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

PARMO VERTICAL SAFETY MONITORING REPORT

(Presented by United States/PARMO)

SUMMARY

This paper compares actual performance to safety goals that support the continued 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 2020. There are a total of 53 reported large height deviations (LHDs) accounting for 160 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 2020 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 2020 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 2020. The COVID-19 pandemic and associated reduction in air travel had an effect on the traffic levels and reported occurrences during calendar year 2020. 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 2020.

Executive Summary for Pacific Airspace

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 2020 to December 2020.

Pacific Airspace – estimated annual flying hours = 858,079 hours *(note: estimated hours based on Dec 2020 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 25 Total Risk	*31.41×10^{-9}*	*5.0×10^{-9}*	*Above TLS*
Technical Risk	0.08×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	21.96×10^{-9}	-	-
Total Risk	**22.04×10^{-9}**	5.0×10^{-9}	**Above TLS**

Table 1: Pacific Airspace RVSM Risk Estimates

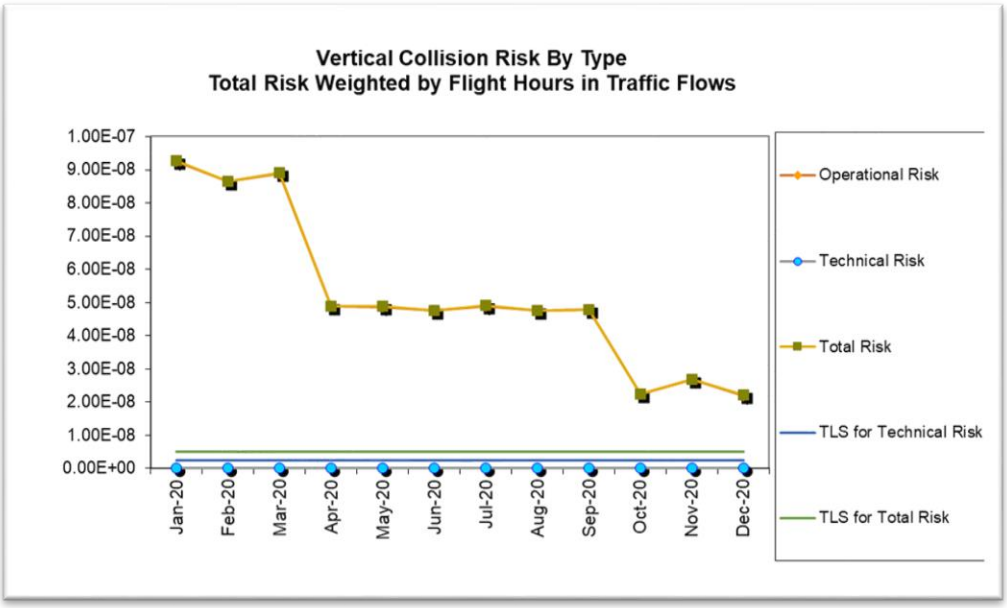

Figure 1: Pacific Airspace RVSM Risk Estimate Trends

2.3 **Table 2** presents a summary of the LHD causes within Pacific airspace from January 2020 until December 2020.

Code	**LHD Category Description**	**No.**
A	Flight crew fails to climb or descend the aircraft as cleared	1
B	Flight crew climbing or descending without ATC clearance	9
C	Incorrect operation or interpretation of airborne equipment	0
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	27
F	ATC transfer of control coordination errors due to technical issues	1
G	Aircraft contingency leading to sudden inability to maintain level	3
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	5
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		51

Table 2: Summary of LHD Causes within Pacific Airspace

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

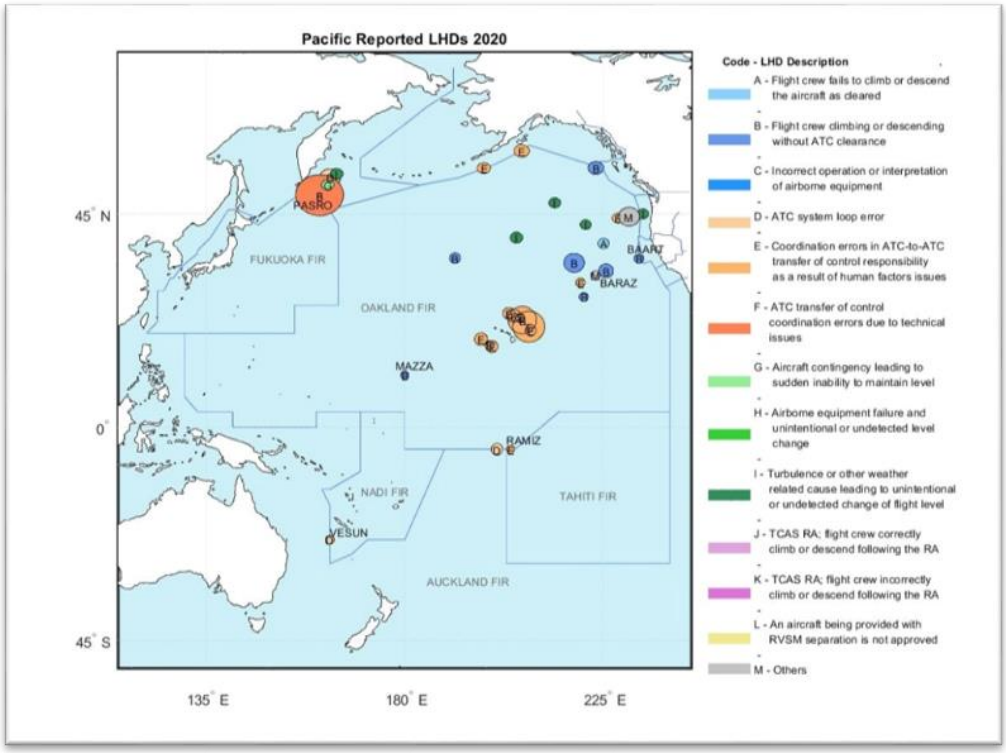

Figure 2: Pacific Airspace – Risk Bearing LHD

2.5 A task force has been established to develop mitigations for the high number of reported category E occurrences between Honolulu Control Facility (HCF) and Oakland center. A summary of the task force progress is provided in the attachment to this paper.

Executive Summary for a Portion of 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 2020 to December 2020.

North East Asia Airspace – estimated annual flying hours = 77,954 hours *(note: estimated hours based on Dec 2020 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 25 Total Risk	*1.07×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Technical Risk	0.23×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	**0.23×10^{-9}**	5.0×10^{-9}	**Below TLS**

Table 3: North East Asia Airspace RVSM Risk Estimates

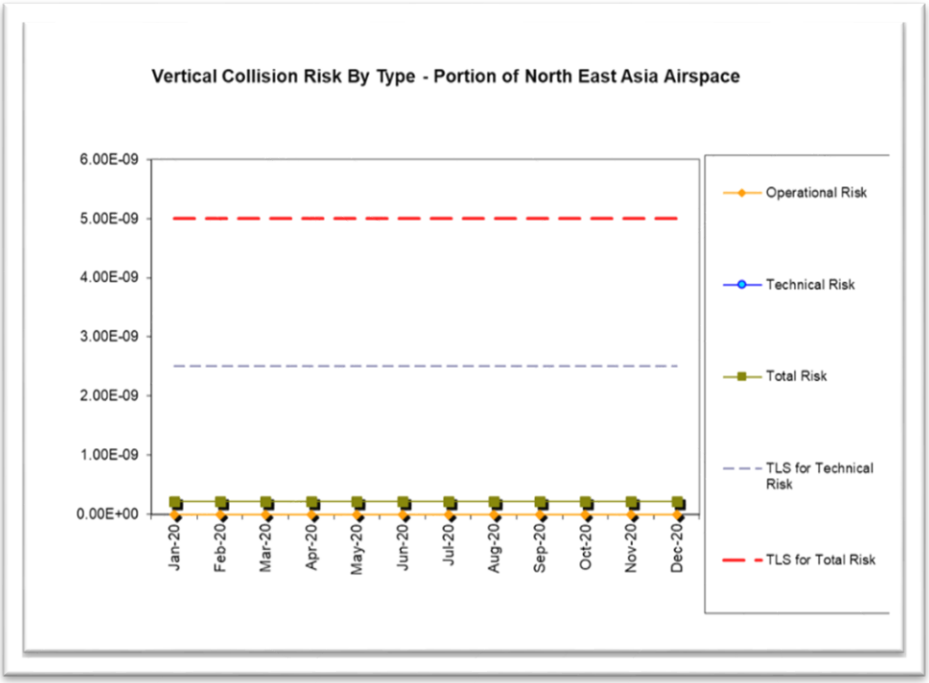

Figure 3: North East Asia Airspace RVSM Risk Estimate Trends

2.7 **Table 4** presents a summary of the LHD causes within North East Asia airspace from January 2020 until December 2020. The two category E LHDs included in Table 4 occurred with the AKARA airspace and are included in a separate working paper to this meeting.

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	2
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		2

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

2.8 **Figure 4** provides the geographic location of risk bearing LHD reports within North East Asia Airspace during the assessment period. It is noted that the two reported LHDs depicted in Figure 4 occurred within the AKARA airspace and are covered in a separate working paper to this meeting.

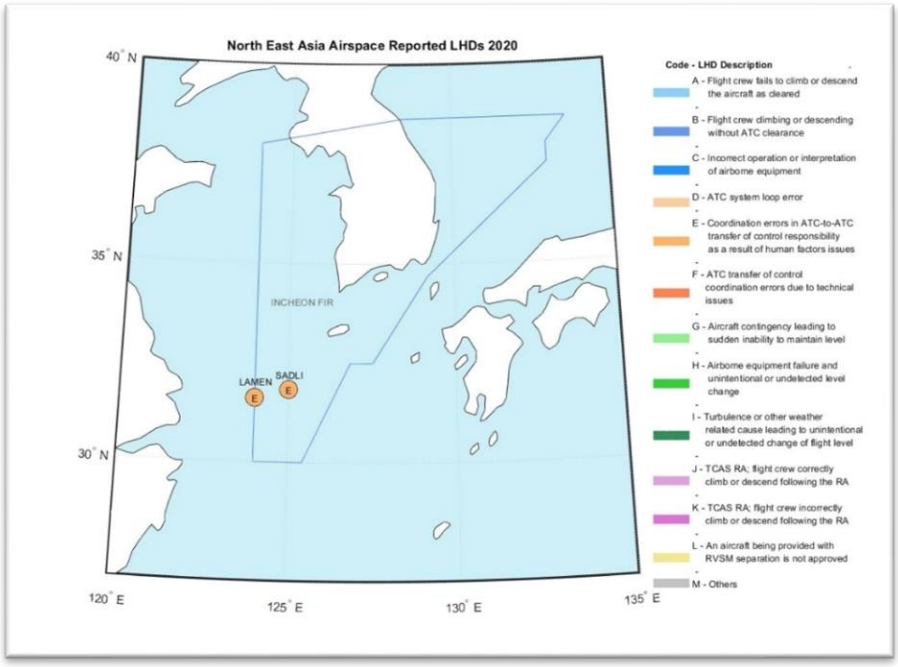

Figure 4: North East Asia Airspace – Reported LHDs

2.9 There is a separate working paper to this meeting which highlights the AKARA airspace.

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 2020 TO December 2020

Prepared by
Pacific Approvals and Registry Monitoring Organization (PARMO) – ***August 2021***
(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 2020 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.

FIR	December 2020 TSD Submitted to PARMO
Anchorage	X
Auckland	X
Incheon	X
Nadi	X
Oakland	X
Tahiti	X

Table 1. December 2020 TSD Submitted to PARMO

2.2 **Large Height Deviation (LHD).** A cumulative 12-month data set of LHD reports was used, covering January to December 2020. **Table 2** indicates those FIRs which submitted LHD reports including nil returns.

	Anchorage	Auckland	Incheon	Nadi	Oakland	Tahiti
Jan 2020	X	X	X	X	X	X
Feb 2020	X	X	X	X	X	X
Mar 2020	X	X	X	X	X	X
Apr 2020	X	X	X	X	X	X
May 2020	X	X	X	X	X	X
Jun 2020	X	X	X	X	X	X
Jul 2020	X	X	X	X	X	X
Aug 2020	X	X	X	X	X	X
Sep 2020	X	X	X	X	X	X
Oct 2020	X	X	X	X	X	X
Nov 2020	X	X	X	X	X	X
Dec 2020	X	X	X	X	X	X

Table 2. Summary of LHD Reports submitted by FIRs

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 2020 to 31 December 2020 inclusive for Pacific airspace.

Month	No. of Non-NIL LHD	LHD Duration (min)	No. Levels Crossed
2020			
January	7	47.88	3
February	3	2	1
March	8	18	15
April	0	0	0
May	1	2.033	0
June	1	1.116	0
July	4	8.316	5
August	2	1.433	0
September	3	6.667	12
October	6	7.467	0
November	6	31.267	0
December	10	33.833	3
Total	**51**	**160.02**	**39**

Table 3. Summary of non-NIL LHD occurrences and duration for Pacific RVSM airspace – Year 2020

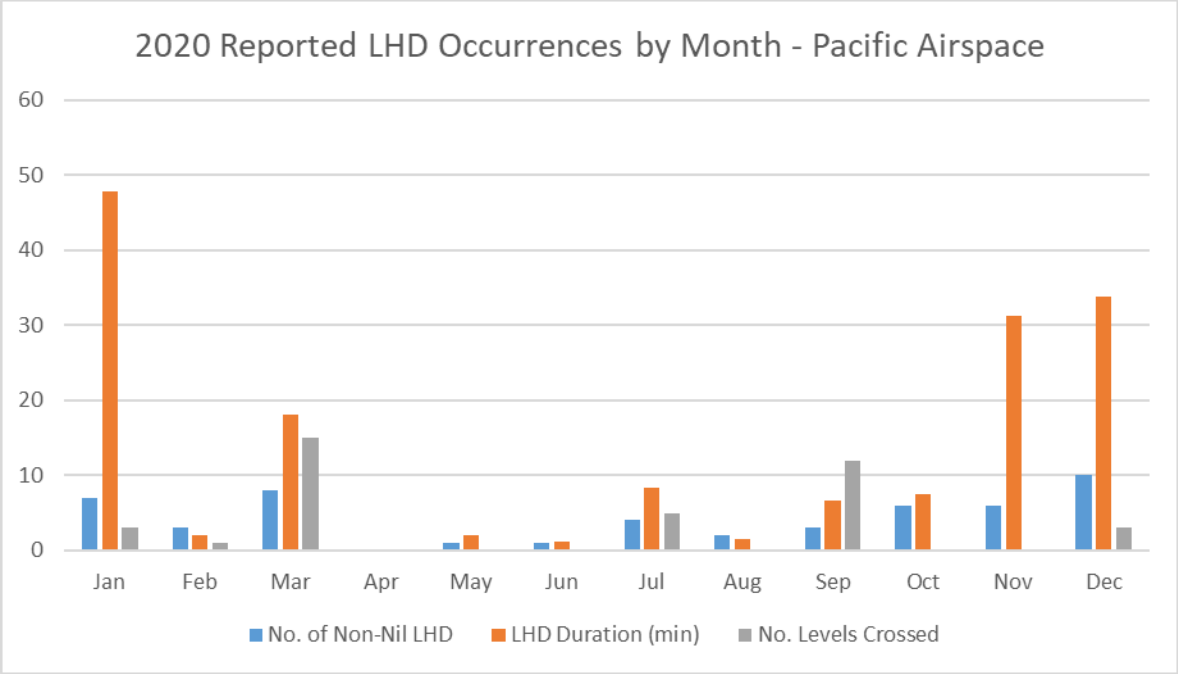

Figure 1. Summary of LHD occurrences by month for Pacific RVSM airspace –2020

3.3 The reported LHDs for Pacific Airspace provided to the PARMO in 2020 indicated there were **160 minutes** of operation at an incorrect flight level. These data show a decrease in both the number of LHD reports received and amount of time spent on incorrect flight levels from calendar year 2019. For comparison, the LHD reports provided to the PARMO within the recent seven-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 different Pacific traffic flows and the corresponding descriptions.

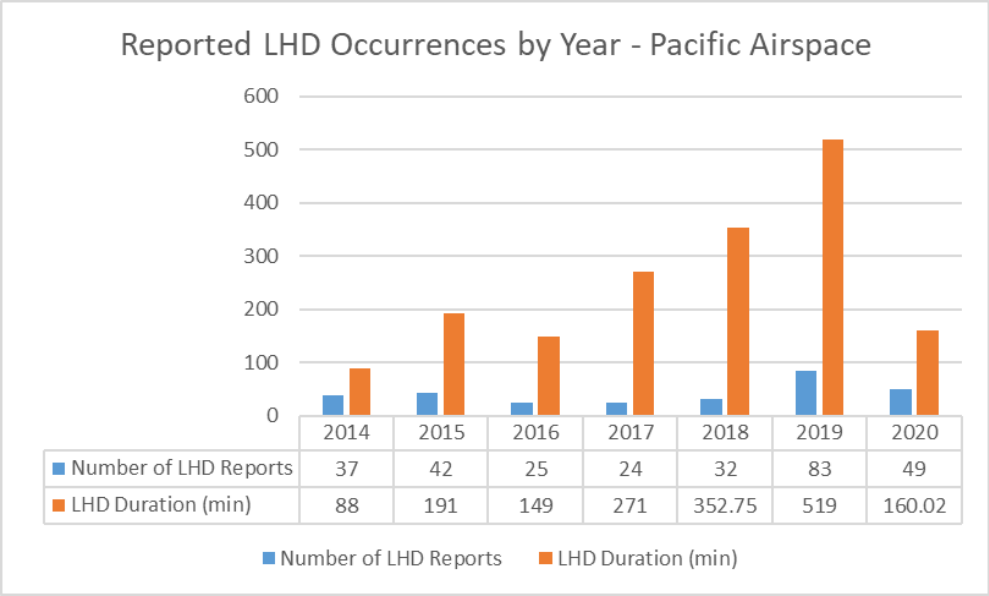

Figure 2. Numbers of LHD Reports Received and Associated LHD Duration – Seven Year Trend

Sub-Region of Pacific	Flow	Description of Flow
North Pacific	North Pacific (NOPAC)	North America west 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

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

3.5 An LHD event with a duration of 20 minutes or more is considered to be a long duration event. There was **one** reported long durations LHD events in 2020. In comparison, there were five and six reported long duration LHD events in 2019 and 2018, respectively.

3.5.1 The longest reported LHD duration was thirty-three minutes, roughly 20 percent of the total LHD duration for 2020 in Pacific airspace. This event involved a commercial operation and although the operation was eligible for Performance-based Communication and Suveillance (PBCS); there was not a successful AFN logon with air traffic control (ATC). This occurrence took place in the North Pacific (NOPAC) area of Pacific airspace. The NOPAC contains traffic operating on fixed airways between North America and Asia. The primary cause of this occurrence was error in ATC-to-ATC transfer due to technical issues. The flight plan information was inaccurately modified while the flight was within domestic airspace. The inaccurate flight plan information was inadvertently passed to the oceanic ATC unit. Automated transfer messages were then sent from the transferring oceanic ATC unit to the receiving oceanic ATC unit without knowledge of the errors. The receiving ATC unit's automation system did not recognize the AIDC transfer message due to the differences in the flight plan information. The scrutiny group estimated that it took 33 minutes for the receiving oceanic ATC unit to identify the AIDC transfer error and correct the aircraft profile within the automation system. There was information from both ATC units for this occurrence. This occurrence took place in January 2020, which accounts for the large spike in LHD Duration shown in Figure 1.

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 2020 to 31 December 2020 inclusive for Pacific RVSM airspace. **Figure 4** provides a geographic chart with the approximate locations of the non-nil LHD reports.

3.7 Table 5 and Figure 3 show categories E and F, errors in ATC-to-ATC transfer are the top contributors to reported LHD occurrences during calendar year 2020. This is consistent with the previous calendar year. Figure 3 provides the observed trend in the numbers of reported LHDs by category over the current four-year period.

3.8 A decrease in both the number of reported LHDs and duration spent at the unexpected/incorrect flight level was observed in 2020 compared to 2019. This result was expected due to the COVID-19 pandemic and the associated reduction in air travel during 2020.

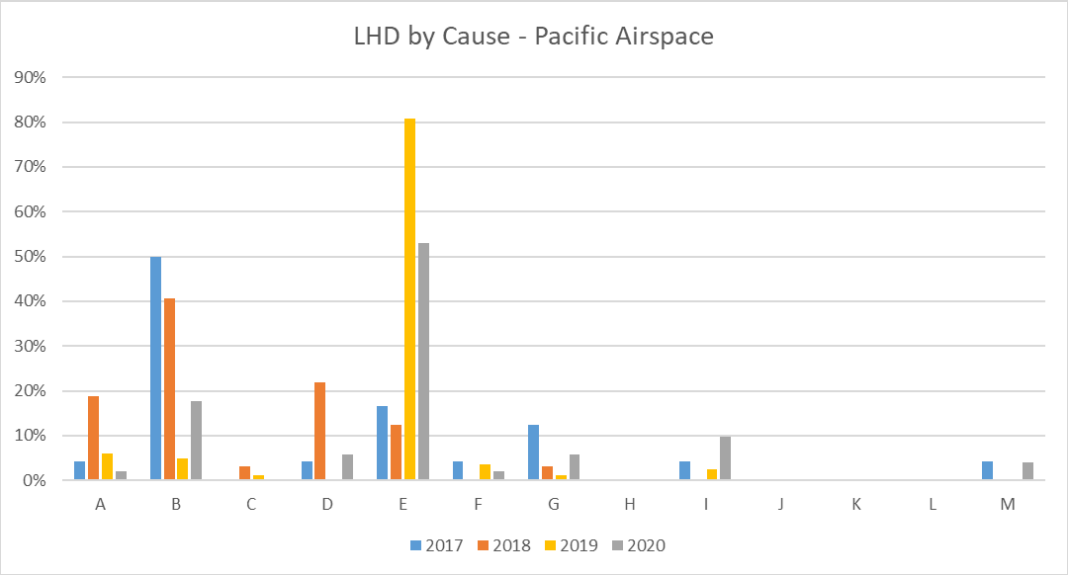

Figure 3. Summary of LHD causes for Pacific RVSM airspace

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;	1	1	0
B	Flight crew climbing /descending without ATC clearance;	9	21.35	16
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);	3	12	8
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);	27	80.67	4
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues;	1	33	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure);	3	0	9
H	Airborne equipment failure leading to unintentional or undetected change of flight level (e.g. altimetry errors)	0	0	0

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
I	Turbulence or other weather related causes	5	2	2
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	2	10	0
	Totals	**51**	**160.02**	**39**

Table 5. 12-month LHD reports by LHD category for Pacific RVSM airspace - 2020

3.9 The reported LHDs for 2020 included a large number of reports classified as category E for transfer errors between Honolulu Control Facility (HCF) and Oakland Oceanic FIR. The scrutiny review group informed PARMO these occurrences affect the user preferred routes (UPRs) crossing fixed airways within Oakland Oceanic FIR. These type of events occur frequently and require significant resources at the ATC facility to investigate underlying causes.

3.10 The resources needed for this activity were made available sporadically during calendar year 2020 due to the COVID-19 pandemic and associated staffing challenges at the Air Route Traffic Control Centers (ARTCCs). The available system data were examined for all of the LHD category E 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 A task force has been established to further investigate these occurrences and determine remedial actions. After being delayed due to the COVID-19 pandemic, 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 is to implement the En Route Automation Modernization (ERAM) system at the HCF by the end of calendar year 2025. Prior to that time, the task force developed the following mitigation strategies:

3.11.1 A procedure that requires the controller to determine the remaining travel time to the boundary fix was approved for the HCF. During this procedure, ATC will compute an estimated time

of arrival (ETA) for the boundary fix and manually transfer the ETA to the next facility. It is noted that this is a manual procedure and is considered to be a short-term solution.

3.11.2 The task force will examine the resulting occurrence data once this short-term solution is in place. If the data show that the short-term solution is not sufficient, there is another procedure that could be implemented for the short-term. This other procedure involves the controller obtaining the ETA for the boundary fix from the air crew and then transferring that time to the receiving facility. This procedure is in use in other oceanic airspace where the United States provides air traffic services.

3.12 Another interim step considered by the task force is to develop Performance Based Navigation (PBN) route structures for HCF. Due to the timeline and funding required for the development of PBN routes, this activity may not be complete prior to the implementation of ERAM in calendar year 2025. However, the task force considered the associated benefits with PBN routes and suggested this this development activity may happen in parallel.

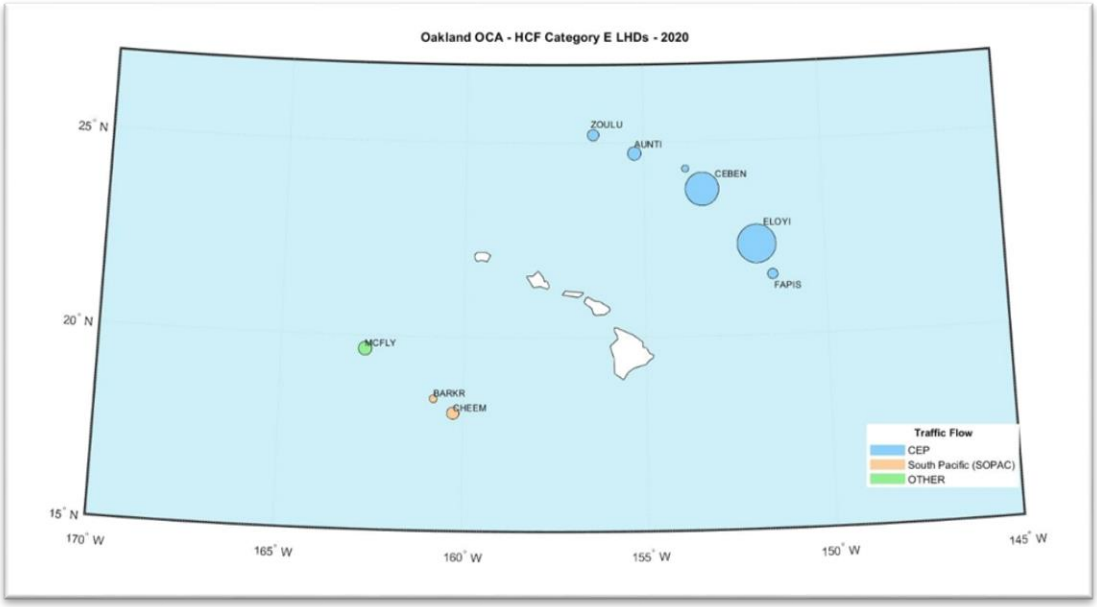

Figure 4. Reported transfer occurrences HCF – Oakland OCA (2020)

3.13 There were sixty-four reported category E occurrences between HCF and Oakland center in calendar year 2020. Twenty-two of these reports had a non-zero duration and are considered to be risk-bearing LHDs. The locations of these twenty-two reported LHDs are shown in **Figure 4**. 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 other traffic flows affected by these transfer errors include South Pacific (SOPAC) and Other traffic flows.

3.14 In calendar year 2020, there were twenty-eight reported LHD category E and F occurrences. This represents more than half of all the reported LHDs in 2020. The associated LHD duration for category E and F reports account for more than seventy-one percent of all LHD duration in calendar year 2020. Most of these occurrences were reported for aircraft transfers between HCF and Oakland center. There were six reported category E LHDs between different ATC facilities, these reports do not show a repeated pattern.

3.15 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 normal times, the CEP traffic flow would have the highest number of flight operations and flying hours compared to all other areas identified in Pacific airspace. However, in calendar year 2020, air travel was significantly impacted by the COVID-19 pandemic providing different traffic volume patterns. The associated traffic flow for each event is based on the origin and destination city pair for the aircraft involved. **Figure 5** 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 (green line in Figure 5) shows the largest decrease in traffic from March 2020 to April 2020. The CENPAC, JPHAWA and SOPAC traffic flows also show COVID-19 related and sustained decreases in traffic counts. The NOPAC traffic flow does show COVID-19 related reductions in traffic counts, but the magnitude is not as large as observed for the other traffic flows.

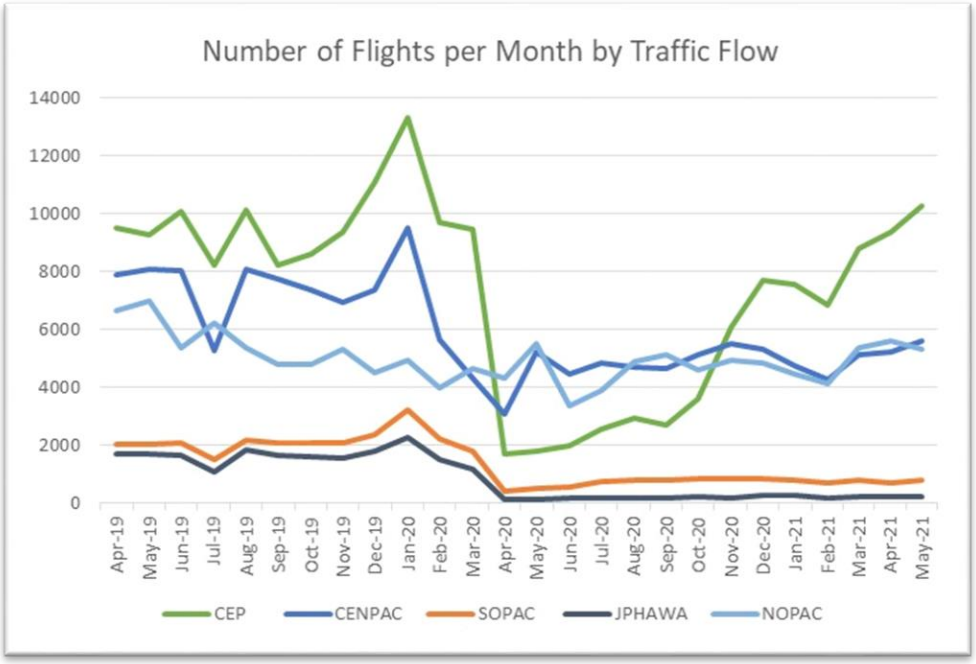

Figure 5. Number of Flights per Month by Traffic Flow

3.16 In 2020, the area of Pacific airspace with the largest reported LHD duration is the CEP traffic flow. This is the traffic flow that contains aircraft operations travelling between North America and Hawaii. **Figure 6** shows the approximate location and cause of all reported LHDs within Pacific airspace.

3.17 **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 2020.

Traffic Flow	A	B	D	E	F	G	I	M	Grand Total
AUSNZJP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
AUSNZSP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**

CENPAC	0.0	3.4	0.0	1.0	0.0	0.0	0.0	0.0	**4.4**
CEP	1.0	18.0	0.0	68.1	0.0	0.0	0.0	10.0	**97.1**
HAWJPN	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	**2.0**
JPNGM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
NADI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
NOPAC	0.0	0.0	7.0	0.0	33.0	0.0	0.0	0.0	**40.0**
OTH	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	**6.1**
SOPAC	0.0	0.0	5.0	5.5	0.0	0.0	0.0	0.0	**10.5**
Grand Total	**1.0**	**21.4**	**12.0**	**80.7**	**33.0**	**0.0**	**2.0**	**10.0**	**160.0**

Table 6. Sum of LHD Duration (minutes) by Pacific Traffic Flow and LHD category - 2020

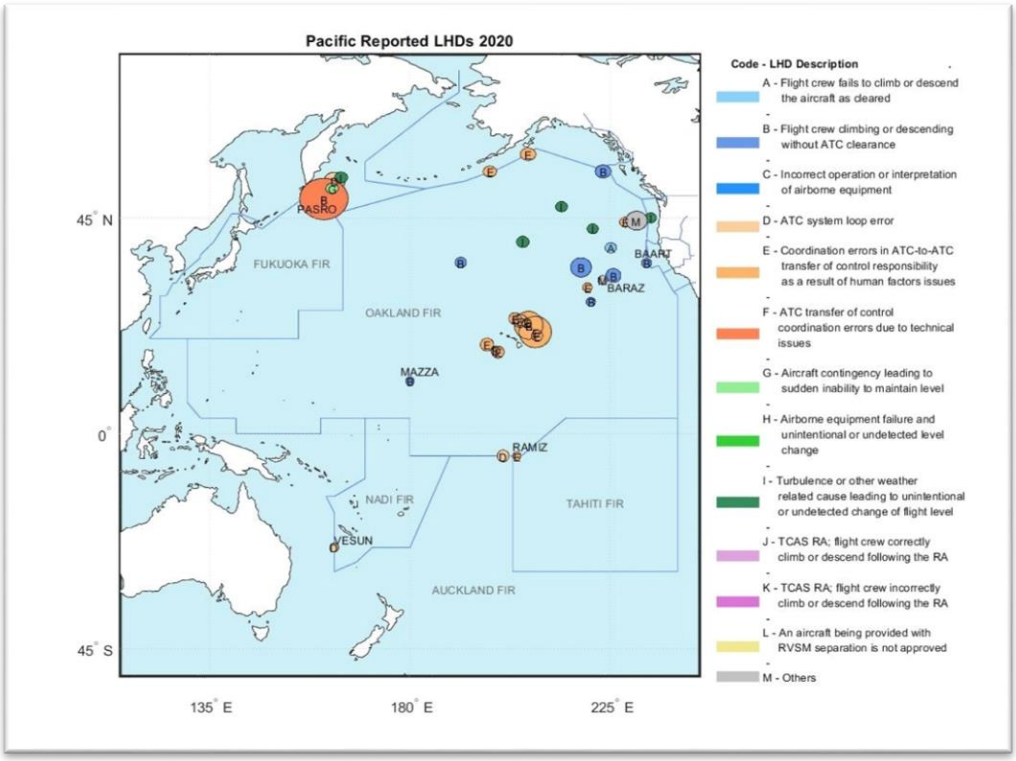

Figure 6. Pacific RVSM airspace LHD locations - 2020

3.18 North East Asia RVSM Airspace

3.19 **Table 7** summarizes the number of LHD occurrences assessed and associated LHD duration (in minutes) or number of levels crossed by month from 1 January 2020 to 31 December 2020 inclusive for North East Asia airspace. The two reported LHD occurrences listed in Table 7 occurred within the AKARA airspace and are covered in a separate working paper for this meeting. There were no other reported LHD occurrences for Incheon airspace in calendar year 2020.

Month-Year	No. of Non-NIL LHD	LHD Duration (min)	No. Levels Crossed
2020			
January	1	0	0

Month-Year	No. of Non-NIL LHD	LHD Duration (min)	No. Levels Crossed
2020			
February	1	0	0
March	0	0	0
April	0	0	0
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	0	0	0
Total	2	0	0

Table 7. Summary of non-NIL LHD occurrences and duration for North East Asia RVSM airspace

3.20 **Table 8** and **Figure 7** summarize the number of reported LHD occurrences by LHD category from 1 January 2020 to 31 December 2020 inclusive for North East Asia RVSM airspace. Figure 7 provides the observed trends in reported LHD category codes for the recent three-year period, this summary does not include occurrences reported within the AKARA area. The two reported LHD occurrences contained in Table 8 and Figure 7 took place within AKARA airspace and are covered in a separate working paper for this meeting.

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;	0	0	0
B	Flight crew climbing /descending without ATC clearance;	0	0	0
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);	0	0	0

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
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);	2	0	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues;	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
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	0	0	0
	Totals	**2**	**0**	**0**

Table 8. LHD Summary by category for North East Asia RVSM airspace

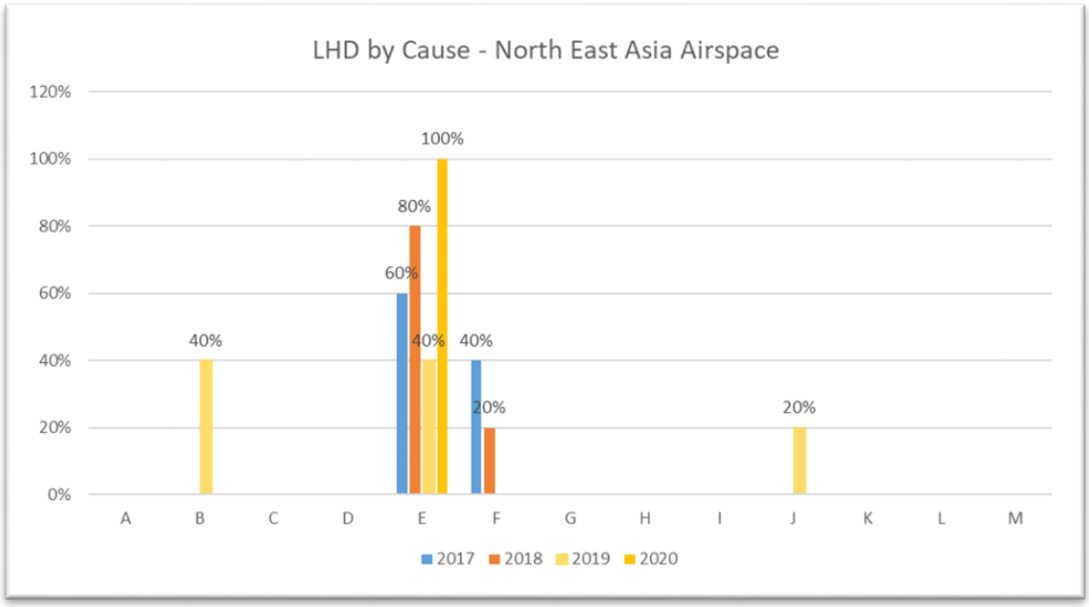

Figure 7. Summary of LHD causes for North East Asia RVSM airspace - 2020

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.

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

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	225,822.79	26.32%	0.037	0.034	0.010	0.443	0.000
CENPAC	288,890.86	33.67%	0.037	0.035	0.010	0.377	0.060
CEP	215,009.22	25.06%	0.026	0.022	0.007	0.257	0.047
JPHAWA	23,904.35	2.79%	0.033	0.032	0.009	0.121	0.002
JPGUAM	5,519.41	0.64%	0.027	0.025	0.008	0.015	0.022
OTHER	13,307.87	1.55%	0.026	0.023	0.008	0.019	0.006
AUSNZSP	26,258.00	3.06%	0.025	0.023	0.007	0.013	0.031
NADI	3,907.00	0.46%	0.031	0.030	0.009	0.024	0.007
AUSNZJP	11,864.48	1.38%	0.034	0.034	0.010	0.041	0.074
SOPAC	43,594.99	5.08%	0.035	0.034	0.010	0.072	0.047
TOTAL	858,078.96	100.00%	0.033 NM	0.031 NM	0.009 NM		
			200.6 ft	***187.6 ft***	***55.0 ft***		

Table 10. Vertical CRM Parameters that Vary by Traffic Flow

4.4 **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation 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.

Pacific Airspace – estimated annual flying hours = 858,079 hours *(note: estimated hours based on Dec 2020 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 25 Total Risk	31.41×10^{-9}	5.0×10^{-9}	*Above TLS*
Technical Risk	0.08×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	21.96×10^{-9}	-	-
Total Risk	**22.04×10^{-9}**	5.0×10^{-9}	**Above TLS**

Table 11. Pacific Airspace Risk Estimates

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 59 percent of the total risk estimate. The total vertical risk estimate without these category E reported LHDs is 8.98×10^{-9} fapfh.

4.6 The decrease in the vertical risk estimate is directly related to the decrease in the time spent at unexpected flight levels as shown earlier. The reduced numbers of operations associated with the COVID-19 pandemic during calendar year 2020 was also a factor in the number of reported occurrences for this year.

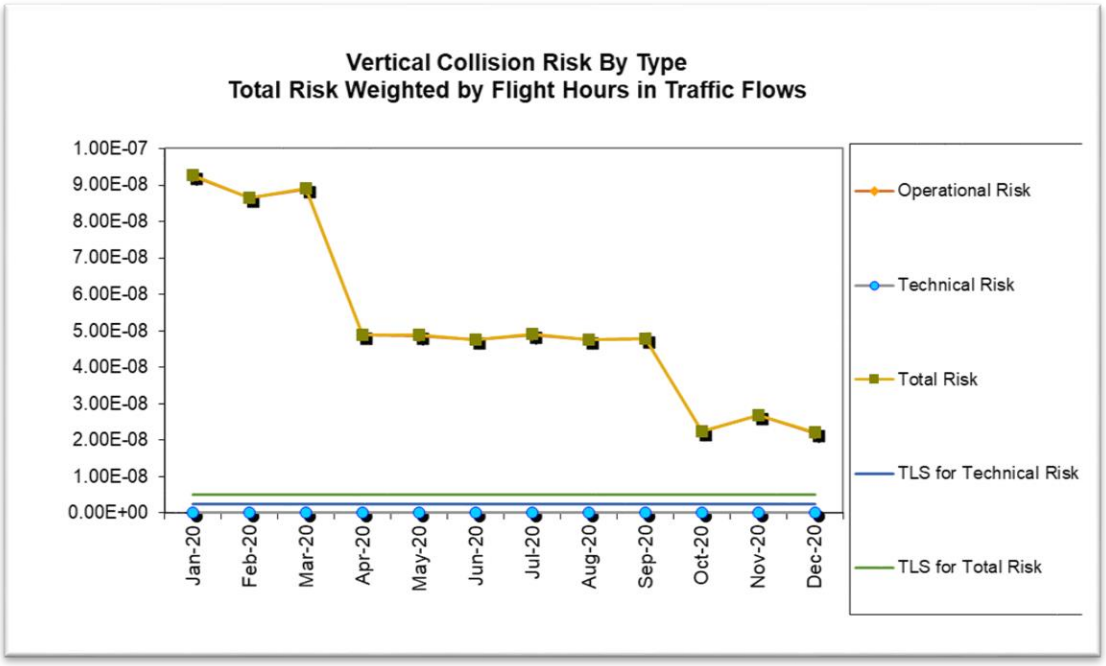

Figure 8. Trends of Risk Estimates for Pacific RVSM Airspace

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**.

Parameter	Description	Value
λ_x	Average aircraft length	0.026 NM
λ_y	Average aircraft wingspan	0.024 NM
λ_z	Average aircraft height	0.008 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	4.68×10^{-9}
Ez(Same)	Same direction vertical occupancy value	0.2677
Ez(Opp)	Opposite direction vertical occupancy value	0.1112

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

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.

North East Asia Airspace – estimated annual flying hours = 77,954 hours *(note: estimated hours based on Dec 2020 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 25 Total Risk	*1.07×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Technical Risk	0.23×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	0.00×10^{-9}	-	-
Total Risk	**0.23×10^{-9}**	5.0×10^{-9}	**Below TLS**

Table 13. North East Asia RVSM Airspace Risk Estimates

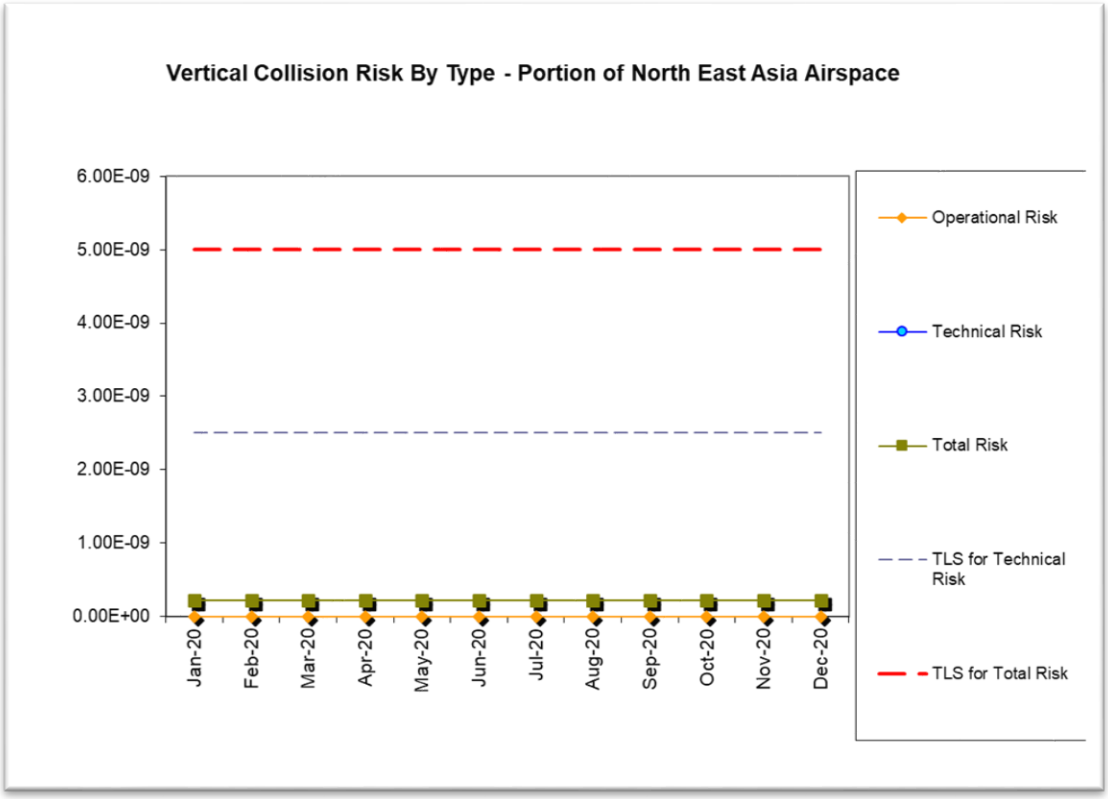

Figure 9. Trends of Risk Estimates for North East Asia RVSM Airspace