International Civil Aviation Organization

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

Bangkok, Thailand, 21 – 24 August 2023

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

PARMO VERTICAL SAFETY MONITORING REPORT 2022

(Presented by United States/PARMO)

SUMMARY

This paper compares actual performance to safety goals that support the continued safe use of reduced vertical separation minimum (RVSM) in Pacific and a portion of North East Asia airspace. This report contains a summary of large height deviation (LHD) reports received by the Pacific Approvals Registry and Monitoring Organization (PARMO) for the most recent reporting period of 1 January to 31 December 2022. There are a total of 70 reported large height deviations (LHDs) accounting for 260 minutes of operation at incorrect flight level in Pacific and a portion of North East Asia RVSM airspace. This report also contains an estimate of the vertical collision risk. The 2022 vertical collision risk estimate for Pacific airspace exceeds the target level of safety (TLS) value of 5.0×10^{-9} fatal accidents per flight hour. The 2022 vertical collision risk estimate for a portion of North East Asia airspace meets the TLS value of 5.0×10^{-9} fatal accidents per flight hour.

1. INTRODUCTION

1.1 The Pacific Approvals Registry and Monitoring Organization (PARMO) produces an annual report for Pacific and North East Asia airspace. The report presented in this paper fulfills the ICAO emphasis on safety management systems; such reporting for international airspace is a component of safety management systems.

1.2 This working paper contains the PARMO safety monitoring report for the time period 1 January to 31 December 2022. This paper contains a summary of large height deviation reports, and estimates of vertical risk for Pacific and North East Asia airspace.

2. DISCUSSION

Attachment A contains the PARMO Vertical Safety Monitoring Report for January to December 2022.

<u>Executive Summary</u>

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

Pacific Airspace – estimated annual flying hours = 1,482,049 hours *(note: estimated hours based on Dec 2022 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 27 Total Risk	*28.2×10^{-9}*	*5.0×10^{-9}*	*Above TLS*
Technical Risk	0.14×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	31.5×10^{-9}	-	-
Total Risk	**32.6×10^{-9}**	5.0×10^{-9}	**Above TLS**

Table 1: Pacific Airspace RVSM Risk Estimates

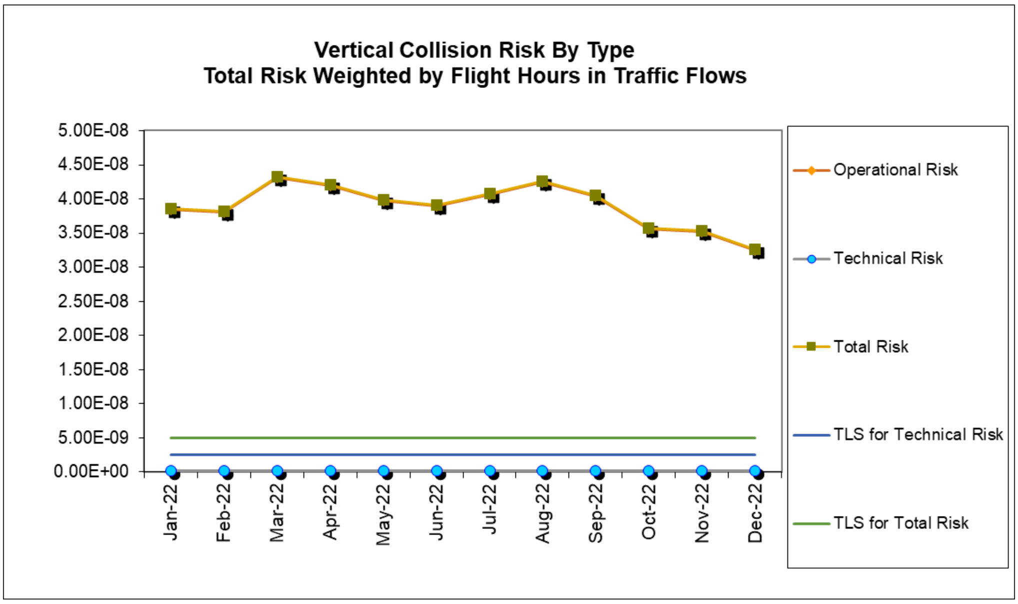

Figure 1: Pacific Airspace RVSM Risk Estimate Trends

2.2 **Table 2** presents a summary of the LHD causes within Pacific airspace from January 2022 until December 2022.

Code	**LHD Category Description**	**No.**
A	Flight crew fails to climb or descend the aircraft as cleared	4
B	Flight crew climbing or descending without ATC clearance	19
C	Incorrect operation or interpretation of airborne equipment	0
D	ATC system loop error	5
E	Coordination errors in the ATC -to-ATC transfer of control responsibility as a result of human factors issues	39
F	ATC transfer of control coordination errors due to technical issues	2
G	Aircraft contingency leading to sudden inability to maintain level	0
H	Airborne equipment failure and unintentional or undetected level change	0
I	Turbulence or other weather related cause leading to unintentional or undetected change of flight level	0
J	TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory	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	1
Total		70

Table 2: Summary of LHD Causes within Pacific Airspace

2.3 **Figure 2** provides the geographic location of risk bearing LHD reports within Pacific Airspace during the assessment period.

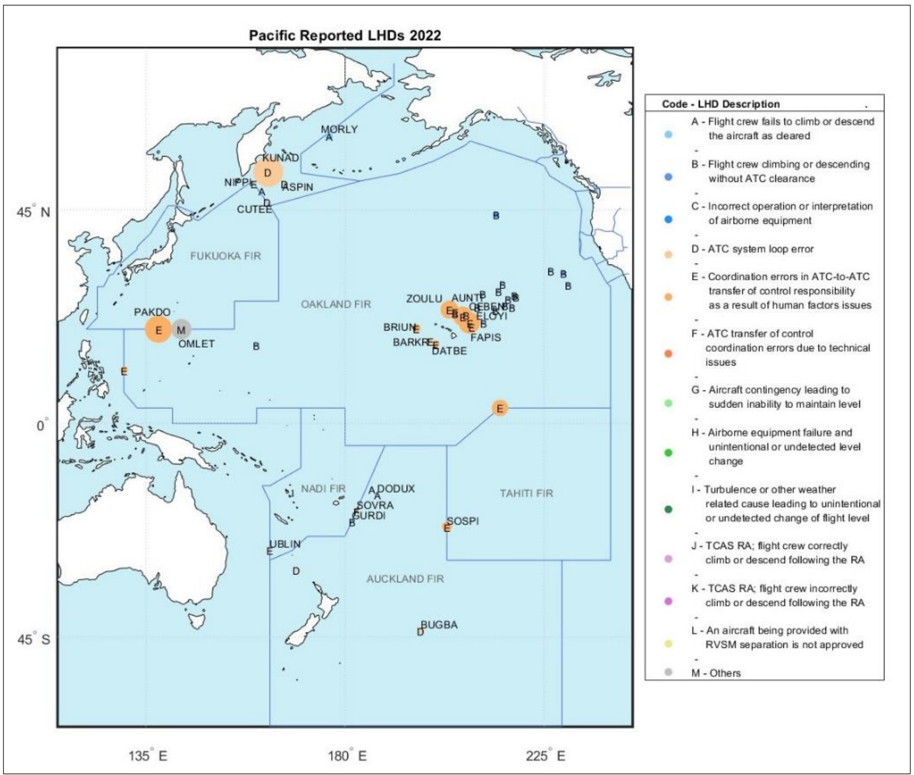

Figure 2: Pacific Airspace – Risk Bearing LHD

2.4 The largest contributors to the vertical collision risk estimate are the reported LHD category E occurrences involving the Honolulu Control Facility and Oakland ARTCC. This specific set of reported LHDs account for 64 percent of the total vertical risk estimate. The current plan is to implement the FAA's En Route Automation Modernization (ERAM) system at the HCF by the end of 2025. The total vertical risk estimate without these category E reported LHDs would be 11.6×10^{-9} fapfh. The implementation of ERAM will fix the problem with the HCF to Oakland ARTCC aircraft transfers. Prior to that time, both facilities have implemented mitigation strategies.

2.5 **Table 3** summarizes Incheon airspace RVSM technical, operational, and total risks. **Figure 3** presents collision risk estimate trends during the period from January 2022 to December 2022.

North East Asia Airspace – estimated annual flying hours = 114,005.7 hours ***(note: estimated hours based on Dec 2022 traffic sample data)***			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 27 Total Risk	*0.04×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Technical Risk	0.09×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	**0.09×10^{-9}**	5.0×10^{-9}	**Below TLS**

Table 3: Incheon RVSM Airspace Vertical Risk Estimates

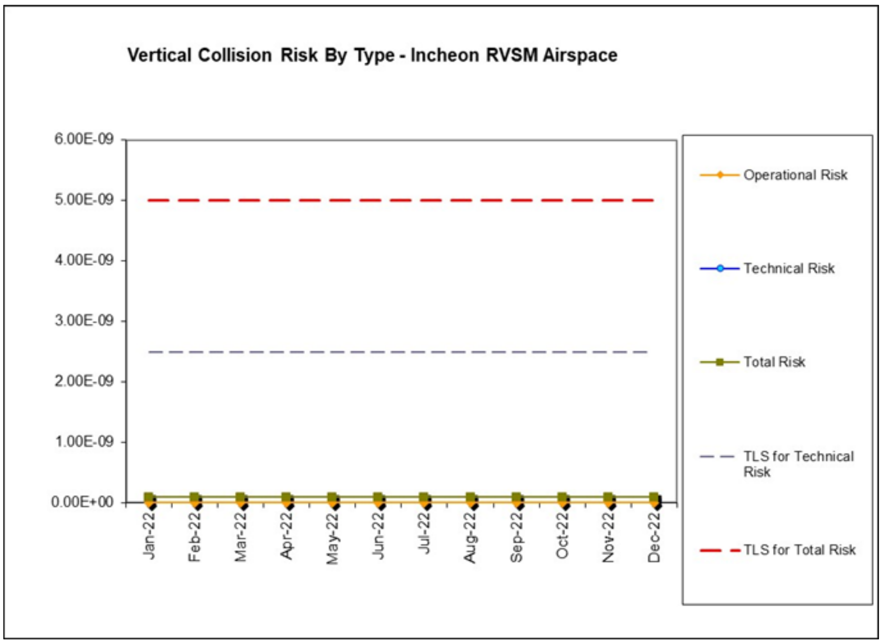

Figure 3: Incheon RVSM Airspace Vertical Risk Estimate Trends

2.6 **Table 4** presents a summary of the LHD causes within Incheon RVSM airspace from January 2022 until December 2022.

Code	LHD Category Description	No.
A	Flight crew fails to climb or descend the aircraft as cleared	0
B	Flight crew climbing or descending without ATC clearance	0
C	Incorrect operation or interpretation of airborne equipment	0
D	ATC system loop error	0
E	Coordination errors in the ATC -to-ATC transfer of control responsibility as a result of human factors issues	108
F	ATC transfer of control coordination errors due to technical issues	0
G	Aircraft contingency leading to sudden inability to maintain level	0
H	Airborne equipment failure and unintentional or undetected level change	0
I	Turbulence or other weather related cause leading to unintentional or undetected change of flight level	0
J	TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory	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		108

Table 2: Summary of LHD Causes within Pacific Airspace

2.7 There were 108 reported LHDs in calendar year 2022, all reported occurrences have zero duration and zero flight levels crossed without ATC clearance. All of the reported occurrences were within the AKARA corridor airspace and will be examined in a separate paper. There were no reported LHD occurrences from other areas within the Incheon FIR during calendar year 2022.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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AIRSPACE SAFETY REVIEW OF THE RVSM IMPLEMENTATION IN PACIFIC AND NORTH EAST ASIA AIRSPACE January 2022 TO December 2022

Prepared by
Pacific Approvals and Registry Monitoring Organization (PARMO) – *July 2023*
(An ICAO APANPIRG approved Regional Monitoring Agency)

1. Introduction

1.1 This report provides an airspace safety review of Reduced Vertical Separation Minimum (RVSM) airspace risk in the Anchorage, Auckland, Incheon, Nadi, Oakland and Tahiti Flight Information Regions (FIRs).

2. Data Sources

2.1 **Traffic Sample Data (TSD).** A TSD covering the month of December 2021 for aircraft operations in the Anchorage, Auckland, Incheon, Nadi, and Oakland FIRs was used as required by ICAO Regional agreement. **Table 1** indicates all FIRs have submitted a TSD to the PARMO.

Table 1. December 2022 TSD Submitted to PARMO

FIR	December 2022 TSD Submitted to PARMO
Anchorage	X
Auckland	X
Incheon	X
Nadi	X
Oakland	X
Tahiti	X

2.2 **Large Height Deviation (LHD).** A cumulative 12-month data set of LHD reports was used, covering January to December 2022. **Table 2** indicates those FIRs which submitted LHD reports including nil reports. All FIRs submitted LHD reports needed to compute the 2022 vertical operational risk estimates.

Table 2. Summary of LHD Reports submitted by FIRs

	Anchorage	Auckland	Incheon	Nadi	Oakland	Tahiti
Jan 2022	X	X	X	X	X	X
Feb 2022	X	X	X	X	X	X
Mar 2022	X	X	X	X	X	X
Apr 2022	X	X	X	X	X	X
May 2022	X	X	X	X	X	X
Jun 2022	X	X	X	X	X	X
Jul 2022	X	X	X	X	X	X
Aug 2022	X	X	X	X	X	X
Sep 2022	X	X	X	X	X	X
Oct 2022	X	X	X	X	X	X

	Anchorage	Auckland	Incheon	Nadi	Oakland	Tahiti
Nov 2022	X	X	X	X	X	X
Dec 2022	X	X	X	X	X	X

3. Summary of LHD Occurrences

3.1 Pacific RVSM Airspace

3.2 **Table 3** and **Figure 1** summarize the number of LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed by month from 1 January 2022 to 31 December 2022 inclusive for Pacific airspace.

Table 3. Summary of reported LHD occurrences and duration for Pacific RVSM airspace – Year 2022

Month	No. of LHD	LHD Duration (min)	No. Levels Crossed
2022			
January	4	2	16
February	3	47	1
March	5	94.05	0
April	6	12.12	1
May	1	0.30	0
June	8	10.58	1
July	6	29.30	0
August	6	15.18	10
September	3	8.95	0
October	9	1.43	1
November	11	35.63	10
December	8	3.50	18
Total	**70**	**260.05**	**58**

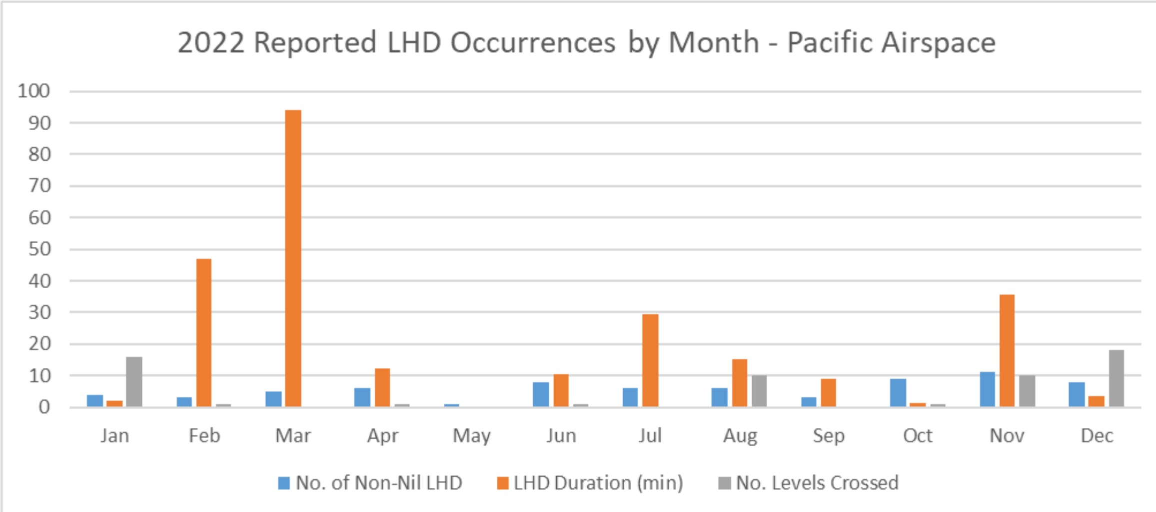
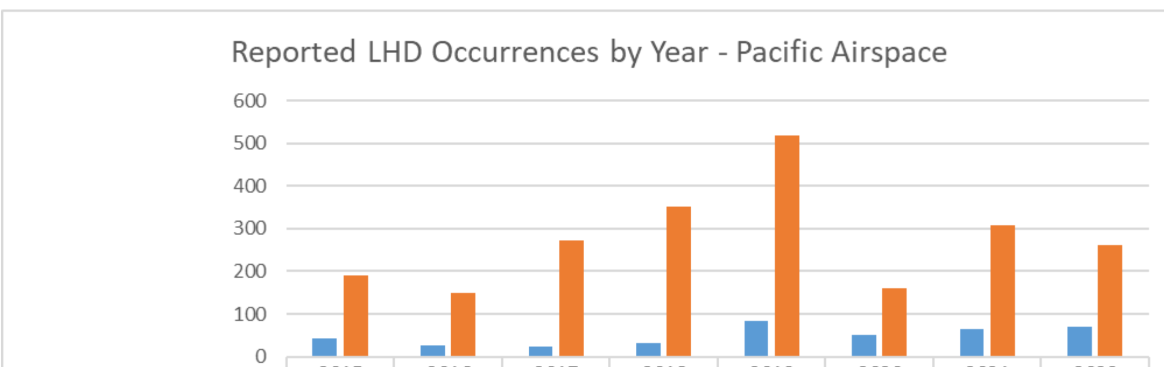


Figure 1. Summary of LHD occurrences by month for Pacific RVSM airspace –2022

3.3 The reported LHDs for Pacific Airspace provided to the PARMO in 2022 indicated there were **260.05 minutes** of operation at an incorrect or unexpected flight level. These data show an increase in the number of LHD reports received, and a decrease in the amount of time spent on incorrect flight levels compared to calendar year 2021. For comparison, the LHD reports provided to the PARMO within the recent eight-year period and associated time spent at incorrect flight level is provided in **Figure 2**.

3.4 The reported LHD durations and number of flight levels crossed are used to estimate vertical risk. The approximate locations of each reported LHD are needed so that the appropriate traffic flow characteristics can be applied to each event in the calculation of risk. **Table 4** provides the Pacific traffic flows and the corresponding descriptions.



	2015	2016	2017	2018	2019	2020	2021	2022
Number of LHD Reports	42	25	24	32	83	51	65	70
LHD Duration (min)	191	149	271	352.75	519	160.02	308.52	260.05

Figure 2. Numbers of LHD Reports Received and Associated LHD Duration

Table 4. Pacific Traffic Flows used for Vertical Collison Risk Estimation

Sub-Region of Pacific	Flow	Description of Flow
North Pacific	North Pacific (NOPAC)	North America to Japan/Korea/beyond plus Japan/Korea to and from Alaska and beyond
	Central Pacific (CENPAC)	Japan/Korea/other Asian origins east to North America
	Central East Pacific (CEP)	North American mainland to and from Hawaii
	Hawaii/Japan (JPHAWA)	Japan/Korea to and from Hawaii
	Japan/Guam (JPGUAM)	Japan/Korea to and from Guam/Saipan/other proximate destinations
	Other (OTHER)	All other North Pacific flights not covered above
South Pacific and Pacific trans-equatorial	Australia/New Zealand/South Pacific States (AUSNZSP)	Australia to and from New Zealand; Australia to and from South Pacific island states; New Zealand to and from South Pacific states
	Nadi (NADI)	Fiji to and from all airports except those in Australia or New Zealand
	Australia-New Zealand/Japan (AUSNZJP)	Australia to and from Japan/Korea; New Zealand to and from Japan/Korea
	South Pacific (SOPAC)	Australia to and from airports in northern hemisphere; New Zealand to and from airports in northern hemisphere

3.5 Long Duration Events

3.5.1 An LHD event with a duration of 20 minutes or more is a long duration event. There were **three** reported long durations LHD events in 2022. For comparison, there were also three long duration LHD events in calendar year 2021. A brief description of each reported long duration LHD follows.

3.5.2 One long duration LLD report involved an aircraft that flew for 57 minutes with an incorrect profile in the ATC automation system. The cause of this report is the use of published airspace fixes that are not in the ATC automation system causing the automation system to disregard those fixes. The LHD category D was assigned to this reported occurrence. This occurrence took place within the NOPAC traffic flow. These airspace fixes have since been removed from publications and there have been no repeat incidents.

3.5.3 There was a reported LHD with 47 minutes duration in February 2022. This occurrence involved ATC transfer errors between Fukuoka and Oakland for an aircraft operation within the Japan/Guam traffic flow (JPGUAM). The scrutiny group estimated that the aircraft spent 47 minutes of travel time in Oakland oceanic airspace before the Guam radar identified the aircraft. This LHD report was classified as category E, human error and the deletion of messages caused the missing transfer information. Both ATC units were notified of this occurrence.

3.5.4 There was a reported LHD with 26 minutes duration in March 2022. This occurrence took place within the JPGUAM traffic flow. The primary cause of this occurrence was miscommunication between the flight operation and ATC. In this case, ATC refers to multiple units, including Fukuoka, Guam and Oakland. All ATC units were informed on this LHD report. ATC did not have full information on this flight operation and assumed the aircraft involved was operating "due regard". This occurrence was classified as category M (other) with a secondary LHD code of 'STATE'.

3.6 **Table 5** and **Figure 3** summarize the number of LHD occurrences, the associated LHD duration (in minutes) and number of flight levels crossed without clearance, by LHD category from 1 January to 31 December 2022 inclusive for Pacific RVSM airspace. **Figure 4** provides a geographic chart with the approximate locations of the non-nil LHD reports. The circle size in Figure 4 represents the LHD duration.

3.7 **Table 5** and **Figure 3** show category E errors in ATC-to-ATC transfer is the top contributor to reported LHD occurrences during calendar year 2022. Figure 3 provides the observed trend in the numbers of reported LHDs by category over the current four-year period.

3.8 There is an overall increase in the number of reported LHDs in 2022 compared to 2021. However, the overall duration spent at the unexpected/incorrect flight level decreased from 2022 compared to 2021.

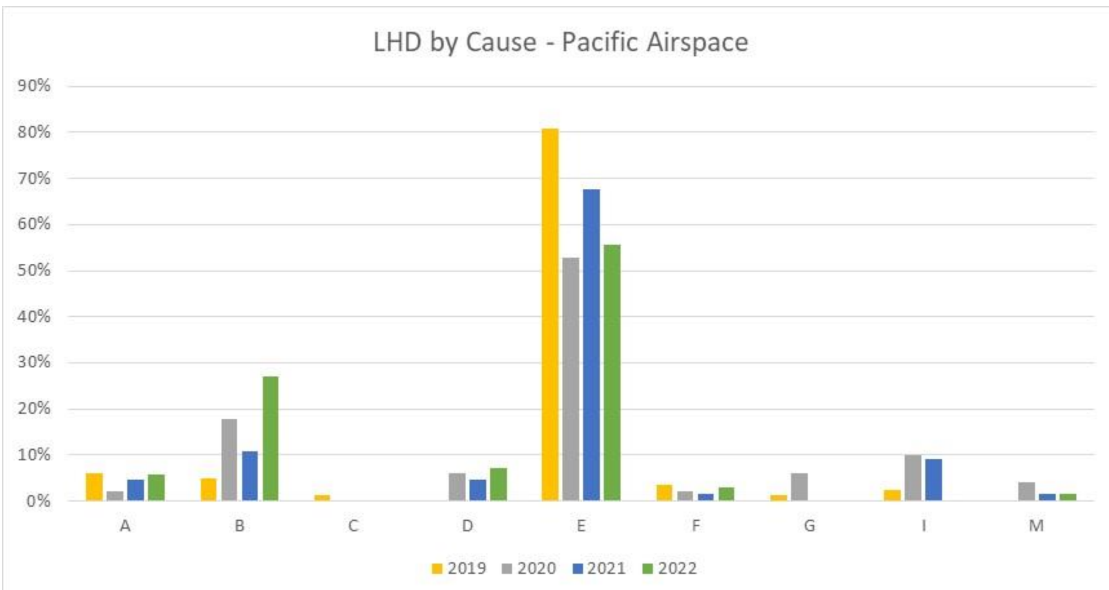


Figure 3. Summary of LHD causes for Pacific RVSM Airspace

Table 5. 12-month LHD reports by LHD category for Pacific RVSM airspace - 2022

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
A	Flight crew failing to climb/descend the aircraft as cleared;	4	3	3

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
B	Flight crew climbing /descending without ATC clearance;	19	3.5	44
C	Incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.)	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message);	5	59	10
E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route etc not in accordance with agreed parameters);	39	168.55	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues;	2	0	1
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure);	0	0	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level (e.g. altimetry errors)	0	0	0
I	Turbulence or other weather related causes	0	0	0
J	TCAS resolution advisory; flight crew correctly following the resolution advisory	0	0	0
K	TCAS resolution advisory; flight crew incorrectly following the resolution advisory	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
M	Other	1	26	0
	Totals	**70**	**260.05**	**58**

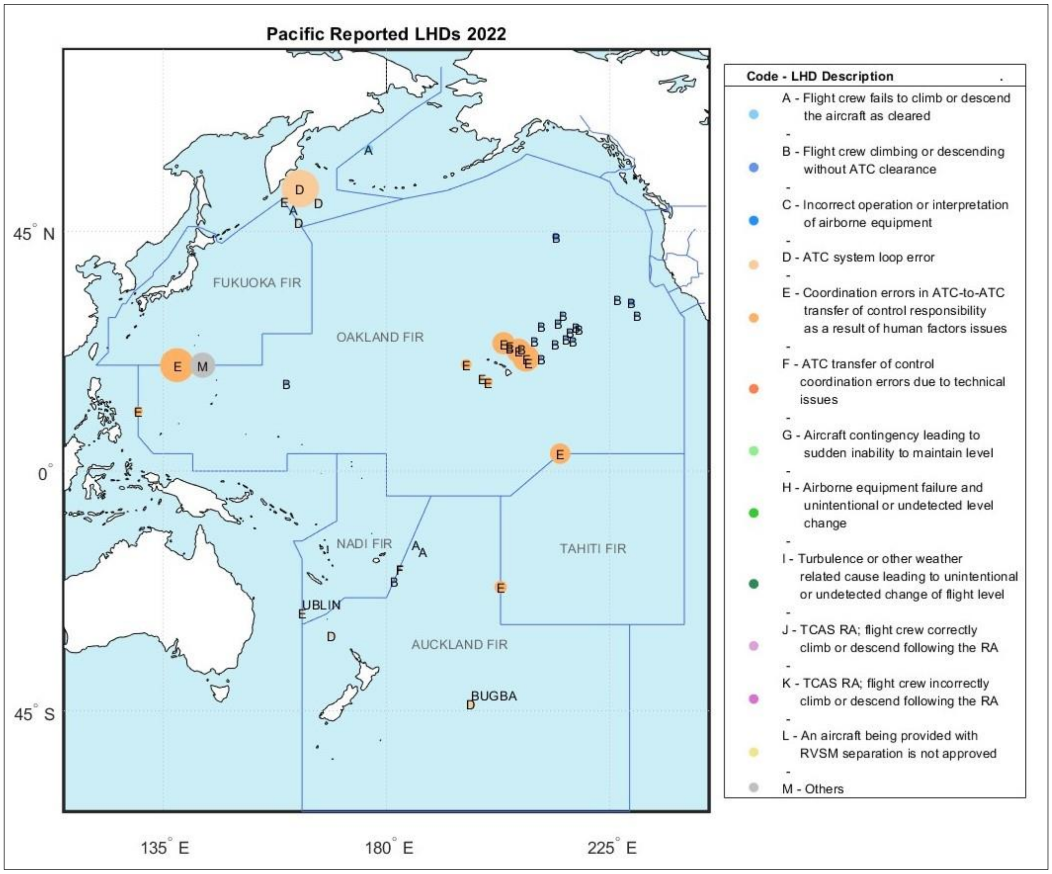


Figure 4. Pacific RVSM airspace LHD locations and durations - 2022

3.9 LHD Category with largest contribution towards vertical risk

3.9.1 The number of reported LHDs categorized as E for all Pacific airspace was forty-one. These reported occurrences represent more than half of all the reported LHDs for Pacific airspace in calendar year 2022. The reported LHD duration for category E reports is 65 percent of all reported LHD duration in calendar year 2022. Most of these occurrences were reported for aircraft transfers between Honolulu Control Facility (HCF) and Oakland ARTCC. There were six reported category E LHDs between different ATC facilities, these reports do not show a repeated pattern.

3.9.2 **Table 6** provides the LHD summary by Pacific traffic flow. The traffic flows listed in Table 6 are described earlier in Table 4. The values provided in Table 6 include the LHD duration in minutes by category code for each traffic flow. The fourth row in the table shows the CEP traffic flow has the largest LHD duration for 2022. Column E in Table 6 shows there were 169 minutes of LHD duration from reported category E LHDs in calendar year 2022.

Table 6. Sum of LHD Duration (minutes) by Pacific Traffic Flow and LHD category - 2022

Traffic Flow	A	B	D	E	F	M	Totals
AUSNZJP	0	0	0	0	0	0	**0**
AUNZSP	0	0	2	6	0	0	**8**

CENPAC	0	2	0	1.8	0	0	**3.78**
CEP	0	1.5	0	85	0	0	**86.93**
NOPAC	3	0	57	0	0	0	**60**
SOPAC	0	0	0	21	0	0	**21.18**
OTHER	0	0	0	7.1	0	0	**7.15**
AUSNZJP	0	0	0	0	0	0	**0**
NADI	0	0	0	0	0	0	**0**
JPGUAM	0	0	0	47	0	26	**73**
JPHAWA	0	0	0	0	0	0	**0**
Total	**3**	**3.5**	**59**	**169**	**0**	**26**	**260.05**

3.9.3 In 2022, the reported LHD with the longest duration, 57 minutes, was in the NOPAC traffic flow. This is the traffic flow that contains aircraft operations travelling between North America and Northern Asia. Although this 57-minute LHD category D report had the longest duration, it was not the reported LHD that had the largest impact on the vertical risk estimate. The vertical risk methodology considers the traffic densities within the Pacific traffic flows (listed in table 4). **Figure 5** shows the location and causal factors for all reported LHDs within Pacific airspace, the size of the circles in Figures 5 represents the individual vertical risk estimate for each reported LHD.

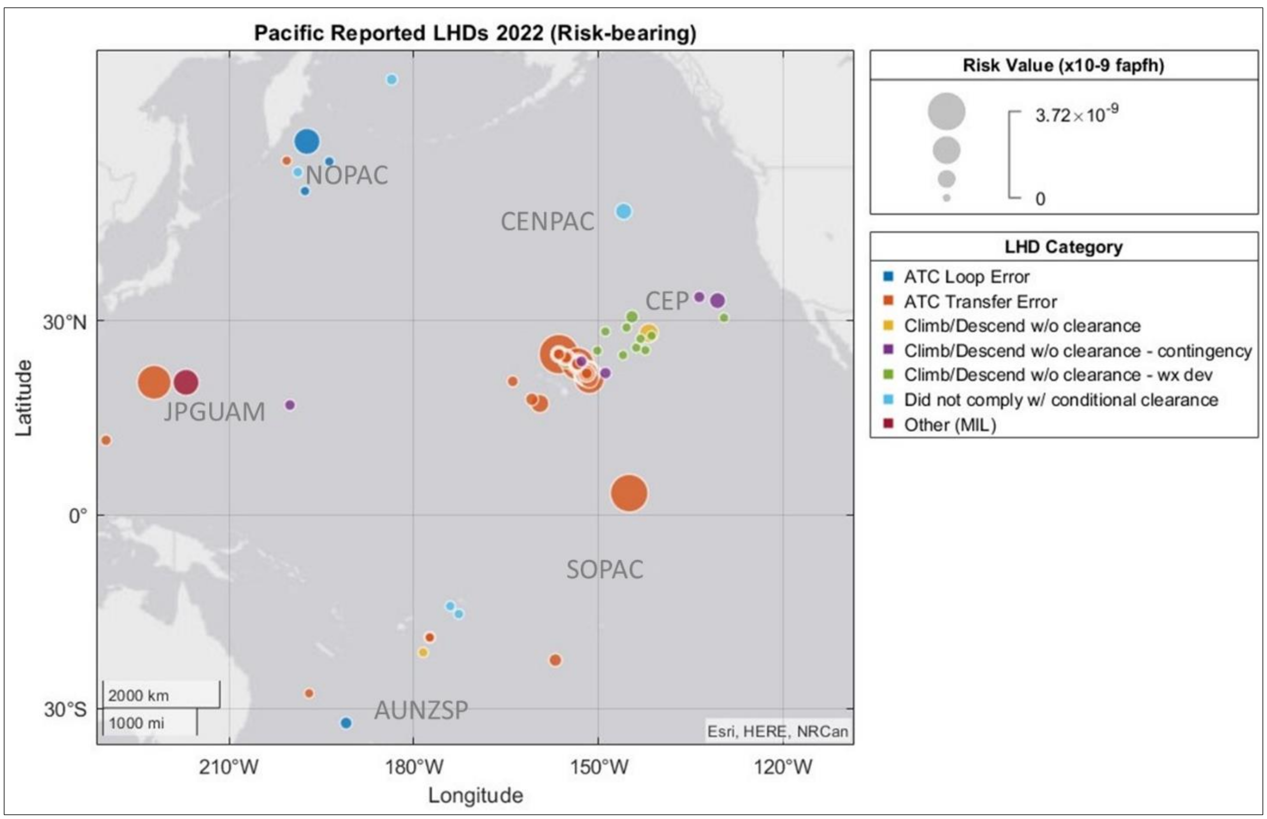


Figure 5. Pacific RVSM airspace LHD locations and vertical risk estimates - 2022

3.9.4 Figure 5 shows a cluster of reported LHDs within the CEP traffic flow, these are addressed in a separate paper.

3.9.5 The reported LHD that is the top contributor to the vertical risk estimate occurred within the CEP traffic flow and was a category E between the HCF and Oakland Oceanic ARTCC. The reported LHD duration was 15.70 minutes, this calculated vertical risk for this occurrence was 3.65×10^{-9} fapfh.

3.9.6 The second highest contribution was a 17-minute reported category E LHD between Tahiti and Oakland FIRs within the SOPAC traffic flow. Tahiti and Oakland have AIDC for automated transfers, the LOA provides backup procedures to be followed when the automated transfer fails. In this case, those backup procedures were not followed. The aircraft involved spent 17 minutes within the Oakland FIR until the profile was corrected, the calculated vertical risk for this occurrence was 3.34×10^{-9} fapfh.

3.9.7 The third highest contribution was a 47-minute category E LHD between Fukuoka and Oakland FIR within the JPGUAM traffic flow. Human error and the deletion of messages caused the missing transfer information. The aircraft involved spent 47 minutes within the Oakland FIR until the profile was corrected, the calculated vertical risk for this occurrence was 2.70×10^{-9} fapfh.

3.10 Reported Category E LHDs Between HCF and Oakland ARTCC

3.10.1 The reported LHDs for 2022 included many reports classified as category E for transfer errors between HCF and Oakland Oceanic FIR. There is a cluster of orange circle around Hawaii visible in Figure 5. The scrutiny review group informed PARMO these occurrences affect the user preferred routes (UPRs) crossing fixed airways within Oakland Oceanic FIR. These events occur frequently and require significant resources at the ATC facility to investigate underlying causes.

3.10.2 The available system data were examined for all the reported occurrences involving HCF and Oakland center. The operational experts from Oakland center determined whether there was any unprotected time within Oakland Oceanic FIR for each occurrence. First, the actual boundary crossing time was noted. Next, the time stamp for an update to the aircraft profile in the Oakland automation system was noted. If the aircraft profile was updated prior to the boundary crossing, the occurrence is considered a reported prevention and has zero duration. If the aircraft profile was updated after the boundary crossing, the occurrence has a non-zero duration and unprotected time within Oakland Oceanic FIR.

3.10.3 A task force was established to further investigate these occurrences and determine remedial actions, the task force met at the HCF early in 2021. The task force reviewed the current systems and procedures at the HCF. It was determined that the HCF does not have the functionality to update the aircraft profile and transfer the updated information to the next facility. The current automation system includes the Surveillance Data Processing (SDP) Microprocessor En Route Automated Radar Tracking System (Micro-EARTS) and the Offshore Flight Data Processing System (OFDPS). The FAA's offshore modernization plan had been delayed for many years due to higher priorities. The current plan to implement the En Route Automation Modernization (ERAM) system at the HCF by the end of 2025. Prior to that time, both facilities have implemented mitigation strategies:

3.10.3.1 A procedure that requires the controller to determine the remaining travel time to the boundary fix is in use by the HCF. During this procedure, ATC computes an estimated time of arrival (ETA) for the boundary fix and manually transfers the ETA to the next facility. It is noted that this is a manual procedure and is considered to be a short-term solution.

3.10.3.2 Oakland center has implemented refresher training for the oceanic controllers. This training instructs the controllers on how to update an aircraft's profile/fix times using the coordination window within the ATC automation system.

3.10.3.3 All of the reported occurrences of this type were validated by Oakland center using the radar information or ADS-C position information from the aircraft. There were extended periods in which the radar used for this validation was out of service, specifically from January 2022 through March 2022. During the outage periods, there are fewer reported occurrences due to the limited investigation and validation of such occurrences.

3.10.4 There were 82 reported category E occurrences between HCF and Oakland center in calendar year 2022. This is a decrease from the 98 reported category E occurrences received for calendar year 2021. Thirty-three of the 82 reports had a non-zero duration and are considered to be risk-bearing LHDs. The locations of these 33 reported LHDs are shown in **Figure 6**. The different colors indicate which traffic flow was affected by the reported occurrence, determined by the city pair. The reported LHD with locations to the east of Hawaii affect the Central East Pacific (CEP) traffic are colored in blue. The remaining traffic flows affected by these transfer errors include South Pacific (SOPAC) and OTHER traffic flows. The size of the circle at each boundary point represents the sum of the individual vertical risk estimates from all the reported category E LHDs. The vertical risk estimates by traffic flow for the LHDs depicted in Figure 6 are shown in **Table 7**.

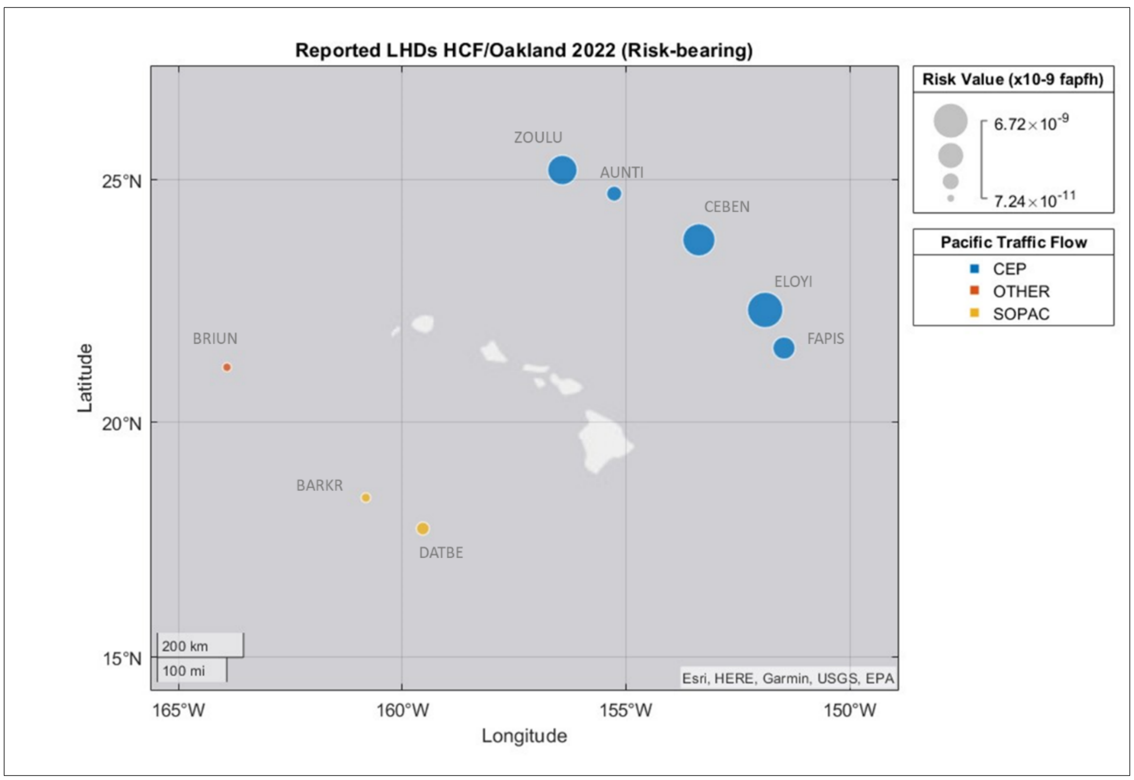


Figure 6. Reported LHDs transfer occurrences HCF – Oakland OCA (2022)

Table 7. Vertical Risk Estimates by Traffic Flow - HCF/Oakland Category E LHD Reports 2022

Traffic Flow	LHD Count	LHD Duration Sum (min)	Sum Vertical Risk Estimate (× 10^{-9} fapfh)
CEP	30	87.68	20.18
OTHER	1	4.150	0.07
SOPAC	2	3.72	0.73

3.10.5 **Table 7** shows the reported category E LHD reports affect the CEP traffic flow in both count and duration. The vertical risk estimate is influenced by both the total duration of the LHD events as well as the high level of traffic density in that area. The sum of the vertical risk estimates shown in Table 7 represents 64 percent of the overall vertical risk estimate for Pacific airspace in 2022.

3.11 Pacific Traffic Counts

3.11.1 The methodology used to estimate vertical risk in Pacific airspace takes into account the location of the reported LHDs. The TSD is used to estimate flying hours and traffic densities separately for different areas within Pacific airspace. The identified traffic flows in Pacific airspace are provided in Table 4. For example, the CEP traffic flow contains aircraft operations travelling between North America and Hawaii. In 2022, the CEP traffic flow had the highest number of flight operations and flying hours compared to all other areas identified in Pacific airspace. The associated traffic flow for each event is based on the origin and destination city pair for the aircraft involved. **Figure 7** shows the numbers of flights observed by month for selected traffic flows, these data are sourced from Anchorage and Oakland oceanic centers. The CEP traffic flow (light blue line in Figure 7) shows the largest decrease in traffic from March 2020 to April 2020. The remaining traffic flows shown in Figure 7, including CENPAC and SOPAC traffic flows, show decreases in traffic related to COVID-19 and continued traffic volume below 2019 levels.

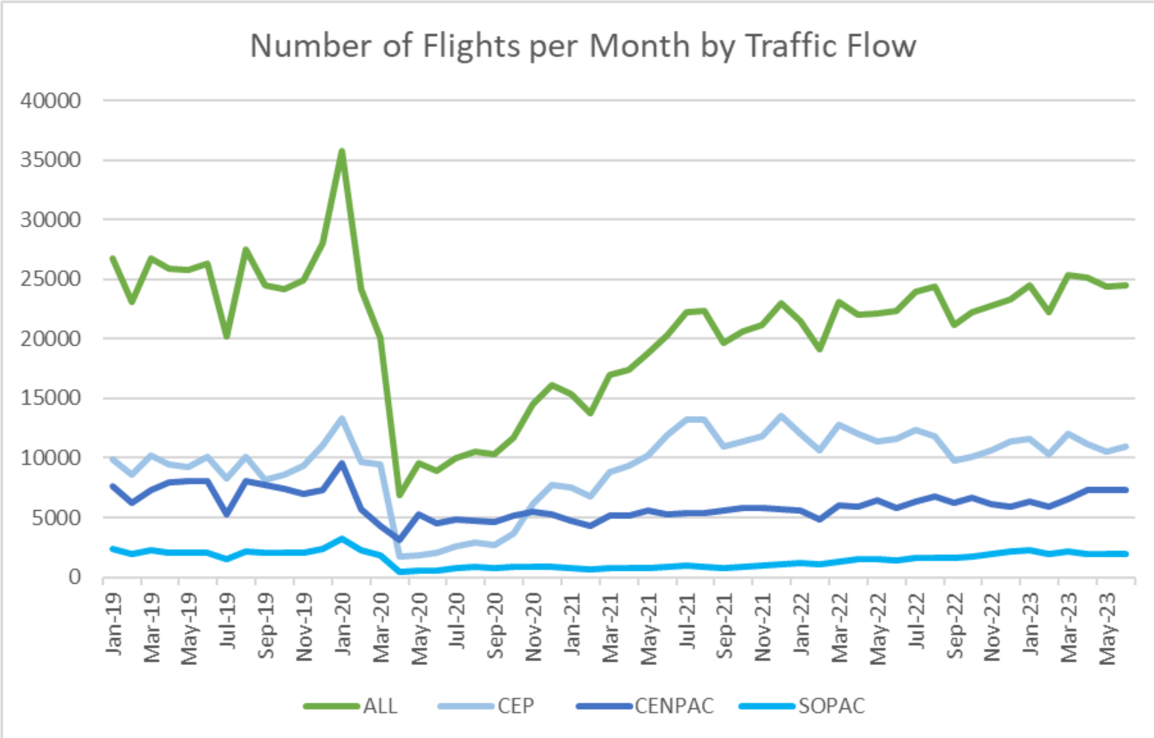


Figure 7. Number of Flights per Month by Traffic Flow

3.12 North East Asia RVSM Airspace

3.12.1 **Table 8** summarizes the number of LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed by month from 1 January 2021 to 31 December 2022 inclusive for Incheon airspace. There were 108 reported LHDs in calendar year 2022, all reported occurrences have zero duration and zero flight levels crossed without ATC clearance. All of the reported occurrences were within the AKARA corridor airspace and will be examined in a separate paper. There were no reported LHD occurrences from other areas within the Incheon FIR during calendar year 2022.

Table 8. Summary of reported LHD occurrences and duration for North East Asia RVSM airspace

Month-Year	No. of LHD	LHD Duration (min)	No. Levels Crossed
2022			
January	9	0	0
February	4	0	0
March	3	0	0
April	0	0	0
May	3	0	0
June	6	0	0
July	5	0	0
August	24	0	0
September	20	0	0

Month-Year	No. of LHD	LHD Duration (min)	No. Levels Crossed
2022			
October	18	0	0
November	13	0	0
December	3	0	0
Total	108	0	0

4. Risk Assessment and Safety Oversight

4.1 Pacific RVSM airspace

4.2 **Collision Risk Model (CRM) Parameters**

4.3 The value of the parameters in the CRM used to estimate risk in Pacific RVSM airspace, are summarized in **Table 9**. Other collision risk model parameters that vary by traffic flow include aircraft size, occupancy values, and flying hours. These parameters are shown in **Table 10** by traffic flow. Table 4 contains a listing and description for each traffic flow.

Table 9. Estimates of the parameters in the CRM for Pacific RVSM airspace

Parameter	Description	Value
$\overline{\lvert \Delta V \rvert}$	Average relative same-direction speed	13 Knots
$\overline{\lvert V \rvert}$	Average aircraft speed	480 knots
$\overline{\lvert \dot{y} \rvert}$	Average relative cross-track speed	5 knots
$\overline{\lvert \dot{z} \rvert}$	Average relative vertical speed during loss of vertical separation	1.5 knots
$P_z(0)$	Probability two aircraft at the same nominal level are in vertical overlap	0.42
$Pz(1000)$	Probability two aircraft nominally separated by 1 000 ft are in vertical overlap	4.68×10^{-9}

Table 10. Vertical CRM Parameters that Vary by Traffic Flow

Traffic Flow	Annual Flying Hours	Percent	Average Aircraft Length, λx (NM)	Average Aircraft Wingspan, λy (NM)	Average Aircraft Height, λz (NM)	Same Direction Vertical Occupancy, *Ez(Same)*	Opposite Direction Vertical Occupancy, *Ez(Opp)*
NOPAC	238,655	16.1%	0.037	0.034	0.010	0.532	0.001
CENPAC	342,739	23.1%	0.037	0.035	0.010	0.327	0.088
CEP	474,687	32.0%	0.026	0.023	0.007	0.529	0.109
JPHAWA	30,837	2.1%	0.033	0.031	0.009	0.291	0.003
JPGUAM	6,335	0.4%	0.025	0.023	0.008	0.003	0.030
OTHER	15,213	1.0%	0.030	0.027	0.008	0.238	0.003

AUSNZSP	86,860	5.9%	0.025	0.023	0.007	0.027	0.015
NADI	27,577	1.9%	0.031	0.030	0.009	0.027	0.015
AUSNZJP	39,966	2.7%	0.034	0.033	0.009	0.067	0.037
SOPAC	219,180	14.8%	0.034	0.033	0.009	0.137	0.099
TOTAL	1,482,049	100.0%	0.032 NM	0.029 NM	0.009 NM		
			192.5 ft	***178.0 ft***	***52.7 ft***		

4.4 **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM airspace are detailed in **Table 11**. The technical risk meets the agreed target level of safety (TLS) value of no more than 2.5×10^{-9} fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft and to all causes. **The operational and weighted total risk exceeds the specified TLS value** for these components of 5.0×10^{-9} fapfh.

Table 11. Pacific Airspace Risk Estimates

Pacific Airspace – estimated annual flying hours = 1,482,049 hours ***(note: estimated hours based on Dec 2022 traffic sample data)***			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 26 Total Risk	28.21×10^{-9}	5.0×10^{-9}	*Above TLS*
Technical Risk	0.14×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	32.4×10^{-9}	-	-
Total Risk	$\mathbf{32.6 \times 10^{-9}}$	5.0×10^{-9}	**Above TLS**

4.5 **Figure 8** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports. The largest contributors to the vertical collision risk estimate are the reported LHD category E occurrences involving HCF and Oakland center. This specific set of reported LHDs account for 64 percent of the total risk estimate. The total vertical risk estimate without these category E reported LHDs would be 11.6×10^{-9} fapfh. In addition to the removal of the category E occurrences involving HCF and Oakland center, if the two largest duration LHDs (described in section 3.5) are also removed, the vertical risk estimate would be 5.6×10^{-9} fapfh.

4.6 The increase in the vertical risk estimate is directly related to the increase in the time spent at unexpected flight levels.

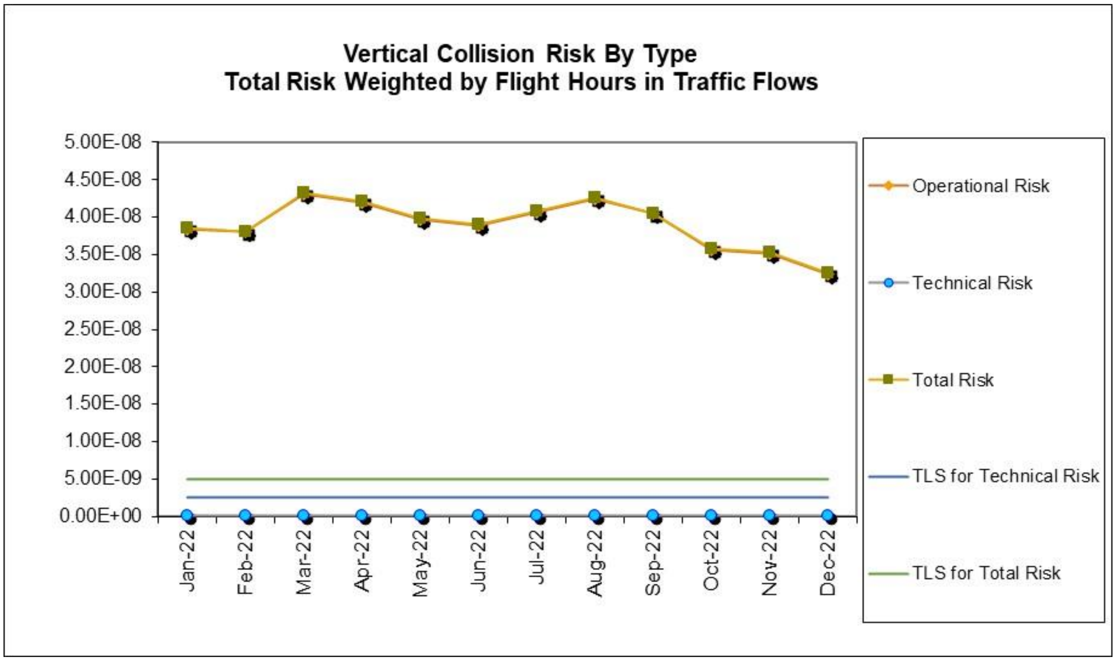


Figure 8. Trends of Risk Estimates for Pacific RVSM Airspace

4.7 North East Asia RVSM airspace

4.8 **Collision Risk Model (CRM) Parameters**

4.9 The value of the parameters in the CRM used to estimate risk in North East Asia RVSM airspace, are summarized in **Table 12**.

Table 12. Estimates of the parameters in the CRM for North East Asia RVSM airspace

Parameter	**Description**	**Value**
λ_x	Average aircraft length	0.034 NM
λ_y	Average aircraft wingspan	0.031 NM
λ_z	Average aircraft height	0.009 NM
$\overline{\|\Delta V\|}$	Average relative same-direction speed	38.3 Knots
$\overline{\|V\|}$	Average aircraft speed	480 knots
$\overline{\|\dot{y}\|}$	Average relative cross-track speed	5 knots
$\overline{\|\dot{z}\|}$	Average relative vertical speed during loss of vertical separation	1.5 knots
$P_z(0)$	Probability two aircraft at the same nominal level are in vertical overlap	0.42
Pz(1000)	Probability two aircraft nominally separated by 1 000 ft are in vertical overlap	4.68×10^{-9}
Ez(Same)	Same direction vertical occupancy value	0.2410
Ez(Opp)	Opposite direction vertical occupancy value	0.0153

4.10 **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 13**. The technical risk meets the agreed TLS value of no more than 2.5×10^{-9} fatal accidents per flight hour due to the loss of a correctly established vertical separation standard of 1,000 ft and to all causes. **The operational and weighted total risk meets the specified TLS value** for these components of 5.0×10^{-9} fapfh.

4.11 **Figure 9** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports.

Table 13. North East Asia RVSM Airspace Risk Estimates

North East Asia Airspace – estimated annual flying hours = 114,005.7 hours *(note: estimated hours based on Dec 2022 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 27 Total Risk	*0.04×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Technical Risk	0.09×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	**0.09×10^{-9}**	5.0×10^{-9}	**Below TLS**

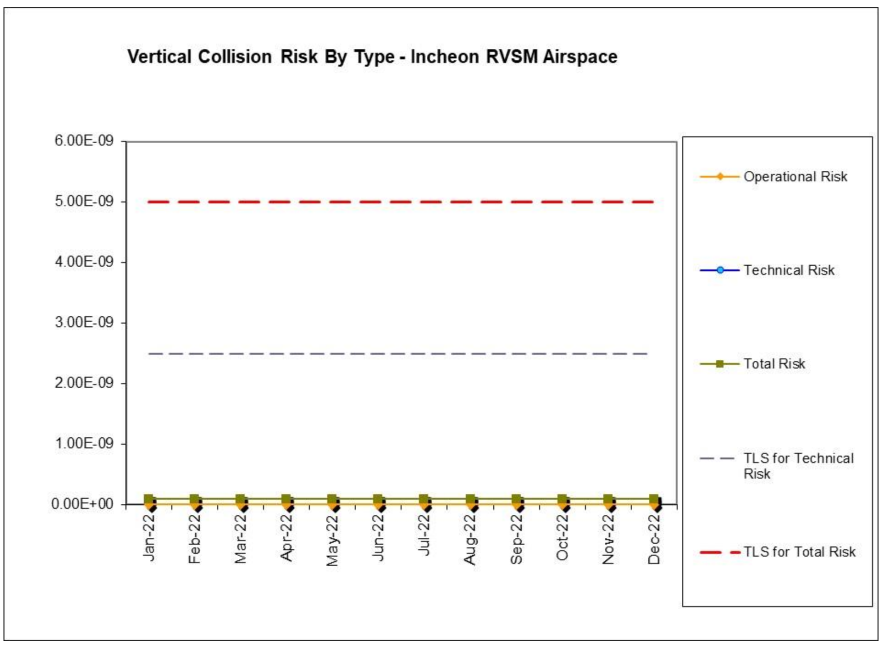


Figure 9. Trends of Risk Estimates for North East Asia RVSM Airspace