



ICAO

International Civil Aviation Organization
**Twenty-Sixth Meeting of the Regional Airspace Safety
Monitoring Advisory Group (RASMAG/26)**
Video Teleconference, 20 - 23 September 2021

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

MAAR VERTICAL SAFETY REPORT

(Presented by the Monitoring Agency for Asia Region)

SUMMARY

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

1. INTRODUCTION

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

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

2. DISCUSSION

Executive Summary: South Asia/Indian Ocean Airspace

2.1 **Table 1** summarizes South Asia/Indian Ocean (SA/IO) airspace RVSM technical, operational, and total risk in 2020. The total risk decreased from 36.78×10^{-9} FAPFH in 2019 to 15.67×10^{-9} FAPFH in 2020, which was a 57% decrease. The estimated annual flight hours also decreased by 66%.

South Asia/Indian Ocean (SA/IO) RVSM Airspace – estimated annual flying hours = 1,201,822 hours (note: estimated hours based on December 2020 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.48×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	15.19×10^{-9}	-	-
Total Risk	15.67×10^{-9}	5.0×10^{-9}	Above Overall TLS

Table 1: Risk Estimates for SA/IO Airspace.

2.2 **Figure 1** presents the trends of collision risk estimates from January 2020 to December 2020, using the appropriate cumulative 12-month data set of LHD reports. The operational and total risk in 2020 showed a downward trend from February to July and stayed steady for the second half of 2020 with a slight increase in October.

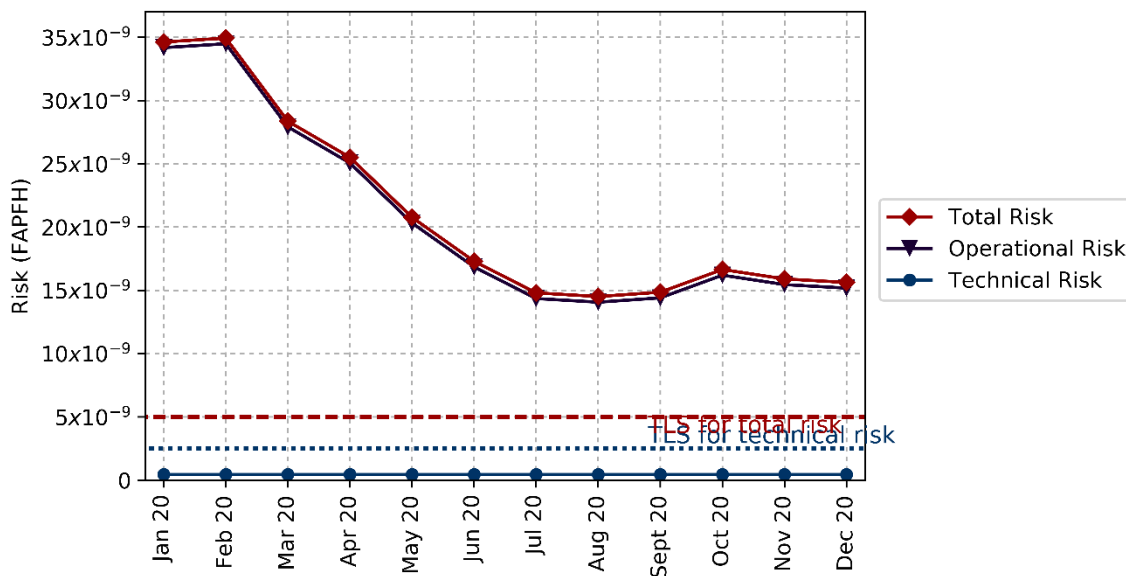


Figure 1: Trends of Risk Estimates for SA/IO Airspace.

2.3 **Table 2** presents a summary of the LHDs by categories within SA/IO airspace from January 2020 to December 2020. The majority of LHDs and durations are in Category E.

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	3	2	0	2	0.02
B	Flight crew climbing/descending without ATC Clearance	0	0	0	0	0
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	1	1	0	1	0.03
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	5	2	20	0	0.49
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a	138	45	597	0	14.57

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)
	result of human 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).	1	0	0	0	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	0	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	4	2	0	0	0.08
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		152	52	617	3	15.19

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

2.4 **Figure 2** depicts geographical locations of all reported LHDs in SA/IO airspace based on LHD reports from January to December 2020.

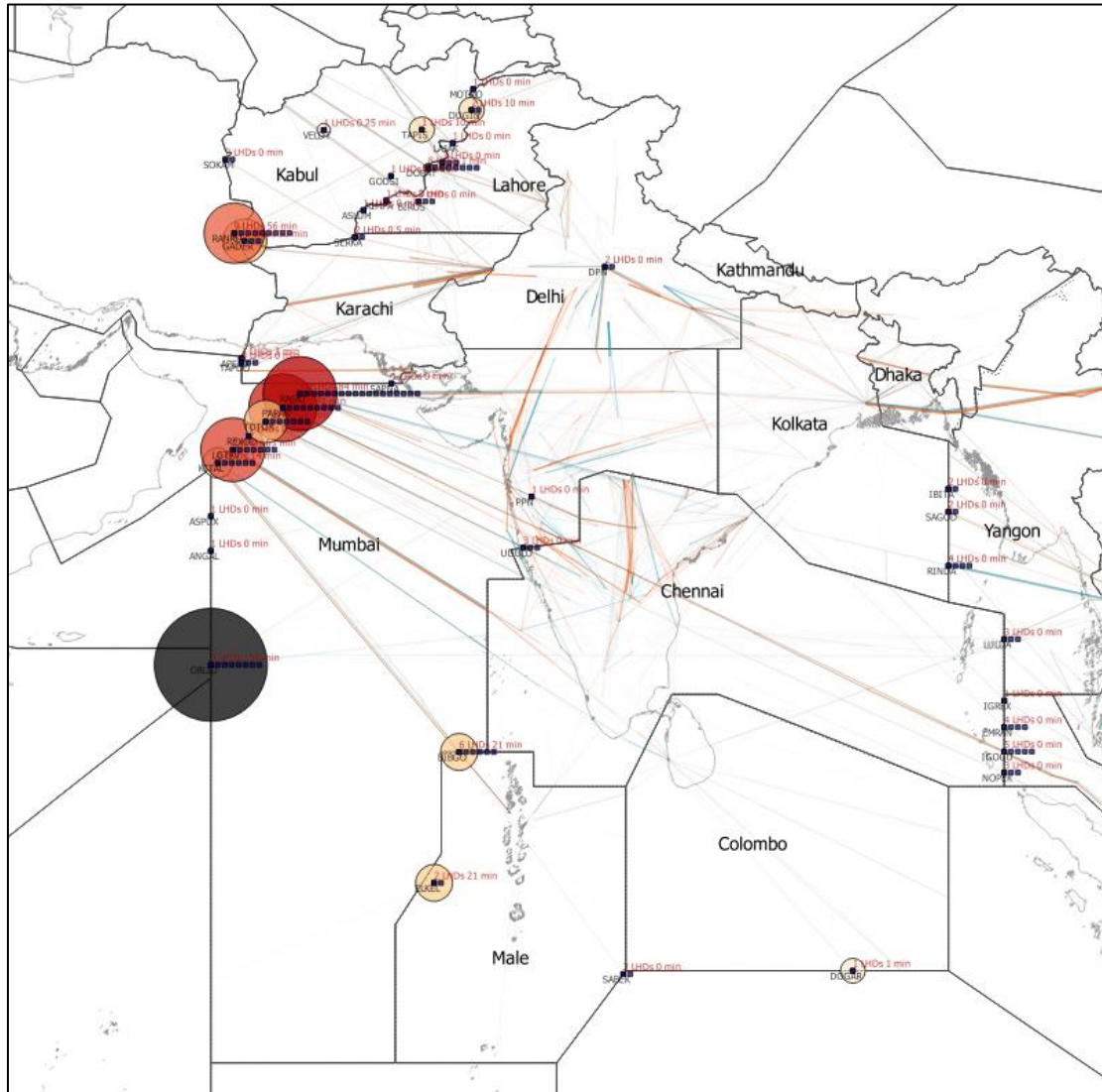


Figure 2: Geographical Location of All LHDs in SA/IO Airspace

2.5 **Figure 3** depicts only LHDs which are determined to be non-zero duration.

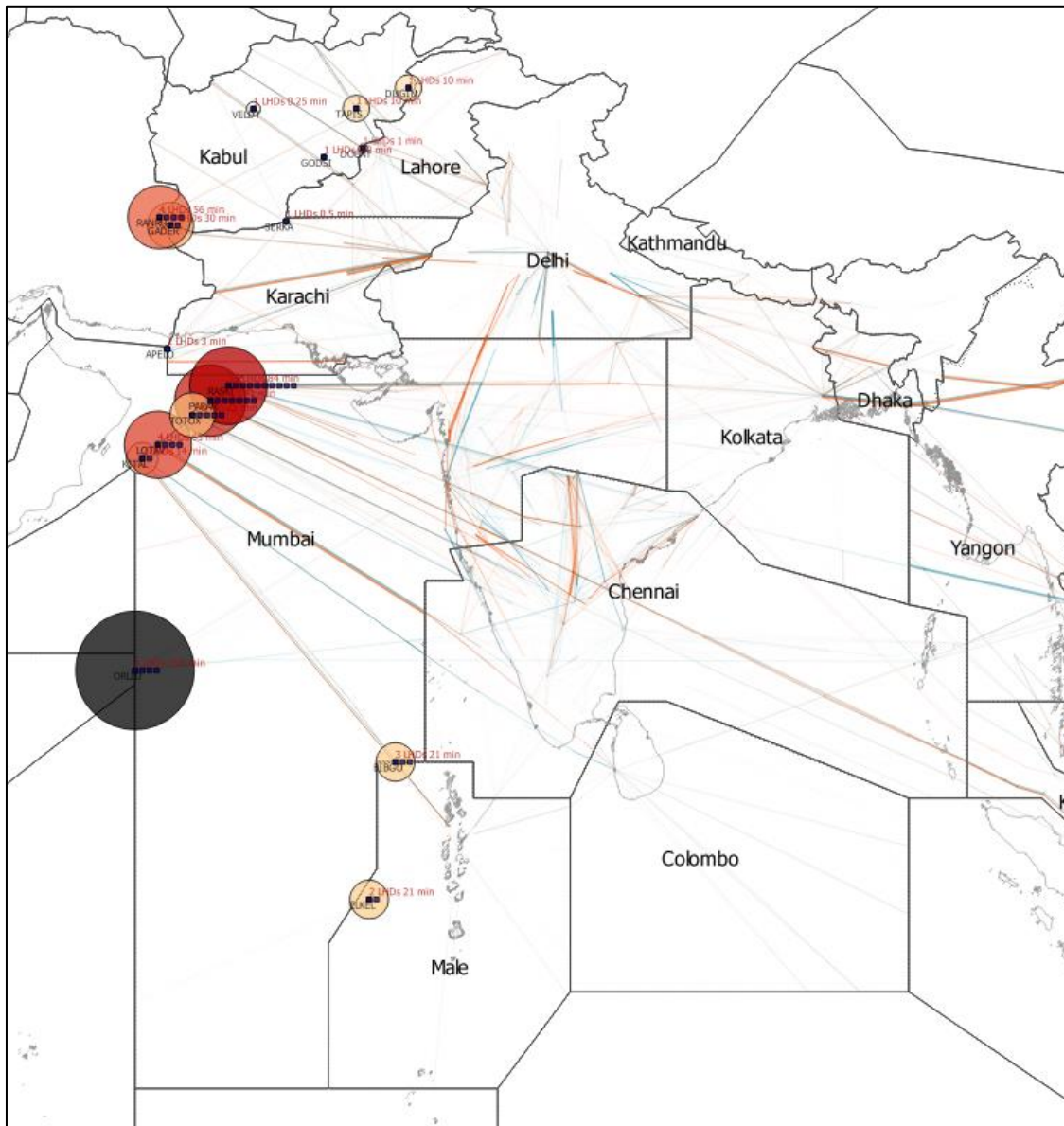


Figure 3: Geographical Locations of ‘Non-zero-duration’ LHDs in SA/IO Airspace

2.6 **LHD Hot Spot G (Sanaa/Muscat – Mumbai) and LHD Hot Spot F (Mogadishu – Mumbai)** at the western boundary of Mumbai FIR remain as LHD hot spots since 2015. **Table 3** shows that the number of non-zero-duration LHDs and the operational risk have been decreasing from 121 non-zero-duration LHDs and the operational risk of 46.35×10^{-9} FAPFH in 2017 to 32 non-zero-duration LHDs and the operational risk of 11.17×10^{-9} FAPFH in 2020. However, these interfaces still remained as LHD hot spots due to the 32 non-zero-duration LHDs accounted for 62% of all non-zero-duration LHDs of the SA/IO airspace and the resultant operational risk of 11.17×10^{-9} FAPFH accounted for 74% of the total operational risk of the SA/IO airspace.

Interface	No. of non-zero-duration LHDs				Operational risk (x 10 ⁻⁹ FAPFH)			
	2017	2018	2019	2020	2017	2018	2019	2020
Mumbai-Muscat	93	97	76	28	32.82	30.38	24.71	6.37
Mumbai-Sanaa	8	1	2	0	6.25	2.28	0.20	0.00
Mumbai-Mogadishu	20	9	3	4	7.28	5.13	0.74	4.80
Total	121	107	81	32	46.35	37.79	25.65	11.17

Table 3: Comparison of Operational Risk of the LHD Hot Spots at the Western Boundary of Mumbai FIR from 2017 to 2020.

2.7 In 2020, there were 4 LHDs whose duration exceeded 30 minutes in the SA/IO airspace. All 4 long duration LHDs occurred at these hot spots. 2 LHDs occurred at Mumbai-Muscat interface and the other 2 LHDs at Mumbai-Mogadishu interface accounting for 13% and 25% of the total operational risk in SA/IO airspace, respectively.

2.8 Similar to the picture of the SA/IO airspace, the majority of LHDs at the western boundary of Mumbai FIR was Category E with sub-category being “No or Late FL revision” and “Negative Transfer”. The poor communication services and lack of surveillance coverage at these interfaces worsened the situation by the long-duration LHDs before the incorrect presences of aircraft were resolved.

2.9 It is strongly recommended that an engineering solution such as AIDC (hard barrier) is implemented with Mumbai FIR to mitigate the risk. Mumbai ACC conducted AIDC trials with Muscat ACC and Mogadishu ACC in March 2021. Some minor systematic issues were found and remained to be resolved before the AIDC implementation could proceed to the next phase.

2.10 Airports Authority of India has implemented the Space Based ADS-B to enhance the surveillance capability particularly in the oceanic airspace. The Space Based ADS-B could enable the controller to identify an LHD occurrence beyond the Transfer of Control (TOC) point. This technology may potentially reduce the LHDs at these Hot Spots.

2.11 **LHD Hot Spot A1 (Kolkata/Dhaka - Yangon) and LHD Hot Spot A2 (Chennai - Kuala Lumpur)** were first identified as hot spots in 2015. As detailed in **Table 4**, the number of LHDs had been decreasing from 275 LHDs in 2018 to 24 LHDs in 2020. And all reported LHDs in 2020 had 0-min duration, resulting in the operational risk of 0 FAPFH.

Interface	No. of LHDs			Operational risk (FAPFH)		
	2018	2019	2020	2018	2019	2020
Kolkata-Yangon	168	59	8	0.60 x 10 ⁻⁹	0.31 x 10 ⁻⁹	0
Chennai-Yangon	14	16	3	0.06 x 10 ⁻⁹	0.49 x 10 ⁻⁹	0
Chennai-Kuala Lumpur	93	88	13	0.66 x 10 ⁻⁹	1.14 x 10 ⁻⁹	0
Total	275	163	24	1.32 x 10⁻⁹	1.94 x 10⁻⁹	0

Table 4: Operational Risk at the Interfaces between Kolkata/Chennai FIR and Yangon FIR, and between Chennai FIR and Kuala Lumpur FIR in 2018, 2019 and 2020

2.12 **Figure 4** provides the geographical visualization of non-zero-duration LHDs and their associated risk grouped into the three interfaces in 2018, 2019 and 2020. Since all the reported LHD occurrences had 0-min duration, the visualization of 2020 did not show any LHD on the map.

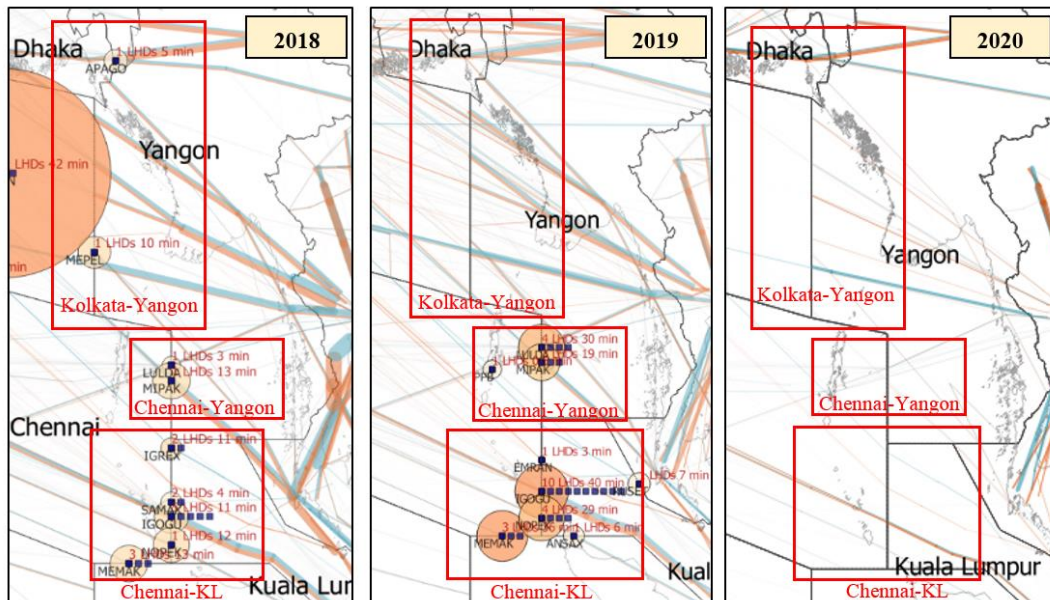


Figure 4: The Visualization of Non-zero-duration LHDs in 2018, 2019 and 2020 between Kolkata FIR, Chennai FIR, Yangon FIR and Kuala Lumpur FIR.

2.13 At the Kolkata-Yangon interface, the issue of LHDs over waypoint APAGO and CHILA was resolved by the implementation of a new procedure since June 2019 to handle the eastbound traffic between Dhaka FIR and Kolkata FIR (as well as coordination with Yangon FIR). Other LHD issues were mitigated by the enhancement of surveillance and communication capabilities. The implementation of ADS-B data sharing between Kolkata ACC and Yangon ACC allowed the controllers to detect and resolve any issue before an aircraft passing the transfer-of-control points. Kolkata ACC and Yangon ACC also agreed to improve their communication with AIDC technology. Their 2nd trail of AIDC implementation in the 1st quarter of 2020 was successful.

2.14 At the Chennai-Yangon interface, the ADS-B data sharing between Chennai FIR and Yangon FIR has not been implemented. The AIDC trial was commenced in January 2018 and encountered an issue from Yangon ACC side. Yangon ACC would contact Chennai ACC for further testing when ready.

2.15 At the Chennai-Kuala Lumpur interface, the ADS-B data sharing also has not been implemented. However, the AIDC has been implemented between the two ACCs with the Letter of Agreement effective from 1st June 2021.

2.16 The fact that the operational risk at these interfaces was reduced to 0 FAPFH in 2020 was because of all the above mentioned safety enhancement initiatives as well as the reduction in traffic volume.

2.17 The **LHD Hot Spot I (Karachi – Kabul)** was de-identified from being an LHD hot spot by RASMAG/25 in 2019 from the fact that the new route Z627 was established and the LHD issues at GADER also seemed to greatly improve. In 2020, Kabul ACC identified and reported more of their operational risk from LHD occurrences within their own airspace and at the boundaries with Lahore FIR and Karachi FIR, as depicted in **Figure 5**. The number of LHDs and operational risk at GADER and RANRU increased in 2020, which most of them were mainly Category E. The poor communication and surveillance coverage did not allow Kabul ACC to detect and resolve the issues before an aircraft passing the transfer-of-control points. This issue would be closely monitored together with the dynamic situation over the Kabul airspace in 2021.

Executive Summary: Southeast Asian Airspace

2.18 **Table 5** summarizes Southeast Asia (SEA) airspace RVSM technical, operational, and total risk in 2020. The total risk decreased from 3.59×10^{-9} FAPFH in 2019 to 1.82×10^{-9} FAPFH in 2020, which was a 48% decrease.

Southeast Asia (SEA) Airspace RVSM Airspace – estimated annual flying hours = 1,054,468 hours (note: estimated hours based on December 2020 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.40×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	1.42×10^{-9}	-	-
Total Risk	1.82×10^{-9}	5.0×10^{-9}	Below Technical TLS

Table 5: Risk Estimates for SEA Airspace

2.19 **Figure 6** presents the trends of collision risk estimates from January 2020 to December 2020, using the appropriate cumulative 12-month data set of LHD reports. The operational and total risk were steadily stable from January to November and then dropped in December.

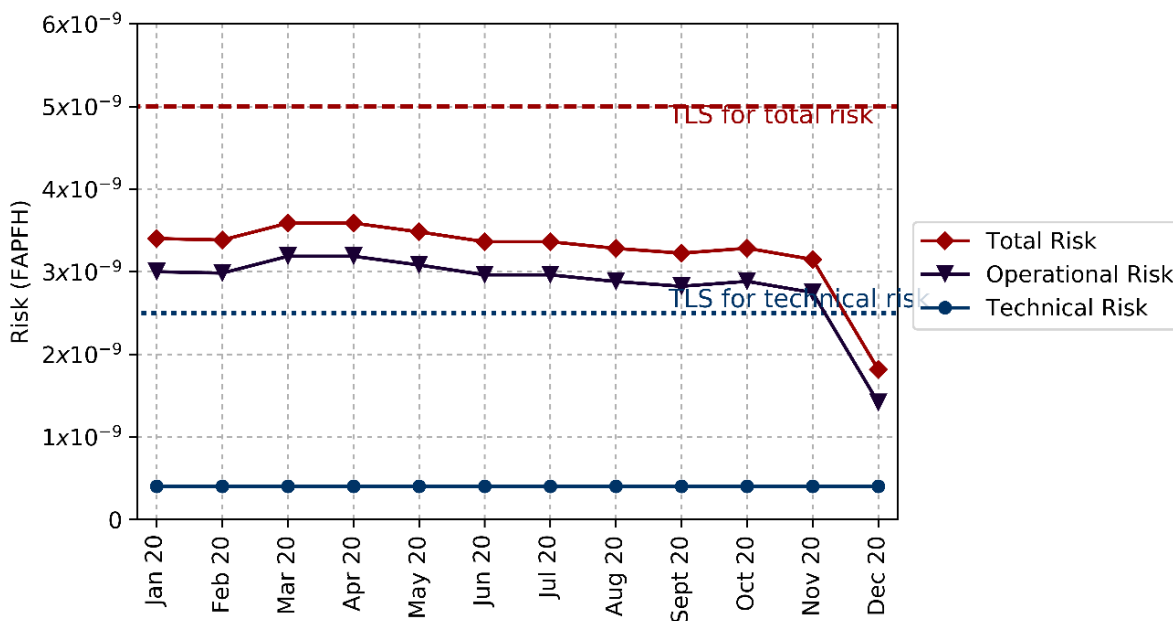


Figure 6: Trends of Risk Estimates for SEA Airspace.

2.20 **Table 6** presents a summary of the LHDs by categories within SEA airspace from January 2020 to December 2020. Category E LHDs remained the most frequent occurrences in the SEA airspace. Out of all 39 LHDs, 27 were classified as Category E. And 6 of these were Category E non-zero-duration LHDs, contributed to most of the operational risk at 1.35×10^{-9} FAPFH.

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	1	0	1	0.01
B	Flight crew climbing/descending without ATC Clearance	0	0	0	0	0
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	1	0	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	0	0	0	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	27	6	59	0	1.35
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).	7	1	2	0	0.05
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	1	1	0	0	0.01
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	2	0	0	0	0
K	TCAS resolution advisory, flight crew incorrectly 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 ($\times 10^{-9}$ FAPFH)
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		39	9	61	1	1.42

Table 6: Summary of LHD by Category for SEA Airspace.

2.21 **Figure 7** depicts geographical locations of all reported LHDs in SEA airspace based on LHD reports from January to December 2020.

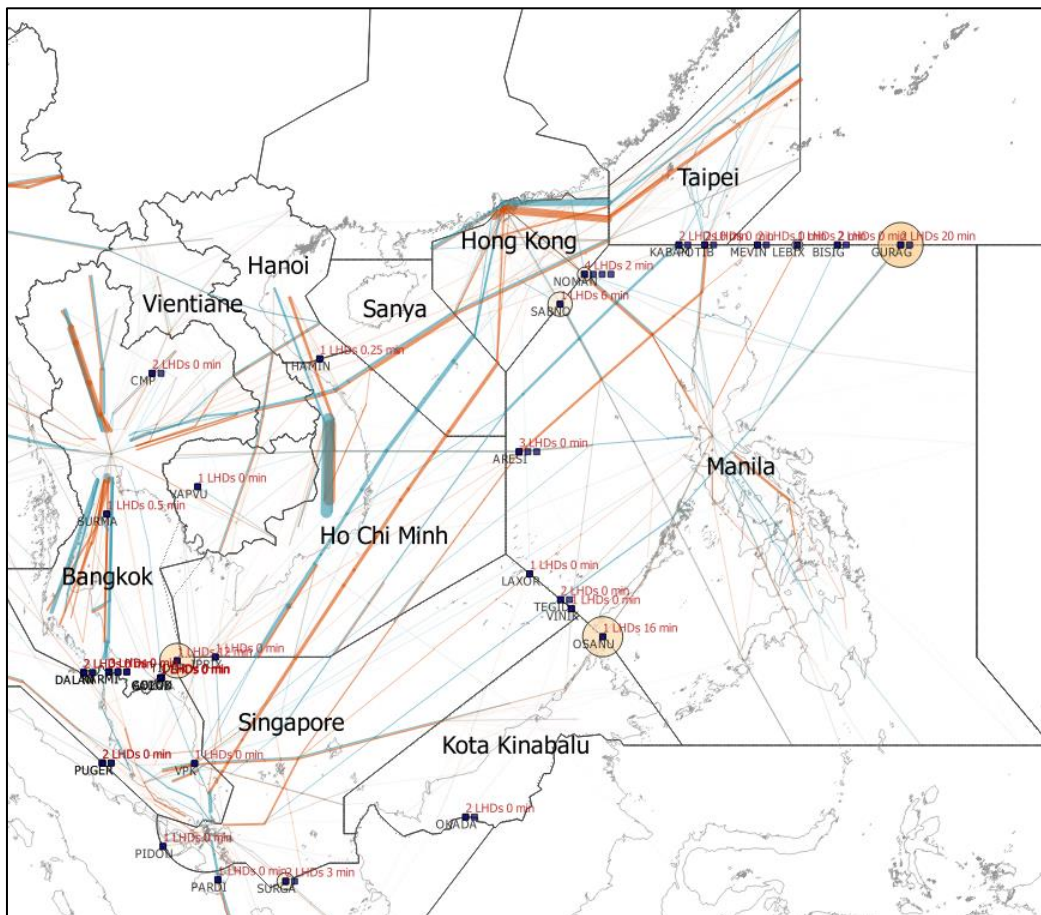


Figure 7: Geographical Locations of All LHDs in SEA Airspace

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

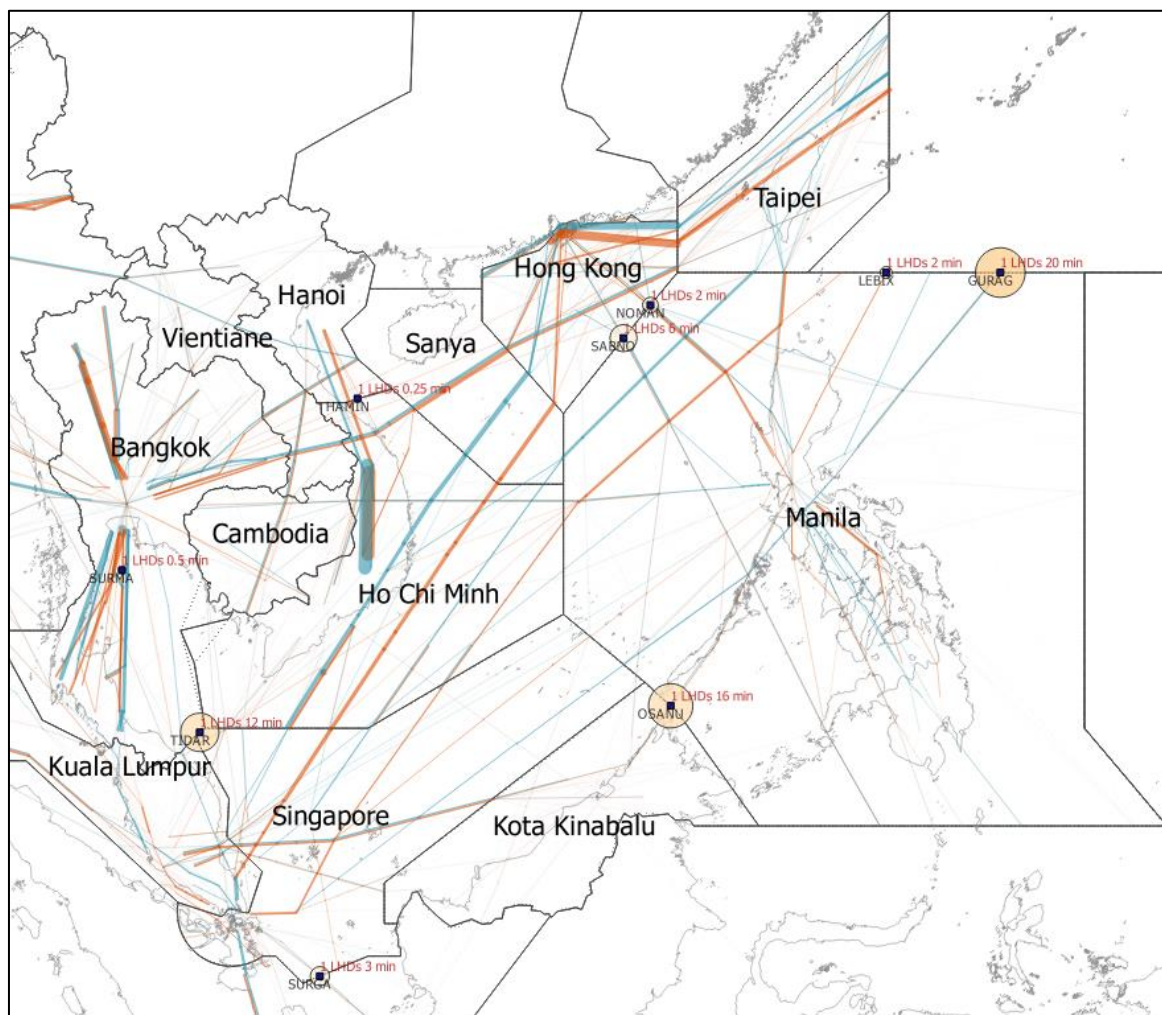


Figure 8: Geographical Locations of ‘Non-zero-duration’ LHDs in SEA Airspace

2.23 In 2020, there were 3 long duration LHDs (of more than 10 minutes) driving risk of the SEA airspace.

2.24 Even though the situation of **LHD Hot Spot D (Manila and all adjacent FIRs)** seemed to be improving, the majority of the reported LHDs and the operational risk of the SEA airspace still remained along the boundaries of Manila FIR. In other words, a total of 24 LHDs at Manila FIR boundaries accounted for 62% of the number of LHDs in the SEA airspace. The resultant operational risk of 1.05×10^{-9} FAPFH accounted for 74% of the operational risk of the SEA airspace.

2.25 There were 2 out of 3 long duration LHDs occurred at Manila FIR boundaries. One occurred at the Manila-Fukuoka interface from “no transfer information”. Another one occurred at the Manila-Kota Kinabalu interface from “no or late estimate time revision”.

2.26 **Figure 9** demonstrates the trend of LHDs being reported along Manila FIR boundaries together with the timeline of major safety improvement implementation by Manila ACC and the adjacent units. Since the transition to the new ATM center in 2018, Manila ACC aimed to continually improve their communication and surveillance capabilities with ADS-C/CPDLC, AIDC and ADS-B technology.

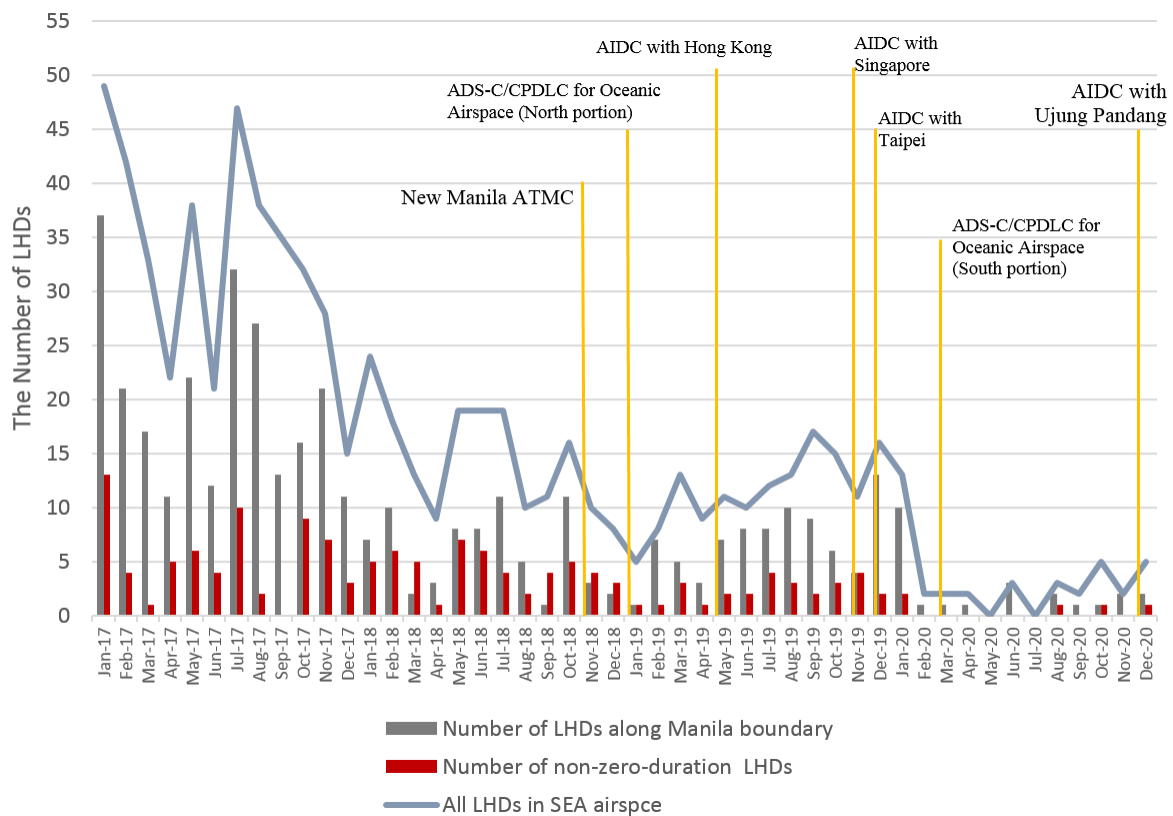


Figure 9: Number of LHDs and non-zero-duration LHDs along Manila Boundary Compared to all LHDs in SEA from 2017 to 2020

2.27 In 2019, the Category F LHD was an emerging issue at Manila boundaries where AIDC was implemented. There were a total of 9 Category F LHDs, and 7 out of 9 LHDs were due to AIDC failures. In 2020, the number of Category F LHDs slightly decreased from 9 to 6 LHDs. Those 6 LHDs were caused by the AIDC system failures and the unsuccessful transfer via AIDC. This issue should be followed up with relevant units and continuously monitored.

Executive Summary: Mongolian Airspace

2.28 **Table 7** summarizes Mongolian airspace RVSM technical, operational, and total risk.

Mongolian RVSM Airspace – estimated annual flying hours = 101,705 hours (note: estimated hours based on December 2020 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.87×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	0.87×10^{-9}	5.0×10^{-9}	Below Overall TLS

Table 7: Risk Estimates for Mongolian Airspace.

2.29 In 2020, no LHD was reported within or at the boundary of the Mongolian airspace.

APANPIRG List of Deficiencies

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

2.31 MAAR received 2020 TSD from all States in timely manner. Furthermore, all States provided good cooperation in revising TSD to the new format and revising their data if any error was found.

2.32 MAAR introduced the new LHD submission system starting in October 2019. Almost all States registered and submitted their LHD reports through the new system in 2020 and 2021. Even though some States submitted their LHDs late, MAAR received LHDs from all States via the current system and also direct emails.

2.33 After RASMAG/25 in October 2020, Afghanistan has submitted all their LHD reports in 2020 and continued the submission up to present in a timely manner. **Table 8** summarizes MAAR’s proposal regarding the APANPIRG List of Deficiencies in the ATM/AIS/SAR fields, under “Non-Provision of Safety Related Data by States”.

State	Proposed Action	Reason for Inclusion/Removal
Afghanistan	Removal	Continuously submitted 2020 and 2021 LHDs.

Table 8: Proposal regarding the APANPIRG List of Deficiencies in the ATM/AIS/SAR fields, under “Non-Provision of Safety Related Data by States”.

Reporting

2.34 The outbreak of COVID-19 pandemic led to the reduction of flights all around the world. As the consequence, the number of LHDs in 2020 also decreased, presumably from the reduced traffic volume. Despite the lockdown and travel restrictions at some locations might make it difficult to access the necessary data, most States regularly submit the LHD reports, analyze the occurrences, and provide good cooperation with MAAR.

2.35 As previously reported during RASMAG/24 and RASMAG/25, MAAR continues to see improvement signs in reporting cultures since 2018. The following are the indicators of improvement in reporting culture.

LHDs within FIRs

2.35.1 Normally, ATCOs report LHDs only when they are affected by mistakes made by ATCOs in their neighboring FIRs. In 2020, the number of reports for LHDs within FIRs increased particularly in Kabul FIR.

Reporting Own Mistakes

2.35.2 In 2020, 8% of all LHDs were reported for ones' own mistake. For example, FIR A submitted a report which showed that FIR A transferred an aircraft with wrong flight level. Singapore, Manila, Hong Kong, Kota Kinabalu, Kuala Lumpur, Afghanistan and Ho Chi Minh FIRs evidently submitted this sort of LHDs.

NIL Reports

2.35.3 In certain months with no LHDs, States are required to confirm no LHD occurrences by submitting "NIL report" to MAAR. The FIRs that always notify MAAR of the 'NIL' report in those months are Phnom Penh, Hong Kong, Vientiane, Taipei, Kuala Lumpur, Kota Kinabalu, Hanoi, Ho Chi Minh, Colombo, Dhaka, Karachi, Kathmandu and Ulaanbaatar. Nonetheless, the low number of LHDs reports and the 'NIL' reports can arguably be an indicator of under-reporting rather than the improvement in reporting culture.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information contained in this paper;
- b) consider the proposal in 2.29 **Table 8** to remove Afghanistan from the APANPIRG List of Deficiencies in the ATM/AIS/SAR fields; and
- c) discuss any relevant matters as appropriate.

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MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2020 to December 2020

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE SOUTH ASIA/INDIAN OCEAN (SA/IO) AIRSPACE
Assessment Period: January 2020 to December 2020**

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

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **South Asia/Indian Ocean (SA/IO)** airspace. The review is conducted based on one-month traffic sample data (TSD) collected in **December 2020** and monthly Large Height Deviation (LHD) reports between **January 2020** and **December 2020** submitted by concerning States in the SA/IO region.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** The TSD covering the month of December 2020 of aircraft operating in the SA/IO airspace is used as required by ICAO regional agreement.

2.2. To investigate if the TSD of December 2020 remains appropriate for the risk estimation, a reference to the ICAO's COVID-19 Air Traffic Dashboards (<https://www.icao.int/sustainability/Pages/COVID-19-Air-Traffic-Dashboard.aspx>) is made. The Operational Impact Dashboard estimates the number of flights using the ADS-B FlightAware data and the ICAO Enterprise Data Management (EDM). As shown in **Figure 1**, the number international flights in the Asia Pacific Region dropped drastically from January to April 2020 and gradually increased since May 2020.

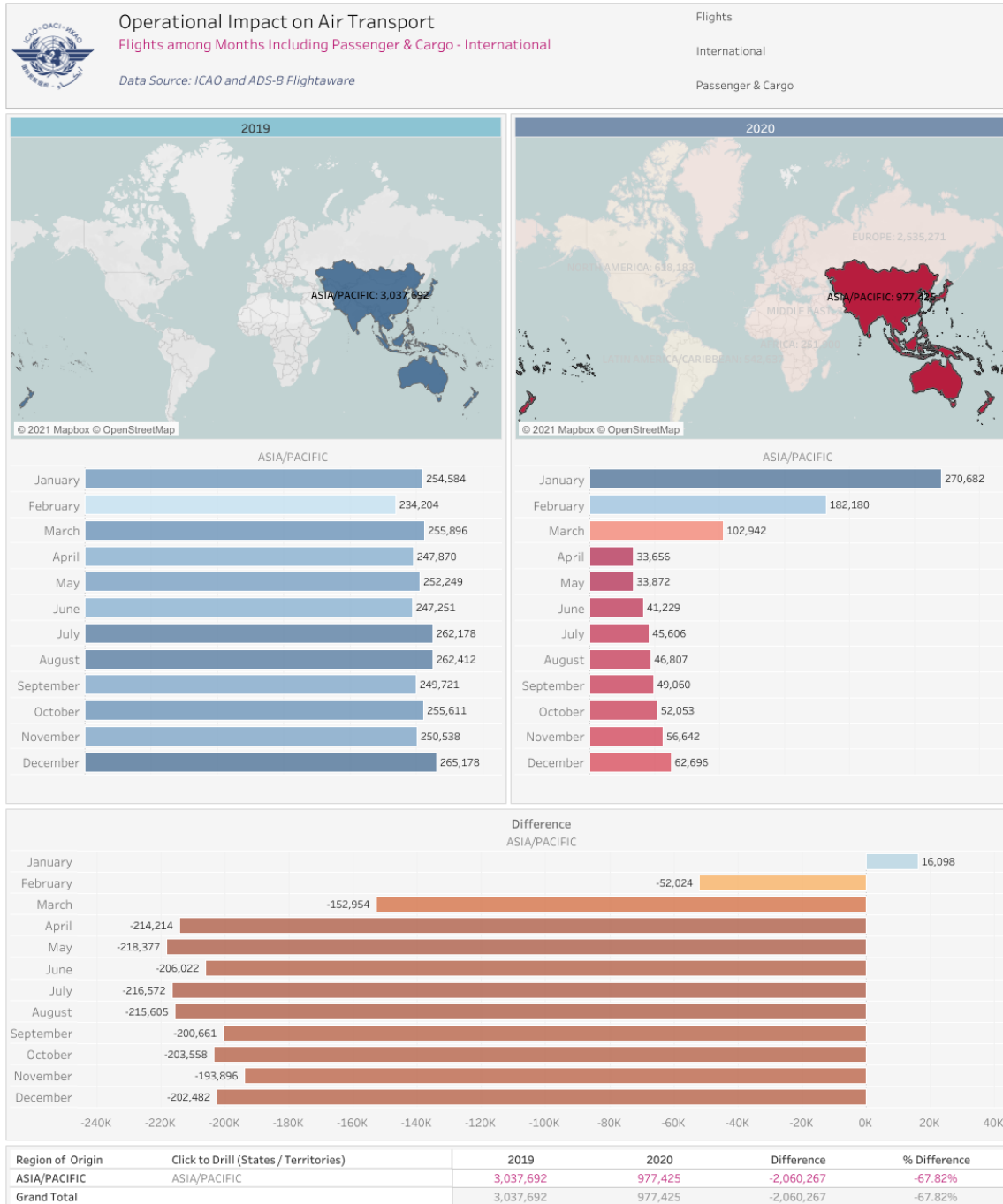


Figure 1: The ICAO’s Operational Impact Dashboard showing the comparison of international flights between 2019 and 2020 of the Asia Pacific Region

2.3. For this investigation, the number of international flights from the ICAO’s dashboard is used for comparison against the annual flight hour estimate from the TSD due to the fact that international flights are expected to spend time maintaining RVSM flight levels in an airspace more than domestic flights which some may not even enter the RVSM airspace. Hence, the change of these two measures between 2019 and 2020 should be resembling.

2.4. **Table 1** shows that the estimated annual RVSM flight hours and flights of the SA/IO TSD in 2020 decreased by 66% and 54% from 2019, respectively, due to the outbreak of COVID-19 pandemic. The RVSM flight hours and flight estimates for Dhaka FIR, however, increased by 20% and 21%, respectively, in 2020 from the TSD.

2.5. The data from ICAO’s dashboard shows that the 2019-to-2020 change in international flight of the SA/IO airspace is a 68% decrease while the change in RVSM annual flight hours estimated from the December 2020 TSD is a 66% decrease. These two measures show the same characteristic at the approximate magnitude. Therefore, it can be inferred that the December 2020 TSD remains a good representative data set for risk estimation in 2020.

FIR	2019-to-2020 Changes in Flight Estimates from TSD		2019-to-2020 Changes in Flight Estimates from the ICAO's Dashboard	
	RVSM Flight Hours	RVSM Flights	All Flights	International Flights
Dhaka	20%	21%	-29%	-53%
Colombo	-27%	-62%	-69%	-69%
Kathmandu	-31%	-74%	-58%	-69%
Male	-37%	-29%	-65%	-61%
Kabul	-56%	-58%	-45%	-43%
Bangkok	-62%	-62%	-53%	-74%
Karachi and Lahore	-63%	-48%	-64%	-47%
Yangon	-66%	-65%	-49%	-68%
Chennai, Delhi, Kolkata and Mumbai	-68%	-47%	-50%	-61%
Kuala Lumpur*	-80%	-81%	-64%	-73%
SA/IO Airspace	-66%	-54%	-53%	-68%

* The ICAO’s dashboard can only show the flight number by State. Consequently, the flight estimates from the ICAO’s dashboard includes both Kuala Lumpur and Kota Kinabalu FIR.

Table 1: The comparison of 2019-to-2020 changes in flight of SA/IO airspace between estimates from the TSD and the ICAO’s dashboard.

2.6. **Large Height Deviation (LHD).** The accumulative 12-month data set of LHD reports covers January 2020 to December 2020. **Table 2** indicates those FIRs which submitted LHD reports including NIL reports. **Appendix A** provides details of LHD reports, including full description of some uncommon LHDs and LHDs with large duration.

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

Table 2: Summary of LHD Reports Submitted by FIRs in 2020

3. Summary of LHD Occurrences

3.1. **Table 3** and **Figure 2** 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 2020 to December 2020. In this report, the number of LHDs includes the LHDs that have zero duration, unless indicated otherwise.

Month (2020)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk ($\times 10^{-9}$ FAPFH)
January	25	8	126	0	3.16
February	34	9	112	0	2.69
March	7	2	13	0	0.32
April	3	2	16	0	0.39
May	3	2	14	0	0.34
June	4	3	104	0	2.55
July	1	1	7	0	0.17
August	9	5	27	2	0.71
September	8	3	37	0	0.91
October	18	10	110	1	2.70
November	18	3	25	0	0.61
December	22	4	26	0	0.64
Total	152	52	617	3	15.19

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

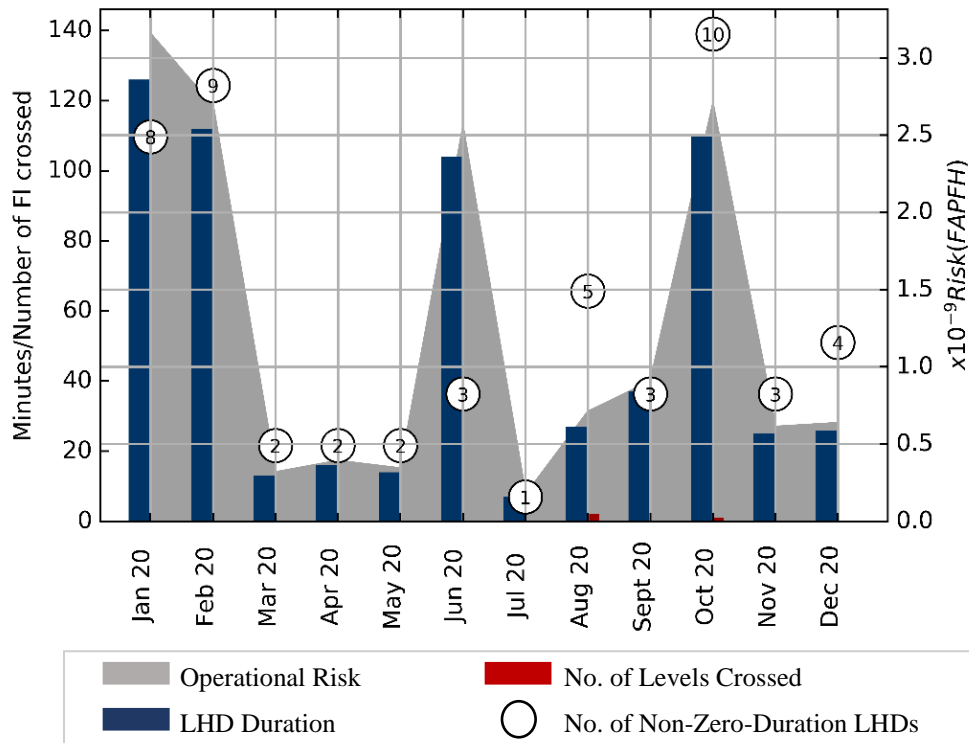


Figure 2: Summary of LHD Occurrences by Month for SA/IO Airspace

3.2. Compared to 2019, the number of LHD reports decreased from 434 to 152. Out of 152 LHDs reported this year, 52 LHDs were non-zero-duration LHDs, which resulted in the total deviation of 617 minutes and 3 flight levels crossed. The operational risk decreased from 35.99×10^{-9} FAPFH in 2019 to 15.19×10^{-9} FAPFH in 2020.

3.3. **Figure 3** and **Table 4** summarize the number of LHDs, the associated LHD duration (in minutes), and the number of incorrect flight levels crossed, by LHD category from January 2020 to December 2020.

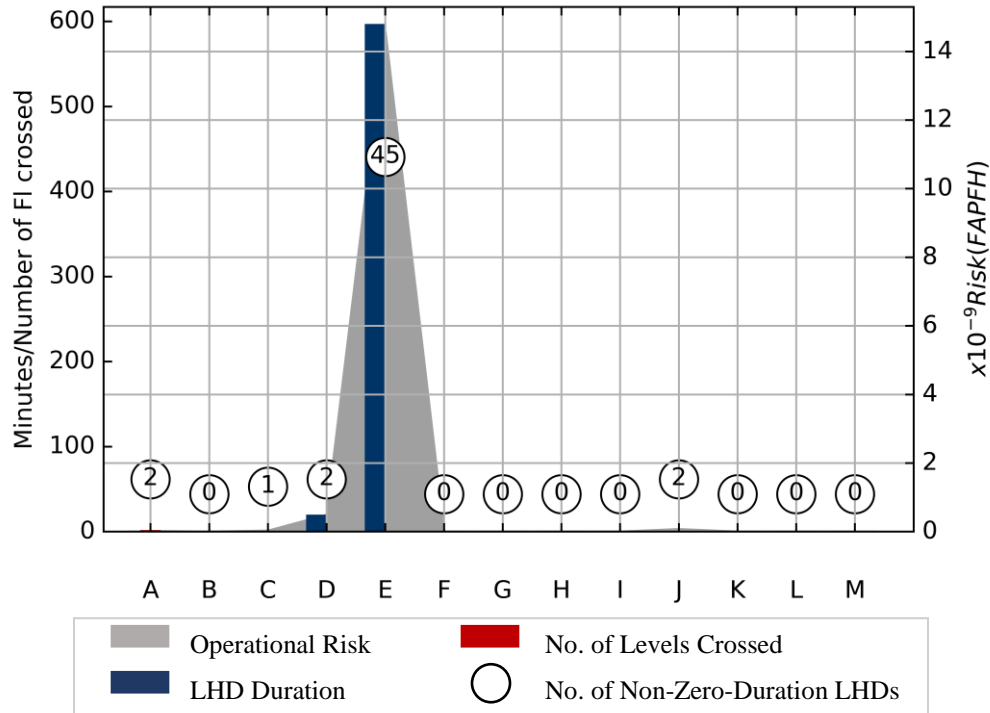


Figure 3: Summary of LHD by LHD Category for SA/IO Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10 ⁻⁹ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	3	2	0	2	0.02
B	Flight crew climbing/descending without ATC Clearance	0	0	0	0	0
C	Incorrect flight level provided due to incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance in FMS, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.).	1	1	0	1	0.03

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)
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	5	2	20	0	0.49
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).	138	45	597	0	14.57
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues (e.g. late or non-existent coordination of flight level).	1	0	0	0	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	0	0	0	0	0
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	4	2	0	0	0.08
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		152	52	617	3	15.19

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

3.4. In 2020, the majority of LHDs and durations in this region were in Category E. The Category E LHDs can be further categorized into sub-categories. **Figure 4** shows the contribution of each sub-category in term of number of LHDs and **Figure 5** shows the contribution in term of risk.

3.5. Within Category-E, “No or late flight level revision” sub-category was the most frequent sub-category at 62%, followed by “No transfer information” sub-category at 31% of the total number of Category E LHDs.

3.6. In term of contribution to the operational risk, “No transfer information” sub-category contributed to more risk than “No or late flight level revision” sub-category. “No transfer information” sub-category contributed to 60% of the total operational risk and “No or late flight level revision” sub-category contributed to 40% of the total operational risk.

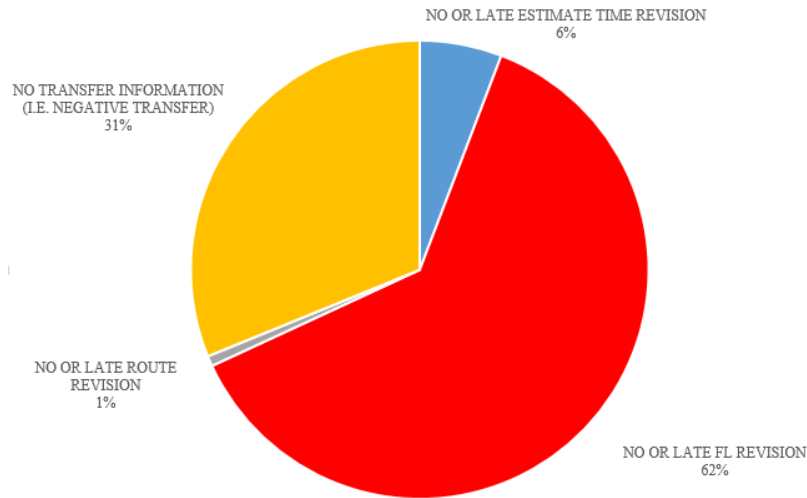


Figure 4: Sub-categories of Category-E LHDs for SA/IO Airspace
(Number of LHDs)

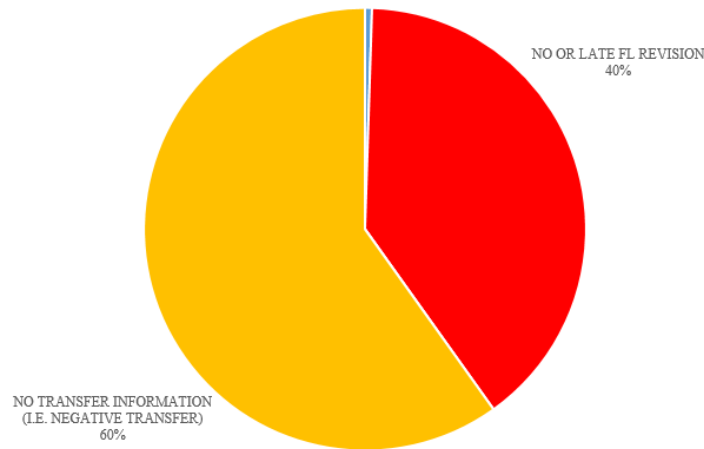


Figure 5: Sub-categories of Category-E LHDs for SA/IO Airspace
(Risk)

4. Risk Assessment and Safety Oversight

4.1. **Collision Risk Model (CRM) Parameters.** The value and the source of the parameters in the CRM used to estimate risk in the RVSM airspace are summarized in **Table 5**.

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	944,491	257,331	Hour	Dec 2020 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.2434 / 0.0228	0.0397	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.0954	0.0174	-	
λ_x	Average aircraft length	0.0281	0.0227	NM	
λ_y	Average aircraft wingspan	0.0254	0.0206	NM	
λ_z	Average aircraft height	0.0079	0.0068	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0281	0.0227	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	30.44	41.50	Knot	Dec 2020 TSD
$ \overline{V} $	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 5: 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 6**. **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 15.67×10^{-9} FAPFH. Therefore, **the total risk exceeds the specified TLS** value for these components of 5.0×10^{-9} FAPFH.

South Asia/Indian Ocean (SA/IO) RVSM Airspace – estimated annual flying hours = 1,201,822 hours (note: estimated hours based on December 2020 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.48×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	15.19×10^{-9}	-	-
Total Risk	15.67×10^{-9}	5.0×10^{-9}	Above Overall TLS

Table 6: Risk Estimates for SA/IO Airspace

4.3. Even though the total risk decreased 57% from 36.78×10^{-9} FAPFH in 2019 to 15.67×10^{-9} FAPFH in 2020, the annual flight hours and flights also decreased by 66% and 54%, respectively.

4.4. **Figure 6** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports. The operational and total risk in 2020 showed a downward trend from February to July and stayed steady for the second half of 2020 with a slight increase in October.

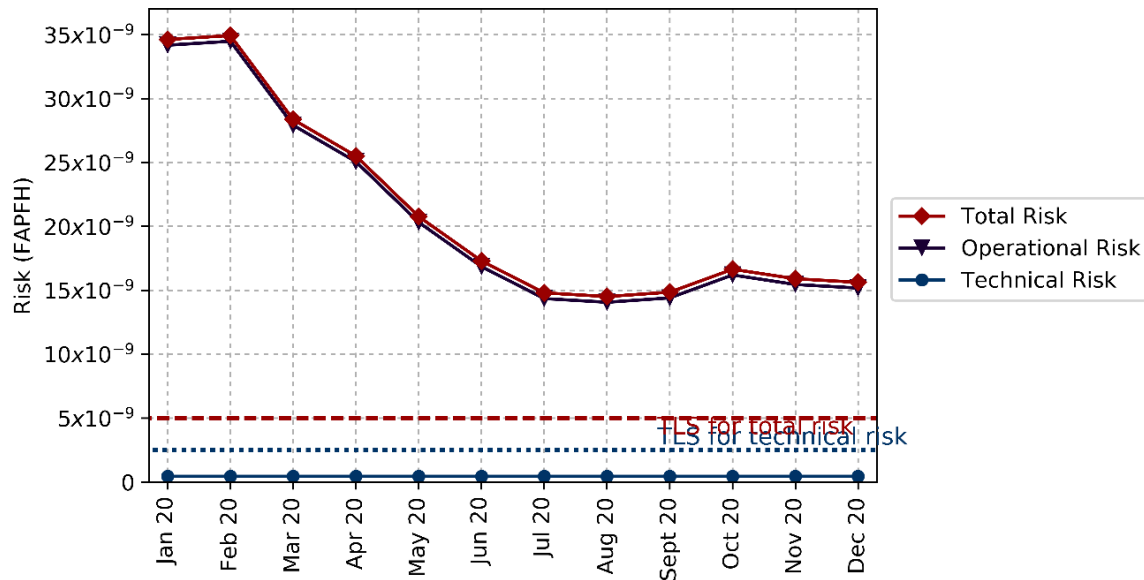


Figure 6: Trends of Risk Estimates for SA/IO Airspace

4.5. A monthly LHD risk value is determined to provide real-time information on actual risk without reliance on historical high-time errors resident within the 12 month data sample. Each block represents each LHD and the height of each block corresponds to risk. The data in **Figure 7** below shows that the operational risk in **8 out of 12 months are above** the average monthly risk. Only the risk in **March, April, May and July** are **below** the average monthly risk. The average monthly risk is calculated from the annual risk of 5.0×10^{-9} FAPFH (red line in Figure 6 below, which is approximately 0.4167×10^{-9} FAPFH).

4.6. The 2020 annual operational risk was influenced by a number of long duration LHDs. There were 4 LHDs whose duration exceeded 30 minutes: a 60-min LHD in January, a 35-min LHD in February, a 94-min LHD in June and a 47-min LHD in October. These 4 long duration LHDs contributed to the operational risk of 5.78×10^{-9} FAPFH which was 38% of the total operational risk of the SA/IO airspace. Further analysis would be presented in Section 5.

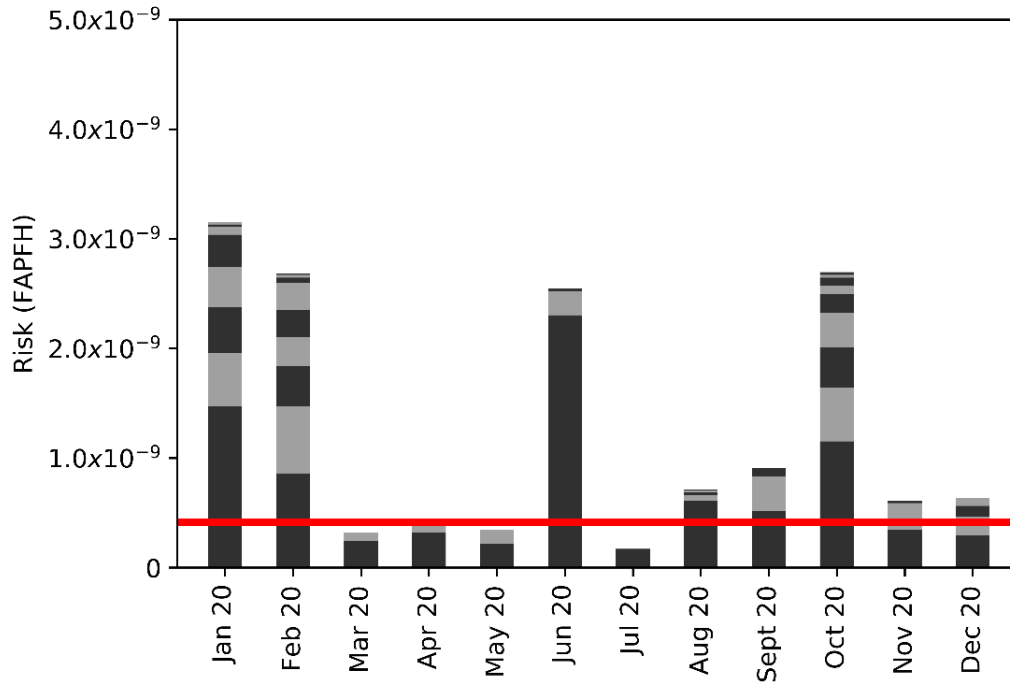


Figure 7: Monthly LHD Risk Estimates for SA/IO Airspace.
Red line is the average monthly value for an annual risk of 5.0×10^{-9} FAPFH. Risk is measured in Fatal Accidents per Flight Hour (FAPFH).

5. Analysis of Operational Errors

5.1 **Figure 8** depicts geographical locations of all reported LHDs in SA/IO airspace based on LHD reports from January to December 2020. **Figure 9** 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.

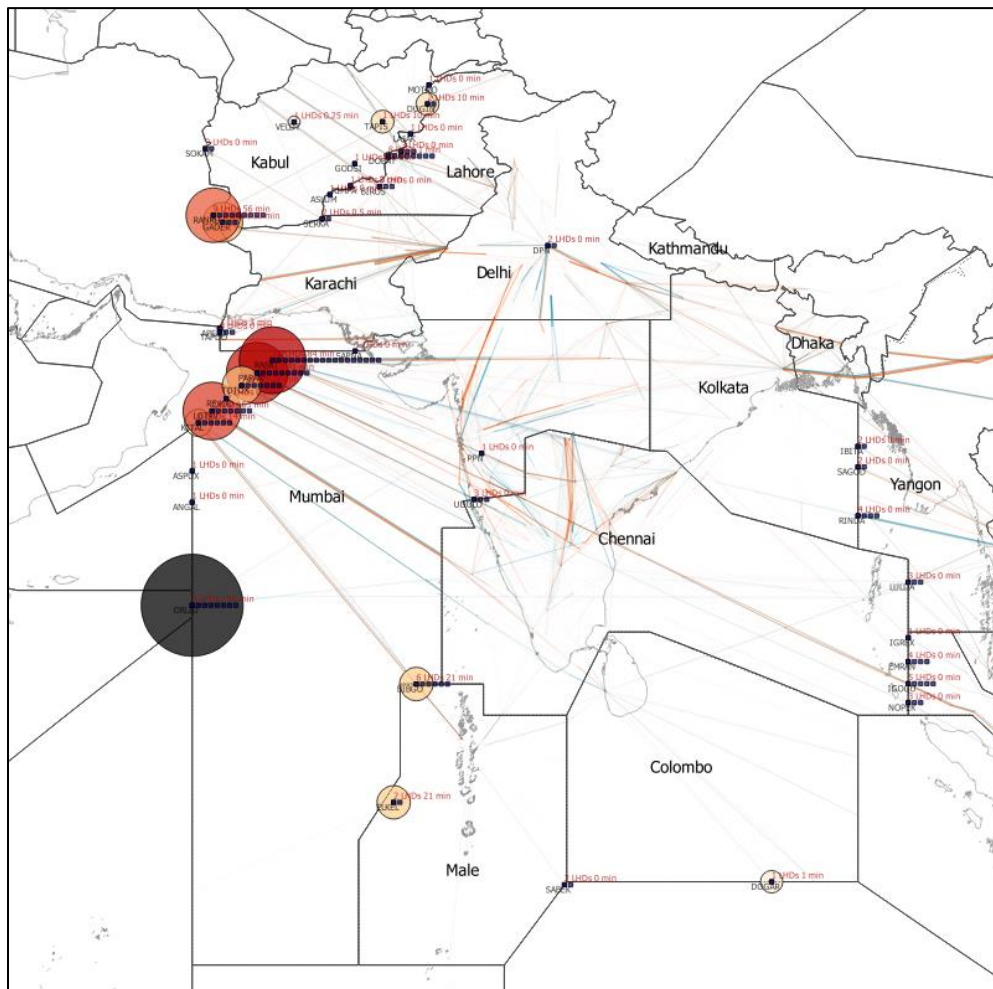


Figure 8: Geographical Locations of All LHD Reports in SA/IO Airspace

5.2 **Figure 9** depicts only LHDs which are determined to be non-zero duration.

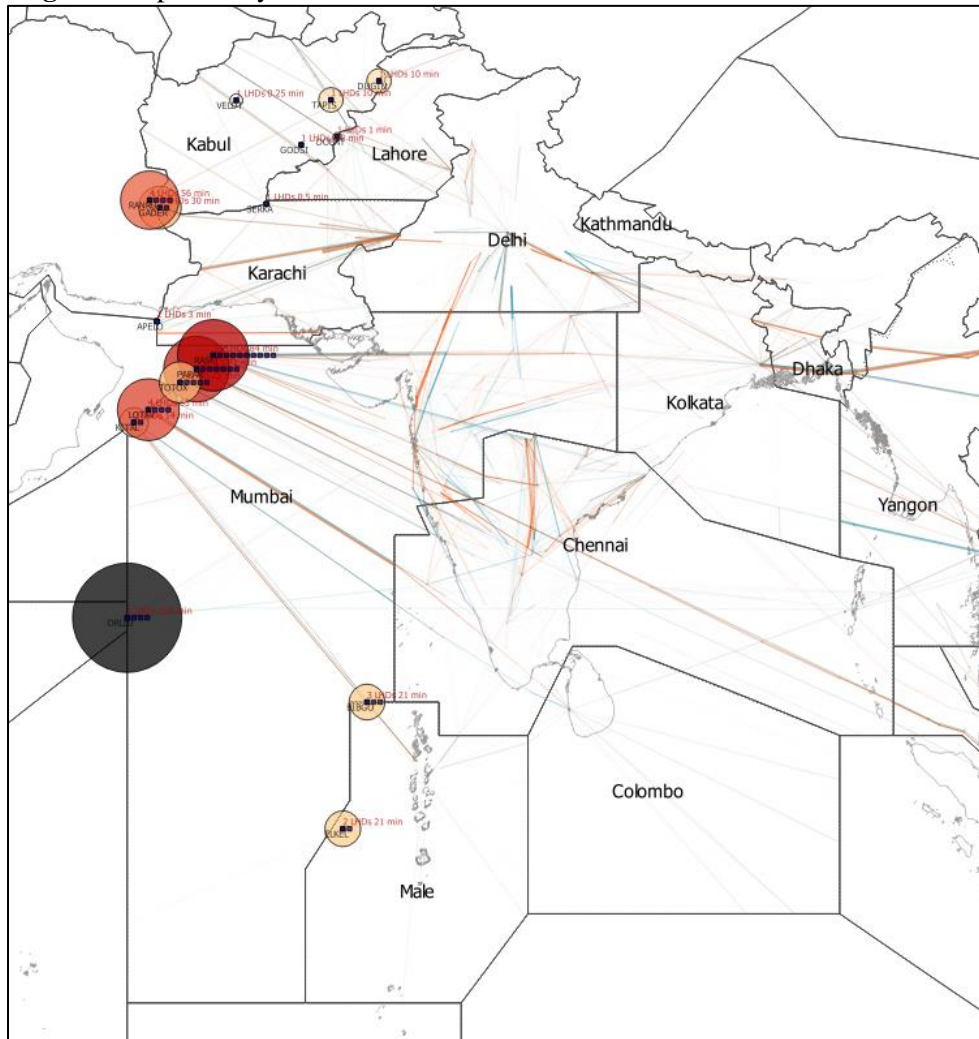


Figure 9: Geographical Locations of ‘Non-zero-duration’ LHDs in SA/IO Airspace

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

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

5.4 **Table 7** summaries the non-zero-duration LHDs and operational risk at the western boundary of Mumbai FIR from 2017 to 2020. When compared to the previous years, the number of non-zero-duration LHDs and the operational risk had been decreasing from 121 non-zero-duration LHDs and the operational risk of 46.35×10^{-9} FAPFH in 2017 to 32 non-zero-duration LHDs and the operational risk of 11.17×10^{-9} FAPFH in 2020. However, these interfaces still remained as LHD hot spots due to the 32 non-zero-duration LHDs accounted for 62% of all non-zero-duration LHDs of the SA/IO airspace and the resultant operational risk of 11.17×10^{-9} FAPFH accounted for 74% of the total operational risk of the SA/IO airspace.

Interface	No. of non-zero-duration LHDs				Operational risk (x 10 ⁻⁹ FAPFH)			
	2017	2018	2019	2020	2017	2018	2019	2020
Mumbai-Muscat	93	97	76	28	32.82	30.38	24.71	6.37
Mumbai-Sanaa	8	1	2	0	6.25	2.28	0.20	0.00
Mumbai-Mogadishu	20	9	3	4	7.28	5.13	0.74	4.80
Total	121	107	81	32	46.35	37.79	25.65	11.17

Table 7: Comparison of Operational Risk of the LHD Hot Spots at the Western Boundary of Mumbai FIR from 2017 to 2020.

5.5 At Mumbai-Muscat interface, the number of LHDs and the operational risk had been decreasing since 2019. In comparison with 2019, the number of LHDs decreased by 63% from 76 LHDs to 28 LHDs and the operational risk decreased by 74% from 24.71 x 10⁻⁹ FAPFH in 2019 to 6.37 x 10⁻⁹ FAPFH in 2020. However, the operational risk of 6.37 x 10⁻⁹ FAPFH at this interface accounted for 42% of the operational risk in the SA/IO airspace. Out of the 4 long duration LHDs, 2 occurred at this interface with the operational risk of 2.01 x 10⁻⁹ FAPFH, accounting for 13% of the operational risk in SA/IO airspace.

5.6 At the Mumbai-Sanaa interface, all the reported LHDs had 0-min duration and, hence, the operational risk was estimated as 0 FAPFH.

5.7 At Mumbai-Mogadishu interface, the number of LHDs only increased from 3 LHDs in 2019 to 4 LHDs in 2020 but the operational risk significantly increased about 6.5 times from 0.74 x 10⁻⁹ FAPFH in 2019 to 4.8 x 10⁻⁹ FAPFH in 2020. This was mainly caused by the other 2 long duration LHDs with the operational risk of 3.77 x 10⁻⁹ FAPFH, accounting for 25% of the operational risk in SA/IO airspace.

5.8 Similar to the picture of the SA/IO airspace, the majority of LHDs at the western boundary of Mumbai FIR was Category E with sub-categories being “No or Late FL revision” and “Negative Transfer”. The poor communication services and lack of surveillance coverage at these interfaces worsened the situation by the long duration LHDs before the incorrect presences of aircraft were resolved.

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

5.10 According to the final report of the Seventh Meeting of the Asia/Pacific ATS Inter-facility Data-link Communication Implementation Task Force (APA TF/7) of APANPIRG, the AIDC trials between Mumbai ACC and Muscat ACC, and between Mumbai ACC Mogadishu ACC had been conducted in March 2021. Some minor systematic issues were found and remained to be resolved before the AIDC implementation could proceed to the next phase.

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

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

5.12 The interfaces between Kolkata/Chennai FIR and Yangon FIR, and between Chennai FIR and Kuala Lumpur FIR were first identified as LHD hot spots in 2015. As detailed in **Table 8**, the number of LHDs had been decreasing from 275 LHDs in 2018 to 24 LHDs in 2020. And all reported LHDs in 2020 had 0-min duration, resulting in the operational risk of 0 FAPFH.

5.13 **Table 8** also provides the details of LHDs and operational risk at each interface over the past 3 years. When compared to the previous years, the number of LHDs in 2020 significantly decreased and the operational risk decreased to 0 FAPFH at all interfaces. **Figure 10** provides the geographical visualization of the non-zero-duration LHDs and their associated risk grouped into the three interfaces in 2018, 2019 and 2020. Since all the reported LHD occurrences had 0-min duration, the visualization of 2020 did not show any LHD on the map.

Interface	No. of LHDs			Operational Risk (x 10 ⁻⁹ FAPFH)		
	2018	2019	2020	2018	2019	2020
Kolkata-Yangon	168	59	8	0.60	0.31	0
Chennai-Yangon	14	16	3	0.06	0.49	0
Chennai-Kuala Lumpur	93	88	13	0.66	1.14	0
Total	275	163	24	1.32	1.94	0

Table 8: Operational Risk at the Interfaces between Kolkata/Chennai FIR and Yangon FIR, and between Chennai FIR and Kuala Lumpur FIR in 2018, 2019 and 2020

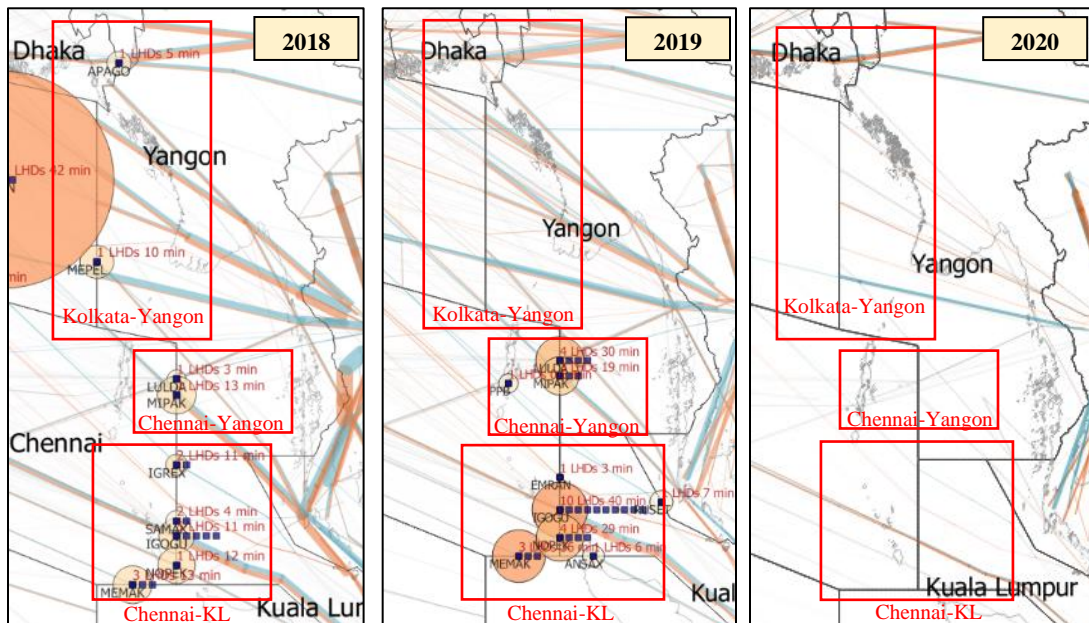


Figure 10: The Visualization of Non-zero-duration LHDs in 2018, 2019 and 2020 between Kolkata FIR, Chennai FIR, Yangon FIR and Kuala Lumpur FIR.

5.14 At the Kolkata-Yangon interface, the issue of LHDs over waypoint APAGO and CHILA was resolved by the implementation of a new procedure since June 2019 to handle the eastbound traffic between Dhaka FIR and Kolkata FIR (as well as coordination with Yangon FIR). Other LHD issues were mitigated by the enhancement of surveillance and communication capabilities. The implementation of ADS-B data sharing between Kolkata ACC and Yangon ACC allowed the controllers to detect and resolve any issue before an aircraft passing the transfer-of-control points. Kolkata ACC and Yangon ACC also agreed to improve their communication with AIDC technology. Their 2nd trial of AIDC implementation in the 1st quarter of 2020 was successful according to the final report of APA TF/7.

5.15 At the Chennai-Yangon interface, the ADS-B data sharing between Chennai FIR and Yangon FIR has not been implemented. As detailed in the final report of APA TF/7, the AIDC trial was commenced in January 2018 and encountered an issue from Yangon ACC side. Yangon ACC would contact Chennai ACC for further testing when ready.

5.16 At the Chennai-Kuala Lumpur interface, the ADS-B data sharing also has not been implemented. However, the AIDC has been implemented between the two ACCs with the Letter of Agreement effective from 1st June 2021, as reported in the APA TF/7.

5.17 The fact that the operational risk at these interfaces was reduced to 0 FAPFH in 2020 was because of all the above mentioned safety enhancement initiatives as well as the reduction in traffic volume.

LHD Hot Spot I (Karachi – Kabul)

5.18 The LHD hot spot I between Karachi FIR and Kabul FIR was first identified in 2018 due to the high number of LHDs and operational risk at GADER in 2017 as shown in **Figure 11**. Later in July 2019, the new route Z627 was established for traffic between Tehran FIR and Kabul FIR. This new route was expected to decrease the workload and alleviate the complicated handling an aircraft among Tehran ACC, Karachi ACC, and Kabul ACC over a short route segment of A453 between GADER and PIRAN, as depicted in **Figure 12**.

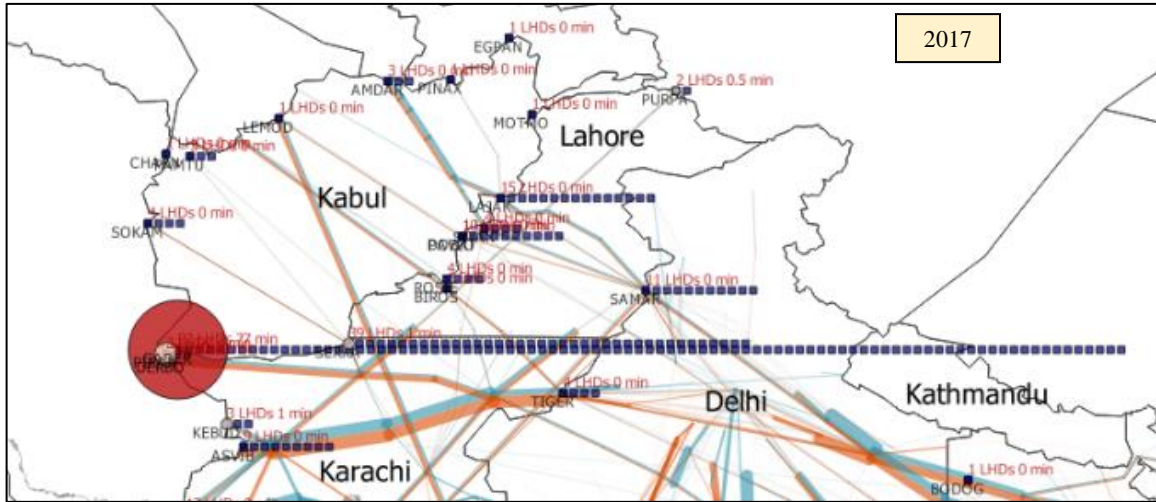


Figure 11: The Visualization of LHDs and Risk at Hot Spot I in 2017.

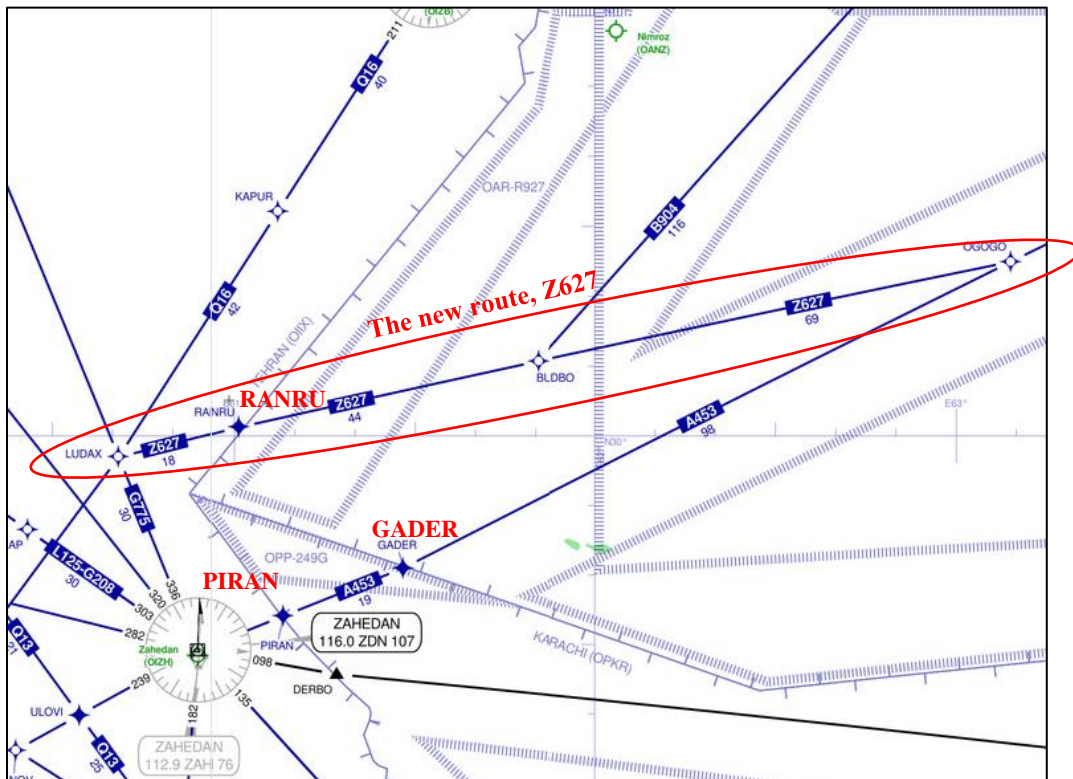


Figure 12: The Visualization of the New Route, Z627, between Tehran FIR and Kabul FIR.

5.19 With the increased awareness of the issue and the establishment of the new route in July 2019, the number of LHDs and the operational risk continually decreased in 2018 and 2019, as shown in **Figure 13**. The RASMAG/25 finally decided to de-identify this interface as an LHD hot spot.

5.20 In 2020, Kabul ACC identified and reported more of their operational risk from LHD occurrences within their own airspace and at the boundaries with Lahore FIR and Karachi FIR. The number of LHDs and operational risk at GADER and RANRU increased in 2020, which most of them were mainly Category E. The poor communication and surveillance coverage did not allow Kabul ACC to detect and resolve the issues before an aircraft passing the transfer-of-control points. This issue would be closely monitored together with the dynamic situation over the Kabul airspace in 2021.

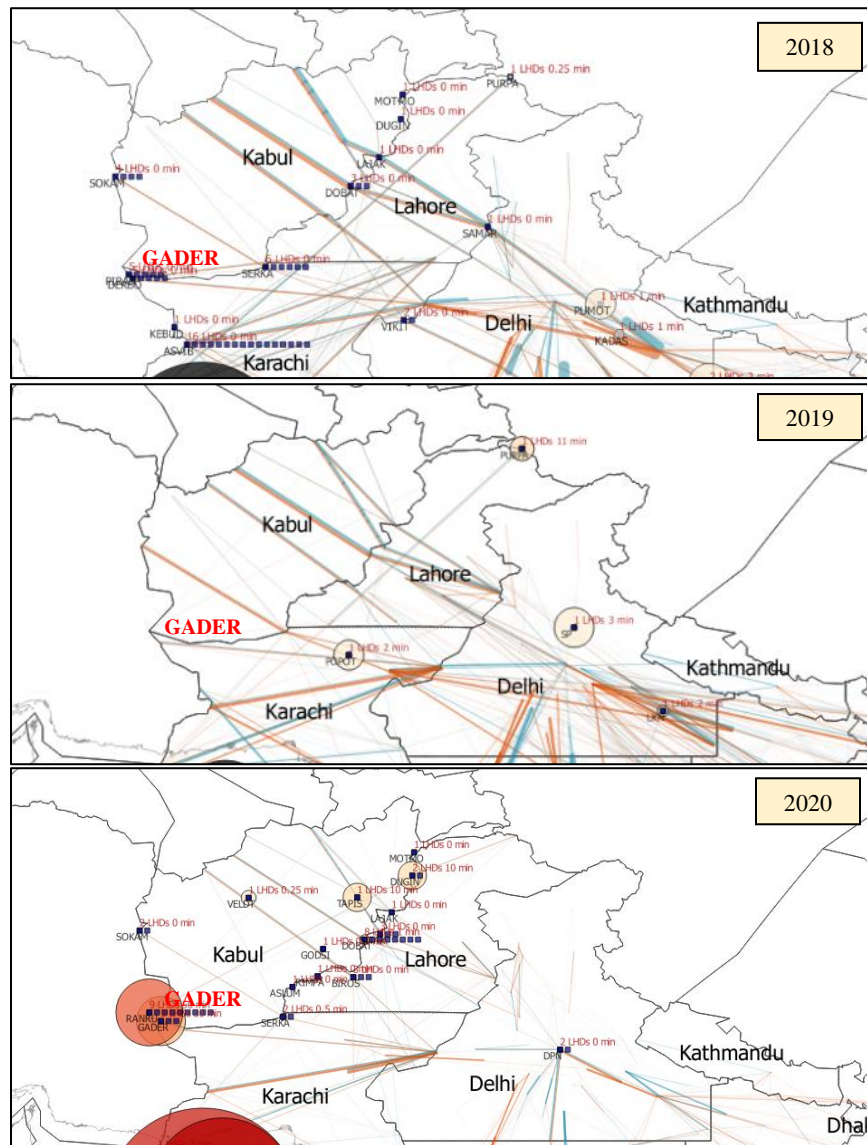


Figure 13: The Visualization of LHDs and Risk at Hot Spot I in 2018, 2019 and 2020.

Other LHD Observations in the SA/IO Airspace

5.21 The number of LHDs and operational risk at Mumbai-Male interface increased in 2020, as shown in **Figure 14**. It was reported during the APA TF/7 that the AIDC implementation trails between Mumbai ACC and Male ACC were successful. The safety assessment for AIDC implementation was conducted in April 2021 and the Letter of Agreement between the two ACCs were expected to be signed shortly.

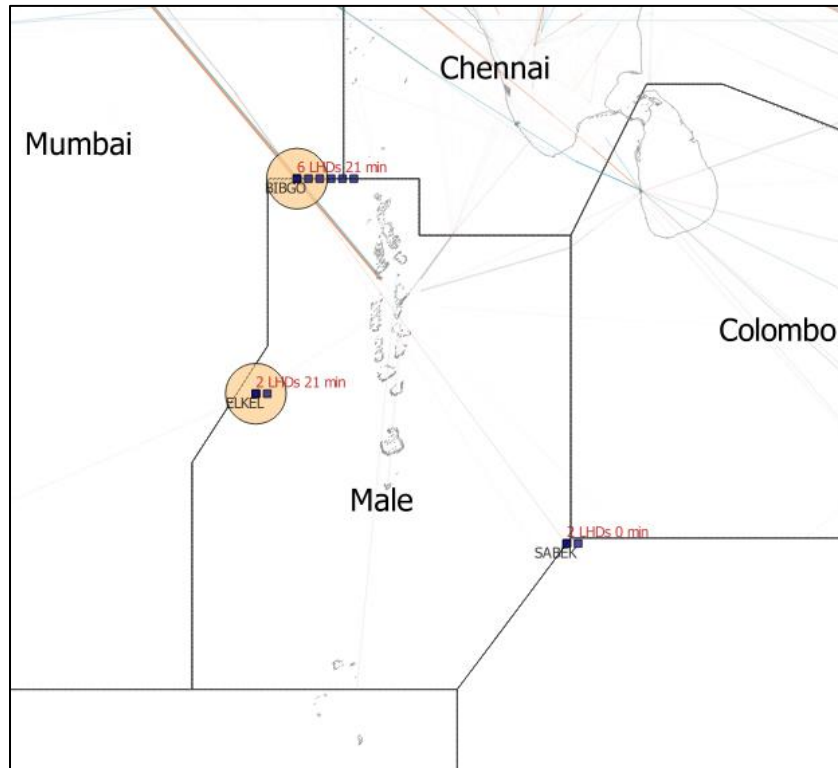


Figure 14: The Visualization of the LHDs along Male's boundaries in 2020.

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

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
19/1/2020	NTM	FL410	FL390	0	E	NO OR LATE FL REVISION
2/1/2020	WLM	FL360	FL380	0	E	NO OR LATE FL REVISION
5/1/2020	WLM	FL340	FL380	0	E	NO OR LATE FL REVISION
21/1/2020	WLM	FL300	FL380	0	E	NO OR LATE FL REVISION
2/1/2020	VRP	FL320	FL300	0	E	NO OR LATE FL REVISION
19/1/2020	VRP	FL360	FL340	0	E	NO OR LATE FL REVISION
19/1/2020	VRP	FL340	FL320	0	E	NO OR LATE FL REVISION
1/1/2020	WUT	FL330	FL350	12	E	NO OR LATE FL REVISION
4/1/2020	WUT	FL350	FL390	1	E	NO OR LATE FL REVISION
6/1/2020	WUT	FL350	FL410	0	E	NO OR LATE FL REVISION
7/1/2020	WUT	FL290	FL350	1	E	NO OR LATE FL REVISION
8/1/2020	WUT	FL330	FL350	0	E	NO OR LATE FL REVISION
12/1/2020	WUT		FL410	17	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
20/1/2020	WUT	FL290	FL310	20	E	NO OR LATE FL REVISION LHD nature: No or late FL revision
20/1/2020	WUT	FL310	FL350	0	E	NO OR LATE FL REVISION
20/1/2020	WUT		FL370	60	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/1/2020	WUT	FL310	FL350	0	E	NO OR LATE FL REVISION
23/1/2020	NTM		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/1/2020	NTM		FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/1/2020	NTM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
31/1/2020	NTM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/2/2020	LPO	FL310	FL370	3	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
10/2/2020	YFF		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/2/2020	YFF		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/2/2020	YFF		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
1/2/2020	WLM	FL340	FL360	0	E	NO OR LATE FL REVISION
6/2/2020	WLM	FL380	FL340	0	E	NO OR LATE FL REVISION
14/2/2020	WLM	FL280	FL340	0	E	NO OR LATE FL REVISION
25/2/2020	WLM	FL350	FL310	0	E	NO OR LATE FL REVISION
25/2/2020	WLM	FL350	FL370	0	E	NO OR LATE FL REVISION
25/2/2020	WLM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
15/2/2020	VRP	FL360	FL380	0	E	NO OR LATE FL REVISION
16/2/2020	VRP	FL320	FL320	0	E	NO OR LATE ROUTE REVISION
25/2/2020	VRP	FL360	FL320	0	E	NO OR LATE FL REVISION
1/2/2020	WUT	FL310	FL290	35	E	NO OR LATE FL REVISION LHD nature: No or late FL revision
1/2/2020	WUT	FL290	FL310	0	E	NO OR LATE FL REVISION
4/2/2020	WUT	FL350	FL370	2	E	NO OR LATE FL REVISION
5/2/2020	WUT	FL390	FL410	0	E	NO OR LATE FL REVISION
6/2/2020	WUT		FL330	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
8/2/2020	WUT	FL310	FL330	0	E	NO OR LATE FL REVISION
16/2/2020	WUT	FL310	FL330	1	E	NO OR LATE FL REVISION
16/2/2020	WUT		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/2/2020	WUT	FL330	FL370	0	E	NO OR LATE FL REVISION
26/2/2020	WUT	FL310	FL390	0	E	NO OR LATE FL REVISION
29/2/2020	WUT	FL350	FL370	10	E	NO OR LATE FL REVISION
3/1/2020	IKR	FL410	FL450	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
18/2/2020	IKR		FL390	11	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/5/2020	IKR		FL390	9	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/5/2020	IKR	FL330	FL390	0	E	NO OR LATE FL REVISION
16/2/2020	NTM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
16/2/2020	NTM	FL330	FL322	0	E	None
4/8/2020	IKR		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/2/2020	NTM	FL300	FL340	0	E	NO OR LATE FL REVISION
6/3/2020	WUT		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/3/2020	WUT	FL330	FL370	0	E	NO OR LATE FL REVISION
6/3/2020	WUT	FL370	FL390	0	E	NO OR LATE FL REVISION
7/3/2020	WUT	FL370	FL390	3	E	NO OR LATE FL REVISION
7/3/2020	WUT	FL370	FL410	0	E	NO OR LATE FL REVISION
11/3/2020	WUT	FL350	FL370	0	E	NO OR LATE FL REVISION
29/4/2020	WUT		FL370	13	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/4/2020	WUT	FL330	FL350	3	E	NO OR LATE FL REVISION
11/4/2020	WUT	FL330	FL350	0	E	NO OR LATE FL REVISION
9/5/2020	WUT	FL310	FL330	5	E	NO OR LATE FL REVISION
19/6/2020	WUT		FL410	94	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
19/6/2020	WUT	FL370	FL350	0	E	NO OR LATE FL REVISION
20/6/2020	WUT	FL370	FL390	9	E	NO OR LATE FL REVISION
20/6/2020	WUT	FL370	FL330	1	E	NO OR LATE FL REVISION
23/7/2020	WUT	FL350	FL370	7	E	NO OR LATE FL REVISION
13/8/2020	NTM	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
18/8/2020	WUT	FL330	FL350	2	E	NO OR LATE FL REVISION
23/8/2020	WUT		FL350	25	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/8/2020	WUT	FL330	FL350	0	E	NO OR LATE FL REVISION
23/9/2020	VRP	FL340	FL380	0	E	NO OR LATE FL REVISION
23/9/2020	NTM		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
22/9/2020	WLM	FL300	FL340	0	E	NO OR LATE FL REVISION
2/9/2020	WUT		FL390	21	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/9/2020	WUT	FL370	FL390	13	E	NO OR LATE FL REVISION
29/9/2020	WUT	FL330	FL350	3	E	NO OR LATE FL REVISION
4/8/2020	CBO	FL300	FL300	0	J	None
6/10/2020	CBO		FL340	0	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/10/2020	CBO	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
23/9/2020	NTM		FL350	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/10/2020	CBO	FL320	FL329	0.5	A	None
11/1/2020	AGC	FL290	FL370	15	E	None
15/1/2020	AGC	FL390	FL285	0.25	J	None
18/1/2020	AGC	FL300	FL280	0	E	NO OR LATE FL REVISION
1/2/2020	AGC	FL290	FL350	15	E	NO OR LATE FL REVISION
29/10/2020	AGC	FL290	FL290	0	E	None
30/10/2020	AGC	FL290	FL330	15	E	NO OR LATE FL REVISION LHD nature: No or late FL revision
30/10/2020	AGC	FL350	FL350	3	E	None
5/2/2020	AGC	FL380	FL380	10	E	None
30/10/2020	AGC	FL370	FL330	13	E	NO OR LATE FL REVISION LHD nature: No or late FL revision
30/10/2020	AGC	FL350	FL350	0	E	None

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
8/2/2020	AGC		FL370	25	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
12/3/2020	AGC	FL390	FL390	10	D	None
9/8/2020	AGC	FL290	FL301	0.5	A	PILOT MISUNDERSTANDS ATC CLEARANCE
29/8/2020	AGC	FL380	FL360	1	C	None
29/8/2020	AGC	FL370	FL366	0.2	J	None
24/9/2020	AGC	FL370	FL340	0	E	LOA VIOLATION
13/11/2020	AGC	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
13/11/2020	AGC	FL390	FL370	0	E	NO OR LATE FL REVISION
27/10/2020	WUT	FL370	FL330	0	E	NO OR LATE FL REVISION
26/10/2020	WUT	FL350	FL350	1	E	NO OR LATE FL REVISION
25/10/2020	WUT	FL310	FL330	0	E	NO OR LATE FL REVISION
25/10/2020	WUT		FL370	47	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/10/2020	WUT	FL370	FL390	1	E	NO OR LATE FL REVISION
2/10/2020	WUT	FL370	FL350	20	E	NO OR LATE FL REVISION
20/10/2020	VRP	FL340	FL360	0	E	NO OR LATE FL REVISION
19/11/2020	AGC	FL410	FL410	10	D	None
19/11/2020	AGC	FL410	FL410	0	D	None
11/2/2020	WLM	FL360	FL340	0	E	NO OR LATE FL REVISION
22/11/2020	NTM	FL350	FL390	0	E	NO OR LATE FL REVISION
20/11/2020	YFF	FL390	FL410	0	E	NO OR LATE FL REVISION
21/11/2020	YFF	FL370	FL350	0	E	NO OR LATE FL REVISION
21/11/2020	YFF	FL350	FL390	0	E	NO OR LATE FL REVISION
22/11/2020	YFF	FL290	FL290	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
25/11/2020	YFF	FL410	FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/11/2020	YFF	FL350	FL390	0	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
28/11/2020	YFF	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
12/10/2020	IKR		FL170	7	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
27/10/2020	IKR	FL390	FL410	3	E	NO OR LATE FL REVISION
29/10/2020	IKR		FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/12/2020	IKR		FL330	12	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/12/2020	AGC	FL370	FL390	0	E	NO OR LATE FL REVISION
24/12/2020	AGC	FL350	FL350	0	E	NO OR LATE ESTIMATE TIME REVISION
25/12/2020	AGC		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/12/2020	AGC	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
27/12/2020	AGC		FL400	0	E	NO OR LATE FL REVISION
2/12/2020	YFF	FL330	FL350	0	E	NO OR LATE FL REVISION
3/12/2020	YFF	FL350	FL370	0	E	NO OR LATE FL REVISION
5/12/2020	YFF	FL390	FL370	0	E	NO OR LATE FL REVISION
5/12/2020	YFF	FL370	FL370	0	E	NO OR LATE ESTIMATE TIME REVISION
10/12/2020	YFF	FL330	FL330	0	E	NO OR LATE ESTIMATE TIME REVISION
7/12/2020	YFF	FL390	FL290	0	E	NO OR LATE FL REVISION
12/12/2020	NTM		FL410	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/11/2020	WUT	FL350	FL390	0	E	NO OR LATE FL REVISION
16/11/2020	WUT	FL330	FL370	14	E	NO OR LATE FL REVISION
20/11/2020	WUT		FL350	1	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
3/12/2020	WUT	FL390	FL370	3	E	NO OR LATE FL REVISION

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
9/12/2020	WUT	FL310	FL370	7	E	NO OR LATE FL REVISION
13/12/2020	WUT		FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
16/12/2020	WUT	FL330	FL350	0	E	NO OR LATE FL REVISION
17/12/2020	WUT		FL390	4	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/12/2020	WUT	FL330	FL350	0	E	NO OR LATE FL REVISION
19/12/2020	WUT	FL330	FL370	0	E	NO OR LATE FL REVISION
29/11/2020	WLM		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
29/11/2020	WLM		FL380	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
22/12/2020	WLM		FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
27/11/2020	BRS		FL370	0	D	None
14/2/2020	BRS		FL320	0	A	None
6/2/2020	WUT		FL300	0	D	None
8/12/2020	CBO	FL310	FL306	0	J	None

MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2020 to December 2020

**AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN
THE SOUTHEAST ASIA AIRSPACE**
Assessment Period: January 2020 to December 2020

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

1. Introduction

This report provides an airspace safety review of RVSM airspace risk in the **Southeast Asia (SEA)** airspace. The review is conducted based on a one-month traffic sample data (TSD) collected in **December 2020** and monthly Large Height Deviation (LHD) reports between **January 2020** and **December 2020** submitted by concerning States in the SEA region.

2. Data Sources

2.1. **Traffic Sample Data (TSD).** A TSD covering the month of December 2020 of aircraft operating in the SEA airspace is used as required by ICAO regional agreement.

2.2. To investigate if the TSD of December 2020 remains appropriate for the risk estimation, a reference to the ICAO's COVID-19 Air Traffic Dashboards (<https://www.icao.int/sustainability/Pages/COVID-19-Air-Traffic-Dashboard.aspx>) is made. The Operational Impact Dashboard estimates the number of flights using the ADS-B FlightAware data and the ICAO Enterprise Data Management (EDM). As shown in **Figure 1**, the number international flights in the Asia Pacific Region dropped drastically from January to April 2020 and gradually increased since May 2020.

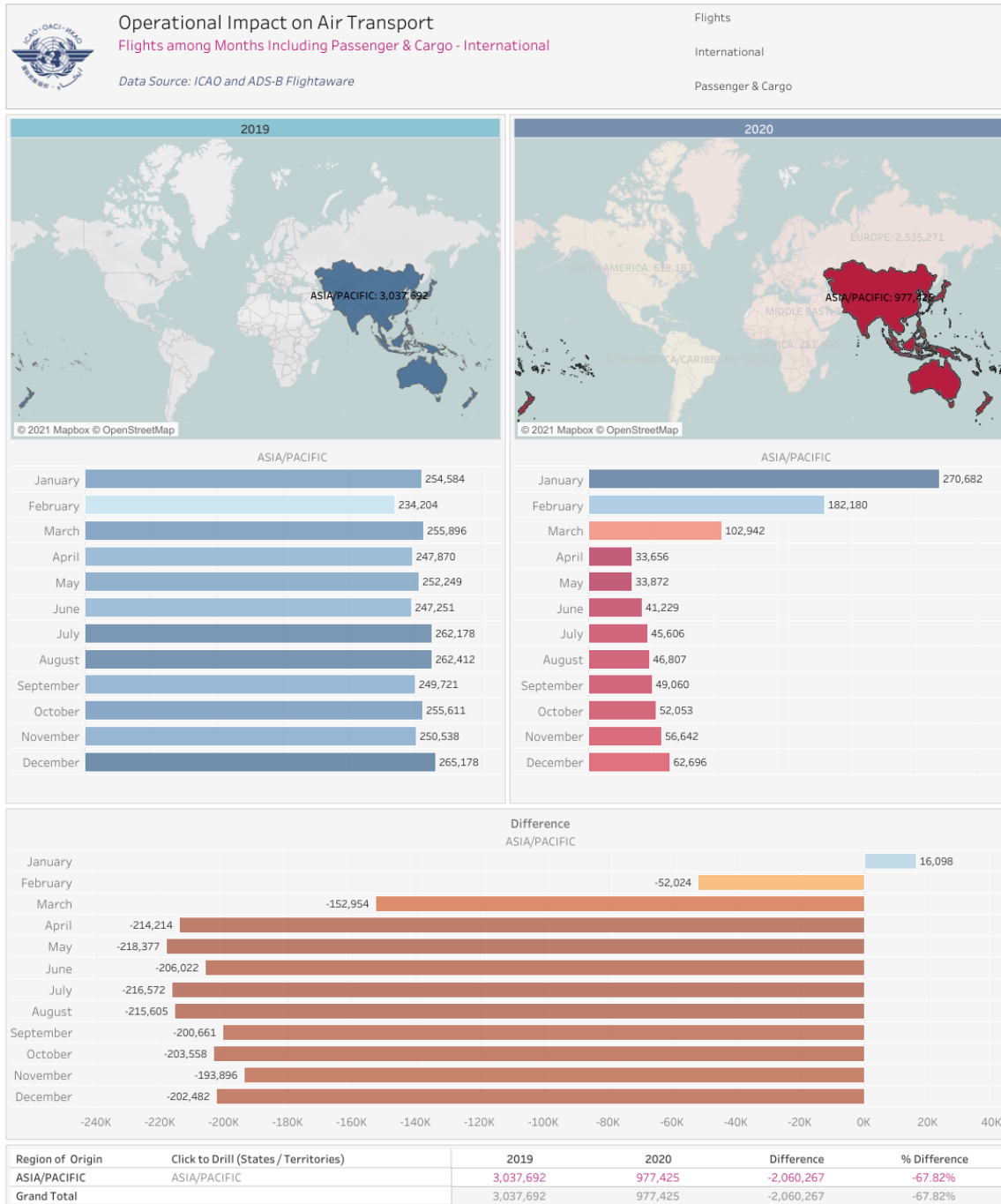


Figure 1: The ICAO’s Operational Impact Dashboard showing the comparison of international flights between 2019 and 2020 of the Asia Pacific Region

2.3. For this investigation, the number of international flights from the ICAO’s dashboard is used for comparison against the annual flight hour estimate from the TSD due to the fact that international flights are expected to spend time maintaining RVSM flight levels in an airspace more than domestic flights which some may not even enter the RVSM airspace. Hence, the change of these two measures between 2019 and 2020 should be resembling.

2.4. **Table 1** shows that the estimated annual RVSM flight hours and flights of the SEA TSD in 2020 decreased by 69% and 71% from 2019, respectively, due to the outbreak of COVID-19 pandemic.

2.5. The data from ICAO’s dashboard shows that the 2019-to-2020 change in international flight of the SEA airspace is a 70% decrease while the change in RVSM annual flight hours estimated from the December 2020 TSD is a 69% decrease. These two measures show the same characteristic at the approximate magnitude. Therefore, it can be inferred that the December 2020 TSD remains a good representative data set for risk estimation in 2020

FIR	2019-to-2020 Change in Flight Estimates from TSD		2019-to-2020 Changes in Flight Estimates from the ICAO's Dashboard	
	RVSM Flight Hours	RVSM Flights	All Flights	International Flights
Hanoi and Ho Chi Minh	-56%	-62%	-38%	-70%
Bangkok	-62%	-62%	-53%	-74%
Hong Kong	-69%	-71%	-62%	-63%
Manila	-73%	-72%	-68%	-68%
Phnom Pehn	-73%	-79%	-75%	-77%
Taibei	-74%	-71%	13%	12%
Singapore	-76%	-77%	-68%	-69%
Kuala Lumpur and Kota Kinabalu	-81%	-82%	-64%	-73%
Vientiane	-82%	-82%	-64%	-76%
SEA Airspace	-69%	-71%	-58%	-70%

Table 1: The comparison of 2019-to-2020 changes in flight of SEA airspace between estimates from the TSD and the ICAO’s dashboard.

2.6. **Large Height Deviation (LHD).** A cumulative 12-month data set of LHD reports covers January 2020 to December 2020. **Table 2** indicates those FIRs, which submitted LHD reports including NIL reports. **Appendix A** provides details of LHD reports, including full description of some uncommon LHDs and LHDs with large duration.

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

Table 2: Summary of LHD Reports Submitted by FIRs in 2020

3. Summary of LHD Occurrences

3.1. **Table 3** and **Figure 2** 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 2020 to December 2020. In this report, the number of LHDs includes the LHDs that have zero duration, unless indicated otherwise.

Month (2020)	No. of LHD	No. of Non-zero-duration LHD	LHD Duration (Min)	No. of Levels Crossed	Operational Risk (x10 ⁻⁹ FAPFH)
January	13	3	39	0	0.91
February	2	0	0	0	0.00
March	2	1	12	0	0.28
April	2	0	0	0	0.00
May	3	0	0	0	0.00
June	3	0	0	0	0.00
July	2	0	0	0	0.00
August	5	1	6	0	0.14
September	2	0	0	0	0.00
October	5	3	2	1	0.06
November	13	0	0	0	0.00
December	2	1	2	0	0.03
Total	39	9	61	1	1.42

Table 3: Summary of LHD by Month for SEA Airspace

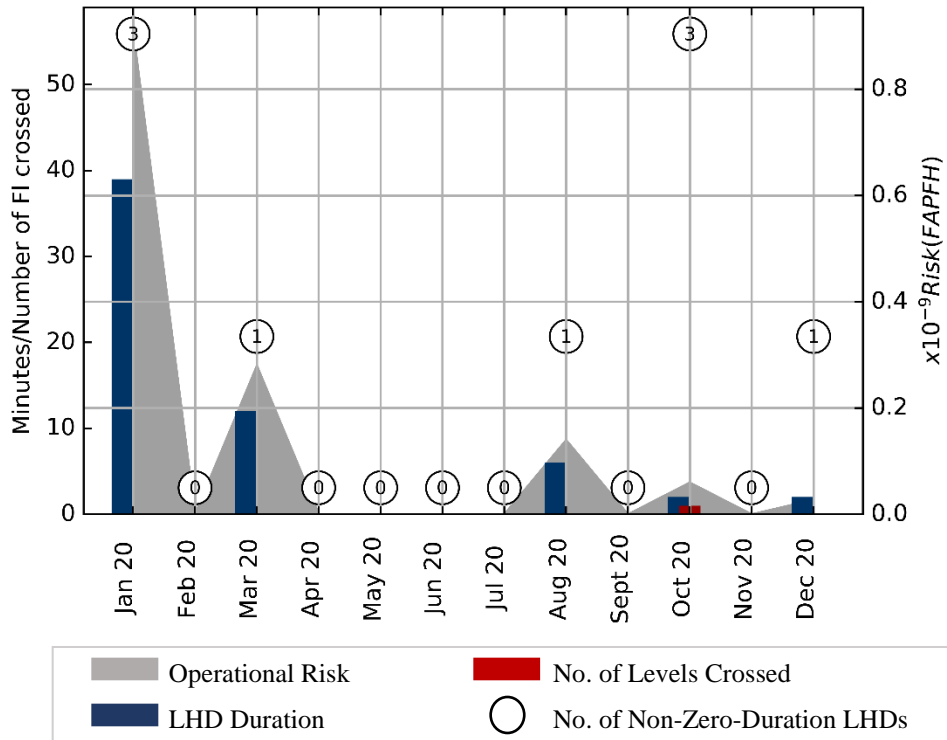


Figure 2: Summary of LHDs by Month for SEA Airspace

3.2. The number of LHDs significantly decreased from 145 in 2019 to 39 in 2020. The number of non-zero-duration LHDs decreased from 17 in 2019 to 9 in 2020. The total LHD duration decreased from 123 minutes to 61 minutes. The number of flight level crossed decreased from 6.5 flight levels in 2019 to 1 flight level in 2020. As a result, the total operational risk decreased from 2.09×10^{-9} Fatal Accident per Flight Hour (FAPFH) to 1.42×10^{-9} FAPFH.

3.3. **Figure 3** and **Table 4** summarize the number of LHDs, the associated LHD duration (in minutes) and number of flight levels crossed, by LHD category from January 2020 to December 2020.

3.4. In 2020, Category E LHDs remained the most frequent occurrences in the SEA airspace. Out of all 39 LHDs, 27 were classified as Category E. And 6 of these were Category E non-zero-duration LHDs, contributed to most of the operational risk at 1.35×10^{-9} FAPFH.

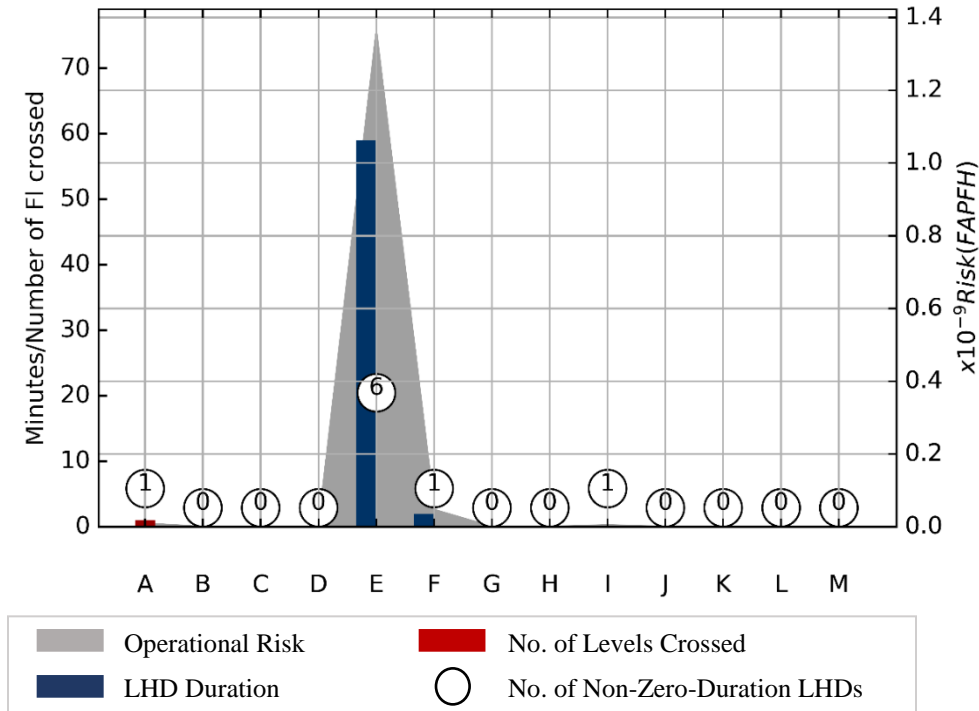


Figure 3: Summary of LHD by LHD Category for SEA Airspace

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk ($\times 10^{-9}$ FAPFH)
A	Flight crew failing to climb/descend the aircraft as cleared	1	1	0	1	0.01
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	1	0	0	0	0

LHD Category Code	LHD Category Description	No. of LHDs	No. of Non-zero-duration LHDs	LHD Duration (Min)	No. of levels Crossed	Operational Risk (x10 ⁻⁹ FAPFH)
	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.).					
D	ATC system loop error; (e.g. ATC issues incorrect flight level clearance or flight crew misunderstands the flight level clearance message)	0	0	0	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination of flight level).	27	6	59	0	1.35
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).	7	1	2	0	0.05
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure)	0	0	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level.	0	0	0	0	0
I	Turbulence or other weather related causes leading to unintentional or undetected change of flight level	1	1	0	0	0.01
J	TCAS resolution advisory, flight crew correctly climb or descend following the resolution advisory	2	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		39	9	61	1	1.42

Table 4: Summary of LHD by Category for SEA 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 5**.

Parameter	Description	Value Bi-Dir	Value Uni-Dir	Unit	Based On
T	Annual flight hours	707,993	346,475	Hour	Dec 2020 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.2051/ 0.0112	0.1257	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.0921	0.0229	-	
λ_x	Average aircraft length	0.0288	0.0319	NM	
λ_y	Average aircraft wingspan	0.0263	0.0292	NM	
λ_z	Average aircraft height	0.0080	0.0086	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0288	0.0319	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	30.20	28.15	Knot	Dec 2020 TSD
$ \overline{V} $	Average absolute aircraft ground speed	480	480	Knot	Conservative value used in previous assessments

Table 5: 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 6**. **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 1.82×10^{-9} FAPFH, which also **meets the specified TLS** value for these components of 5.0×10^{-9} FAPFH.

Southeast Asia (SEA) RVSM Airspace – estimated annual flying hours = 1,054,468 hours (note: estimated hours based on December 2020 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.40×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	1.42×10^{-9}	-	-
Total Risk	1.82×10^{-9}	5.0×10^{-9}	Below Technical TLS

Table 6: Risk Estimates for SEA Airspace

4.3. The total risk of the SEA airspace decreased from 3.59×10^{-9} FAPFH in 2019 to 1.82×10^{-9} FAPFH in 2020, accounting for 48% decrease.

4.4. **Figure 4** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHDs. The operational and total risk were steadily stable from January to November and then dropped in December.

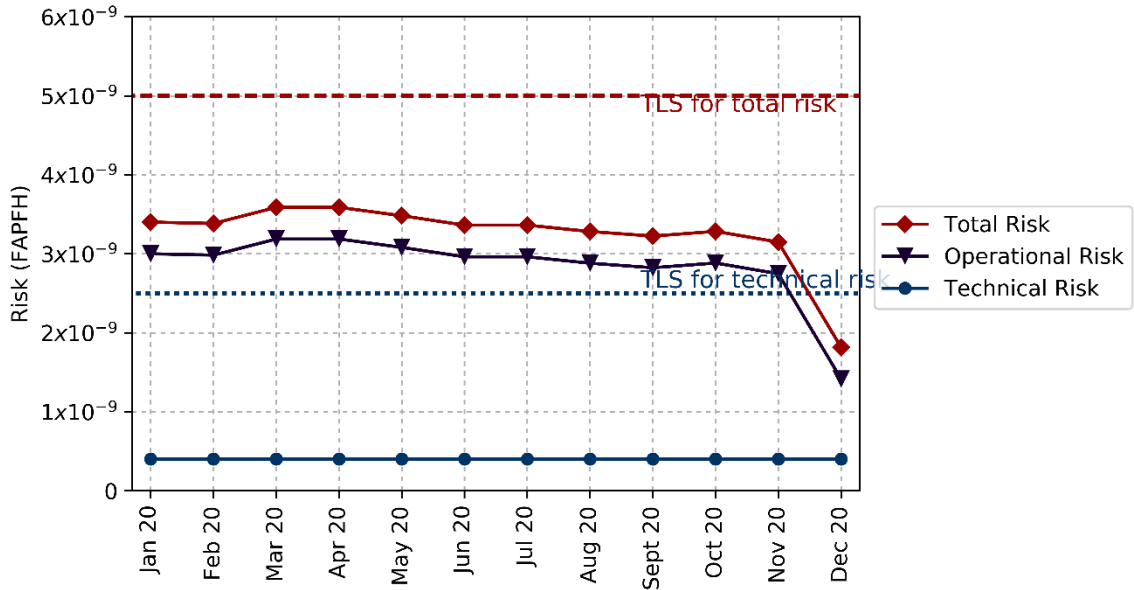


Figure 4: Trends of Risk Estimates for SEA Airspace

4.5. A monthly LHD risk value is determined to provide real-time information on actual risk without reliance on historical high-time errors resident within the 12 month data sample. **Figure 5** demonstrates monthly LHD risk, where each individual block represents one LHD event and height of each block corresponds to risk of each LHD. The red horizontal line represents the average monthly risk of the annual risk of 5.0×10^{-9} (red line in Figure 6 below, which is approximately 0.4167×10^{-9} fatal accidents per flight hour).

4.6. As depicted in **Figure 5**, there were 3 long duration LHDs (of more than 10 minutes) driving risk of the SEA airspace in 2020; specifically 2 LHDs occurred in Junaury with the duration of 20 minutes and 16 minutes, and another LHD occurred in March with the duration of 12 minutes. These 3 long duration LHDs resulted in the operational risk of 1.12×10^{-9} FAPFH, accounting for 79% of the total operational risk of SEA airspace. More details would be provided in Section 5.

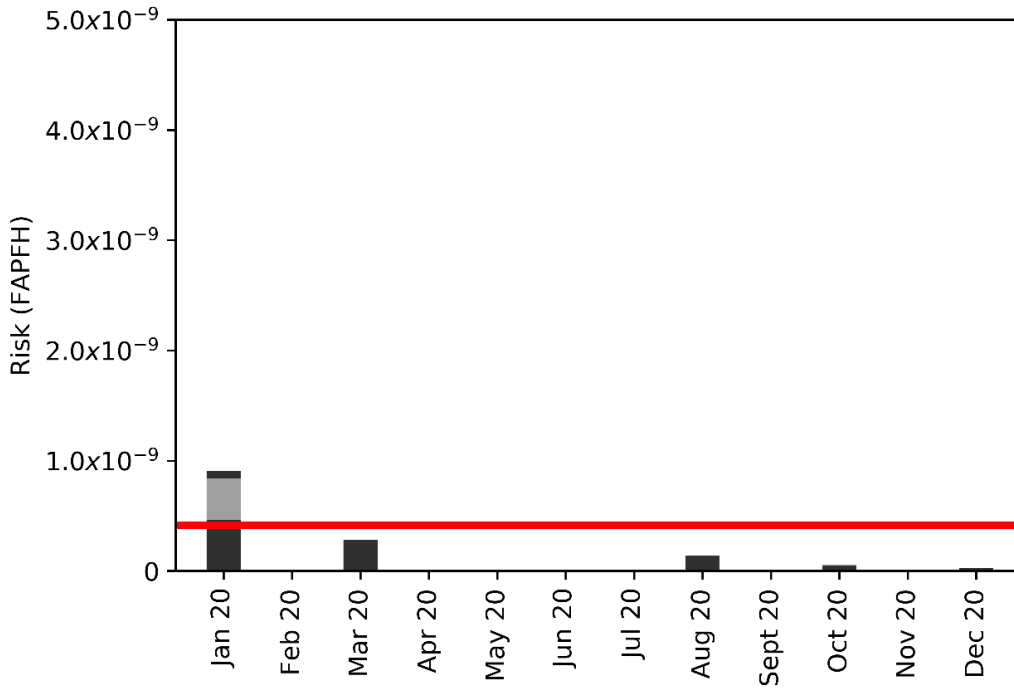


Figure 5: Monthly LHD Risk Estimates for SEA Airspace.

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

5. Analysis of Operational Errors

5.1 **Figure 6** depicts geographical locations of all reported LHDs in SEA airspace based on LHD reports from January to December 2020. **Figure 7** depicts only LHDs which are determined to be non-zero duration. The following are symbols and color codes used in the visualizations:

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

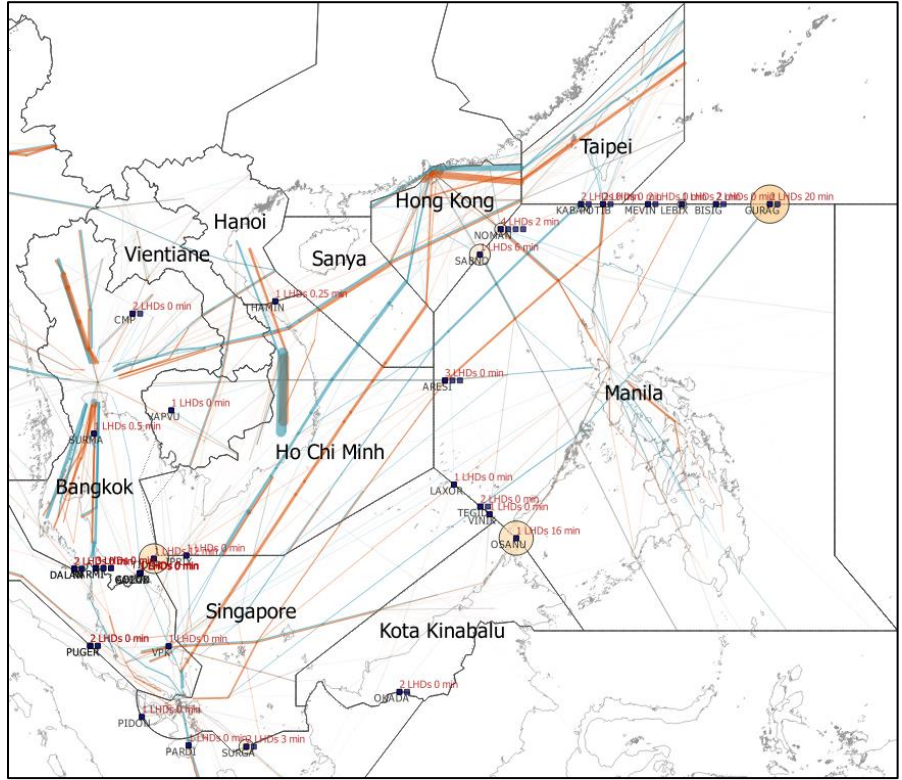


Figure 6: Geographical Locations of All LHDs in SEA Airspace

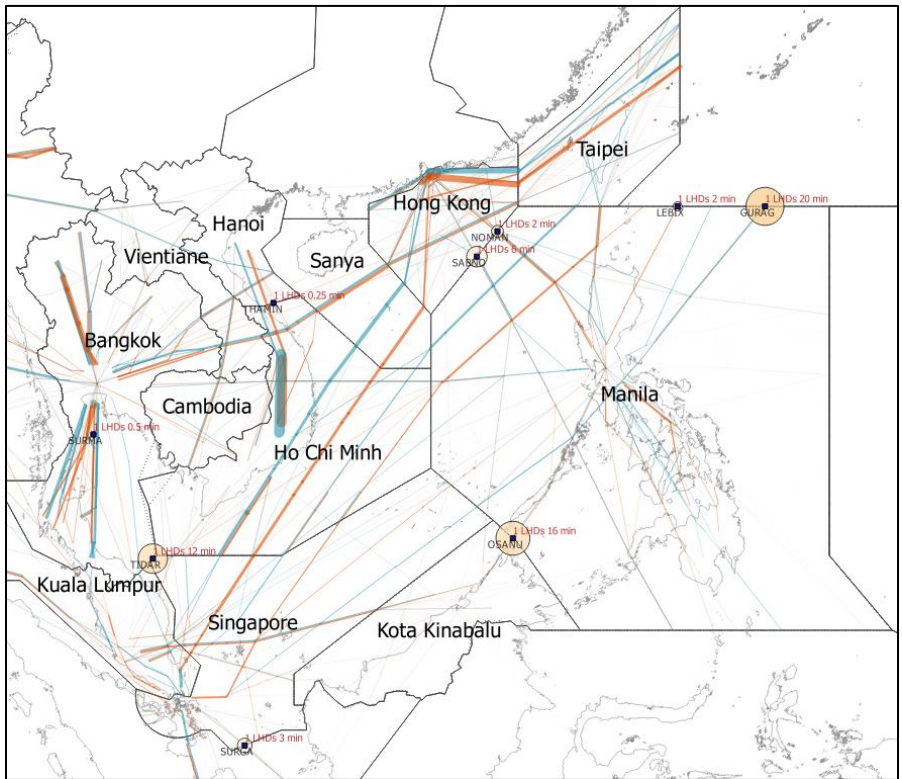


Figure 7: Geographical Locations of 'Non-zero-duration' LHDs in SEA Airspace

LHD Hot Spot D (Manila)

5.2 **Table 7** summaries the number of LHDs and the associated operational risk at Manila FIR boundaries in 2019 and 2020. The number of LHDs along Manila FIR boundaries significantly decreased from 99 LHDs in 2019 to 24 LHDs in 2020. The operational risk also decreased from 1.74×10^{-9} FAPFH in 2019 to 1.05×10^{-9} FAPFH in 2020.

Interface	Number of LHDs		Number of non-zero-duration LHDs		Operational Risk (x 10 ⁻⁹ FAPFH)	
	2019	2020	2019	2020	2019	2020
Manila-Kobe/Fukuoka	15	5	1	2	1.36	0.49
Manila-Ho Chi Minh	20	4	0	0	0	0
Manila-Hong Kong*	17	5	0	2	0	0.19
Manila-Kota Kinabalu	11	2	3	1	0.08	0.37
Manila-Naha	0	2	0	0	0	0
Manila-Singapore*	17	3	5	0	0.28	0
Manila Taipei*	16	3	0	0	0	0
Manila-Ujung Pandang*	3	0	1	0	0.02	0
Manila-Oakland	0	0	0	0	0	0
Total	99	24	10	5	1.74	1.05

* The interface with fully operational AIDC

Table 7: The Number of LHDs, Non-zero-duration LHDs and Operational Risk in 2019 and 2020 Along Manila FIR Boundaries.

5.3 **Figure 8** depicts the number of LHDs and operational risk along Manila FIR boundaries which clearly shows a better risk picture in 2020 when compared with 2019. At the same time, the traffic movement also decreased in 2020 as indicated by the thinner turquoise and orange lines.

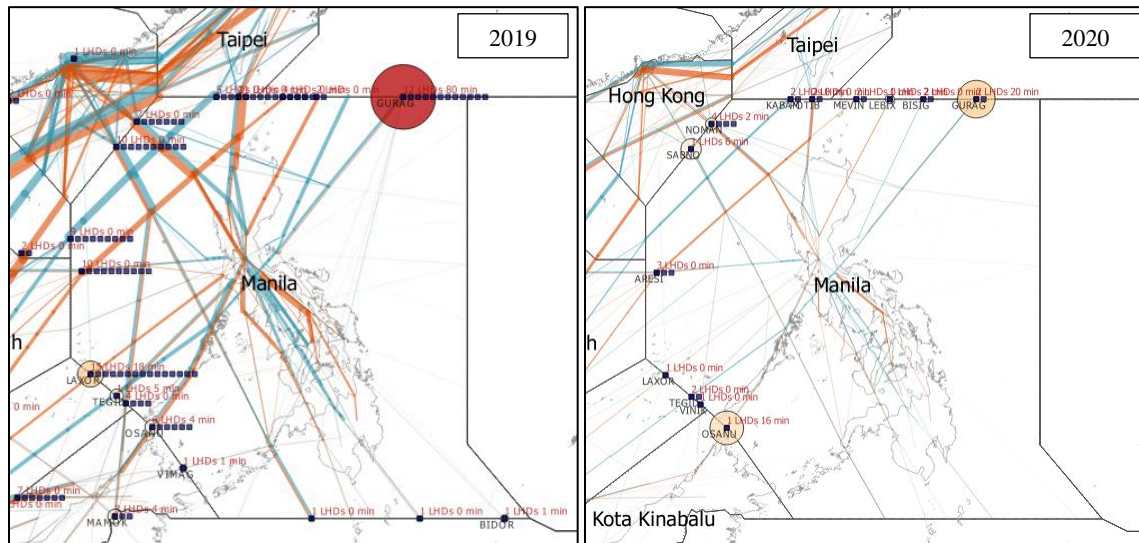


Figure 8: Number of LHDs and risk along Manila FIR boundaries in 2019 and 2020

5.4 Even though the situation seemed to be improving, the majority of the reported LHDs and the operational risk of the SEA airspace still remained along the boundaries of Manila FIR. In other words, a total of 24 LHDs at Manila FIR boundaries accounted for 62% of the number of LHDs in the SEA airspace. The resultant operational risk of 1.05×10^{-9} FAPFH accounted for 74% of the operational risk of the SEA airspace.

5.5 2 out of 3 long duration LHDs in the SEA airspace occurred at Manila FIR boundaries. One occurred at the Manila-Fukuoka interface from “no transfer information”. Another one occurred at the Manila-Kota Kinabalu interface from “no or late estimate time revision”.

5.6 Since Manila FIR boundaries were identified as an LHD hot spot in 2015, a number of safety improvement activities were initiated in forms of soft barriers (like safety awareness campaign and training) and hard barriers (like the enhancement of the new ATM system and CNS capabilities). **Figure 9** depicts the trend of LHDs being reported along Manila FIR boundaries together with the timeline of major safety improvement implementation by Manila ACC and the adjacent units.

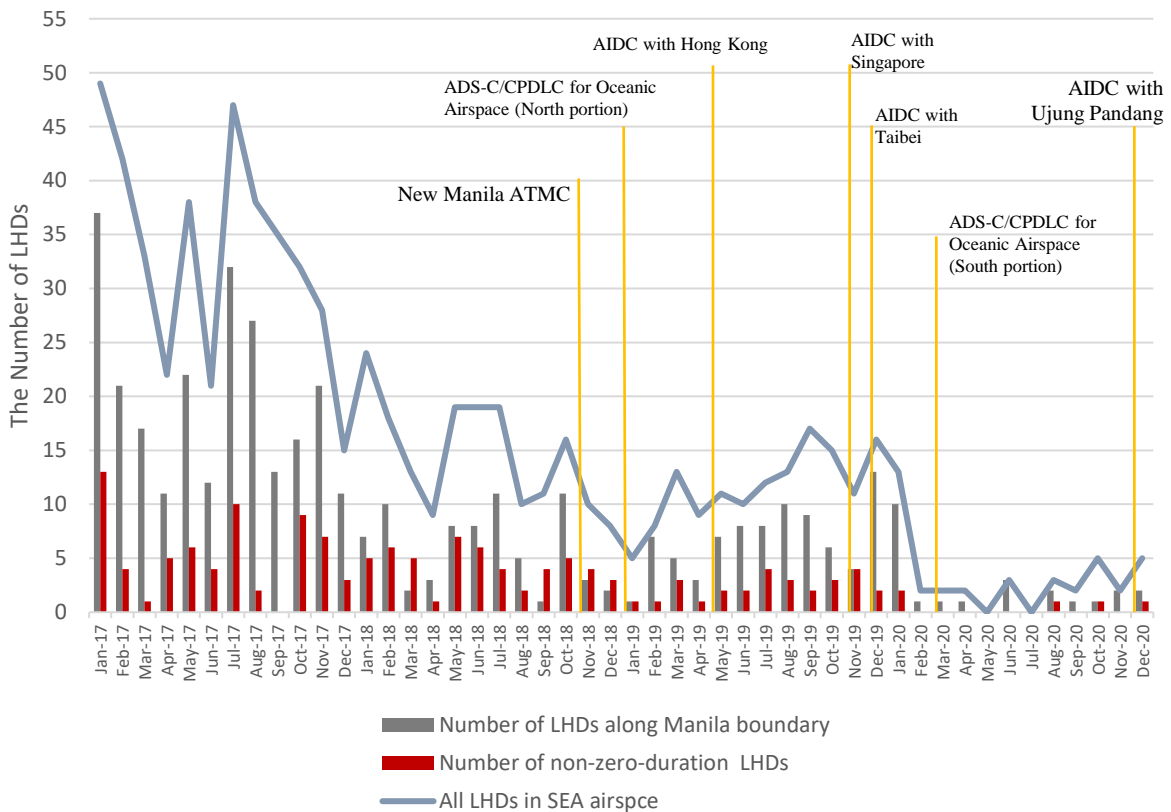


Figure 9: Number of LHDs and non-zero-duration LHDs along Manila Boundary Compared to all LHDs in SEA from 2017 to 2020

5.7 The Philippines successfully transferred to the new ATM system at Manila ATMC in November 2018. In 2020, Manila ACC was expected to be able to re-sectorize into 9 sectors from 4 sectors in the legacy system.

5.8 ADS-C/CPDLC was integrated in the controller’s workstations. The North portion of West Pacific Oceanic airspace was integrated in January 2019, the South portion of West Pacific

Oceanic airspace in March 2020, and the South China Sea in February 2021. Thus, ADS-C/CPDLC was expected to completely cover the whole Manila FIR.

5.9 The surveillance capability was also enhanced to cover the whole FIR and beyond their boundaries with 10 new radar sites which were operational together with the new ATM system in November 2018. The ADS-B expansion project was also planned to cover the remaining surveillance gaps. In 2020, Manila ACC and Singapore ACC were expected to share their ADS-B data over the Manila-Singapore interface, as reported in IP04 during RASMAG/24 held in July 2019.

5.10 By December 2020, Manila ACC successfully implemented AIDC with Hong Kong, Singapore, Taipei, and Ujun Pandang ACC. The technical AIDC test with Ho Chi Minh ACC was successful in June 2021 but the operational trial was pending due to the issue of AFTN Link. Manila ACC also planned to have the technical AIDC test with Oakland ACC, Kota Kinabalu ACC, Kobe ACC and Fukuoka ATMC.

5.11 In 2019, the Category F LHD was an emerging issue at Manila boundaries where AIDC was implemented. There were a total of 9 Category F LHDs, and 7 out of 9 LHDs were due to AIDC failures. In 2020, the number of Category F LHDs slightly decreased from 9 to 6 LHDs. Those 6 LHDs were caused by the AIDC system failures and the unsuccessful transfer via AIDC. This issue should be followed up with relevant units and continuously monitored.

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

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
6/1/2020	TZF	FL320	FL360	0	E	NO OR LATE FL REVISION
3/1/2020	IEZ	FL330	FL370	3	E	NO OR LATE FL REVISION
20/1/2020	VRG			0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
21/1/2020	VRG	FL380	FL380	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
19/1/2020	VRG	FL330	FL330	20	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/1/2020	VRG	FL340	FL340	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
24/1/2020	VRG	FL340	FL340	0	F	LOA VIOLATION
30/1/2020	VRG	FL310	FL310	0	C	TIME ESTIMATE FROM PILOT (AIRCRAFT AVIONICS) IS NOT ACCURATE ENOUGH
27/1/2020	VRG			0	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
10/2/2020	IEZ	FL380	FL400	0	E	NO OR LATE FL REVISION
22/2/2020	VRG	FL400	FL390	0	E	NO OR LATE FL REVISION
17/3/2020	IEZ	FL370	FL370	12	E	NO OR LATE ESTIMATE TIME REVISION
4/3/2020	VRG			0	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/4/2020	IEZ	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
11/4/2020	IEZ	FL360	FL360	0	E	NO OR LATE ROUTE REVISION
13/1/2020	JGR	FL350	FL370	0	E	NO OR LATE FL REVISION
13/1/2020	JGR	FL370	FL330	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
15/1/2020	JGR	FL310		16	E	NO OR LATE ESTIMATE TIME REVISION
31/1/2020	JGR	FL350	FL390	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR

Date	Source	Assigned FL	Observed/Reported FL	Minutes at Incorrect FL/No. FL crossed without clearance	Category	Cause
13/6/2020	VRG		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
18/6/2020	VRG		FL400	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
27/6/2020	TAE	FL350	FL360	0	E	None
23/8/2020	VRG	FL330	FL330	6	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
26/8/2020	VRG	FL380	FL380	0	E	NO OR LATE ESTIMATE TIME REVISION
27/9/2020	VRG	FL380	FL340	0	E	ATC-TO-ATC READBACK-HEARBACK ERROR
7/9/2020	IEZ		FL310	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
4/8/2020	ZWP	FL300	FL300	0	J	None
6/10/2020	ZWP		FL340	0	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
6/10/2020	ZWP	FL360	FL360	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
14/10/2020	ZWP	FL320	FL329	0.5	A	None
7/10/2020	NUD	FL350	FL346	0.25	I	None
11/10/2020	VRG	FL370	FL370	2	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
22/11/2020	UPT	FL370	FL370	0	F	None
22/11/2020	VRG	FL370	FL370	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
17/12/2020	IEZ		FL380	0	F	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
11/12/2020	IEZ	FL270	FL290	0	E	NO OR LATE FL REVISION
18/12/2020	VRG	FL390	FL390	0	E	NO TRANSFER INFORMATION (I.E. NEGATIVE TRANSFER)
30/12/2020	VRG	FL310	FL350	2	E	NO OR LATE FL REVISION
8/12/2020	ZWP	FL310	FL306	0	J	None

MONITORING AGENCY FOR ASIA REGION (MAAR)



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

January 2020 to December 2020

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

Assessment Period: January 2020 to December 2020

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 2020** and monthly Large Height Deviation (LHD) reports between **January 2020** and **December 2020** submitted by Mongolia.

2. Data Sources

2.1. Traffic Sample Data (TSD). A TSD covering the month of December 2020 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 2020 to December 2020. **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 2020

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 2020 to December 2020 by month and by LHD category, respectively.

3.2. In 2020, no LHD involving Ulaanbaatar FIR was reported.

Month (2020)	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 Mongolia 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	100,166	1,539	Hour	Dec 2020 TSD
$E_z(\text{same})$	Same-direction vertical occupancies	0.3381/ 0.0004	0.0000	-	
$E_z(\text{opposite})$	Opposite-direction vertical occupancies	0.1567	0.0383	-	
λ_x	Average aircraft length	0.0345	0.0300	NM	
λ_y	Average aircraft wingspan	0.0317	0.0273	NM	
λ_z	Average aircraft height	0.0093	0.0083	NM	
λ_h	Diameter of the disk representing the shape of an aircraft in the horizontal plane	0.0345	0.0300	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	20.75	0.00	Knot	Dec 2020 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** also **meets the specified TLS** value for these components of 5.0×10^{-9} FAPFH.

Mongolian RVSM Airspace – estimated annual flying hours = 101,705 hours <i>(note: estimated hours based on December 2020 traffic sample data)</i>			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.87×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	0.87×10^{-9}	5.0×10^{-9}	Below Overall TLS

Table 5: Risk Estimates for Mongolian Airspace

5. Analysis of Operational Errors

No LHD was reported within or at the boundary of the Mongolian airspace. Hence, the analysis of operational errors cannot be conducted.