*International Civil Aviation Organization*

**Thirtieth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/30)**

Bangkok, Thailand, 14 – 17 July 2025

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

# PARMO VERTICAL SAFETY MONITORING REPORT 2024

(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 January to December 2024. There are a total of 90 reported large height deviations (LHDs) accounting for 880.5 minutes of operation at incorrect flight level in Pacific airspace and 123 reported occurrences for North East Asia RVSM airspace. This report also contains an estimate of the vertical collision risk. The 2024 vertical collision risk estimate for Pacific airspace exceeds the target level of safety (TLS) value of $5.0 \times 10^{-9}$ fatal accidents per flight hour. The 2024 vertical collision risk estimate for North East Asia airspace meets the TLS value of $5.0 \times 10^{-9}$ 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 period January to December 2024. This paper contains a summary of large height deviation reports, and estimates of vertical risk for Pacific and North East Asia airspace.

## 2. DISCUSSION

2.1 **Attachment A** contains the PARMO Vertical Safety Monitoring Report for January to December 2024.

Executive Summary

2.2 **Table 1** summarizes Pacific airspace RVSM technical, operational, and total risks. **Figure 1** presents collision risk estimate trends during the period from January 2024 to December 2024.

**Table 1:** Pacific Airspace RVSM Risk Estimates

| **Pacific Airspace – estimated annual flying hours = 1,933,809 hours** *(note: estimated hours based on Dec 2024 traffic sample data)* | | | |
|---|---|---|---|
| **Source of Risk** | **Risk Estimation** | **TLS** | **Remarks** |
| *RASMAG 29 Total Risk* | *$18.6 \times 10^{-9}$* | *$5.0 \times 10^{-9}$* | *Above TLS* |
| Technical Risk | $0.08 \times 10^{-9}$ | $2.5 \times 10^{-9}$ | Below Technical TLS |
| Operational Risk | $25.3 \times 10^{-9}$ | - | - |
| Total Risk | **$25.4 \times 10^{-9}$** | $5.0 \times 10^{-9}$ | **Above TLS** |

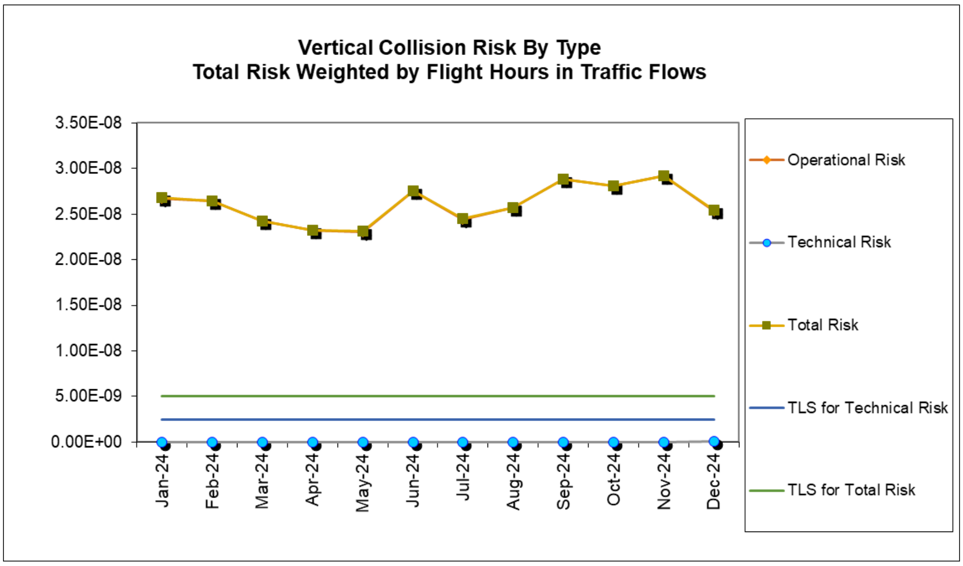


**Figure 1:** Pacific Airspace RVSM Risk Estimate Trends

2.3 **Table 2** presents a summary of the LHD causes within Pacific airspace from 01 January 2024 until 31 December 2024.

**Table 2**: Summary of LHD Causes within Pacific Airspace

| **Code** | **LHD Category Description** | **No.** |
|---|---|---|
| A | Flight crew fails to climb or descend the aircraft as cleared | 2 |
| B | Flight crew climbing or descending without ATC clearance | 24 |
| C | Incorrect operation or interpretation of airborne equipment | 3 |
| D | ATC system loop error | 3 |
| E | Coordination errors in the ATC -to-ATC transfer of control responsibility as a result of human factors issues (transfer information was incorrect or late/non-existent) | 53 |
| F | ATC transfer of control coordination errors due to technical issues | 3 |
| 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 | 2 |
| **Total** | | **90** |

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

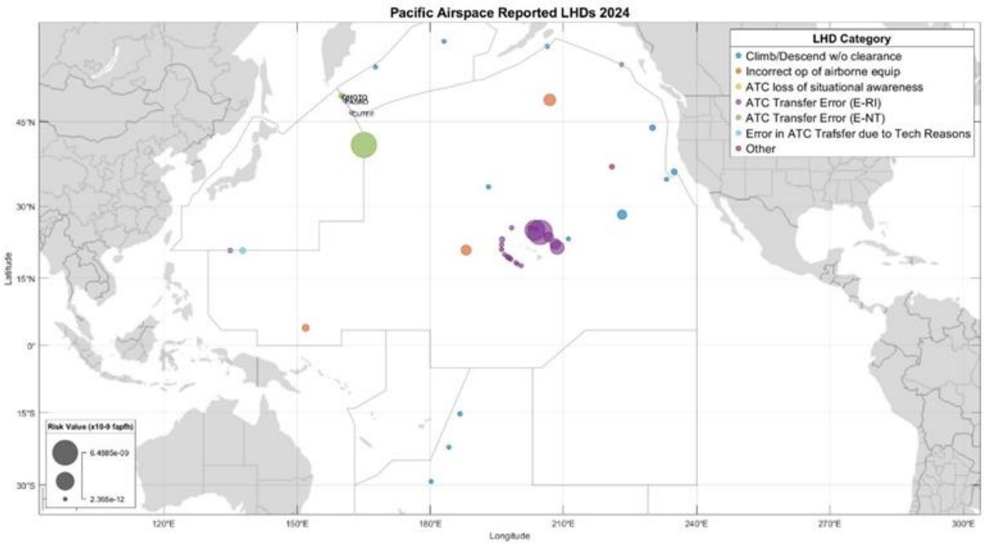


**Figure 2: Pacific Airspace – Risk Bearing LHD**

2.5 The highest contributor towards the vertical risk estimate is one long duration occurrence within the CENPAC traffic flow and the errors in ATC coordination between Oakland Center and Honolulu Control Facility. The reported ATC coordination occurrences between Oakland Center and Honolulu Control Facility are part of the Hot Spot N area and are covered in a separate paper to this meeting.

North East Asia Airspace

2.6 **Table 3** summarizes North East Asia airspace RVSM technical, operational, and total risks. **Figure 3** presents collision risk estimate trends during the period from January to December 2024.

**Table 3:** North East Asia Airspace RVSM Risk Estimates

| **North East Asia Airspace – estimated annual flying hours = 197,565.8 hours** ***(note: estimated hours based on Dec 2024 traffic sample data)*** | | | |
|---|---|---|---|
| **Source of Risk** | **Risk Estimation** | **TLS** | **Remarks** |
| *RASMAG 29 Total Risk* | *$0.17 \times 10^{-9}$* | *$5.0 \times 10^{-9}$* | *Below TLS* |
| Technical Risk | $0.56 \times 10^{-9}$ | $2.5 \times 10^{-9}$ | Below Technical TLS |
| Operational Risk | $0.00 \times 10^{-9}$ | - | - |
| Total Risk | $\mathbf{0.56 \times 10^{-9}}$ | $5.0 \times 10^{-9}$ | **Below TLS** |

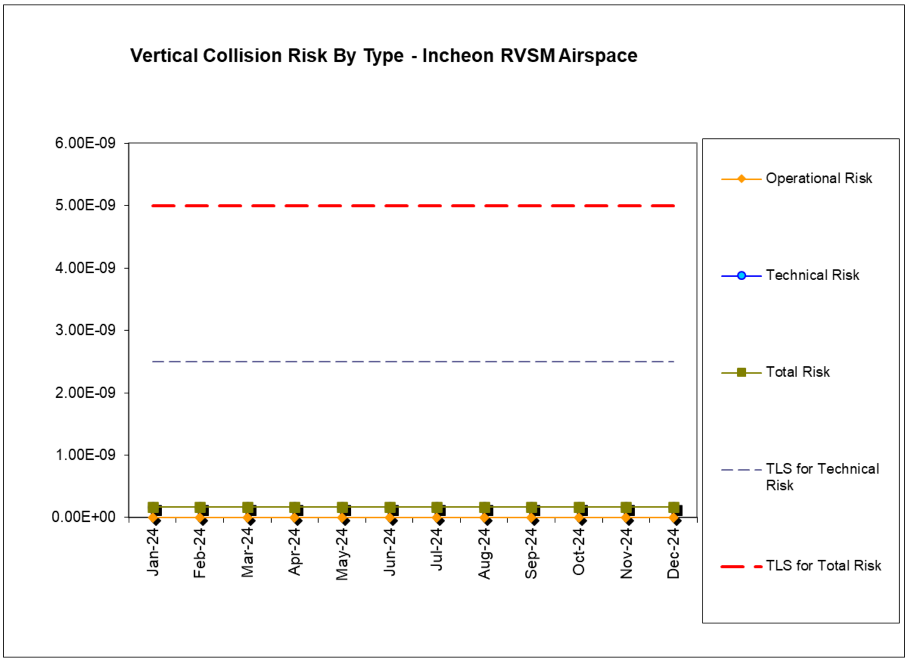


**Figure 3:** North East Asia Airspace RVSM Risk Estimate Trends

2.7 **Table 4** presents a summary of the LHD causes within North East Asia Airspace from January through December 2024. There were 123 reported LHDs affecting the Incheon FIR, all reported occurrences have zero duration and zero flight levels crossed without ATC clearance. These reported occurrences are within the AKARA corridor airspace and are examined in a separate paper.

**Table 4**: Summary of LHD Causes within North East Asia Airspace

| Code | LHD Category Description | No. |
|---|---|---|
| A | Flight crew fails to climb or descend the aircraft as cleared | 0 |
| B | Flight crew climbing or descending without ATC clearance | 0 |
| C | Incorrect operation or interpretation of airborne equipment | 0 |
| D | ATC system loop error | 0 |
| E | Coordination errors in the ATC -to-ATC transfer of control responsibility<br>as a result of human factors issues | 123 |
| 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 | | 123 |

2.8 **Figure 4** provides the geographic location of LHD reports within North East Asia during the assessment period. There were 120 reports at the SADLI fix location, 2 reports at the ONIKU fix and 1 report at the ATOTI fix. All reported LHDs indicated risk was mitigated by available surveillance and direct speech circuit, or other means.

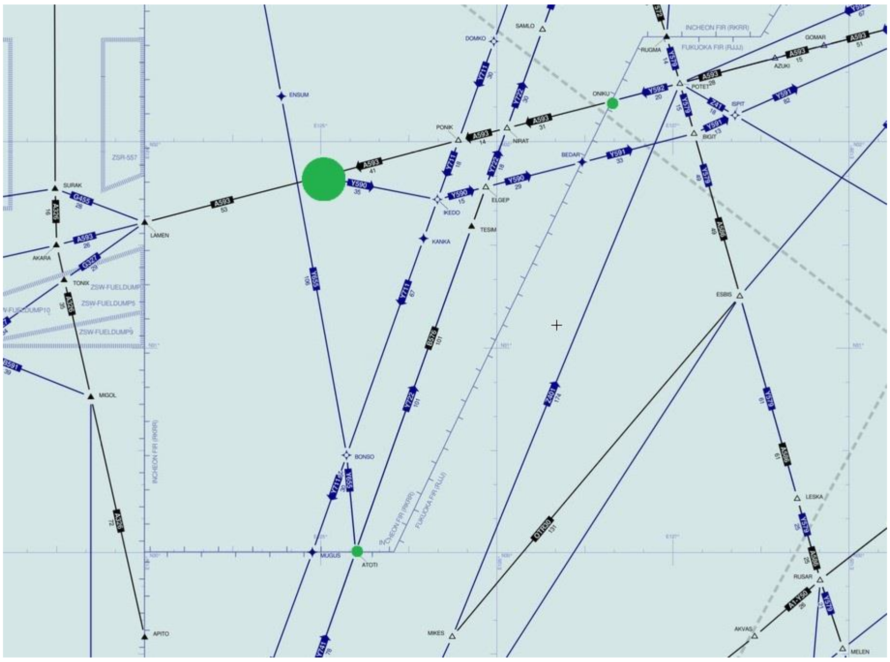


**Figure 4**: North East Asia Airspace – Risk Bearing LHD

## 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 to December 2024

**Prepared by**
**Pacific Approvals and Registry Monitoring Organization (PARMO) –** ***July 2025***
***(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 2024 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 2024 TSD Submitted to PARMO

| FIR | December 2024 TSD Submitted to PARMO |
|---|---|
| Anchorage | X |
| Auckland | X |
| Incheon[1] | X |
| Nadi | X |
| Oakland | X |
| Tahiti[2] | X |

2.2 **Large Height Deviation (LHD).** A cumulative 12-month data set of LHD reports was used, covering January to December 2024. **Table 2** indicates those FIRs which submitted LHD reports including nil reports. All FIRs submitted LHD reports needed to compute the 2024 vertical operational risk estimates.

**Table 2.** Summary of LHD Reports submitted by FIRs

| | Anchorage | Auckland | Incheon | Nadi | Oakland | Tahiti |
|---|---|---|---|---|---|---|
| Jan 2024 | X | X | X | X | X | X |
| Feb 2024 | X | X | X | X | X | X |
| Mar 2024 | X | X | X | X | X | X |
| Apr 2024 | X | X | X | X | X | X |
| May 2024 | X | X | X | X | X | X |
| Jun 2024 | X | X | X | X | X | X |
| Jul 2024 | X | X | X | X | X | X |
| Aug 2024 | X | X | X | X | X | X |
| Sep 2024 | X | X | X | X | X | X |

[1] Incheon provided PARMO with two TSD; June and December 2024
[2] Tahiti provided PARMO with four TSD; March, June, September and December 2024

| | Anchorage | Auckland | Incheon | Nadi | Oakland | Tahiti |
|---|---|---|---|---|---|---|
| Oct 2024 | X | X | X | X | X | X |
| Nov 2024 | X | X | X | X | X | X |
| Dec 2024 | 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 January to December 2024 inclusive for Pacific airspace.

**Table 3.** Summary of reported LHD occurrences and duration for Pacific RVSM airspace – Year 2024

| Month | No. of LHD | LHD Duration (min) | No. Levels Crossed |
|---|---|---|---|
| **2024** | | | |
| January | 19 | 108.3 | 4 |
| February | 2 | 10.7 | 3 |
| March | 6 | 0 | 1 |
| April | 4 | 105.1 | 8 |
| May | 0 | 0 | 0 |
| June | 11 | 160.7 | 1 |
| July | 10 | 41.1 | 1 |
| August | 8 | 307.3 | 0 |
| September | 11 | 62.4 | 2 |
| October | 6 | 28 | 4 |
| November | 11 | 50.1 | 3 |
| December | 2 | 6.8 | 0 |
| **Total** | **90** | **880.5** | **27** |

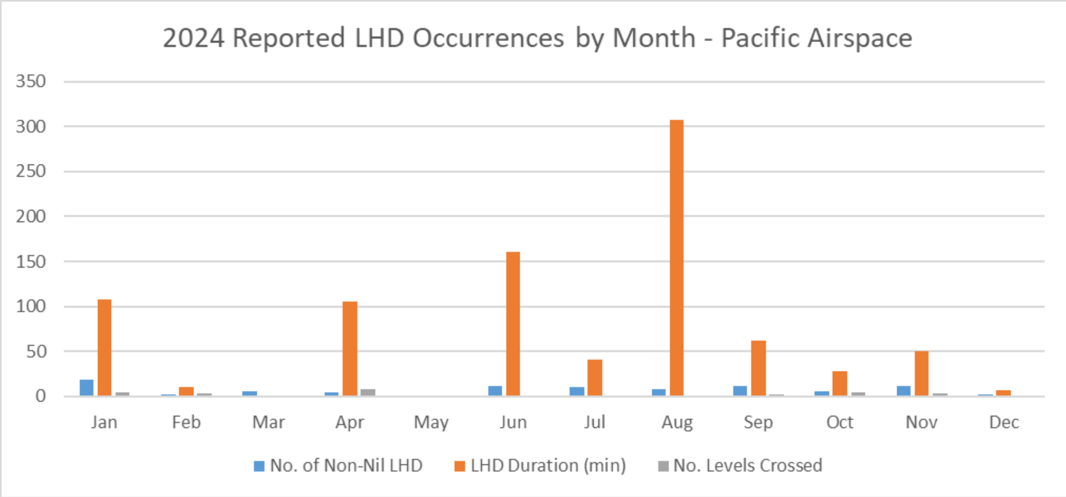


**Figure 1.** Summary of LHD occurrences by month for Pacific RVSM airspace –2024

3.3 The reported LHDs for Pacific Airspace provided to the PARMO in 2024 have **880.5 minutes** of operation at an incorrect or unexpected flight level. These data show an increase in the number of LHD reports received and a significant increase in the amount of time spent on incorrect flight levels compared to calendar year 2023. For comparison, the LHD reports provided to the PARMO within the recent 10-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.

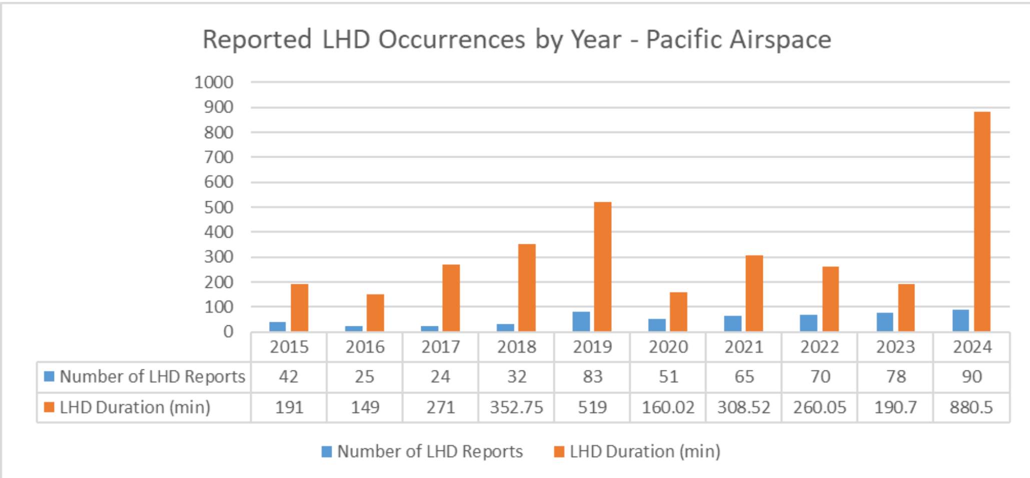


**Figure 2.** Numbers of LHD Reports Received and Associated LHD Duration

**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 (AUNZSP) | 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 (AUNZJP) | 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 **five** reported long durations LHD events in 2024. For comparison, there were three long duration LHD events in each of the calendar years 2021, 2022, and 2023. A brief description of each reported long duration LHD follows.

3.5.2 One long duration LHD report involved an aircraft in the low-density OTHER traffic flow. The aircraft operator had another aircraft within the CEP traffic flow with the same flight identification. The ATC automation system provided alerts for multiple uses of the same flight identification in the airspace, but those messages were not acted on appropriately. The ATC automation system protected the profile for the flight operation within the CEP traffic flow. The flight operation with the unprotected profile flew within a much lower density area of the airspace for 240 minutes. The impact on the collision risk estimate for this occurrence was not significantly affected due to the low density of the airspace. The LHD category C was assigned to this reported occurrence, with a D sub-category. Planned enhancements to the ATC automation software will prevent multiple aircraft with the same flight identification to be in the airspace at the same time. In addition, ATC refresher training was also done as a result of this occurrence.

3.5.3 There was a long duration LHD reported with 100 minutes duration within the CENPAC traffic flow. This occurrence involved an error in the transfer between adjacent ATC units and a flight plan that had timed out of the ATC automation system. The LHD category assigned to this report was E with a sub-category of E-NT to indicate there was no ATC transfer for this operation. In addition, another sub-category of M (other) was assigned. The note for category M relates to the ATC automation parameter that specifies the time the system maintains a flight plan. As a result of this occurrence, changes were made to extend the time the ATC automation parameter maintains filed flight plans in the system.

3.5.4 There was a long duration LHD reported with 90 minutes duration within the OTHER traffic flow. This report was assigned category C. In this occurrence the pilot was following a different routing that expected by ATC. This occurrence affected the ATC transfer into adjacent airspace. The impact on the collision risk estimate for this occurrence was not significantly affected due to the low density of the airspace.

3.5.5 There was a long duration reported LHD with 45 minutes duration with the Japan-Guam traffic flow. This occurrence involved non-normal coordination between two ATC units. The aircraft operation was diverting to another airport, but this was misunderstood by ATC, language was a barrier in the voice communication. The impact on the collision risk estimate for this occurrence was not significantly affected due to the low density of the Japan-Guam traffic flow. This occurrence was classified as category E, with a sub-category of E-RI, no revision to the boundary time for the ATC coordination. An additional LHD sub-category D was assigned to denote the ATC loss of situational awareness.

3.5.6 There was another long duration reported LHD with 45 minutes duration within the NOPAC traffic flow. This occurrence was caused by the ATC automation system holding onto a flight plan from the previous day. Multiple warning messages were not actioned by ATC during the occurrence. As a result of this occurrence, changes were made to the ATC automation system that will prevent future occurrences. In addition, ATC refresher training was also done because of this occurrence. This occurrence was classified as category D.

3.5.7 There was a reported LHD with one level crossed and 19 minutes duration within the CENPAC traffic flow. This occurrence was caused by the aircraft being incorrectly connected to the ARINC test bench and not the oceanic ARTCC. A data link problem report (PR) was opened to investigate this event. This occurrence was classified as category C.

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 2024 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 contribution towards the vertical collision risk estimate at each reported LHD location.

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 2024. The category E subcategories for no revision to the coordination, E-RI, and no ATC coordination, E-NT, are denoted in Table 5. Figure 3 provides the observed trend in the numbers of reported LHDs by category over the current five-year period.

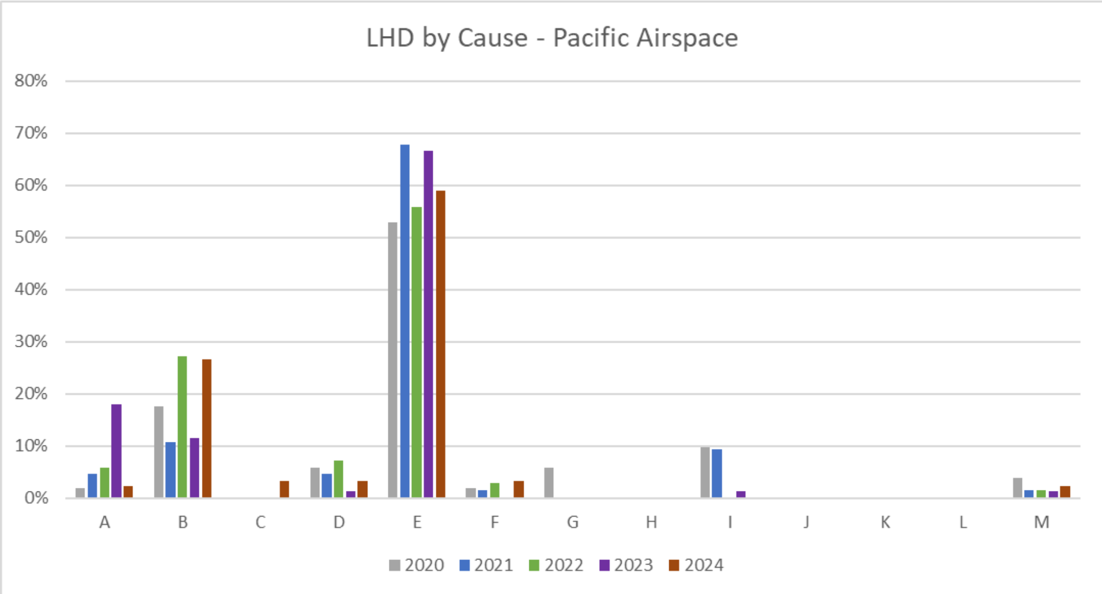


**Figure 3.** Summary of LHD causes for Pacific RVSM Airspace

**Table 5.** 12-month LHD reports by LHD category for Pacific RVSM airspace - 2024

| 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; | 2 | 0.0 | 0 |
| B | Flight crew climbing /descending without ATC clearance; | 24 | 27.0 | 23 |
| 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.) | 3 | 349.0 | 1 |
| D | ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message); | 3 | 72.1 | 0 |
| E, E-RI | Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility as a result of human factors issues (incorrect time estimate/actual, flight level, ATS route etc not in accordance with agreed parameters); | 52 | 314.4 | 1 |
| E, E-NT | Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility as a result of human factors issues (late or non-existent coordination); | 1 | 100.0 | 0 |
| F | Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues; | 3 | 18.0 | 0 |
| G | Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure); | 0 | 0.0 | 0 |

| LHD Category Code | LHD Category Description | No of LHD Occurrences | LHD Duration (Min) | No. of Flight Levels Transitioned Without Clearance |
|---|---|---|---|---|
| H | Airborne equipment failure leading to unintentional or undetected change of flight level (e.g. altimetry errors) | 0 | 0.0 | 0 |
| I | Turbulence or other weather-related causes | 0 | 0.0 | 0 |
| J | TCAS resolution advisory; flight crew correctly following the resolution advisory | 0 | 0.0 | 0 |
| K | TCAS resolution advisory; flight crew incorrectly following the resolution advisory | 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 |
| M | Other | 2 | 0.0 | 2 |
| | **Totals** | **90** | **880.5** | **27** |

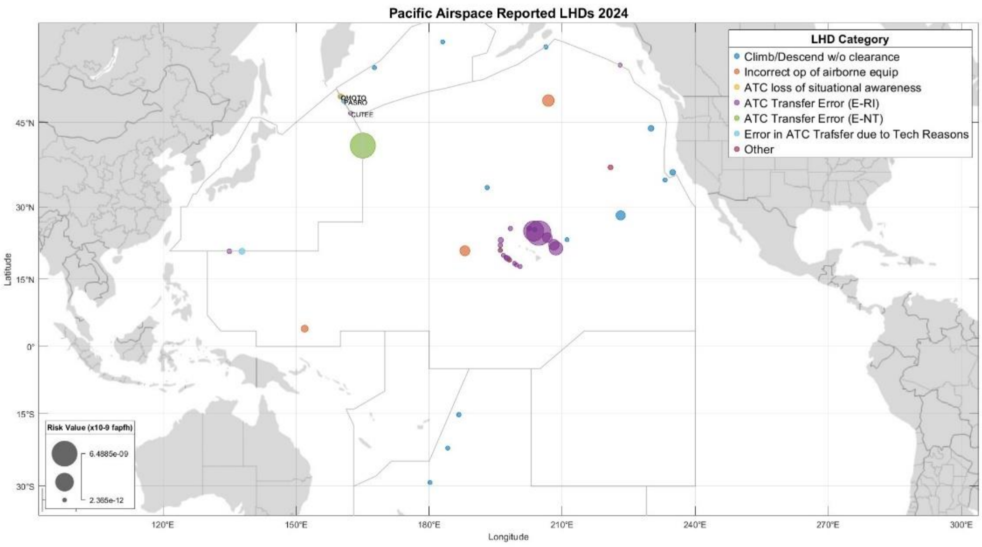

**Figure 4.** Pacific RVSM airspace LHD locations and Risk Estimates - 2024

3.8 <u>LHD Category B</u>

3.8.1 There were 24 reported LHDs assigned to category B, flight crew climbing/descending without ATC clearance.

3.8.2 Nine of the category B LHDs were marked as involving a weather deviation. These occurrences were reported with the CENPAC (3), CEP (3), JPHAWA (2), and NOPAC (1) traffic flows.

3.8.3 Two of the category B LHDs occurred within the CEP traffic flow and were marked as involving an aircraft emergency. One report indicated 8 flight levels and the other indicated 3 flight levels were descended through without clearance. Both reports indicated the descend speed was rapid.

3.8.4 The remaining thirteen category B reports were not assigned a sub-category.

3.9 LHD Category with largest contribution towards vertical risk

3.9.1 The number of LHDs assigned to category E and subcategory of E-RI, no revision to the transfer information, for all Pacific airspace was fifty-two. These reported occurrences represent more than half of all the reported LHDs, 57%, for Pacific airspace in calendar year 2024. Most of these occurrences were reported for aircraft transfers between Honolulu Control Facility (HCF) and Oakland ARTCC. There were eight reported LHDs involving ATC transfers between other ATC facilities, but these reports do not show a repeated pattern. **Figure 5** shows the comparison of vertical Collision Risk Estimate (CRE) by LHD category.

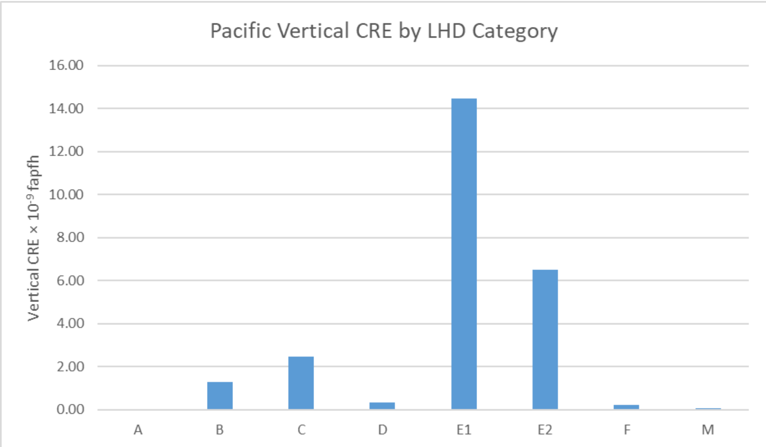


**Figure 5.** Vertical CRE by LHD Category

3.9.2 **Figure 6** provides the Vertical CRE by Pacific traffic flow and LHD Category. The traffic flows listed in Figure 6 are described earlier in Table 4. The data in Figure 6 shows that reported LHDs within the CEP and CENPAC traffic flows provided large risk estimates, from primarily the reported LHD category E with subcategory E-RI, no revision to transfer information, and E-NT, no ATC transfer.

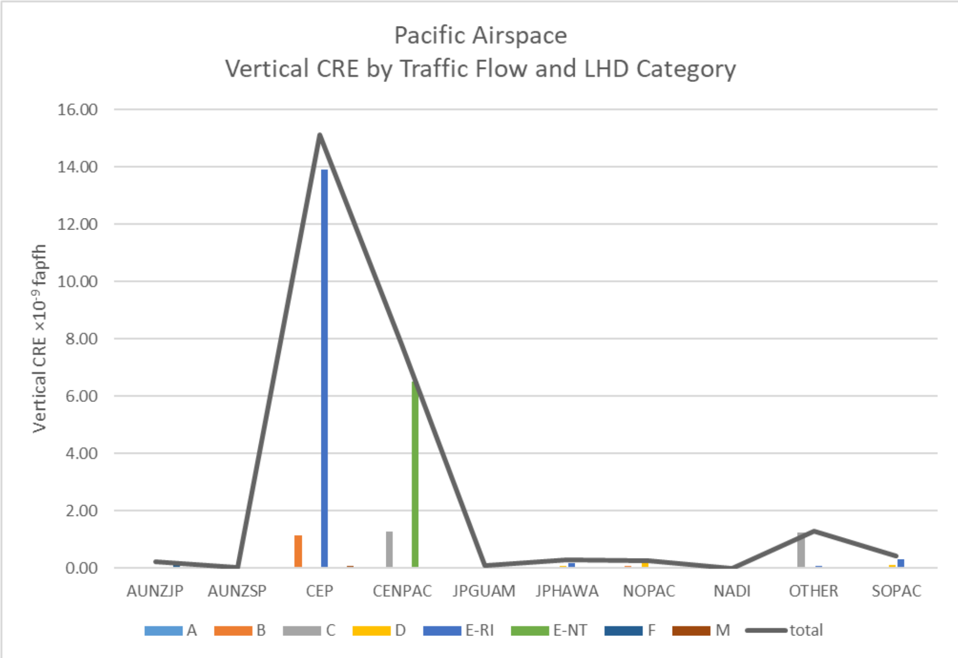


**Figure 6.** Vertical CRE by Pacific Traffic Flow and LHD category – 2024

3.10 In 2024, the top reported LHD in terms of vertical CRE is an LHD within the CENPAC traffic flow with 100 minutes duration. This occurrence was summarized earlier in paragraph 3.5.3. As a result of this reported LHD, changes were made to the ATC automation system to protect against similar occurrences in the future. The assigned LHD category for this event was E with a subcategory of E-NT, no ATC transfer. The vertical CRE for this reported LHD is $6.5 \times 10^{-9}$ fapfh.

3.11 <u>Reported Category E LHDs Between HCF and Oakland ARTCC</u>

3.11.1 The reported LHDs for 2024 included many reports classified as category E with a subcategory E-RI, no revision to transfer information, for transfer errors between HCF and Oakland Oceanic FIR. There is a cluster of purple circles around Hawaii visible in Figure 4. 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.

3.11.2 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.

3.11.3 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 2027. Prior to that time, both facilities have implemented mitigation strategies:

3.11.3.1 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 a short-term solution.

3.11.3.2 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. All the reported occurrences of this type were validated by Oakland center using the radar information or ADS-C position information from the aircraft.

3.11.4 There were 99 reported category E with subcategory E-RI, no revision to the transfer information, between HCF and Oakland center in calendar year 2024. This is a slight increase from the 83 reported category E occurrences received for calendar year 2023. Forty-eight of the 99 reports had non-zero duration and are considered to be risk-bearing LHDs. The locations of these 48 reported LHDs are shown in **Figure 7**. 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), Japan-Hawaii (JPHAWA) 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 7 are shown in **Table 6**.

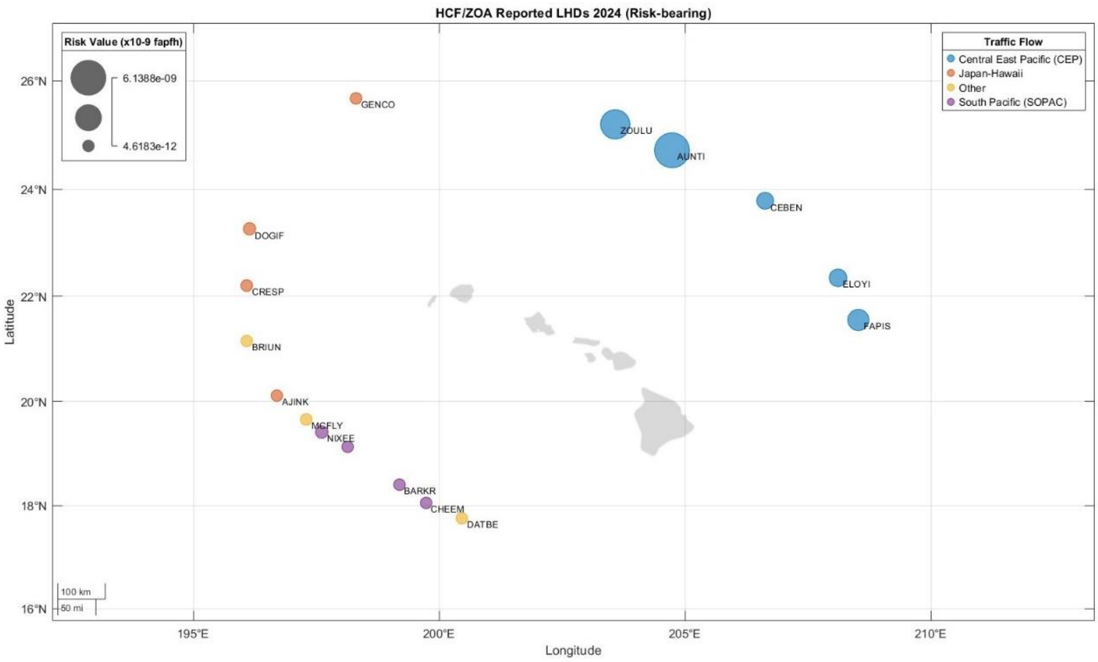


**Figure 7.** Reported LHDs transfer occurrences HCF – Oakland OCA (2024)

**Table 6.** Vertical Risk Estimates by Traffic Flow - HCF/Oakland Category E and subcategory E-RI, No Revision to Transfer Information, 2024

| Traffic Flow | LHD Count | LHD Duration Sum (min) | Sum Vertical Risk Estimate (× $10^{-9}$ fapfh) |
|---|---|---|---|
| CEP | 31 | 183.8 | 13.8 |
| Japan-Hawaii | 5 | 32.6 | 0.2 |
| OTHER | 4 | 10.7 | 0.07 |
| SOPAC | 8 | 40.3 | 0.3 |

3.11.5 Table 6 shows the reported category E and subcategory E-RI, no revision to transfer information, affect the CEP traffic flow in both count and duration. The vertical risk estimate is influenced by both the total duration of LHD events as well as the high level of traffic density in that area. The sum of the vertical risk estimates shown in Table 6 represents 54 percent of the overall vertical risk estimate for Pacific airspace in 2024.

3.12 Pacific Traffic Counts

3.12.1 The methodology used to estimate vertical risk in Pacific airspace considers 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 2024, 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 8** shows the numbers of flights observed by month for selected traffic flows, these data are sourced from the Oakland oceanic center.

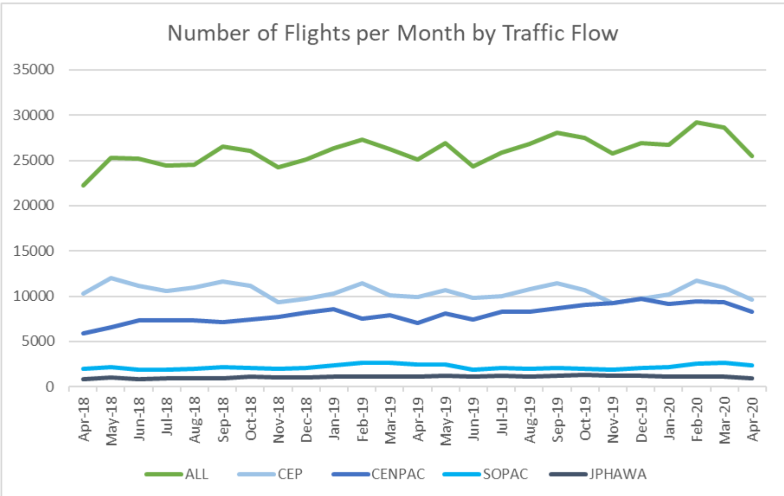


**Figure 8.** Number of Flights per Month by Traffic Flow

## 3.13 North East Asia RVSM Airspace

3.13.1 **Table 7** summarizes the number of LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed by month from January to December 2024 inclusive for

Incheon airspace. There were 123 reported LHDs in calendar year 2024 affecting the Incheon FIR, all reported occurrences have zero duration and zero flight levels crossed without ATC clearance. These reported occurrences are within the AKARA corridor airspace and are also examined in a separate paper.

**Table 7.** Summary of reported LHD occurrences and duration for North East Asia RVSM airspace

| Month-Year | No. of LHD | LHD Duration (min) | No. Levels Crossed |
|---|---|---|---|
| **2024** | | | |
| January | 11 | 0 | 0 |
| February | 4 | 0 | 0 |
| March | 10 | 0 | 0 |
| April | 11 | 0 | 0 |
| May | 21 | 0 | 0 |
| June | 13 | 0 | 0 |
| July | 15 | 0 | 0 |
| August | 12 | 0 | 0 |
| September | 2 | 0 | 0 |
| October | 12 | 0 | 0 |
| November | 10 | 0 | 0 |
| December | 2 | 0 | 0 |
| **Total** | 123 | 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 8**. Other collision risk model parameters that vary by traffic flow include aircraft size, occupancy values, and flying hours. These parameters are shown in **Table 9** by traffic flow. Table 4 contains a listing and description for each traffic flow.

**Table 8.** 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 | $4.68 \times 10^{-9}$ |

**Table 9.** Vertical CRM Parameters that Vary by Traffic Flow

| Traffic Flow | Annual Flying Hours | Percent | Average Aircraft Length, $\lambda x$ (NM) | Average Aircraft Wingspan, $\lambda y$ (NM) | Average Aircraft Height, $\lambda z$ (NM) | Same Direction Vertical Occupancy, *Ez(Same)* | Opposite Direction Vertical Occupancy, *Ez(Opp)* |
|---|---|---|---|---|---|---|---|
| **NOPAC** | 387,123.9 | 20.0% | 0.037 | 0.034 | 0.010 | 0.100 | 0.000 |
| **CENPAC** | 490,374.1 | 25.4% | 0.037 | 0.035 | 0.010 | 0.463 | 0.033 |
| **CEP** | 481,227.3 | 24.9% | 0.026 | 0.023 | 0.007 | 0.450 | 0.000 |
| **JPHAWA** | 52,467.3 | 2.7% | 0.033 | 0.031 | 0.009 | 0.141 | 0.000 |
| **JPGUAM** | 14,221.8 | 0.7% | 0.025 | 0.023 | 0.008 | 0.010 | 0.001 |
| **OTHER** | 16,511.1 | 0.9% | 0.030 | 0.027 | 0.008 | 0.028 | 0.002 |
| **AUSNZSP** | 70,125.8 | 3.6% | 0.025 | 0.023 | 0.007 | 0.030 | 0.021 |
| **NADI** | 26,321.4 | 1.4% | 0.031 | 0.030 | 0.009 | 0.013 | 0.020 |
| **AUSNZJP** | 89,167.2 | 4.6% | 0.034 | 0.033 | 0.009 | 0.014 | 0.013 |
| **SOPAC** | 306,269.5 | 15.8% | 0.034 | 0.033 | 0.009 | 0.074 | 0.003 |
| **TOTAL** | 1,933,809.4 | 100.0% | 0.033 NM | 0.031 NM | 0.009 NM | | |
| | | | ***199.2 ft*** | ***186.2 ft*** | ***54.2 ft*** | | |

4.4 **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM airspace are detailed in **Table 10**. The technical risk meets the agreed target level of safety (TLS) value of no more than $2.5 \times 10^{-9}$ 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 $5.0 \times 10^{-9}$ fapfh.

**Table 10.** Pacific Airspace Risk Estimates

| **Pacific Airspace – estimated annual flying hours = 1,933,809 hours** ***(note: estimated hours based on Dec 2024 traffic sample data)*** | | | |
|---|---|---|---|
| **Source of Risk** | **Risk Estimation** | **TLS** | **Remarks** |
| *RASMAG 29 Total Risk* | *$18.6 \times 10^{-9}$* | *$5.0 \times 10^{-9}$* | *Above TLS* |
| Technical Risk | $0.08 \times 10^{-9}$ | $2.5 \times 10^{-9}$ | Below Technical TLS |
| Operational Risk | $25.3 \times 10^{-9}$ | - | - |
| Total Risk | **$25.4 \times 10^{-9}$** | $5.0 \times 10^{-9}$ | **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, along with several long duration reported LHDs. The vertical CRE associated with the HCF and Oakland center transfer errors is $14.4 \times 10^{-9}$ fapfh. The total vertical risk estimate without these category E reported LHDs would be $11 \times 10^{-9}$ fapfh.

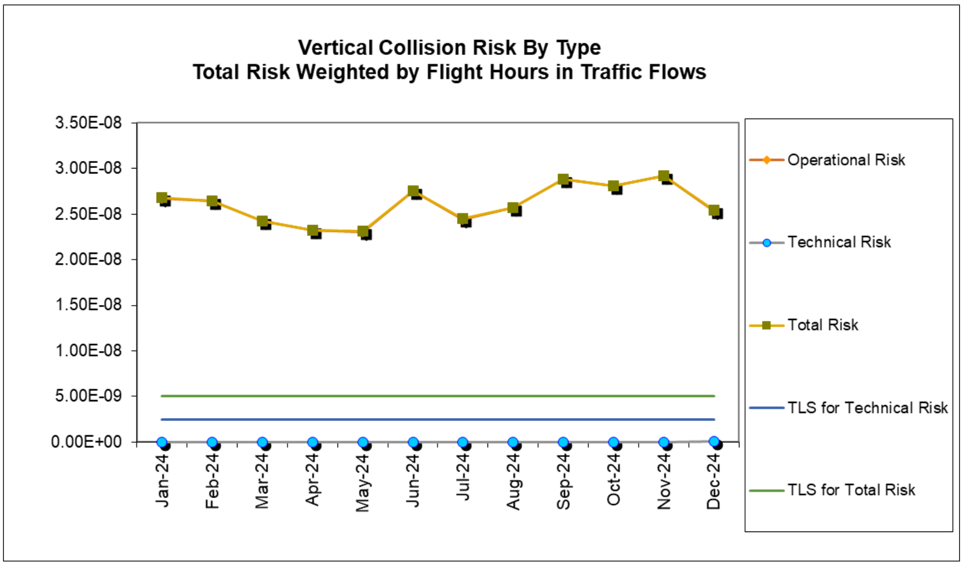


**Figure 8.** Trends of Risk Estimates for Pacific RVSM Airspace

<u>North East Asia RVSM airspace</u>

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

4.7 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 |
|---|---|---|
| $\lambda_x$ | Average aircraft length | 0.034 NM |
| $\lambda_y$ | Average aircraft wingspan | 0.031 NM |
| $\lambda_z$ | Average aircraft height | 0.009 NM |
| $\overline{\lvert\Delta V\rvert}$ | Average relative same-direction speed | 38.3 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 | $4.68 \times 10^{-9}$ |
| *Ez(Same)* | Same direction vertical occupancy value | 0.6317 |
| *Ez(Opp)* | Opposite direction vertical occupancy value | 0.0735 |

4.8 **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 $2.5 \times 10^{-9}$ 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 $5.0 \times 10^{-9}$ fapfh.

4.9 **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 = 197,565.8 hours** *(note: estimated hours based on Dec 2024 traffic sample data)* | | | |
|---|---|---|---|
| **Source of Risk** | **Risk Estimation** | **TLS** | **Remarks** |
| *RASMAG 29 Total Risk* | *$0.17 \times 10^{-9}$* | *$5.0 \times 10^{-9}$* | *Below TLS* |
| Technical Risk | $0.56 \times 10^{-9}$ | $2.5 \times 10^{-9}$ | Below Technical TLS |
| Operational Risk | $0.00 \times 10^{-9}$ | - | - |
| Total Risk | $\mathbf{0.56 \times 10^{-9}}$ | $5.0 \times 10^{-9}$ | **Below TLS** |

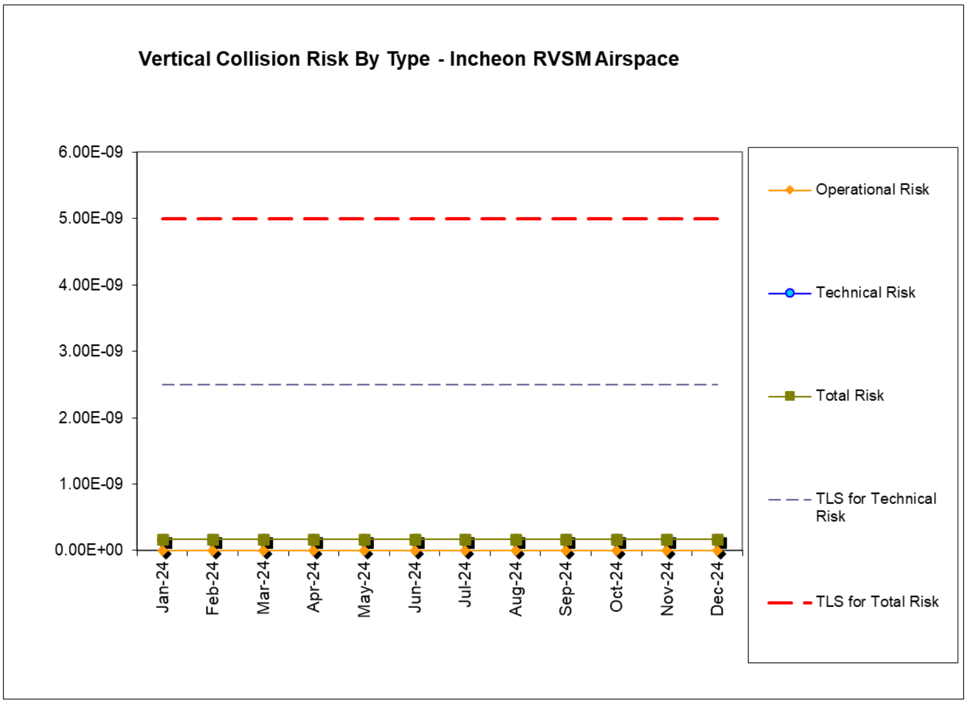


**Figure 9.** Trends of Risk Estimates for North East Asia RVSM Airspace