii) the boundary between Chennai FIR and Kuala Lumpur FIR (Hot Spot A2) is labelled as a potential non-hot spot (paragraph 2.20);
 - iv) all Manila FIR boundaries (Hot Spot D) are labelled as a potential non-hot spot, subject to the assessment result from JASMA (paragraph 2.31);
 - v) the boundary between Singapore FIR and Jakarta FIR (Hot Spot J) remains as a hot spot (paragraph 2.34); and
 - vi) the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR is included on the hot spot list as a new Hot Spot (paragraph 2.38);
- b) consider maintaining Afghanistan on the List of Deficiencies in the ATM and Airspace Safety, under “Non-Provision of Safety-related Data” (paragraph 2.44);
- 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 2.48); and
- d) discuss any relevant matters as appropriate.

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MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2022 to December 2022

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE SOUTH ASIA/INDIAN OCEAN (SA/IO) AIRSPACE**
Assessment Period: January 2022 to December 2022

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 **South Asia/Indian Ocean (SA/IO)** airspace. The review is conducted based on one-month traffic sample data (TSD) collected in **December 2022** and monthly Large Height Deviation (LHD) reports between **January 2022 and December 2022** submitted by the concerning States in SA/IO Airspace.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** The TSD covering the month of December 2022 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 2022 to December 2022. **Table 1** indicates the FIRs that submitted LHD reports, including NIL reports. MAAR has not received any LHD report or LHD-related response from Kabul ACC since 16 August 2021 until the present time. **Appendix A** provides details of LHD reports and 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 2022. ‘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 2022 to December 2022.

| Month (2022) | No. of LHD | No. of Non-zero-duration LHD | LHD Duration (Min) | No. of Levels Crossed | Operational Risk ($\times 10^{-9}$ FAPFH) |
|--------------|------------|------------------------------|--------------------|-----------------------|--|
| January | 8 | 0 | 0 | 0 | 0 |
| February | 6 | 2 | 7 | 0 | 0.15 |
| March | 8 | 1 | 6 | 0 | 0.12 |
| April | 10 | 2 | 2 | 0 | 0.04 |
| May | 13 | 3 | 19 | 0 | 0.40 |
| June | 13 | 0 | 0 | 0 | 0 |
| July | 10 | 0 | 0 | 0 | 0 |
| August | 23 | 1 | 1 | 0 | 0.02 |
| September | 17 | 3 | 7 | 0 | 0.15 |
| October | 14 | 2 | 6 | 0 | 0.12 |
| November | 11 | 1 | 1 | 0 | 0.02 |
| December | 15 | 1 | 2 | 0 | 0.04 |
| Total | 148 | 16 | 51 | 0 | 1.06 |

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

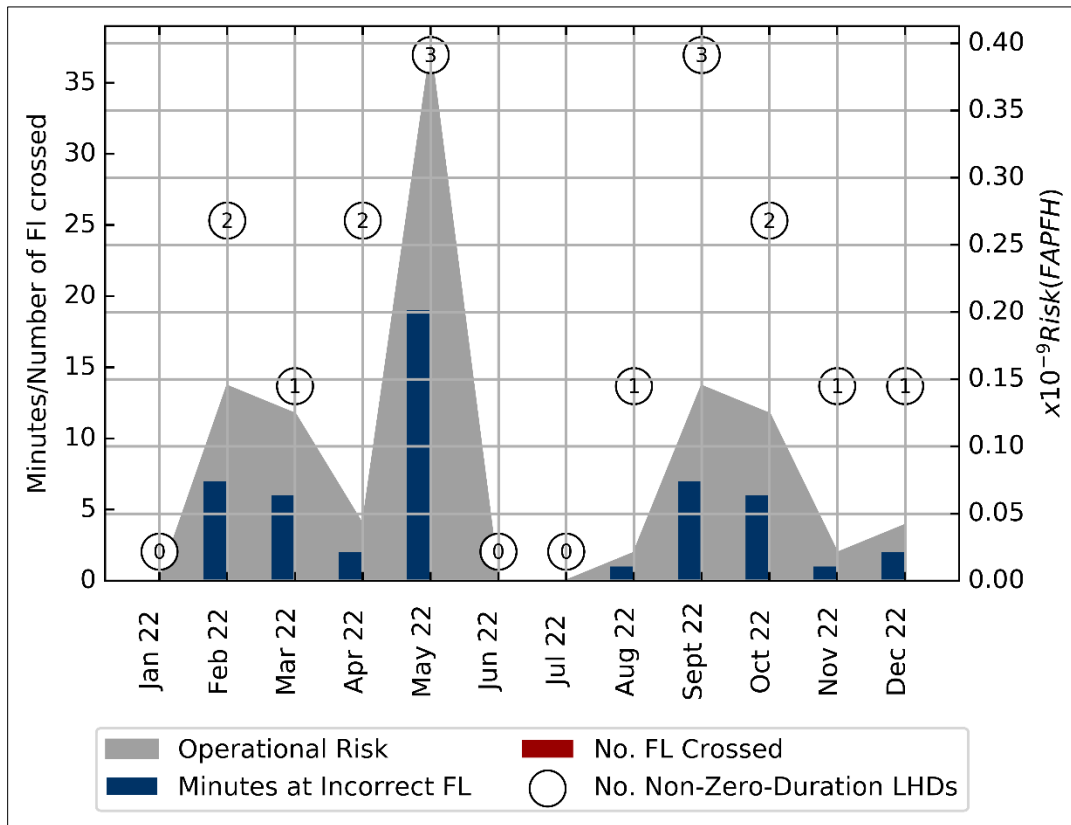


Figure 1: Summary of LHDs by month for SA/IO Airspace

3.2. Compared to 2021, the number of LHDs slightly increased from 134 to 148 in 2022. Conversely, the number of non-zero-duration LHD decreased from 30 in 2021 to 16 in 2022. The reduction in the number of non-zero-duration LHDs resulted in the significant decrease in the operational risk from 5.15×10^{-9} FAPFH in 2021 to 1.06×10^{-9} FAPFH in 2022. **Figure 1** shows that the number of non-zero-duration LHD in each month ranges from 0 to 3. Additionally, the highest monthly risk occurred in May 2022.

3.3. **Figure 2** and **Table 3** summarize the number of LHDs, the associated LHD duration (in minutes), and the number of incorrect flight levels crossed, by LHD category from January 2022 to December 2022.

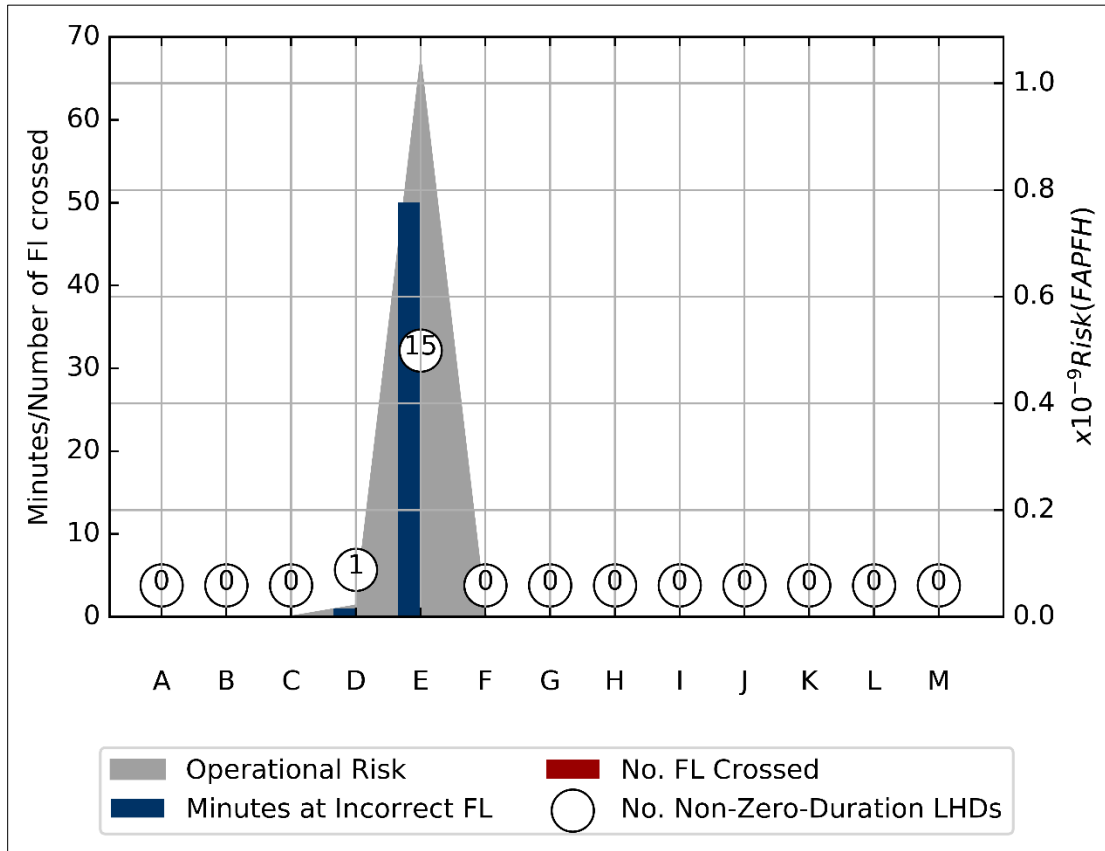


Figure 2: Summary of LHD by category for SA/IO Airspace

| LHD Category Code | LHD Category Description | No. of LHDs | No. of Non-zero-duration LHDs | LHD Duration (Min) | No. of levels Crossed | Operational Risk (x10⁻⁹ FAPFH) |
|--------------------------|---|--------------------|--------------------------------------|---------------------------|------------------------------|--|
| A | Flight crew failing to climb/descend the aircraft as cleared | 2 | 0 | 0 | 0 | 0 |
| B | Flight crew climbing/descending without ATC Clearance | 1 | 0 | 0 | 0 | 0 |
| C | Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.). | 0 | 0 | 0 | 0 | 0 |
| D | ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message) | 1 | 1 | 1 | 0 | 0.02 |
| 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). | 141 | 15 | 50 | 0 | 1.04 |
| 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. | 1 | 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 |

| 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 | 2 | 0 | 0 | 0 | 0 |
| Total | | 148 | 16 | 51 | 0 | 1.06 |

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

3.4. In 2022, more than 95% of the total number of LHDs and the operational risk in SEA Airspace were in Category E, which was further categorized into sub-categories. **Figure 3** shows the contribution of each sub-category in terms of the number of LHDs and **Figure 4** shows the contribution in terms of risk.

3.5. In **Figure 3**, the “No or late flight level revision” sub-category accounted for 80% of the total number of Category E LHDs, while the “No Transfer Information” sub-category was 13.33%. Other sub-categories constituted less than 6.67% of the total number of Category E LHDs.

3.6. In terms of contribution to the operational risk, the “No or late flight level revision” sub-category accounted for 72% of the total Category E operational risk, while the “No Transfer Information” sub-category was 16%. Other sub-categories contributed to 12% of the total Category E operational risk. The sub-category proportions of the Category E operational risk were similar to the sub-category proportions of the number of Category E LHDs.

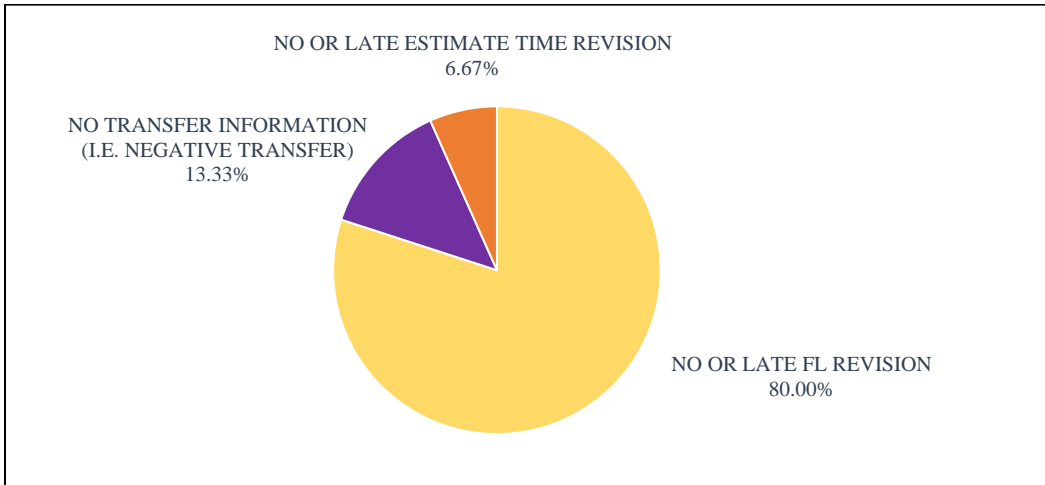


Figure 3: Sub-categories of Category-E LHDs for SA/IO Airspace

(The number of LHDs)

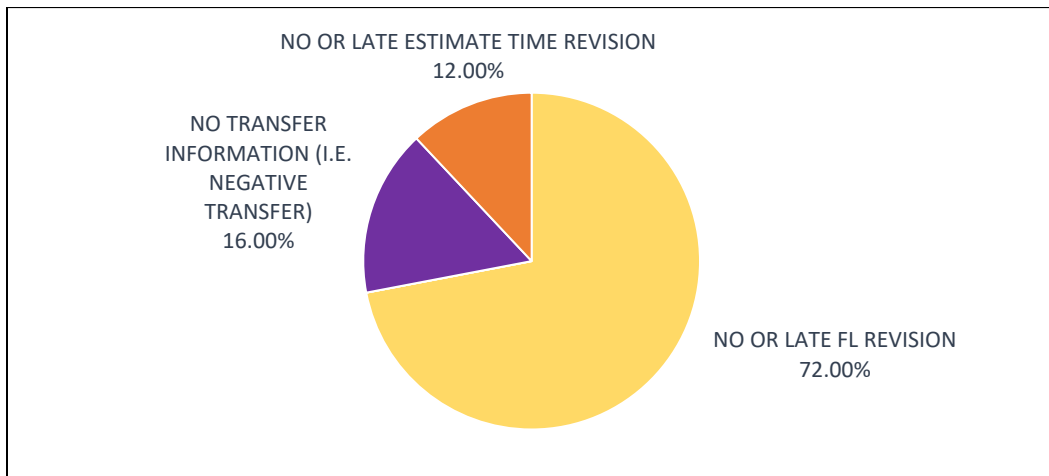


Figure 4: Sub-categories of Category-E LHDs for SA/IO Airspace (Operational risk)

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 | 2,306,186 | 699,455 | Hour | Dec 2022 TSD |
| $E_z(\text{same})$ | Same-direction vertical occupancies | 0.4000 / 0.0336 | 0.0696 | - | |
| $E_z(\text{opposite})$ | Opposite-direction vertical occupancies | 0.1480 | 0.0347 | - | |
| λ_x | Average aircraft length | 0.0285 | 0.0250 | NM | |
| λ_y | Average aircraft wingspan | 0.0263 | 0.0228 | NM | |
| λ_z | Average aircraft height | 0.0081 | 0.0073 | NM | |
| λ_h | Diameter of the disk representing the shape of an aircraft in the horizontal plane | 0.0285 | 0.0250 | NM | |
| $P_z(0)$ | Probability of vertical overlap (with planned vertical separation equal to zero) | 0.538 | 0.538 | - | Conservative value used in previous assessments |
| $ \overline{\Delta V} $ | Average relative along-track speed between aircraft on same direction routes | 42.03 | 49.15 | Knot | Dec 2022 TSD |
| $ \overline{V} $ | Average absolute aircraft ground speed | 480 | 480 | Knot | Conservative value used in previous assessments |

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

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. **The technical risk**, defined as the probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and all causes, **meets the TLS** value of 2.5×10^{-9} FAPFH. Additionally, **the total risk** is 1.75×10^{-9} FAPFH, which also **meets the specified TLS** value of 5.0×10^{-9} FAPFH.

| SA/IO Airspace – estimated annual flying hours = 3,005,641 hours (note: estimated hours based on Dec 2022 traffic sample data) | | | |
|---|-----------------------|----------------------|---------------------|
| Source of Risk | Risk Estimation | TLS | Remarks |
| RASMAG 27 Total Risk | 5.62×10^{-9} | 5.0×10^{-9} | Above TLS |
| Technical Risk | 0.69×10^{-9} | 2.5×10^{-9} | Below Technical TLS |
| Operational Risk | 1.06×10^{-9} | - | - |
| Total Risk | 1.75×10^{-9} | 5.0×10^{-9} | Below TLS |

Table 5: Risk estimates for SA/IO Airspace

4.3. **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD. The operational and total risk in 2022 showed a downward trend. The total risk dramatically decreased by 69% from 5.62×10^{-9} FAPFH in 2021 to 1.75×10^{-9} FAPFH in 2022. Furthermore, the total risk become below the specified TLS in 2022.

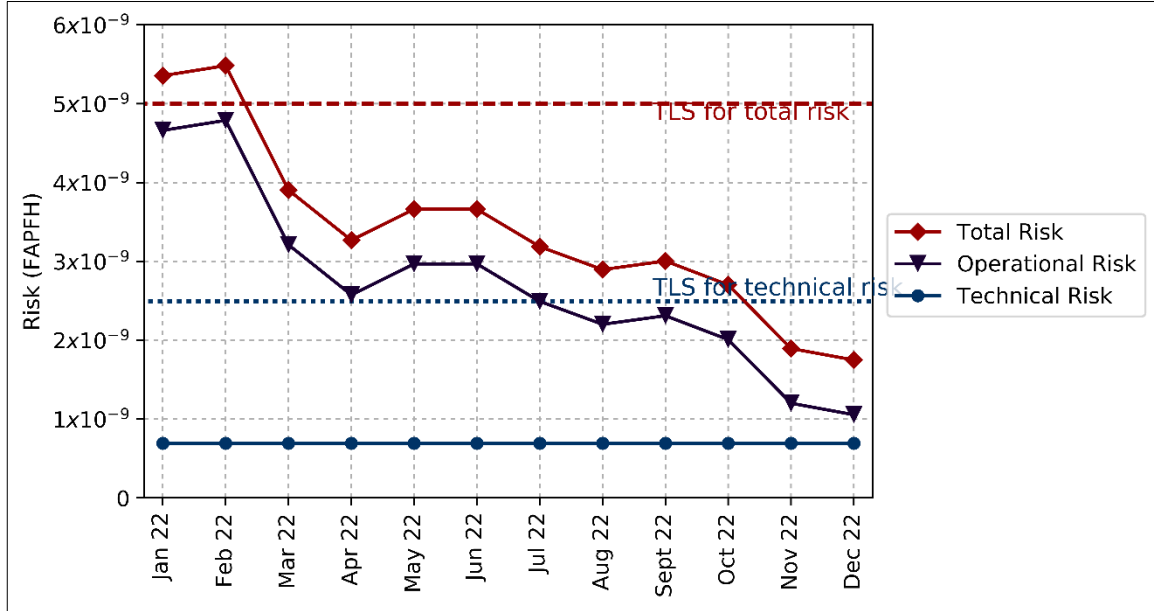


Figure 5: Trends of risk estimates for SA/IO Airspace

4.4. **Figure 6** demonstrates monthly operational risk, where each individual block represents one LHD and height of each block corresponds to the operational risk of each LHD. The monthly operational risk value is determined to provide real-time information on actual risk, without relying on historical high-time errors present within the 12-month data sample.

4.5. In **Figure 6**, the total operational risk in each month is **below** the average monthly operational risk, calculated by dividing the annual risk of 5.0×10^{-9} FAPFH by 12 (the red line in **Figure 6** approximately 0.4167×10^{-9} FAPFH). The highest monthly operational risk occurred in May 2022, with a total of 3 non-zero-duration LHDs. Two of these non-zero-duration LHDs were at the Mumbai-Muscat boundary, while the remaining one was at the Kuala Lumpur-Jakarta boundary. Furthermore, among these three LHDs was the one with the longest duration in SA/IO Airspace, containing 10 minutes in duration and contributing to the operational risk of 0.21×10^{-9} FAPFH.

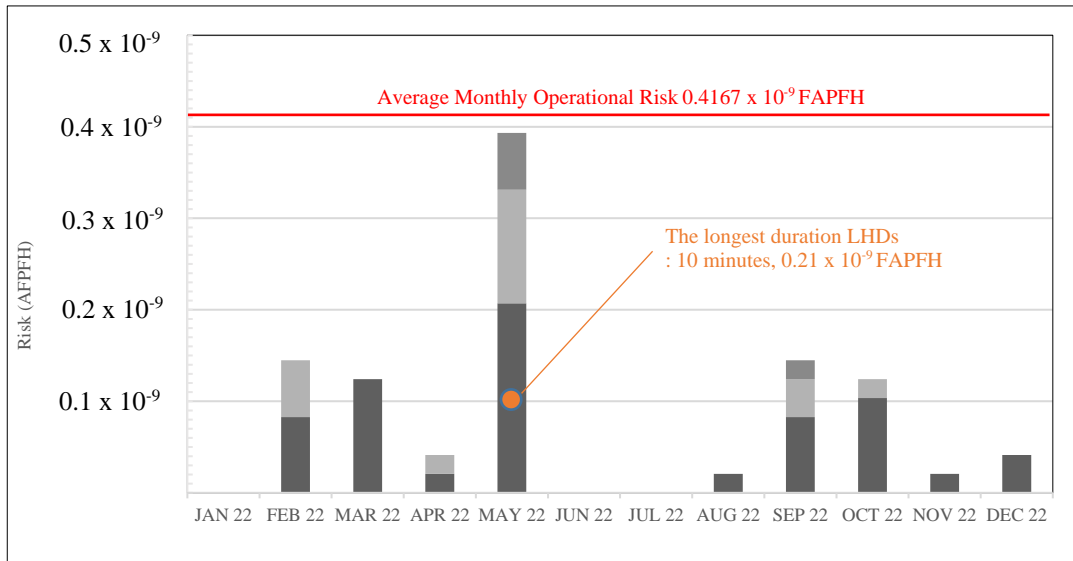


Figure 6: Monthly operational risk estimates for SA/IO Airspace. Red line is the average monthly value for an annual risk of 5.0×10^{-9} FAPFH.

5. Analysis of Operational Errors

5.1 **Figure 7** depicts geographic locations of all reported LHDs in SA/IO Airspace based on LHD reports from January to December 2022. **Figure 8** depicts only LHDs which are determined to be non-zero duration. The following are symbols and color codes used in the visualizations:

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

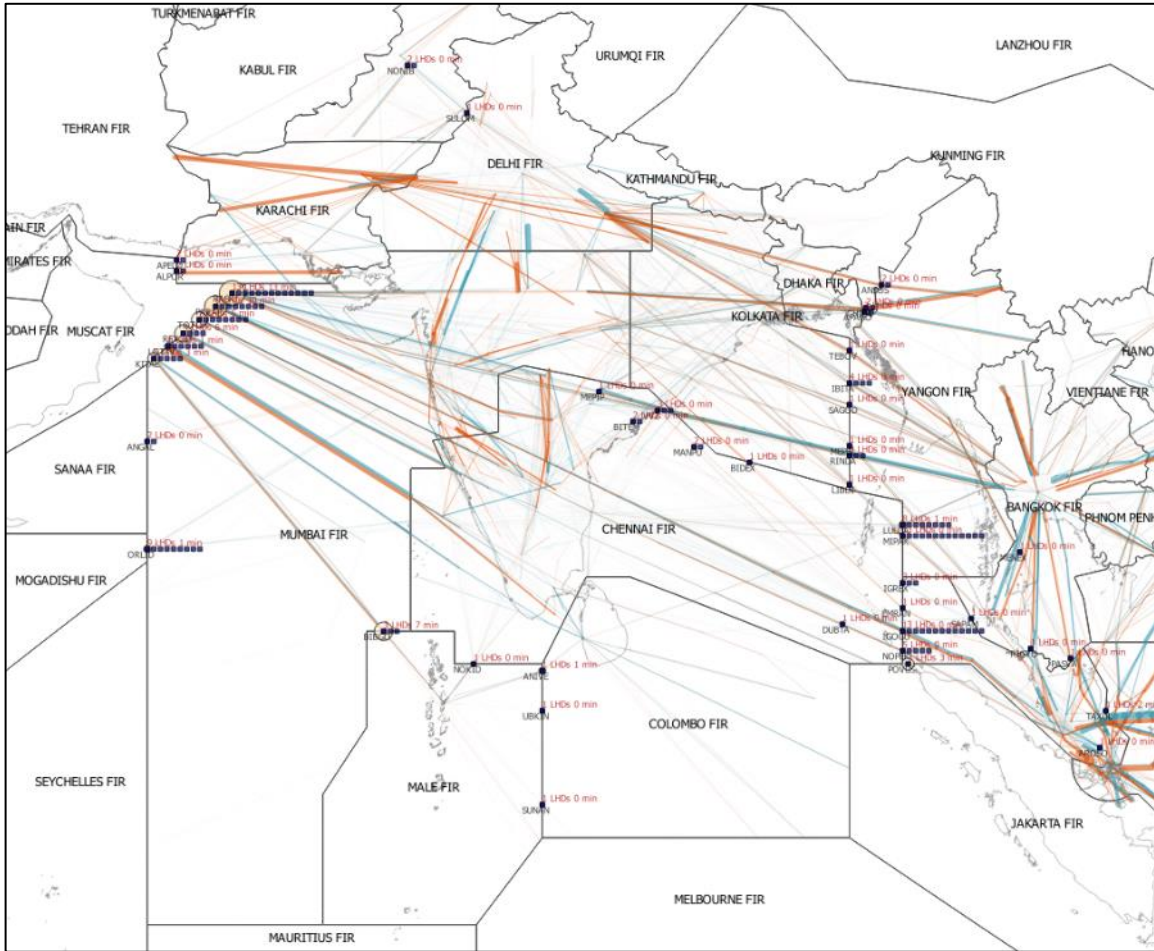


Figure 7: Geographic locations of all LHDs in SA/IO Airspace

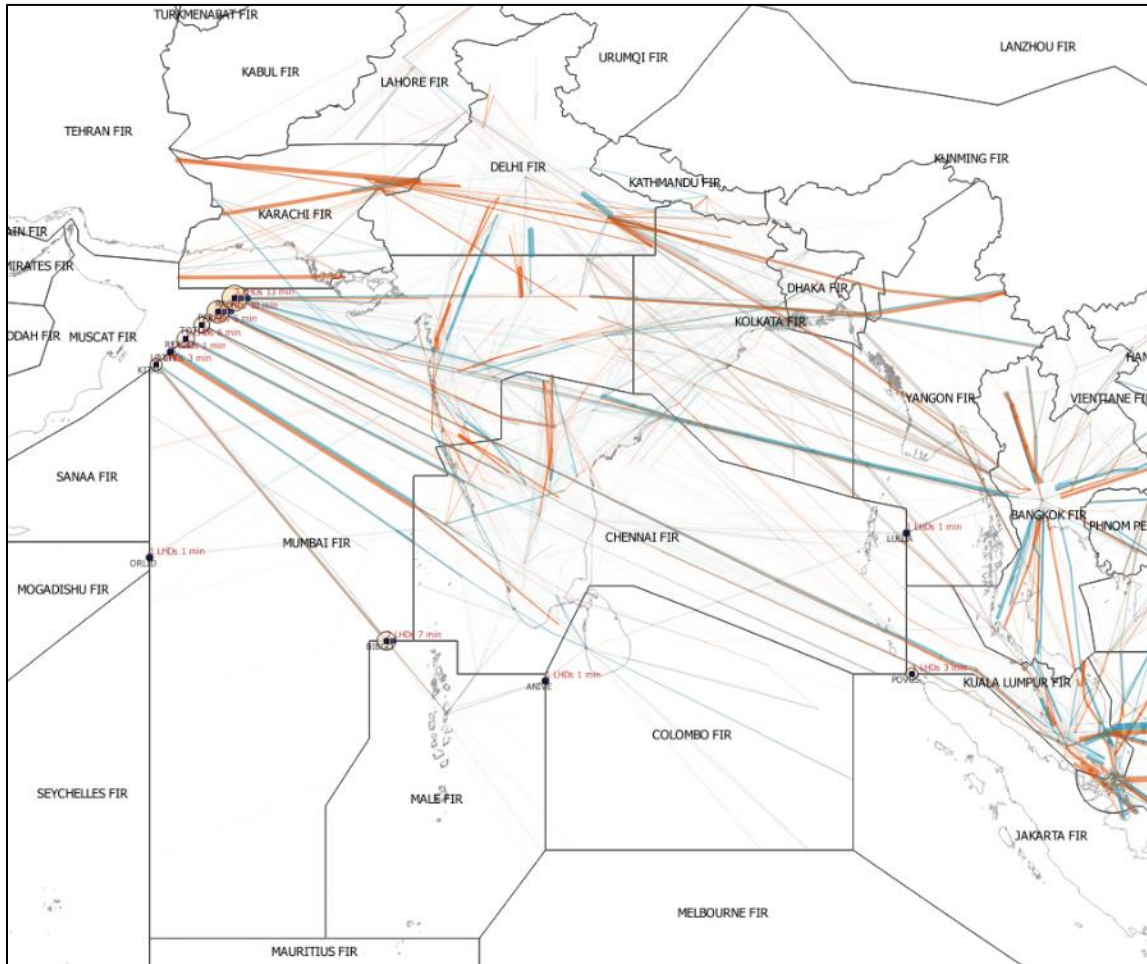


Figure 8: Geographic locations of 'non-zero-duration' LHDs in SA/IO Airspace

LHD Hot Spot identification

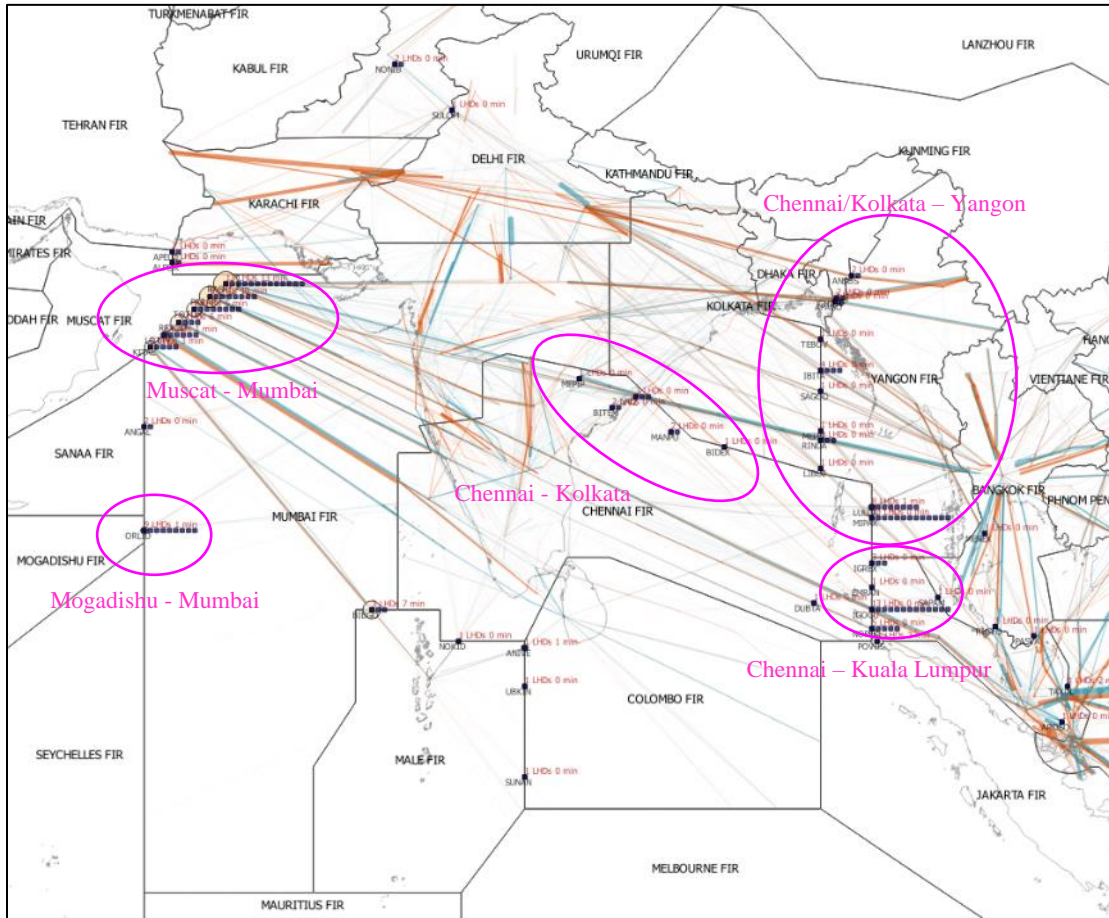


Figure 9: Geographic locations of identified LHD clusters in SA/IO Airspace

5.2 In the process of identifying hot spots in SA/IO Airspace, five (5) LHD clusters are identified as shown in pink ovals in **Figure 9**.

5.3 **Table 6** shows the profile of the LHD clusters in SA/IO Airspace and the determining criteria for 2022. The total number of LHDs was 148. The operational risk was 1.06×10^{-9} FAPFH. As a result, the criteria for the number of LHDs is 24.67 (calculated from $148 / [5 + 1]$), the criteria for the operational risk is 0.18×10^{-9} FAPFH (calculated from $1.06 / [5 + 1]$), and the criteria for the TLS is 5×10^{-9} FAPFH.

| SA/IO | 2022 |
|--|--------------|
| Number of Clusters | 5 |
| Number of LHDs | 148 |
| Operational Risk ($\times 10^{-9}$ FAPFH) | 1.06 |
| Criteria: Number of LHDs | 24.67 |
| Criteria: Risk ($\times 10^{-9}$ FAPFH) | 0.18 |
| Criteria: TLS ($\times 10^{-9}$ FAPFH) | 5.00 |

Table 6: The profile of the LHD clusters in SA/IO Airspace and the determining criteria for 2022

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.

| 2022 Clusters (SA/IO) | Mumbai-Muscat (Hot Spot G) | Mumbai-Mogadishu (Hot Spot F) | Chennai/Kolkata-Yangon (Hot Spot A1) | Chennai-Kuala Lumpur (Hot Spot A2) | Chennai-Kolkata |
|---|----------------------------|-------------------------------|--------------------------------------|------------------------------------|-----------------|
| Number of LHDs | 43 | 9 | 40 | 22 | 9 |
| Check Criteria: Number \geq 24.67 | Positive | Negative | Positive | Negative | Negative |
| Operational Risk ($\times 10^{-9}$ FAPFH) | 0.79 | 0.02 | 0.02 | 0.00 | 0.00 |
| Check Criteria: Operational Risk \geq 0.18×10^{-9} FAPFH | Positive | Negative | Negative | Negative | Negative |
| Check Criteria: Operation Risk \geq 5.00×10^{-9} FAPFH | Negative | Negative | Negative | Negative | Negative |

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

5.5 Regarding the result in **Table 7**, the following clusters satisfy the hot spot criteria in 2022:

- Mumbai-Muscat boundary (Hotspot G); and
- Chennai/Kolkata-Yangon boundary (Hot Spot A1).

5.6 On the other hand, the following boundaries are listed as LHD hot spots but do not satisfy the hot spot criteria in 2022:

- Mumbai-Mogadishu boundary (Hotspot F); and
- Chennai- Kuala Lumpur boundary (Hot Spot A2).

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

5.7 Since 2015, the **Western boundaries of Mumbai FIR** have been identified as LHD hot spots G and F at three boundaries. The first boundary is between Muscat FIR and Mumbai FIR, including waypoints RASKI, PARAR, TOTOX, REXOD, LOTAV, KITAL and ASPUX. The second boundary is between Sanaa FIR and Mumbai FIR, including waypoints ANGAL, GIDAS and NABIL. The last boundary is the waypoint ORLID, which lies between Mogadishu FIR and Mumbai FIR.

5.8 **Table 8** summarizes the number of LHDs, the number of non-zero-duration LHDs, and operational risk at the western boundary of Mumbai FIR from 2020 to 2022. **Figure 10** shows Geographic locations of non-zero-duration LHDs and operation risk at Hot Spot G and F from 2020 to 2022.

5.9 At Mumbai-Muscat boundary, the number of LHDs slightly decreased from 44 in 2021 to 43 in 2022. However, the number of non-zero-duration LHDs and the operational risk significantly decreased from 2020 to 2022. In 2022, the non-zero-duration LHDs reduced to 10 and contributed to the operational risk of 0.79×10^{-9} FAPFH.

5.10 At Mumbai-Sanaa boundary, the number of LHDs decreased from 4 in 2021 to 2 in 2022. However, there was no non-zero-duration LHD, resulting in zero operational risk in 2022.

5.11 At Mumbai-Mogadishu boundary, the number of LHDs increased from 5 in 2021 to 9 in 2022. On the other hand, the number of non-zero-duration LHDs was only 1, and the operational risk was 0.02×10^{-9} FAPFH.

| Boundary | Number of LHDs | | | Number of non-zero-duration LHDs | | | Operational Risk (10^{-9} FAPFH) | | |
|------------------|----------------|-----------|-----------|----------------------------------|-----------|-----------|--|-------------|-------------|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Mumbai-Muscat | 48 | 44 | 43 | 28 | 17 | 10 | 6.37 | 1.35 | 0.79 |
| Mumbai-Sanaa | 1 | 4 | 2 | 0 | 1 | 0 | 0.00 | 0.07 | 0.00 |
| Mumbai-Mogadishu | 8 | 5 | 9 | 4 | 1 | 1 | 4.80 | 0.12 | 0.02 |
| Total | 57 | 53 | 54 | 32 | 19 | 11 | 11.17 | 1.54 | 0.81 |

Table 8: Comparison of the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot G and Hot Spot F from 2020 to 2022

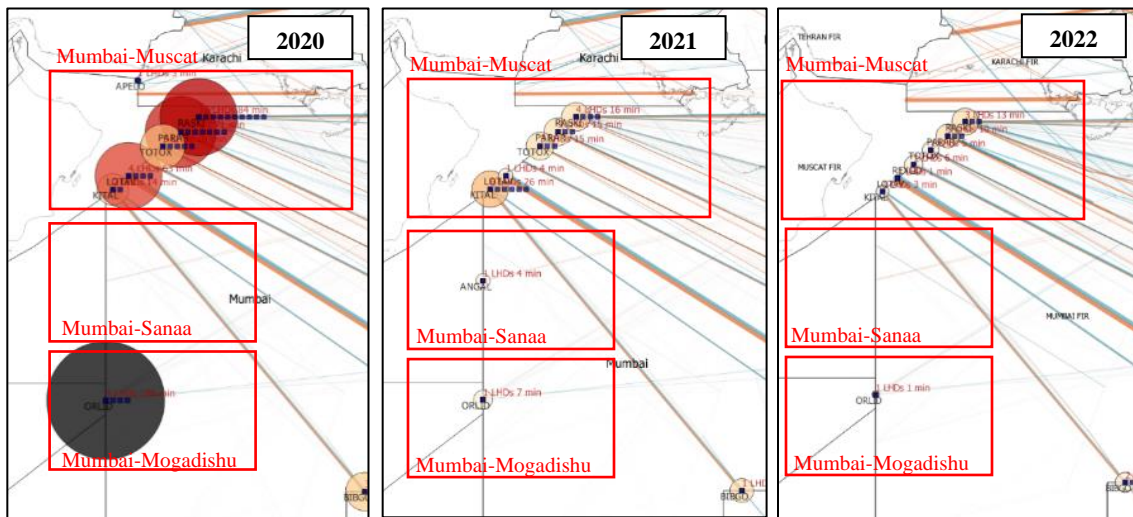


Figure 10: Geographic locations of non-zero-duration LHDs and operation risk at Hot Spot G and F from 2020 to 2022.

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

5.13 From 2015 to 2019, poor communication services and limited surveillance coverage at the boundaries led to a high number of long-duration LHDs and operational risk. However, in 2020 and 2021, the long-duration LHDs were reduced, and operational risks were significantly lower compared to 2019. The decreasing trend was potentially due to the traffic reduction during the COVID-19 pandemic and the implementation of Space-Based ADS-B in February 2020. This implementation enhanced surveillance capability, allowing controllers to detect LHDs beyond the Transfer of Control (TOC) point. Consequently, the duration of LHDs and operational risk decreased significantly starting in 2020.

5.14 Despite a partial recovery in traffic, the total number of LHDs in 2022 closely resembled the figures from 2020 and 2021. However, both the total duration and the associated operational risk consistently decreased. This trend reaffirms the effectiveness of the implementation of Space-Based ADS-B as a mitigation measure for the LHD issue at the Western Boundary of Mumbai FIR.

5.15 In order to address the cause (prevention) of LHD Category E, the ATS Inter-Facility Data Communication (AIDC) implementation between Mumbai ACC and Muscat ACC, as well as Mumbai ACC and Mogadishu ACC is identified. However, the implementation remained in the testing phase, as indicated in the final report of the Tenth Meeting of the Aeronautical Communication Services Implementation Coordination Group (ACSICG/10) held in May 2023.

5.16 In the process of identifying hot spot, the Mumbai-Muscat boundary (Hot Spot G) continues to meet the criteria in terms of the number of LHDs and the operational risk as shown in **Table 7**. In addition, the number of LHDs at the Mumbai-Mogadishu boundary (Hot Spot F) slightly increased in 2022. Therefore, the Western Boundary of Mumbai FIR (Hot Spot G and F) should remain as hot spots 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 (Kolkata/Dhaka/Chennai - Yangon) and A2 (Chennai – Kuala Lumpur)

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

5.18 **Table 9** provides the number of LHDs, the number of non-zero-duration LHDs and operational risk at Hot Spot A1 and A2 from 2020 to 2022. The number of LHDs increased from 24 in 2020 and 30 in 2021 to 62 in 2022. Out of 62 LHDs, there was only one non-zero-duration LHD, accounting for 0.02×10^{-9} FAPFH. **Figure 11** provides the geographic locations of the non-zero-duration LHDs and their associated operational risk grouped at the three boundaries in 2020, 2021, and 2022.

| Boundary | Number of LHDs | | | Number of non-zero-duration LHDs | | | Operational Risk (10^{-9} FAPFH) | | |
|----------------------|----------------|-----------|-----------|----------------------------------|----------|----------|--|-------------|-------------|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Kolkata-Yangon | 8 | 1 | 17 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 |
| Chennai-Yangon | 3 | 8 | 23 | 0 | 0 | 1 | 0.00 | 0.00 | 0.02 |
| Chennai-Kuala Lumpur | 13 | 21 | 22 | 0 | 1 | 0 | 0.00 | 0.05 | 0.00 |
| Total | 24 | 30 | 62 | 0 | 1 | 1 | 0.00 | 0.05 | 0.02 |

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 2020 to 2022.

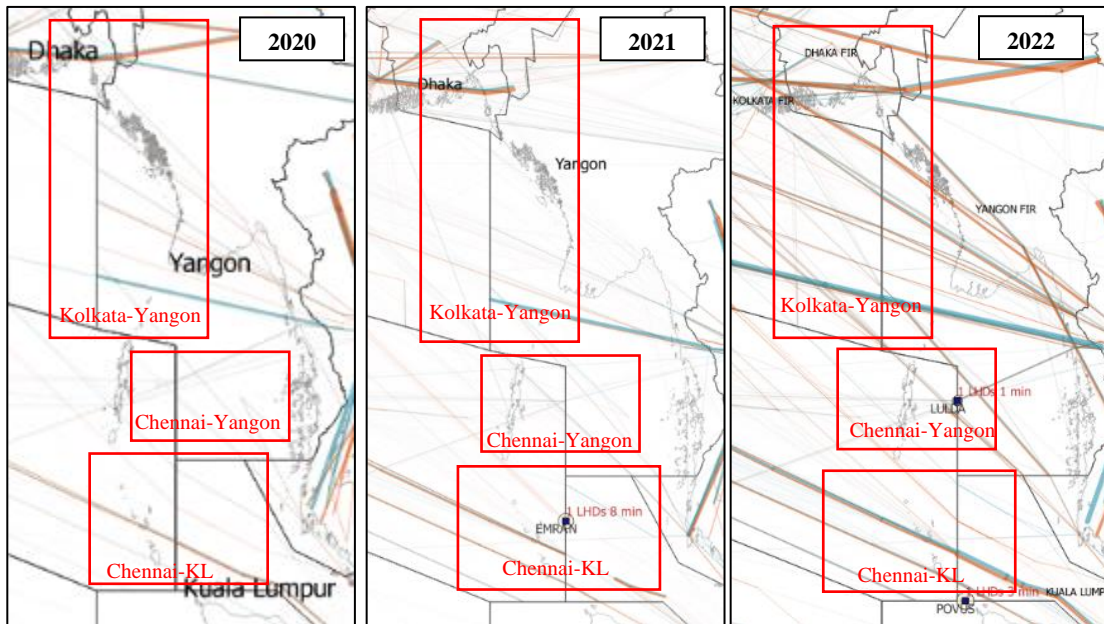


Figure 11: Geographic locations of non-zero-duration LHDs and operation risk at Hot Spot A1 and A2 from 2020 to 2022.

5.19 At the Kolkata-Yangon and Chennai-Yangon boundaries, the number of LHDs significantly increased in 2022. All LHDs at these two boundaries were in Category E. The increase in the number of LHDs can be attributed by the recovery of traffic, as depicted by the numerous thicker turquoise and orange lines in **Figure 11**. Thus, controllers might face the rapid increase in workload, which could easily lead to human errors. At these two boundaries, there were no non-zero-duration LHDs in 2020 and 2021. However, there was only one non-zero-duration LHD in 2022. As a result, the operational risk was 0.02×10^{-9} FAPFH, which was the total operational risk at Hot Spot A1 and A2.

5.20 At Chennai-Kuala Lumpur boundary, the number of LHDs slightly increased from 21 in 2021 to 22 in 2022. Nonetheless, there was no non-zero-duration LHD or operational risk.

5.21 According to WP/03 of the Fourth Meeting of the Bay of Bengal Traffic Flow Review Group (BOBTFRG/4) held in December 2022, the Airport Authority of India informed that Chennai FIR built-up the following CNS/ATM infrastructure to prepare for the anticipated growth in air traffic:

- Integrating the ADS-B data from Kolkata ACC into Chennai ATM automation unit,
- Maintaining the operation of Space-Based ADS-B,
- Considering the implementation of PBCS,
- Enhancing the VHF coverage,
- Implementing the AIDC, and
- Enhancing the HF radio.

5.22 As mentioned in RASMAG/26 and RASMAG/27, the implementation of Space-Based ADS-B among Indian FIRs, along with ADS-B data sharing between Kolkata ACC and Yangon ACC, minimized the number of non-zero-duration LHDs and led to the low level of operational risk throughout 2020, 2021, and 2022

5.23 Furthermore, the AIDC operation has been successfully implemented between Chennai OCC and Kuala Lumpur ACC since January 2021. However, the AIDC between Kolkata and

Yangon together with between Chennai and Yangon have not been operated yet, as mentioned in Attachment H in the final report of the ACSICG/10 held in May 2023. The AIDC trial between Chennai OCC and Yangon ACC commenced in January 2018 and encountered an issue from Yangon ACC side. Yangon ACC would contact Chennai OCC for further testing when it was ready. The trial of AIDC between Kolkata ACC and Yangon ACC in the 1st quarter of 2020 was successful, and the LOA would be negotiated and signed.

5.24 Regarding the process of identifying hot spots, the Hot Spot A1 (the boundaries between Kolkata /Dhaka/Chennai FIR and Yangon FIR) satisfies the criteria in terms of the number of LHD in 2022, as shown in **Table 7**. Hot Spot A1 should remain on the hot spot list and should be monitored until further safety improvement initiatives are implemented and successfully reduce the number of LHDs and the associated risks.

5.25 On the other hand, Hot Spot A2 (the boundary between Chennai FIR and Kuala Lumpur FIR) does not satisfy any hot spot identification criteria. Hence, Hot Spot A2 is proposed as the potential non-hot spot. If this boundary does not satisfy the hot spot criteria again in 2023, Hot Spot A2 can be proposed for removal from the list of hot spots.

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 |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 27/1/2022 | ZMW | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 17/1/2022 | ZMW | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 22/1/2022 | ZMW | | FL390 | 0 | E | NO OR LATE FL REVISION |
| 9/1/2022 | CEO | FL390 | FL410 | 0 | E | NO OR LATE FL REVISION |
| 31/1/2022 | CEO | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 20/1/2022 | BLN | FL380 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 20/1/2022 | BLN | | FL340 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 17/1/2022 | KVB | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 27/2/2022 | CEO | FL330 | FL350 | 3 | E | NO OR LATE FL REVISION |
| 23/2/2022 | CEO | FL370 | FL390 | 4 | E | NO OR LATE FL REVISION |
| 22/2/2022 | CEO | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 9/2/2022 | CEO | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 23/2/2022 | FII | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 3/3/2022 | CEO | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 5/3/2022 | CEO | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 5/3/2022 | CEO | | FL350 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 9/3/2022 | CEO | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 12/3/2022 | CEO | FL370 | FL410 | 0 | E | NO OR LATE FL REVISION |
| 13/3/2022 | CEO | FL330 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 19/3/2022 | CEO | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 5/4/2022 | BLN | FL400 | FL360 | 1 | E | NO OR LATE FL REVISION |
| 10/4/2022 | BLN | FL340 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 10/4/2022 | BLN | FL340 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 15/4/2022 | BLN | FL320 | FL320 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 18/4/2022 | BLN | | FL380 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 24/4/2022 | BLN | | FL340 | 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 |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 29/4/2022 | CEO | FL310 | FL330 | 1 | E | NO OR LATE FL REVISION |
| 9/4/2022 | CEO | FL330 | FL330 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 25/4/2022 | FII | FL360 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 29/4/2022 | SBV | | FL410 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 2/5/2022 | BLN | FL300 | FL320 | 0 | E | NO OR LATE FL REVISION |
| 5/5/2022 | BLN | FL340 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 1/6/2022 | FFV | FL300 | FL340 | 0 | E | NO OR LATE FL REVISION |
| 1/6/2022 | FFV | FL320 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 30/5/2022 | BLN | | FL400 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 26/5/2022 | BLN | | FL360 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 26/5/2022 | BLN | | FL380 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 6/6/2022 | CAI | FL390 | FL410 | 0 | E | NO OR LATE FL REVISION |
| 3/5/2022 | CEO | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 8/5/2022 | CEO | FL370 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 12/5/2022 | CEO | | FL410 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 26/5/2022 | CEO | | FL330 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 27/5/2022 | CEO | FL330 | FL350 | 10 | E | NO OR LATE FL REVISION |
| 30/5/2022 | CEO | | FL350 | 6 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 20/5/2022 | SBV | | FL330 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 30/5/2022 | SBV | FL310 | FL330 | 3 | E | NO OR LATE FL REVISION |
| 15/6/2022 | SBV | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 27/6/2022 | BLN | FL340 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 3/6/2022 | BLN | FL340 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 6/6/2022 | BLN | | FL340 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 12/6/2022 | BLN | | FL320 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 25/6/2022 | BLN | | 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 |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 15/6/2022 | CEO | FL390 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 28/6/2022 | CEO | | FL330 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 12/6/2022 | CAI | FL350 | FL330 | 0 | E | NO OR LATE FL REVISION |
| 18/7/2022 | CAI | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 6/7/2022 | BLN | FL300 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 9/7/2022 | BLN | | FL380 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 18/7/2022 | BLN | FL340 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 19/7/2022 | BLN | FL370 | FL370 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 22/7/2022 | BLN | FL350 | FL350 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 27/7/2022 | BLN | FL340 | FL400 | 0 | E | NO OR LATE FL REVISION |
| 31/7/2022 | BLN | | FL340 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 8/8/2022 | CAI | FL390 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 13/8/2022 | CAI | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 5/8/2022 | CAI | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 11/8/2022 | CAI | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 14/8/2022 | CAI | FL350 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 14/8/2022 | CAI | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 8/8/2022 | CAI | FL370 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 14/8/2022 | CAI | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 9/8/2022 | FFV | FL320 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 19/8/2022 | FFV | | FL320 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 1/8/2022 | BLN | FL340 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 3/8/2022 | BLN | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 12/8/2022 | BLN | | FL360 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 15/8/2022 | BLN | FL380 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 22/8/2022 | BLN | | FL360 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 22/8/2022 | BLN | | FL380 | 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 |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 18/8/2022 | BLN | FL360 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 14/8/2022 | CEO | FL330 | FL350 | 1 | E | NO OR LATE FL REVISION |
| 17/8/2022 | CEO | FL370 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 20/8/2022 | CEO | FL410 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 28/8/2022 | CEO | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 30/8/2022 | CEO | FL330 | FL310 | 0 | E | NO OR LATE FL REVISION |
| 30/8/2022 | CEO | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 2/7/2022 | CEO | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 21/7/2022 | CEO | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 22/6/2022 | FFV | FL350 | FL360 | 0 | A | PILOT MISUNDERSTANDS ATC CLEARANCE |
| 23/9/2022 | XSR | FL320 | FL324 | 0 | A | None |
| 5/10/2022 | FFV | FL340 | FL344 | 0 | H | None |
| 11/9/2022 | ZMW | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 19/10/2022 | SBV | | FL350 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 12/9/2022 | BLN | FL340 | FL340 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 16/9/2022 | BLN | FL300 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 16/9/2022 | BLN | | FL340 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 27/9/2022 | BLN | FL320 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 5/9/2022 | BLN | FL370 | FL373 | 0 | B | None |
| 2/9/2022 | CEO | FL330 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 10/9/2022 | CEO | FL410 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 19/9/2022 | CEO | FL330 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 19/9/2022 | CEO | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 22/9/2022 | CEO | FL390 | FL310 | 4 | E | NO OR LATE FL REVISION |
| 24/9/2022 | CEO | FL370 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 27/9/2022 | CEO | FL350 | FL370 | 2 | E | NO OR LATE FL REVISION |
| 1/10/2022 | CEO | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 7/10/2022 | CEO | FL290 | FL310 | 0 | E | NO OR LATE FL REVISION |
| 8/10/2022 | CEO | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 15/10/2022 | CEO | FL330 | FL370 | 5 | E | NO OR LATE FL REVISION |

| Date | Source | Assigned FL | Observed/Reported FL | Minutes at Incorrect FL/No. FL crossed without clearance | Category | Description |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 19/10/2022 | CEO | FL330 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 19/10/2022 | CEO | FL310 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 19/9/2022 | FII | FL400 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 3/11/2022 | SBV | FL310 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 6/11/2022 | SBV | FL370 | FL330 | 0 | E | NO OR LATE FL REVISION |
| 6/10/2022 | BLN | FL360 | FL340 | 0 | E | NO OR LATE FL REVISION |
| 14/10/2022 | BLN | FL330 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 22/10/2022 | BLN | FL360 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 28/10/2022 | BLN | FL340 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 2/11/2022 | CEO | FL330 | FL310 | 0 | E | NO OR LATE FL REVISION |
| 5/11/2022 | CEO | FL330 | FL370 | 1 | E | NO OR LATE FL REVISION |
| 13/11/2022 | CEO | FL390 | FL410 | 0 | E | NO OR LATE FL REVISION |
| 21/11/2022 | BLN | FL400 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 18/11/2022 | CAI | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 18/10/2022 | CAI | FL390 | FL410 | 0 | E | NO OR LATE FL REVISION |
| 30/9/2022 | CAI | | | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 10/12/2022 | CAI | FL310 | FL330 | 0 | E | NO OR LATE FL REVISION |
| 14/11/2022 | CAI | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 5/12/2022 | CAI | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 17/11/2022 | SBV | | FL380 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 20/2/2022 | KVB | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 27/11/2022 | SBV | | FL410 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 27/11/2022 | SBV | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 31/3/2022 | KVB | FL390 | FL390 | 6 | E | NO OR LATE ESTIMATE TIME REVISION |
| 14/9/2022 | KVB | FL380 | FL360 | 1 | D | ATC ISSUES INCORRECT CLEARANCE TO PILOT |
| 28/10/2022 | KVB | FL330 | FL350 | 1 | E | NO OR LATE FL REVISION |
| 31/12/2022 | YZJ | FL330 | | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 21/12/2022 | KVB | FL360 | FL360 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 13/12/2022 | XSR | FL400 | FL400 | 0 | M | PILOT MISUNDERSTANDS ATC CLEARANCE |

| Date | Source | Assigned FL | Observed/Reported FL | Minutes at Incorrect FL/No. FL crossed without clearance | Category | Description |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 19/12/2022 | XSR | FL340 | FL340 | 0 | M | PILOT MISUNDERSTANDS ATC CLEARANCE |
| 4/12/2022 | CEO | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 5/12/2022 | CEO | | FL350 | 2 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 15/12/2022 | CEO | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 23/12/2022 | CEO | FL370 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 24/12/2022 | CEO | FL350 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 25/12/2022 | CEO | FL370 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 26/12/2022 | CEO | FL370 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 11/12/2022 | BLN | FL340 | FL400 | 0 | E | NO OR LATE FL REVISION |
| 11/12/2022 | BLN | FL380 | FL340 | 0 | E | NO OR LATE FL REVISION |

MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2022 to December 2022

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE SOUTHEAST ASIA AIRSPACE**
Assessment Period: January 2022 to December 2022

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 2022** and monthly Large Height Deviation (LHD) reports between **January 2022** and **December 2022** submitted by concerning States in the SA/IO airspace.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2022 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 2022 to December 2022. **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 | Taipei |
|---------------|------------|-----------|-----------|---------------|--------------|--------|-----------|---------|-------|-------------|--------|
| January | X | X | X | X | X | X | X | X | X | X | X |
| February | X | X | X | X | X | X | X | X | X | X | X |
| March | X | X | X | X | X | X | X | X | X | X | X |
| April | X | X | X | X | X | X | X | X | X | X | X |
| May | X | X | X | X | X | X | X | X | X | X | X |
| June | X | X | X | X | X | X | X | X | X | X | X |
| July | X | X | X | X | X | X | X | X | X | X | X |
| August | X | X | X | X | X | X | X | X | X | X | X |
| September | X | X | X | X | X | X | X | X | X | X | X |
| October | X | X | X | X | X | X | X | X | X | X | X |
| November | X | X | X | X | X | X | X | X | X | X | X |
| December | X | X | X | X | X | X | X | X | X | X | X |

Table 1: Summary of LHD reports submitted by FIRs in 2022. '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 2022 to December 2022.

| Month (2022) | No. of LHD | No. of Non-zero-duration LHD | LHD Duration (Min) | No. of Levels Crossed | Operational Risk (x10 ⁻⁹ FAPFH) |
|--------------|------------|------------------------------|--------------------|-----------------------|--|
| January | 5 | 2 | 13 | 0 | 0.24 |
| February | 5 | 1 | 1 | 0 | 0.02 |
| March | 4 | 1 | 3 | 0 | 0.04 |
| April | 2 | 0 | 0 | 0 | 0.00 |
| May | 5 | 2 | 2 | 0 | 0.04 |
| June | 4 | 0 | 0 | 0 | 0.00 |
| July | 5 | 2 | 3 | 0 | 0.05 |
| August | 7 | 2 | 5 | 0 | 0.07 |
| September | 3 | 1 | 2 | 0 | 0.04 |
| October | 10 | 4 | 12 | 0 | 0.21 |
| November | 3 | 2 | 19 | 0 | 0.31 |
| December | 10 | 2 | 9 | 0 | 0.17 |
| Total | 63 | 19 | 69 | 0 | 1.18 |

Table 2: Summary of LHD by month for SEA Airspace

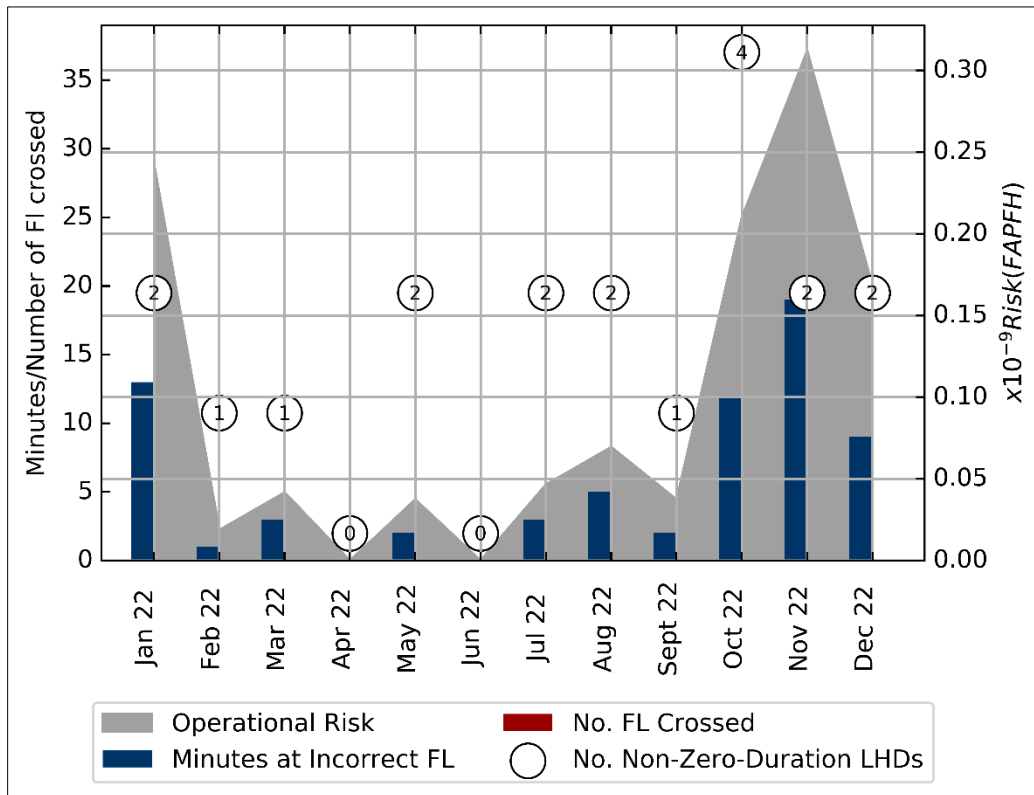


Figure 1: Summary of LHDs by month for SEA Airspace

3.2. Compared to 2021, the number of LHDs slightly decreased from 72 to 63 in 2022. Out of 63 LHDs, 19 were non-zero-duration LHDs, with a total duration of 69 minutes and no crossed flight level. The total operational risk also decreased from 2.13×10^{-9} FAPFH in 2021 to 1.18×10^{-9} FAPFH in 2022.

3.3. **Figure 2** and **Table 3** summarize the number of LHDs, the associated LHD duration (in minutes) and the number of incorrect flight levels crossed, by the LHD category from January 2022 to December 2022.

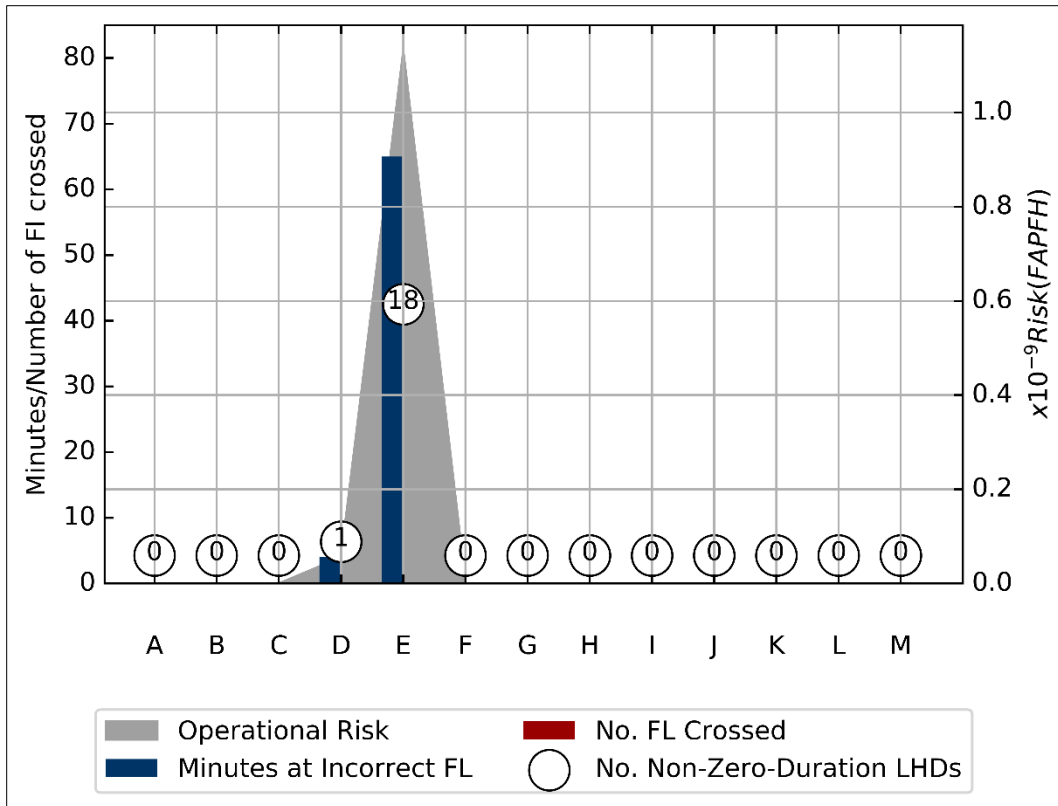


Figure 2: Summary of LHD by category for SEA Airspace

| LHD Category Code | LHD Category Description | No. of LHDs | No. of Non-zero-duration LHDs | LHD Duration (Min) | No. of levels Crossed | Operational Risk ($\times 10^{-9}$ FAPFH) |
|-------------------|--|-------------|-------------------------------|--------------------|-----------------------|--|
| A | Flight crew failing to climb/descend the aircraft as cleared | 1 | 0 | 0 | 0 | 0 |
| B | Flight crew climbing/descending without ATC Clearance | 1 | 0 | 0 | 0 | 0 |
| C | Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of | 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) |
|-------------------|--|-------------|-------------------------------|--------------------|-----------------------|--|
| | ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, 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 | 1 | 4 | 0 | 0.05 |
| 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). | 57 | 18 | 65 | 0 | 1.13 |
| F | Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level). | 1 | 0 | 0 | 0 | 0 |
| G | Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure) | 0 | 0 | 0 | 0 | 0 |
| H | Airborne equipment failure leading to unintentional or undetected change of flight level. | 1 | 0 | 0 | 0 | 0 |
| I | Turbulence or other weather related causes leading to unintentional or undetected change of flight level | 1 | 0 | 0 | 0 | 0 |
| J | TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory | 0 | 0 | 0 | 0 | 0 |
| K | TCAS resolution advisory, flight crew incorrectly climb or descend following the resolution advisory. | 0 | 0 | 0 | 0 | 0 |
| L | An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan). | 0 | 0 | 0 | 0 | 0 |
| M | Other | 0 | 0 | 0 | 0 | 0 |
| Total | | 63 | 19 | 69 | 0 | 1.18 |

Table 3: Summary of LHD by category for SEA Airspace

3.4. In 2022, the majority of LHDs, non-zero-duration LHDs, duration and operational risk in SEA Airspace were in Category E, which can be further categorized into sub-categories. **Figure 3** shows the contribution of each sub-category in terms of the number of LHDs and **Figure 4** shows the contribution in terms of risk.

3.5. In **Figure 3**, the “No or Late Flight Level Revision” sub-category accounted for 44.44%, the “No Transfer Information” sub-category accounted for 38.89%, “No or late time revision” sub-category accounted for 11.11%, and other sub-categories accounted for 5.56% of the total number of Category E LHDs.

3.6. In terms of contribution to the operational risk as shown in **Figure 4**, the “No or Late Time Revision” sub-categories accounted for 36.44% of the total operational risk of SEA Airspace. The “No or Late Flight Level Revision” sub-category accounted for 35.07% and the “No Transfer Information” sub-category accounted for 27.26% of the total operational risk of SEA Airspace. It should be noted that even though the "No or Late Estimate Time Revision" sub-category has a smaller number of LHDs at 11.11%, but it contributed to the largest portion of operational risk at 36.44%, compared to the LHDs in other sub-categories.

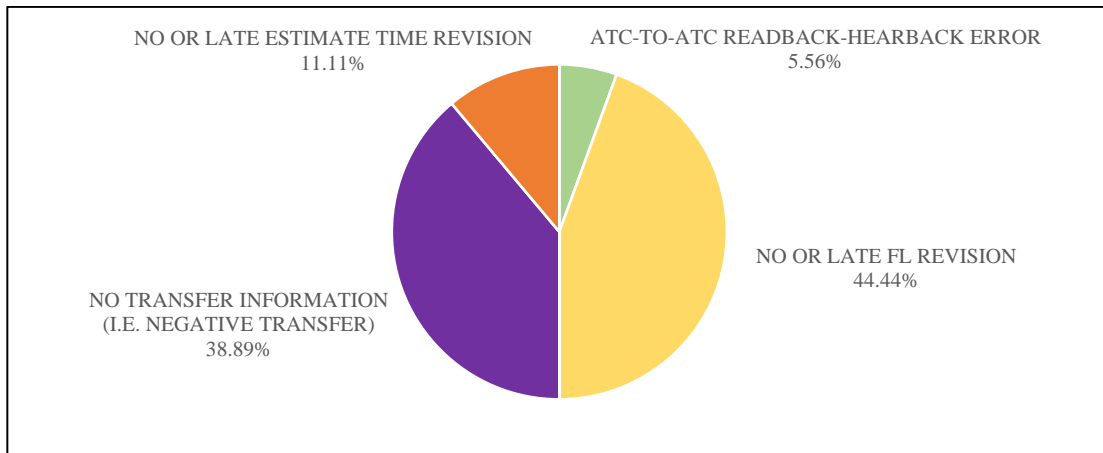


Figure 3: Sub-categories of Category-E LHDs for SEA Airspace

(The number of LHDs)

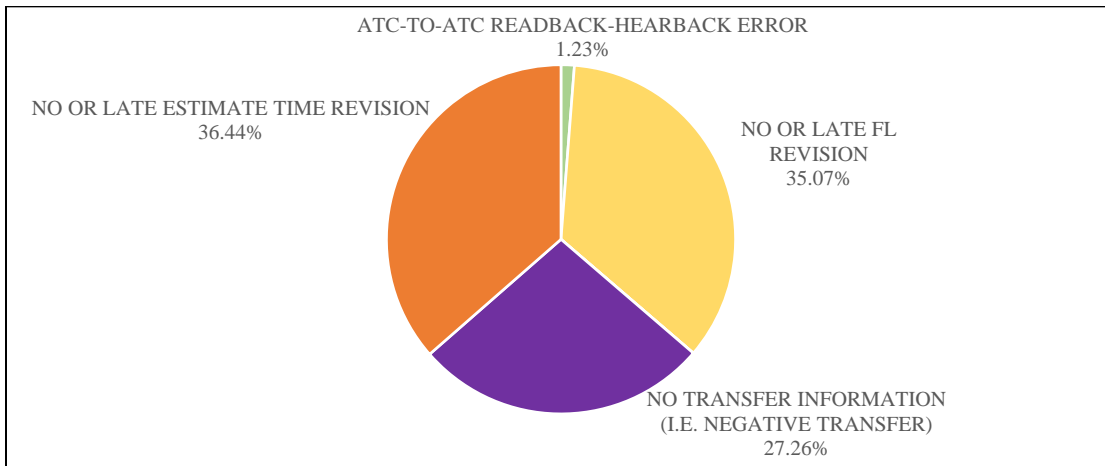


Figure 4: Sub-categories of Category-E LHDs for SEA Airspace (Operational risk)

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 | 1,461,357 | 514,389 | Hour | Dec 2022 TSD |
| $E_z(\text{same})$ | Same-direction vertical occupancies | 0.2856/ 0.0255 | 0.1838 | - | |
| $E_z(\text{opposite})$ | Opposite-direction vertical occupancies | 0.1418 | 0.0250 | - | |
| λ_x | Average aircraft length | 0.0265 | 0.0300 | NM | |
| λ_y | Average aircraft wingspan | 0.0243 | 0.0276 | NM | |
| λ_z | Average aircraft height | 0.0076 | 0.0083 | NM | |
| λ_h | Diameter of the disk representing the shape of an aircraft in the horizontal plane | 0.0265 | 0.0300 | NM | |
| Pz(0) | Probability of vertical overlap (with planned vertical separation equal to zero) | 0.538 | 0.538 | - | Conservative value used in previous assessments |
| $ \overline{\Delta V} $ | Average relative along-track speed between aircraft on same direction routes | 33.36 | 39.98 | Knot | Dec 2022 TSD |
| $ \overline{V} $ | Average absolute aircraft ground speed | 480 | 480 | Knot | Conservative value used in previous assessments |

Table 4: Estimates of the parameters in the CRM for SEA Airspace

4.2. **Risk Estimation Results.** The results for the technical, operational and total risk for the RVSM implementation are detailed in **Table 5**. **The technical risk**, defined as probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and to all causes, **meets the TLS** value of 2.5×10^{-9} FAPFH. **The total risk** is 1.83×10^{-9} FAPFH, which also **meets the specified TLS** value of 5.0×10^{-9} FAPFH.

| SEA Airspace – estimated annual flying hours = 1,975,746 hours (note: estimated hours based on Dec 2022 traffic sample data) | | | |
|---|---|----------------------|---------------------|
| Source of Risk | Risk Estimation | TLS | Remarks |
| RASMAG 27 Total Risk | 2.58×10^{-9} | 5.0×10^{-9} | Below TLS |
| Technical Risk | 0.65×10^{-9} | 2.5×10^{-9} | Below Technical TLS |
| Operational Risk | 1.18×10^{-9} | - | - |
| Total Risk | 1.83×10^{-9} | 5.0×10^{-9} | Below TLS |

Table 5: Risk estimates for SEA Airspace

4.3. **Figure 5** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHDs. In 2022, both operational and total risk show as the downward trend. The total risk decreased by 29% from 2.58×10^{-9} FAPFH in 2021 to 1.83×10^{-9} FAPFH in 2022.

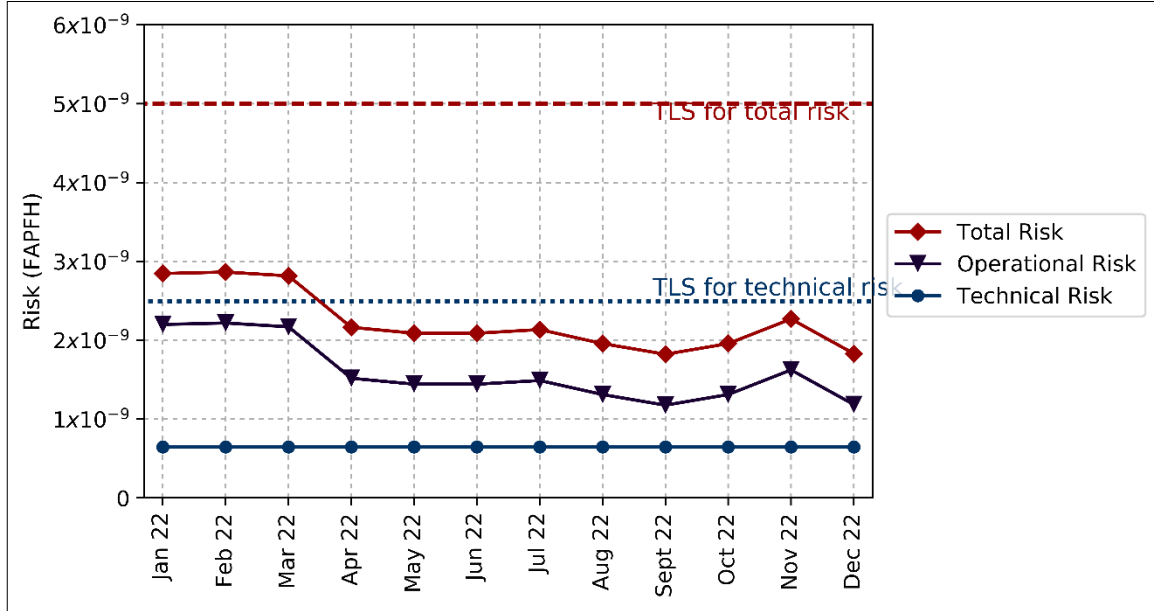


Figure 5: Trends of risk estimates for SEA Airspace

4.4. **Figure 6** demonstrates monthly operational risk, where each individual block represents one LHD and height of each block corresponds to operational risk of each LHD. The monthly operational risk value is determined to provide real-time information on actual risk, without relying on historical high-time errors present within the 12-month data sample. In **Figure 6**, the total operational risk in each month is below the average monthly operational risk, where calculated by dividing the annual risk of 5.0×10^{-9} FAPFH by 12 (the red line in **Figure 6** approximately 0.4167×10^{-9} FAPFH).

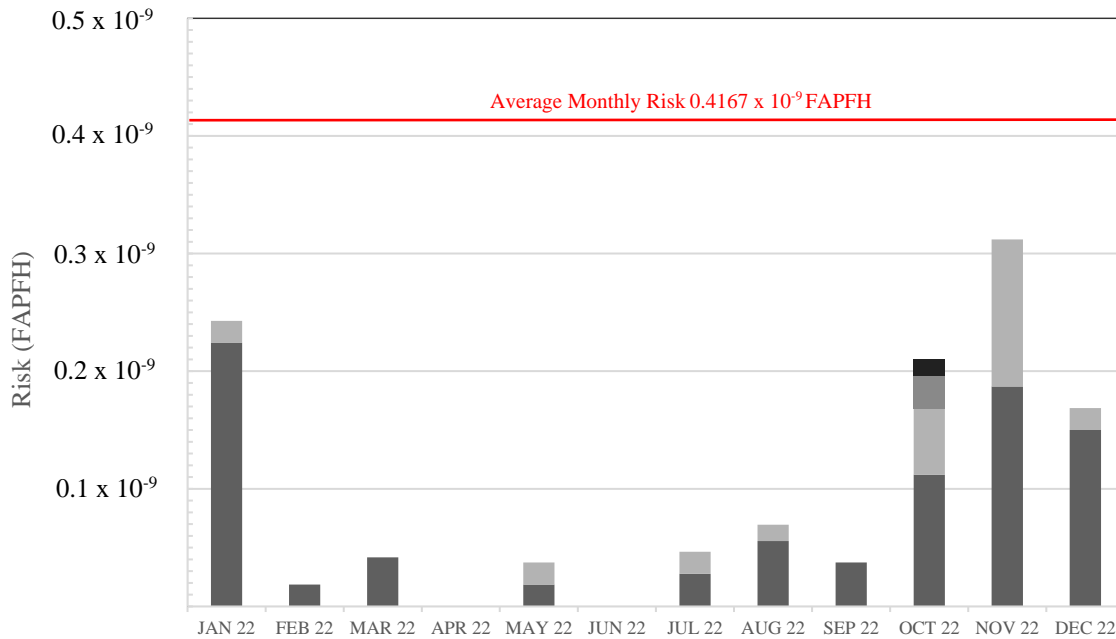


Figure 6: Monthly operational risk estimates for SEA Airspace. Red line is the average monthly value for an annual risk of 5.0×10^{-9} FAPFH.

5. Analysis of Operational Errors

5.1 **Figure 7** depicts geographical locations of all reported LHDs in SEA airspace based on LHD reports from January to December 2022. **Figure 8** depicts only LHDs which are determined to be non-zero duration. The following are symbols and color codes used in the visualizations:

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

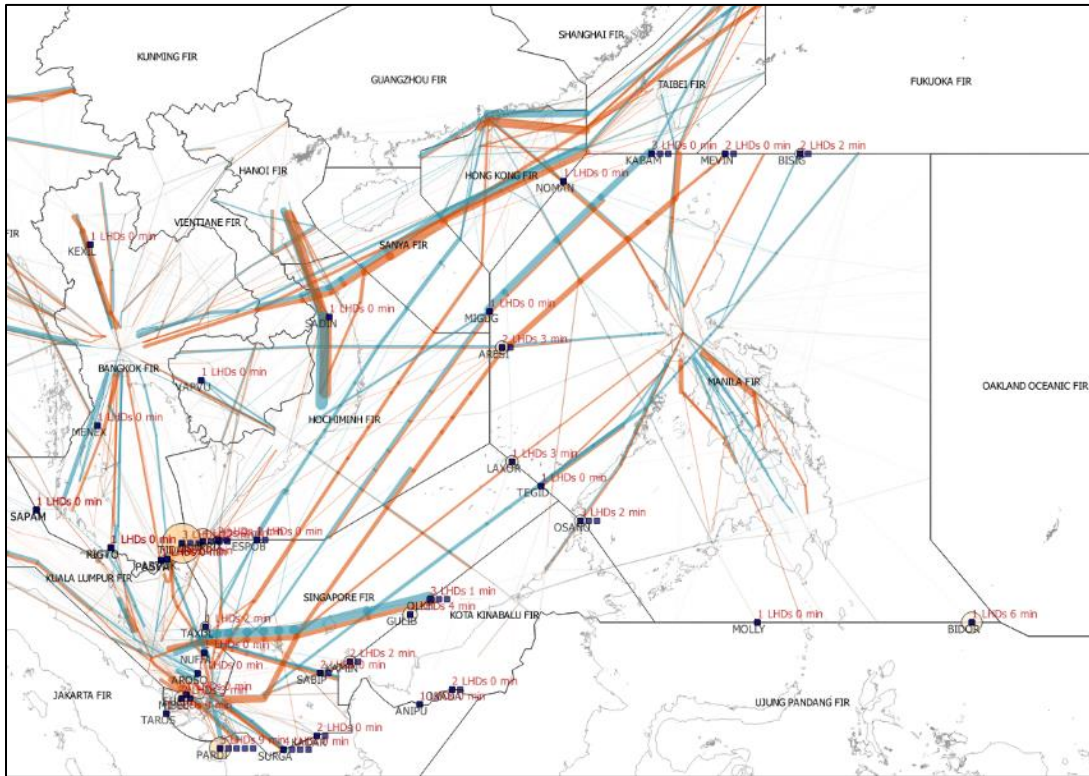


Figure 7: Geographical locations of All LHDs in SEA Airspace

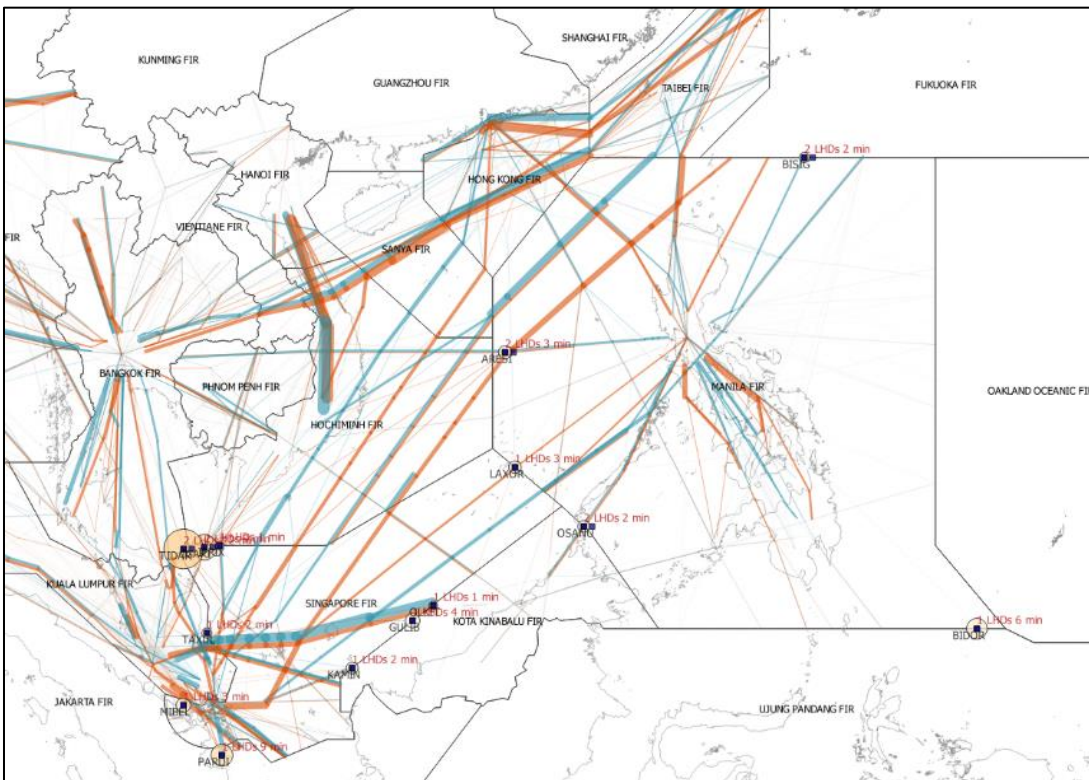


Figure 8: Geographical locations of 'non-zero-duration' LHDs in SEA Airspace

LHD Hot Spot identification

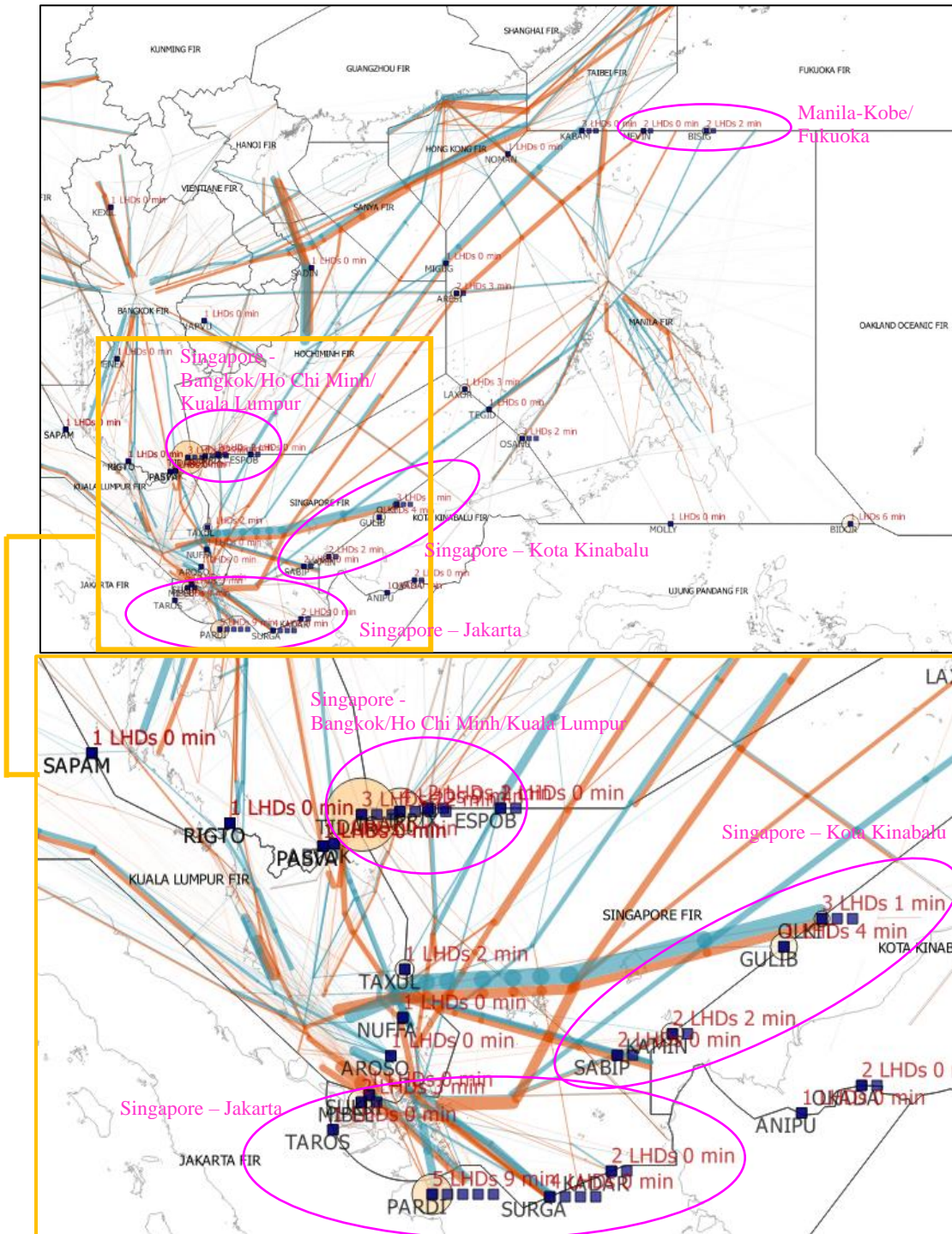


Figure 9: Geographical locations of identified LHD clusters in SEA Airspace

5.2 In the process of identifying hot spots in SEA Airspace, four (4) LHD clusters are identified as shown in pink ovals in **Figure 9**.

5.3 **Table 6** shows the profile of the LHD clusters in SEA Airspace and the determining criteria in 2022.

| SEA | 2022 |
|---|-------|
| Number of Clusters | 4 |
| Number of LHDs | 63 |
| Operational Risk (x 10 ⁻⁹ FAPFH) | 1.18 |
| Criteria: Number of LHDs | 12.60 |
| Criteria: Operational Risk (x 10 ⁻⁹ FAPFH) | 0.24 |
| Criteria: TLS (x 10 ⁻⁹ FAPFH) | 5.00 |

Table 6: The profile of the LHD clusters in SEA Airspace and the determining criteria for 2022

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

| 2022 Clusters (SEA) | Manila-Kobe/ Fukuoka (Hot Spot D) | Singapore- Jakarta (Hot Spot J) | Singapore- Bangkok/ Ho Chi Minh/ Kuala Lumpur | Singapore- Kota Kinabalu |
|---|---|---------------------------------------|--|-----------------------------|
| Number of LHDs | 4 | 14 | 11 | 8 |
| Check Criteria: Number >= 12.60 | Negative | Positive | Negative | Negative |
| Operational Risk (x 10 ⁻⁹ FAPFH) | 0.03 | 0.18 | 0.60 | 0.11 |
| Check Criteria: Operational Risk >= 0.24 x 10 ⁻⁹ FAPFH | Negative | Negative | Positive | Negative |
| Check Criteria: Operational Risk >= 5.00 x 10 ⁻⁹ FAPFH | Negative | Negative | Negative | Negative |

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

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

- Singapore - Jakarta boundary (Hot Spot J); and
- Singapore - Bangkok/Ho Chi Minh/Kuala Lumpur boundary.

5.6 At Singapore-Jakarta boundary (Hot Spot J), the number of LHDs exceeded the criteria. This cluster also satisfied the hot spot criteria in 2021.

5.7 At the boundaries of Manila FIR (Hot Spot D), **only one LHD cluster** at Manila-Kobe/Fukuoka boundary satisfied the hot spot criteria in 2021, but none satisfied the hot spot criteria in 2022.

LHD Hot Spot D (Manila)

5.8 **Figure 10** depicts the geolocation of the number of LHDs and operational risk along Manila FIR boundaries from 2019 to 2022. In **Figure 10**, the traffic movement in 2022 has recovered when compared with 2020 and 2021, as indicated by the thicker turquoise and orange lines. However, the volume of traffic movement in 2022 did not reach the level observed in 2019. Despite this, the operational risk significantly decreased in 2022 as the disappearance of the risk's circle.

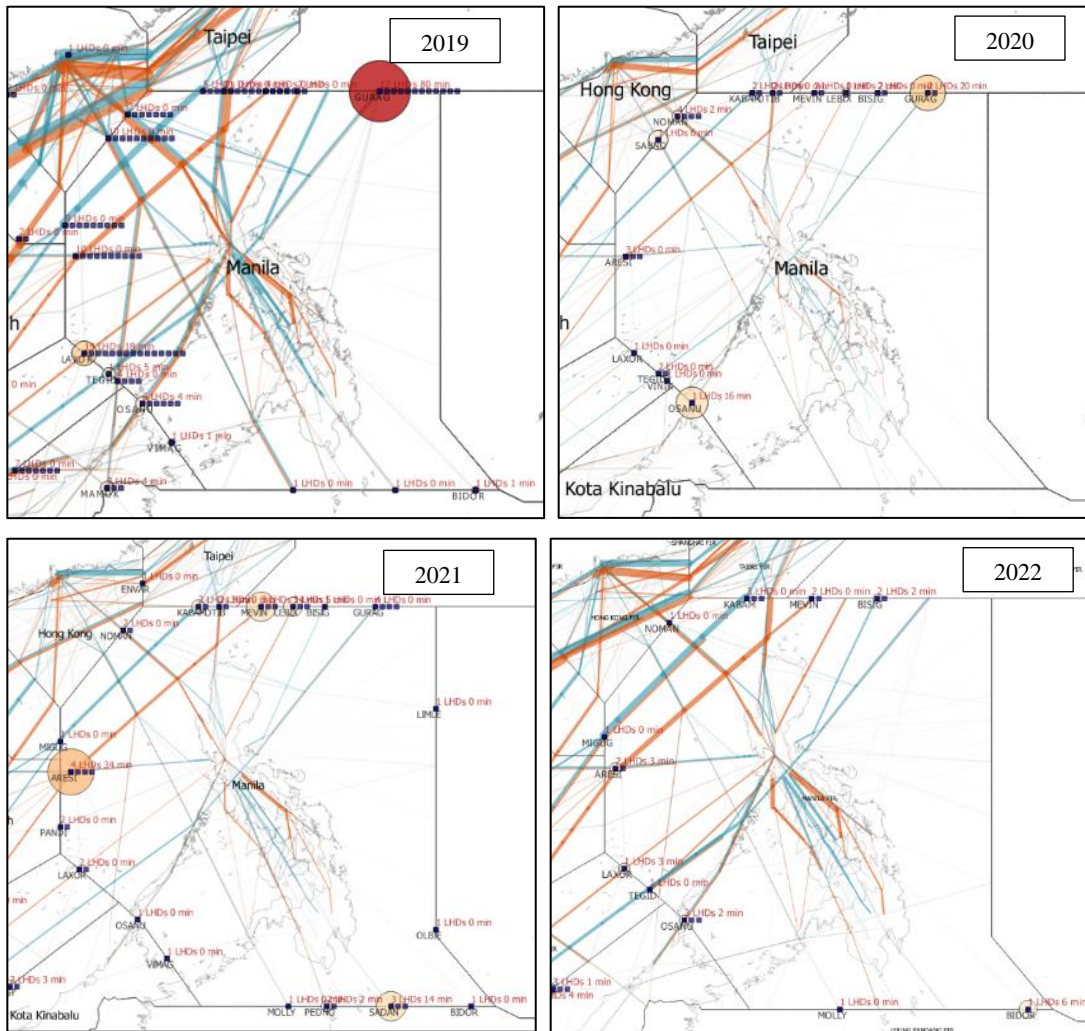


Figure 10: Geographic locations of LHDs and operational risk along Manila FIR boundaries in 2019, 2020, 2021 and 2022

5.9 **Table 8** summarizes the number of LHDs, the number of non-zero-duration LHDs and the associated operational risk along Manila FIR boundaries in 2020, 2021 and 2022. The number of LHDs along Manila FIR boundaries significantly decreased from 37 LHDs in 2021 to 18 LHDs in 2022. Similarly, the operational risk dramatically decreased from 1.65×10^{-9} FAPFH in 2021 to 0.27×10^{-9} FAPFH in 2022. The operational risk at Manila FIR boundaries accounted for only 23% of the total operational risk in SEA Airspace. This marked a significant change from previous years, where the majority of LHDs and operational risk in SEA Airspace were dominated by the number of LHDs and operational risk along Manila FIR boundaries, comprising over 50%.

| Boundary | Number of LHDs | | | Number of non-zero-duration LHDs | | | Operational Risk (10 ⁻⁹ FAPFH) | | |
|----------------------|---------------------|-----------|-----------|----------------------------------|-----------|----------|--|-------------|-------------|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| | Manila-Kobe/Fukuoka | 5 | 11 | 4 | 2 | 4 | 3 | 0.49 | 0.45 |
| Manila-Ho Chi Minh | 4 | 7 | 3 | 0 | 3 | 2 | 0 | 0.77 | 0.05 |
| Manila-Hong Kong | 5 | 2 | 1 | 2 | 0 | 0 | 0.19 | 0 | 0 |
| Manila-Kota Kinabalu | 2 | 2 | 3 | 1 | 0 | 2 | 0.37 | 0 | 0.04 |
| Manila-Sanya | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manila-Singapore | 3 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 0.04 |
| Manila Taibei | 3 | 4 | 3 | 0 | 1 | 0 | 0 | 0.07 | 0 |
| Manila-Ujung Pandang | 0 | 7 | 2 | 0 | 2 | 1 | 0 | 0.36 | 0.11 |
| Manila-Oakland | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 24 | 37 | 18 | 5 | 10 | 9 | 1.05 | 1.65 | 0.27 |

Table 8: The number of LHDs, non-zero-duration LHDs and operational risk along Manila FIR boundaries from 2020 to 2022

5.10 In 2022, the highest number of LHDs occurred at Manila-Kobe/Fukuoka boundary with 4 LHDs. The operational risk at this boundary was 0.03×10^{-9} FAPFH. On the other hand, the highest operational risk of 0.11×10^{-9} FAPFH was at Manila-Ujung Pandang boundary. The operational risk at this boundary was attributed by only one LHD containing 6 minutes in duration.

5.11 After the RASMAG/27 scrutiny group discussion, the Civil Aviation Authority of the Philippines (CAAP) revealed that they conducted multiple training sessions in 2022. These sessions aimed to enhance controller proficiency and review new procedures introduced during the COVID-19 pandemic. Additionally, briefing sessions before shift duty and safety-related discussions were held to improve safety awareness and reduce errors among controllers.

5.12 Since 2018, safety improvement activities have led to a significant reduction in the number of LHDs and operational risk. The new ATM system at Manila ATMC enables the partitioning of Manila ACC into 9 sectors instead of the previous 4 sectors. This system also enhances surveillance capabilities, covering the entire FIR and extending beyond its boundaries with 10 new radar sites. Additionally, successful integration of ADS-C/CPDLC in the controller's workstations now covers the entire oceanic airspace. However, the implementation of AIDC with adjacent ACC is expected to further improve the efficiency of aircraft transfer across the boundaries.

5.13 **Table 9** shows the AIDC implementation status between Manila ACC and the adjacent units. According to the last update in the Appendix H to the final report of ACSICG/10 held in May 2023, the status of AIDC implementation between Manila ACC and the adjacent ACC is detailed in **Table 9**. The status remains the same as mentioned in RASMAG/27.

| 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 |
| Ho Chi Minh ACC | Technical test in November 2021 |
| Oakland ARTCC | Technical test in November 2021 |
| Kota Kinabalu ACC | Awaiting the timetable of Kota Kinabalu |
| Kobe/Fukuoka ACC | Initiated correspondence, awaiting response |
| Japan ATMC | Initiated correspondence, awaiting response |

Table 9: Status of AIDC implementation with Manila ACC

5.14 Regarding the process of identifying hot spots, the Manila-Kobe/Fukuoka boundary satisfied the hot spot criteria in 2021, but not in 2022. Subject to the assessment result from JASMA who is also shared the responsibility of this hot spot, all Manila FIR boundaries (Hot Spot D) may be proposed as the potential non-hot spot. If none of Manila FIR boundaries satisfy the hot spot criteria in 2022 and 2023 for both SEA and Japan Airspaces, Hot Spot D can be proposed for removal from Hot Spot list. But it should be noted that the AIDC implementation between Manila ACC and Kobe/Fukuoka ACC is yet to begin.

LHD Hot Spot J (Singapore-Jakarta boundary)

5.15 Since 2018 the **boundary between Singapore and Jakarta** has been identified as LHD hot spots J. The number of LHDs at Singapore-Jakarta boundary slightly decreased from 16 in 2021 to 14 in 2022. The operational risk also decreased from 0.23×10^{-9} FAPFH in 2021 to 0.18×10^{-9} FAPFH in 2022. All LHDs at this boundary were in Category E.

5.16 As detailed in the final report of ACSICG/10, 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.

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 for 2 consecutive years (2021 and 2022). Therefore, the boundary between Singapore FIR and Jakarta FIR (LHD Hot Spot J) should remain on the hot spot list.

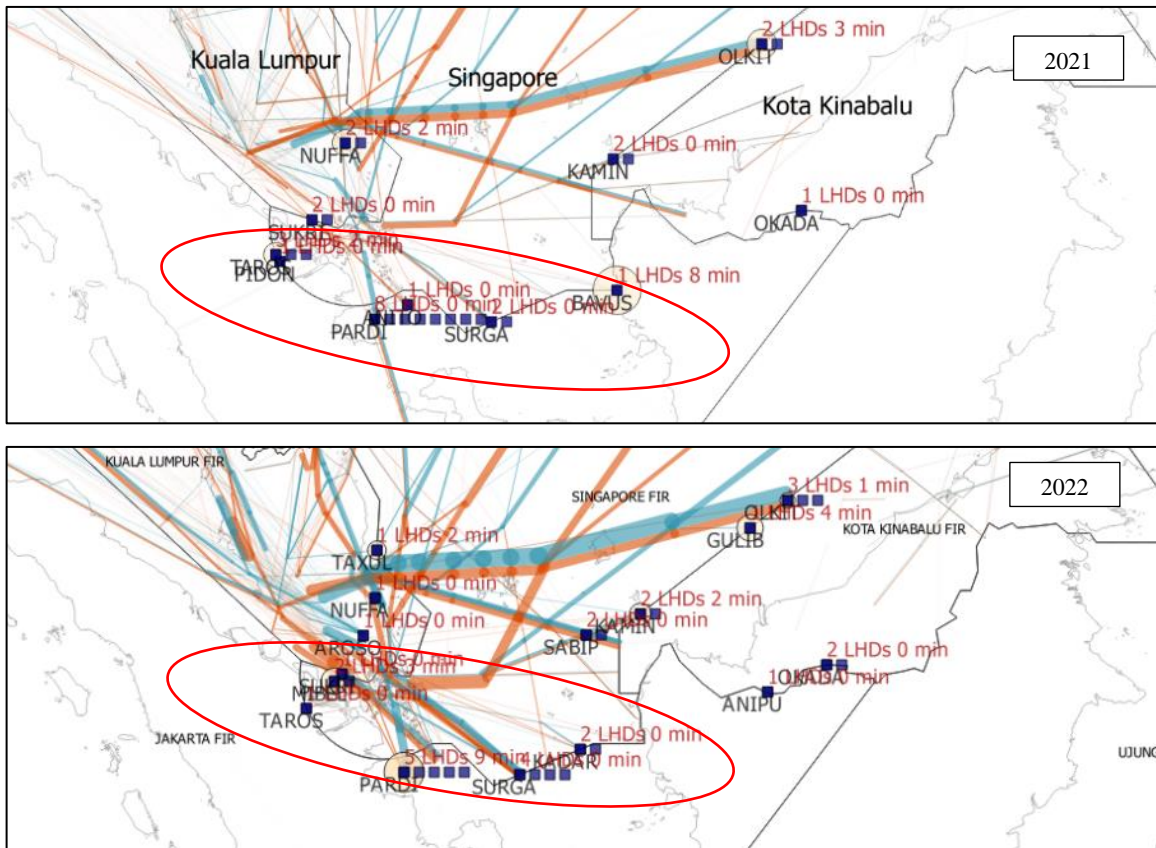


Figure 12: Geographic location of LHDs and operation risk at the boundary between Singapore and Jakarta FIR in 2021 and 2022.

Singapore - Bangkok/Ho Chi Minh/Kuala Lumpur boundary

5.18 In 2022, the number of LHDs at the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR (Waypoint TIDAR, IGARI, IPRIX and ESPOB) increased from 6 in 2021 to 11 in 2022. All LHDs were categorized as Category E. Out of these, there were 5 non-zero-duration LHDs, contributing to 0.60×10^{-9} FAPFH, which was 51 % of the total operational risk in SEA Airspace.

- At TIDAR, two (2) non-zero-duration LHDs were caused by aircrafts entering the FIR earlier than expected without the time revision and undetected for 10 and 12 minutes.
- At IGARI, two (2) non-zero-duration LHDs were caused by aircrafts entering the FIR without prior transfer information (Negative Transfer), and undetected for 1 and 8 minutes.
- At IPRIX, one (1) non-zero-duration LHD was caused by an aircraft entering the FIR without prior transfer information (Negative Transfer), and undetected for 1 minute.

5.19 The route segments of M904 between TIDAR and abeam IKUMI and M765 between IGARI and VENLI over Singapore FIR are very short. The route structure and ATC procedures of handling crossing traffic over this area can be complex between Singapore ACC and the other three (3) adjacent ATS units.

5.20 Regarding the process of identifying hot spots, the LHD cluster at the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR satisfied the hot spot criteria in terms of the operational risk. Consequently, MAAR suggests proposing the boundary between Singapore FIR and Bangkok/Ho Chi Minh/Kuala Lumpur FIR to be included on the hot spot list as a new Hot Spot.

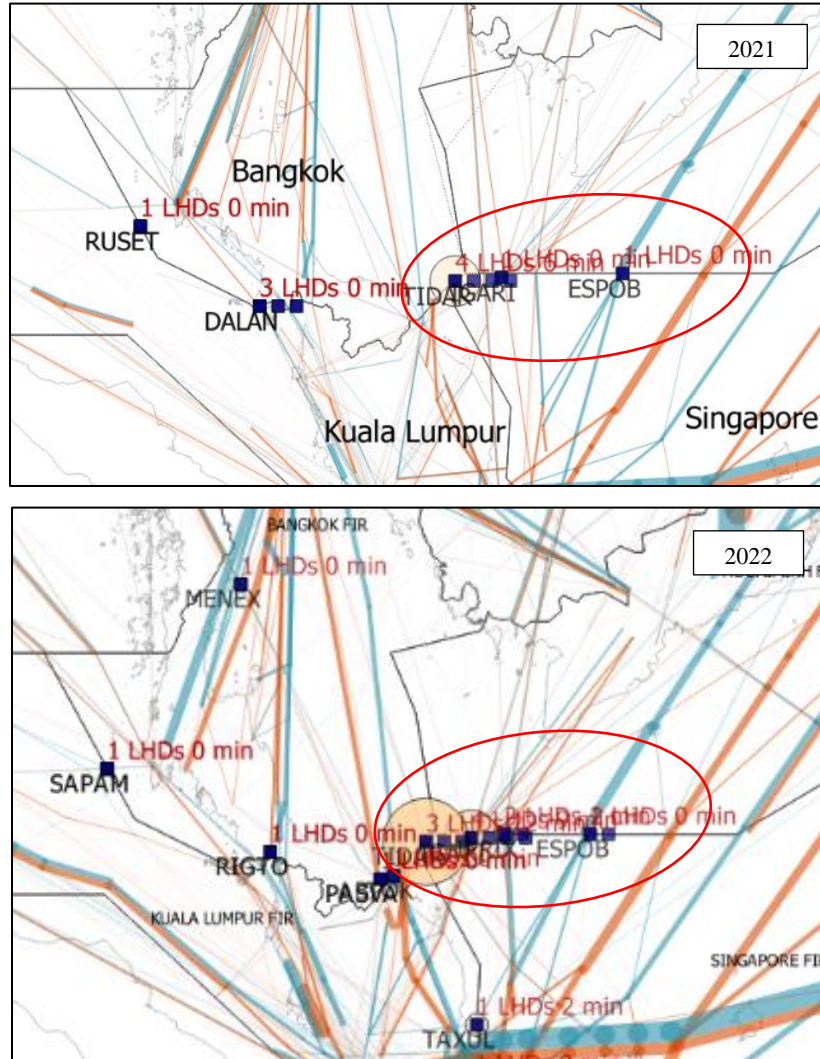


Figure 13: The Visualization of LHDs and operation risk at the boundary between Bangkok FIR and Kuala Lumpur/Singapore FIR in 2021 and 2022.

5.21 During the 31st Aviation Consultative Committee (ACC) Meeting between Malaysia and Thailand held in December 2022, participants discussed the LHD occurrences, the causes, and the coordination procedures between Bangkok FIR and Kuala Lumpur FIR/Singapore FIR. MAAR had a chance to present the LHD reporting process and the recommended Cross-Boundary LHD Coordination Procedure. The meeting agreed to adopt and implement the recommended coordination procedure for facilitating an effective coordination between the Bangkok and Kuala Lumpur ACCs.

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 |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 26/2/2022 | GKO | FL400 | FL410 | 0 | E | NO OR LATE FL REVISION |
| 19/1/2022 | SDO | FL390 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 18/1/2022 | OTT | FL330 | FL290 | 0 | E | NO OR LATE FL REVISION |
| 21/1/2022 | OTT | FL330 | FL330 | 12 | E | NO OR LATE ESTIMATE TIME REVISION |
| 21/1/2022 | OTT | FL330 | FL330 | 1 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 16/2/2022 | OTT | | FL380 | 1 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 20/1/2022 | WQV | FL390 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 18/2/2022 | WQV | FL390 | FL400 | 0 | E | NO OR LATE FL REVISION |
| 18/2/2022 | WQV | FL390 | FL390 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 25/2/2022 | WQV | FL380 | FL380 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 12/3/2022 | WQV | FL400 | FL400 | 0 | E | ATC-TO-ATC READBACK-HEARBACK ERROR |
| 11/3/2022 | OTT | FL380 | FL380 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 27/3/2022 | OTT | FL310 | FL310 | 3 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 27/3/2022 | OTT | FL380 | FL380 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 14/4/2022 | OTT | FL320 | FL350 | 0 | E | NO OR LATE FL REVISION |
| 30/4/2022 | OTT | | FL300 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 3/5/2022 | GKO | FL370 | FL350 | 1 | E | NO OR LATE FL REVISION |
| 1/6/2022 | UBW | FL300 | FL340 | 0 | E | NO OR LATE FL REVISION |
| 1/6/2022 | UBW | FL320 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 20/5/2022 | LTR | FL320 | FL352 | 0 | I | None |

| Date | Source | Assigned FL | Observed/Reported FL | Minutes at Incorrect FL/No. FL crossed without clearance | Category | Description |
|-------------|---------------|--------------------|-----------------------------|---|-----------------|--|
| 21/5/2022 | OTT | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 23/5/2022 | OTT | | FL400 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 4/5/2022 | WQV | FL370 | FL350 | 1 | E | NO OR LATE FL REVISION |
| 5/6/2022 | OTT | FL310 | FL310 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 11/7/2022 | OTT | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 14/7/2022 | OTT | FL400 | FL400 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 29/7/2022 | OTT | FL430 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 9/8/2022 | UBW | FL320 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 19/8/2022 | UBW | | FL320 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 7/7/2022 | WQV | FL370 | FL410 | 1 | E | NO OR LATE FL REVISION |
| 21/7/2022 | WQV | FL390 | FL400 | 2 | E | NO OR LATE FL REVISION |
| 15/8/2022 | OTT | | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 31/8/2022 | OTT | FL280 | FL300 | 4 | D | ATC ISSUES INCORRECT CLEARANCE TO PILOT |
| 5/8/2022 | WQV | | FL360 | 1 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 30/8/2022 | WQV | FL350 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 30/8/2022 | WQV | FL280 | FL300 | 0 | B | None |
| 22/6/2022 | UBW | FL350 | FL360 | 0 | A | PILOT MISUNDERSTANDS ATC CLEARANCE |
| 16/9/2022 | OTT | | FL380 | 2 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 18/9/2022 | OTT | FL360 | FL390 | 0 | E | NO OR LATE FL REVISION |
| 14/9/2022 | OTT | | FL300 | 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 |
|------------|--------|-------------|----------------------|--|----------|--|
| 5/10/2022 | UBW | FL340 | FL344 | 0 | H | None |
| 2/10/2022 | VCP | FL370 | FL370 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 3/10/2022 | OTT | FL360 | FL360 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 16/10/2022 | OTT | | FL330 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 17/10/2022 | OTT | | FL400 | 0 | F | AIDC |
| 25/10/2022 | OTT | FL270 | FL290 | 3 | E | NO OR LATE FL REVISION |
| 26/10/2022 | OTT | FL380 | FL380 | 0 | E | NO OR LATE ESTIMATE TIME REVISION |
| 30/10/2022 | OTT | | FL320 | 2 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 11/11/2022 | OTT | FL340 | FL380 | 9 | E | NO OR LATE FL REVISION |
| 9/11/2022 | OTT | | FL400 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 28/11/2022 | OTT | FL370 | FL370 | 10 | E | NO OR LATE ESTIMATE TIME REVISION |
| 12/10/2022 | WQV | FL320 | FL380 | 1 | E | ATC-TO-ATC READBACK-HEARBACK ERROR |
| 29/10/2022 | WQV | FL340 | FL380 | 6 | E | NO OR LATE FL REVISION |
| 2/12/2022 | GKO | | FL390 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 9/12/2022 | GKO | FL390 | FL380 | 0 | E | NO OR LATE FL REVISION |
| 2/12/2022 | OTT | FL340 | FL380 | 1 | E | NO OR LATE FL REVISION |
| 12/12/2022 | OTT | | FL400 | 0 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 14/12/2022 | OTT | | FL400 | 8 | E | NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER) |
| 18/12/2022 | OTT | FL340 | FL360 | 0 | E | NO OR LATE FL REVISION |
| 18/12/2022 | OTT | FL330 | FL370 | 0 | E | NO OR LATE FL REVISION |
| 24/12/2022 | OTT | FL340 | FL400 | 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 |
|------------|--------|-------------|----------------------|--|----------|------------------------|
| 31/12/2022 | OTT | FL400 | FL340 | 0 | E | NO OR LATE FL REVISION |
| 24/12/2022 | GKO | FL370 | FL330 | 0 | E | NO OR LATE FL REVISION |

MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2022 to December 2022

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE MONGOLIAN AIRSPACE**
Assessment Period: January 2022 to December 2022

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

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **Mongolian Airspace**. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2022** and monthly Large Height Deviation (LHD) reports between **January 2022** and **December 2022** submitted by Mongolia.

2. Data Sources

2.1. Traffic Sample Data (TSD). A TSD covering the month of December 2022 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 2022 to December 2022. **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 2022

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 2022 to December 2022 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: Summary of LHD by Month for Mongolian Airspace

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

4. Risk Assessment and Safety Oversight

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

| Parameter | Description | Value Bi-Dir | Value Uni-Dir | Unit | Based On |
|-------------------------|--|-------------------|---------------|------|--|
| T | Annual flight hours | 44,491 | 240 | Hour | Dec 2022 TSD |
| $E_z(\text{same})$ | Same-direction vertical occupancies | 0.0906/ 0.0032 | 0.0000 | - | |
| $E_z(\text{opposite})$ | Opposite-direction vertical occupancies | 0.0583 | 0.0588 | - | |
| λ_x | Average aircraft length | 0.0314 | 0.0343 | NM | |
| λ_y | Average aircraft wingspan | 0.0291 | 0.0326 | NM | |
| λ_z | Average aircraft height | 0.0087 | 0.0090 | NM | |
| λ_h | Diameter of the disk representing the shape of an aircraft in the horizontal plane | 0.0314 | 0.0343 | NM | |
| $P_z(0)$ | Probability of vertical overlap (with planned vertical separation equal to zero) | 0.538 | 0.538 | - | More conservative value used in previous assessments |
| $ \overline{\Delta V} $ | Average relative along-track speed between aircraft on same direction routes | 30.26 | 0.00 | Knot | Dec 2022 TSD NOTE: $ \overline{\Delta V} $ was calculated based on relative speed of proximate pair on each route type. For uni-dir route, there was no proximate pair. |
| $ \overline{V} $ | Average absolute aircraft ground speed | 480 | 480 | Knot | More conservative value used in previous assessments |

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

4.2. **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 5**. **The technical risk**, defined as probability of fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft. and to all causes, **meets the TLS** value of 2.5×10^{-9} FAPFH. **The total risk** is 0.33×10^{-9} FAPFH, which also **meets the specified TLS** value of 5.0×10^{-9} FAPFH.

| Mongolian Airspace – estimated annual flying hours = 44,732hours (note: estimated hours based on Dec 2022 traffic sample data) | | | |
|--|---|----------------------|---------------------|
| Source of Risk | Risk Estimation | TLS | Remarks |
| <i>RASMAG 27 Total Risk</i> | 0.81×10^{-9} | 5.0×10^{-9} | <i>Below TLS</i> |
| Technical Risk | 0.33×10^{-9} | 2.5×10^{-9} | Below Technical TLS |
| Operational Risk | 0.00×10^{-9} | - | - |
| Total Risk | 0.33×10^{-9} | 5.0×10^{-9} | Below TLS |

Table 5: Risk Estimates for Mongolian Airspace

5. Analysis of Operational Errors

In 2022, no LHD was reported within or at the boundary of the Mongolian Airspace. Hence, the analysis of operational errors cannot be conducted.