



ICAO

International Civil Aviation Organization  
**Twenty-Fifth Meeting of the Regional Airspace Safety  
Monitoring Advisory Group (RASMAG/25)**

Video Teleconference, 27 – 30 October 2020

**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 2019. There are a total of 88 reported large height deviations (LHDs) accounting for 520 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 2019 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 2019 vertical collision risk estimate for a portion of 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 time period 1 January to 31 December 2019. It contains a summary of large height deviation reports, and estimates of vertical risk for Pacific and a portion of North East Asia airspace.

**2. DISCUSSION**

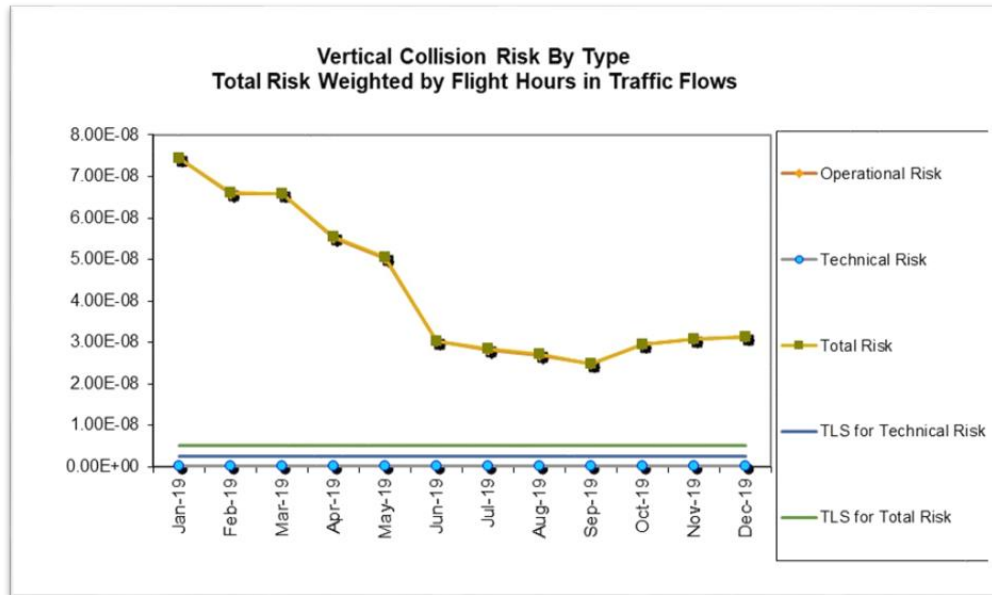
2.1 **Attachment A** contains the PARMO Vertical Safety Monitoring Report for January to December 2019.

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 1 January 2019 to 31 December 2019.

<b>Pacific Airspace – estimated annual flying hours = 1,754,212 hours</b> <i>(note: estimated hours based on Dec 2019 traffic sample data)</i>			
<b>Source of Risk</b>	<b>Risk Estimation</b>	<b>TLS</b>	<b>Remarks</b>
<i>RASMAG 24 Total Risk</i>	$26.46 \times 10^{-9}$	$5.0 \times 10^{-9}$	<i>Above TLS</i>
Technical Risk	$0.17 \times 10^{-9}$	$2.5 \times 10^{-9}$	Below Technical TLS
Operational Risk	$31.24 \times 10^{-9}$	-	-
<b>Total Risk</b>	<b><math>31.41 \times 10^{-9}</math></b>	$5.0 \times 10^{-9}$	<b>Above TLS</b>

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



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

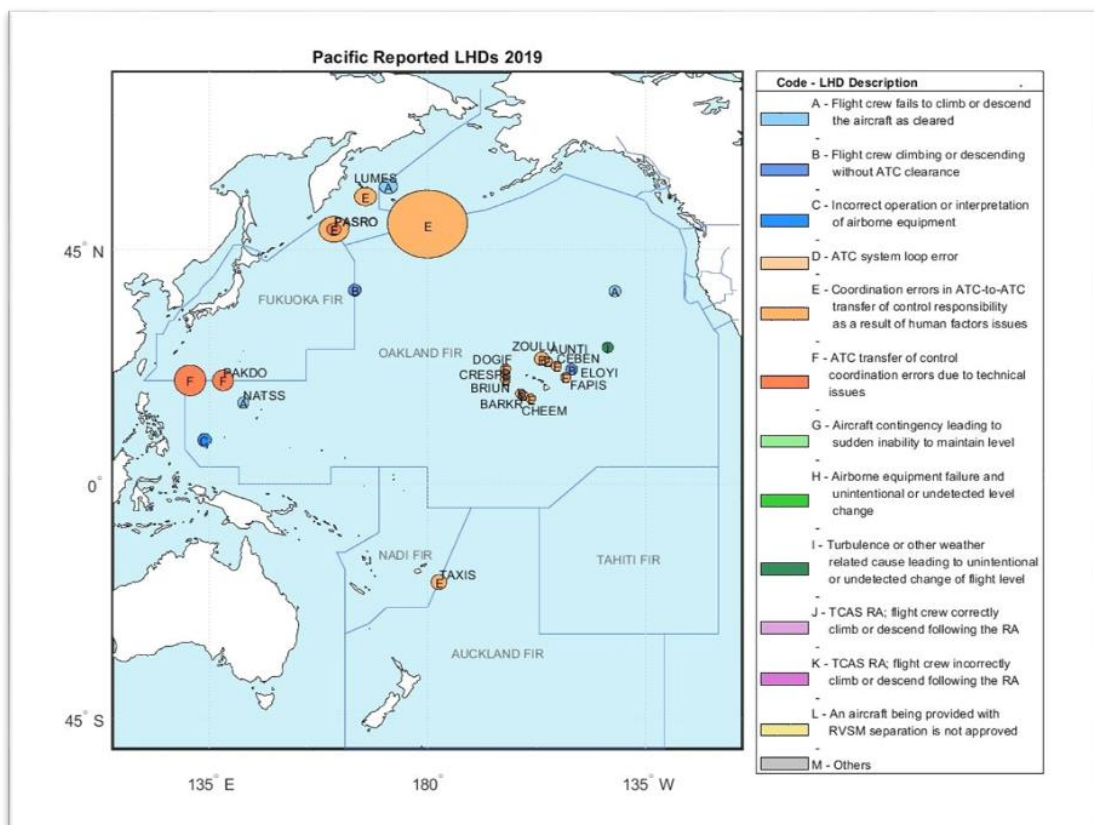
2.3 **Table 2** presents a summary of the LHD causes within Pacific airspace from 1 January 2019 until 31 December 2019.

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;	5	18	3
B	Flight crew climbing /descending without ATC clearance;	4	15	3
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.)	1	18	0
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message);	0	0	0
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);	67	334	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues;	3	130	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure);	1	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
I	Turbulence or other weather related causes	2	4	10
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
	<b>Totals</b>	<b>83</b>	<b>519</b>	<b>16</b>

**Table 2:** Summary of LHD Causes within Pacific Airspace - 2019

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 vertical collision risk estimate for Pacific RVSM airspace increased from the previous year's estimate. There are several factors that contributed towards the increase in estimated vertical risk. One of these factors is the increase in duration associated with the reported LHDs. **Table 4** in the attachment shows this trend over the recent years. Another factor is the occurrence of five long duration LHDs. A long duration LHD has a duration of twenty or more minutes.

2.6 De-identified descriptions of each of the five long duration LHDs are contained in the attachment. All of the five reported long duration LHDs were categorized as errors in ATC-to-ATC transfers.

2.7 A few notable mitigations and improvements implemented as a result of the reported occurrences are included in the following list:

2.7.1 AIDC has now been implemented for aircraft transfers between Anchorage Oceanic and Magadan FIRs. There was a reported LHD with an eighteen-minute duration in January 2019 which occurred prior to the AIDC implementation between the two facilities. This LHD occurrence helped to encourage establishing AIDC between the two facilities.

2.7.2 One ATC facility took action to organize a work group to examine "nuisance" messages because of reported occurrences. Here, the term, "nuisance" is used to describe alerts provided to the controller. The scrutiny review team informed PARMO there are, in general, many out-of-conformance alerts delivered to the controller by the automation system. Sometimes, the controllers receiving the out-of-conformance reports believe they already know the information contained in the alert before reading it completely. These "nuisance" alerts are sometimes discarded.

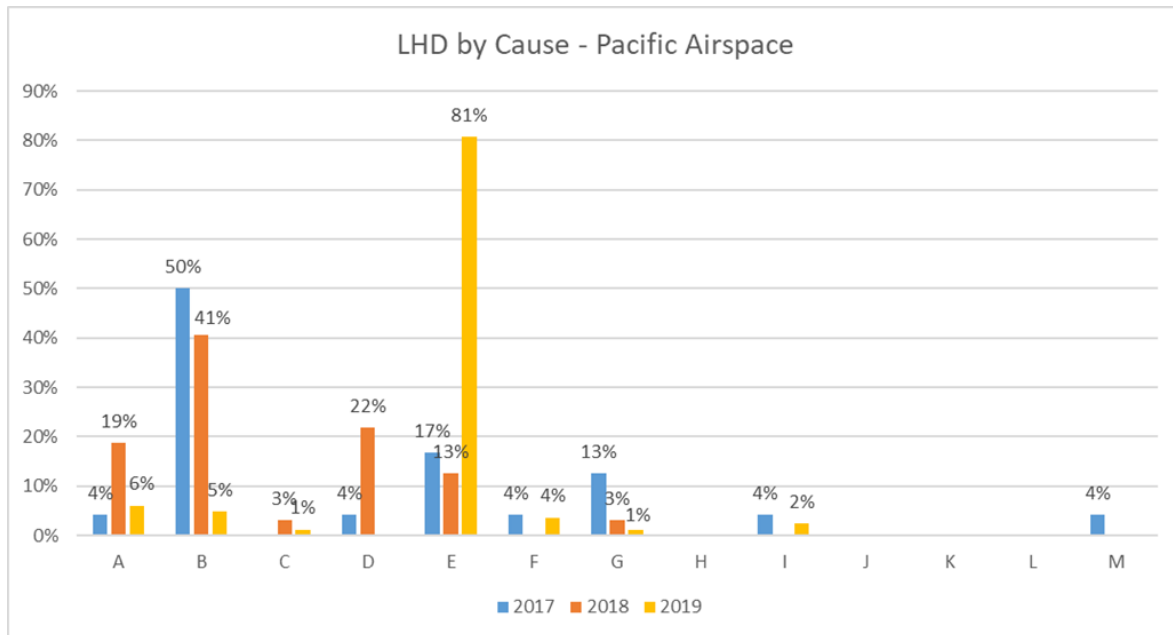
2.7.3 An ATC outage in an adjacent FIR and the related reported occurrences caused one ATC facility to initiate a system service review (SSR). A result of the SSR was to retrain controllers on the use of HOLD messages in the automation system. It took more than a month to have all ATC personnel retrained; this training is now part of the annual refresher training at the facility.

2.7.4 At least one ATC facility utilizes the ADS-C altitude range change (ARC) event contract. When the altitude range is set to include the cleared flight level, it triggers an ADS-C report when the aircraft is outside of the prescribed altitude range. This ATC unit provided an LHD report with category A, air crew failing to climb/descend as cleared, indicating that the ADS-C ARC message triggered a warning message to the controller.

2.7.5 Another ATC facility established a task force to examine repeated occurrences in ATC-to-ATC unit coordination. The current status of the task force work is ongoing, personnel from both facilities are involved in the effort. These occurrences are described in detail in the attachment.

2.8 The analysis for Pacific airspace shows that LHD categories E and F, errors in ATC-to-ATC transfer are the top contributors to reported LHD occurrences airspace during calendar year 2019. This is a change from previous years where categories A and B, air crew climbing/descending without clearance and not in accordance with clearance, were the top contributors to reported occurrences. Figure 3 shows the recent trend by category for reported LHDs in Pacific airspace.

2.9 One reason for the increase in the number of category E LHDs is a large number of reports for transfer errors between Honolulu Control Facility (HCF) and Oakland Oceanic FIR. There were sixty-one reported category E LHDs during the period September to November 2019. These type of events occur frequently and require significant resources at the ATC facility to investigate underlying causes. The resources needed for this activity were made available during the September to November 2019 period, which helps to explain the inconsistent reporting for these occurrences. The attachment provides more detail on these reports.



**Figure 3:** Trend LHD by category for Pacific RVSM airspace

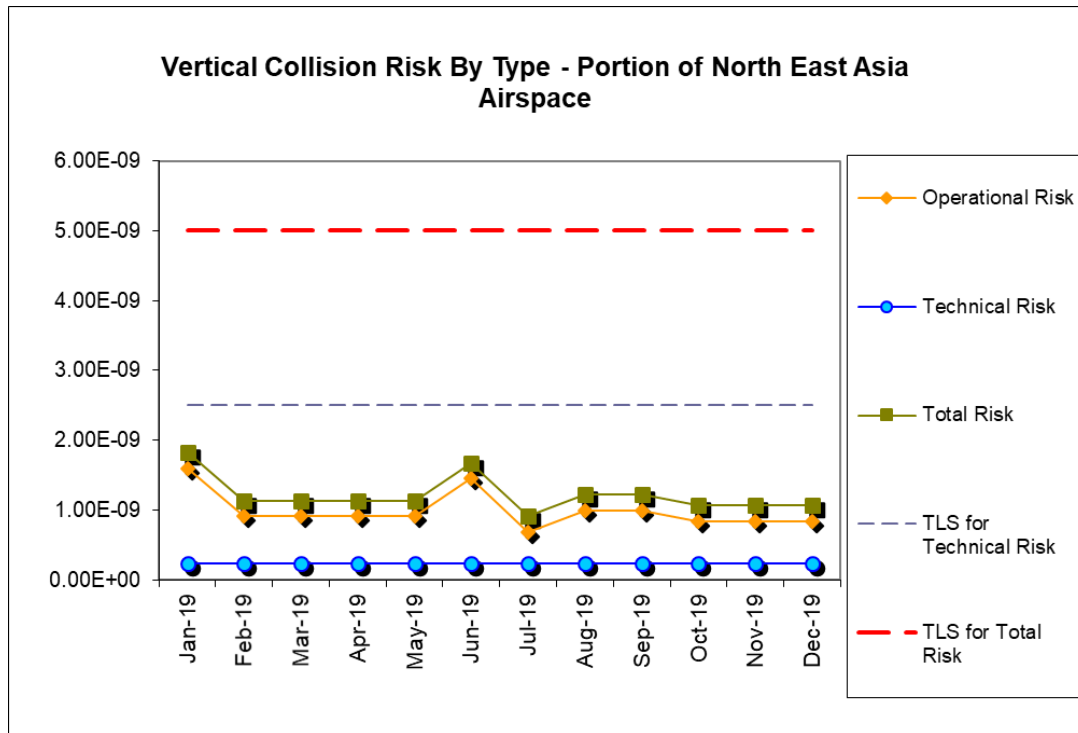
2.10 In 2018, the area of Pacific airspace with the largest reported LHD duration was the Central East Pacific (CEP) traffic flow, and this area was designated as a hot spot. A separate working paper is provided to this meeting on the 2019 reported LHDs in the CEP.

2.11 Another working paper to this meeting summarizes recent changes to the guidance material in the Global Operational Data Link (GOLD) Manual. These changes are related to reported category A and B LHD occurrences where phraseology was determined to be an issue.

2.12 **Table 3** summarizes a portion of North East Asia airspace RVSM technical, operational, and total risks. **Figure 3** presents collision risk estimate trends during the period from January to December 2019.

North East Asia Airspace – estimated annual flying hours = 644,602 hours (note: estimated hours based on Dec 2019 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 24 Total Risk	$4.06 \times 10^{-9}$	$5.0 \times 10^{-9}$	Below TLS
Technical Risk	$0.23 \times 10^{-9}$	$2.5 \times 10^{-9}$	Below Technical TLS
Operational Risk	$0.84 \times 10^{-9}$	-	-
Total Risk	<b><math>1.07 \times 10^{-9}</math></b>	$5.0 \times 10^{-9}$	<b>Below TLS</b>

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



**Figure 3:** A Portion of North East Airspace RVSM Risk Estimate Trends

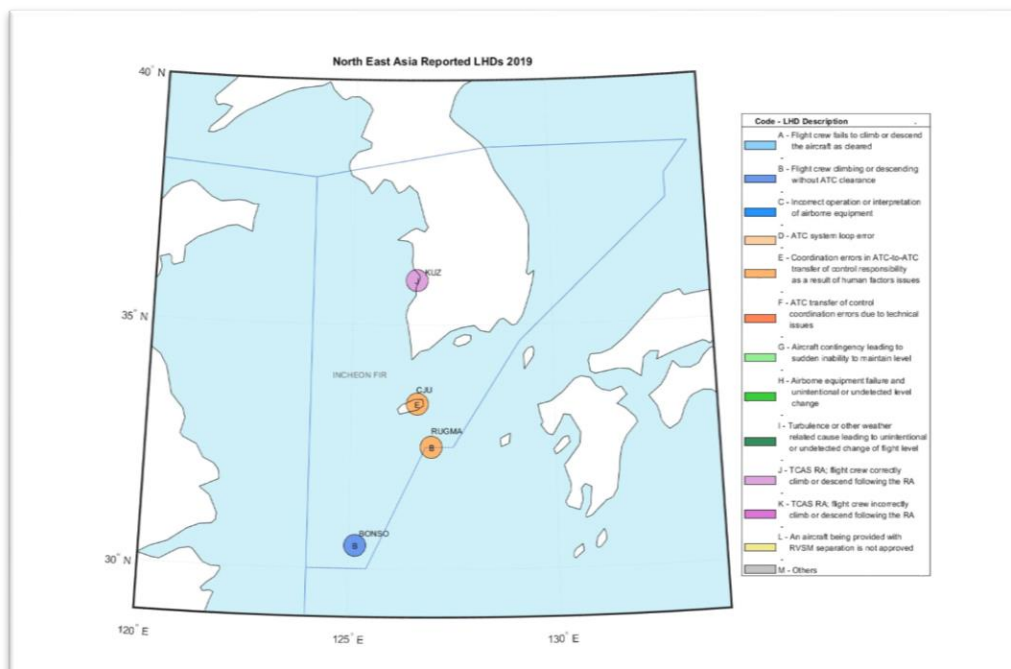
2.13 **Table 4** presents a summary of the LHD causes within North East Asia airspace from January 2019 until December 2019. These data do not include the reported LHDs for the AKARA corridor. The analyses of the AKARA corridor airspace is considered in a separate working paper for this meeting.

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;	2	0.733	3
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
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

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
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	1	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
	<b>Totals</b>	<b>5</b>	<b>0.733</b>	<b>3</b>

**Table 2:** Summary of LHD Causes within North East Asia Airspace

2.14 **Figure 4** provides the geographic location of risk bearing LHD reports within North East Asia airspace during the assessment period.



**Figure 4:** Pacific Airspace – Risk Bearing LHD

- 2.15 The estimate of overall vertical risk for a portion of North East Asia airspace decreased from the estimated provided for calendar year 2018. The reported LHDs for 2019 included two errors in the AIDC transfer information or AIDC failures, all of which were resolved prior to the boundary crossing.

**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 2019 TO December 2019**

Prepared by  
Pacific Approvals and Registry Monitoring Organization (PARMO) – July 2020  
(An ICAO APANPIRG approved Regional Monitoring Agency)

## 1. Introduction

1.1 This report provides an airspace safety review of 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 2019 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 2019 TSD Submitted to PARMO

FIR	December 2019 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 2019. **Table 2** indicates those FIRs which submitted LHD reports including nil returns.

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

	Anchorage	Auckland	Incheon	Nadi	Oakland	Tahiti
Jan 2019	X	X	X	X	X	X
Feb 2019	X	X	X	X	X	X
Mar 2019	X	X	X	X	X	X
Apr 2019	X	X	X	X	X	X
May 2019	X	X	X	X	X	X
Jun 2019	X	X	X	X	X	X
Jul 2019	X	X	X	X	X	X
Aug 2019	X	X	X	X	X	X
Sep 2019	X	X	X	X	X	X
Oct 2019	X	X	X	X	X	X

	Anchorage	Auckland	Incheon	Nadi	Oakland	Tahiti
Nov 2019	X	X	X	X	X	X
Dec 2019	X	X	X	X	X	X

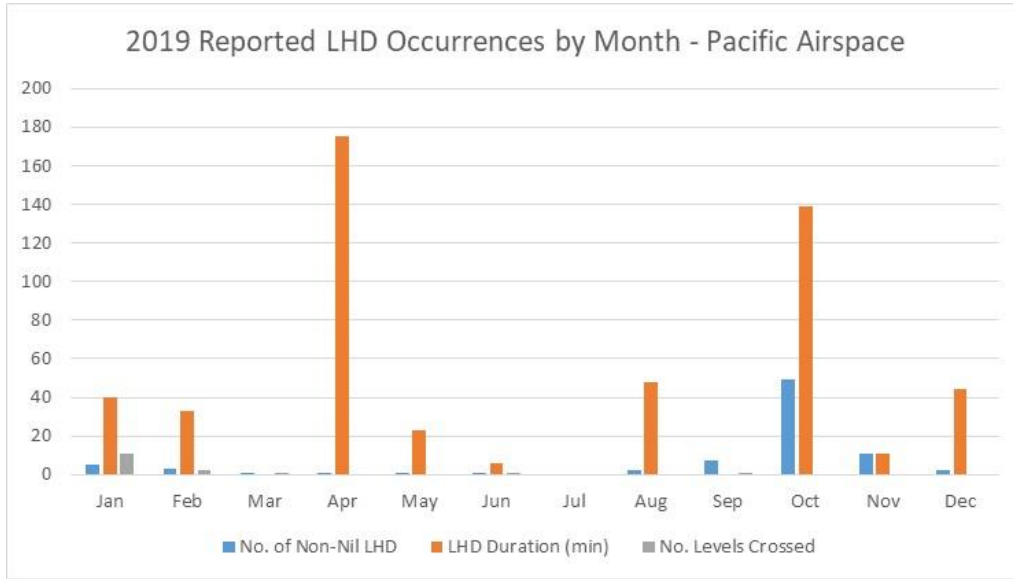
### 3. Summary of LHD Occurrences

#### 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 2019 to 31 December 2019 inclusive for Pacific airspace.

**Table 3:** Summary of non-NIL LHD occurrences and duration for Pacific RVSM airspace – Year 2019

Month	No. of Non-NIL LHD	LHD Duration (min)	No. Levels Crossed
<b>2019</b>			
January	5	40	11
February	3	33	2
March	1	0	1
April	1	175	0
May	1	23	0
June	1	6	1
July	0	0	0
August	2	48	0
September	7	0	1
October	49	139	0
November	11	11	0
December	2	44	0
<b>Total</b>	<b>83</b>	<b>519</b>	<b>16</b>



**Figure 1:** Summary of LHD occurrences by month for Pacific RVSM airspace –2019

3.3 The reported LHDs for Pacific Airspace provided to the PARMO in 2019 indicated there were **519 minutes** of operation at an incorrect flight level. These data show a continued increasing trend in both the number of LHD reports received and amount of time spent on incorrect flight levels. For comparison, the LHD reports provided to the PARMO within the recent six-year period and associated time spent at incorrect flight level is provided in **Table 4**.

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 5** provides the different Pacific traffic flows and the corresponding descriptions.

**Table 4:** Numbers of LHD Reports Received and Associated LHD Duration – Six Year Trend

Calendar Year	Number of LHD Reports	LHD Duration
2014	37	88
2015	42	191
2016	25	149
2017	24	271
2018	32	352.75
2019	83	519

**Table 5: Pacific Traffic Flows used for Vertical Collision Risk Estimation**

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

3.5 An LHD event with a duration of 20 minutes or more is considered to be a long duration event. There were **five** reported long duration LHD events in 2019. In the previous year, 2018, there were six reported long duration LHDs.

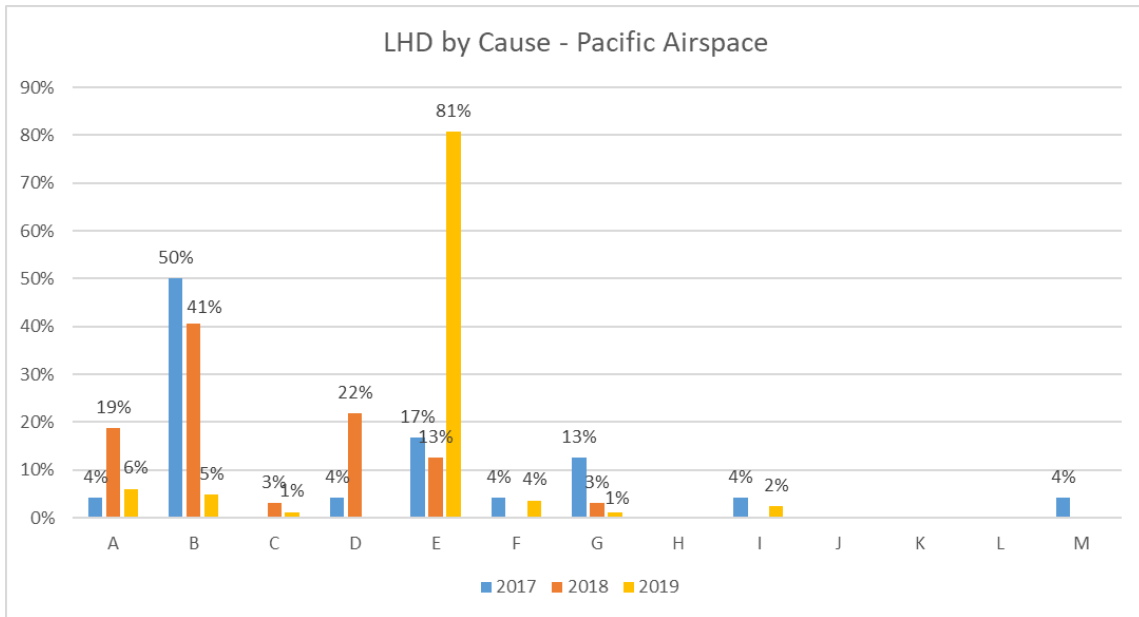
3.5.1 The longest reported LHD duration was one hundred seventy five minutes, roughly 34% of the total LHD duration for 2019 in Pacific airspace. This event involved a commercial operation and all communications between the pilot and ATC were conducted via CPDLC. This event took place in the Central Pacific (CENPAC) area of Pacific airspace. The CENPAC contains traffic between North America and Asia. The primary cause of this occurrence was error in ATC-to-ATC transfer. The pilot received a block altitude clearance while still within the transferring ATC airspace, but the transfer message information was not updated to include the block altitude clearance. The transferring ATC discarded system alert messages related to the coordination for this flight. The error was discovered by the receiving ATC when the aircraft climbed to a different flight level. Although the aircraft was reporting position via ADS-C with a 10-minute frequency, the scrutiny review group determined that there was not enough evidence to indicate the pilot did not occupy an incorrect flight level within the receiving ATC airspace. Both ATC facilities reported this

- occurrence. This occurrence took place in April 2019, which accounts for the large spike in LHD Duration shown in Figure 1.
- 3.5.2 Another event had an LHD duration of eighty-three minutes. This event involved a military operation on a “round-robin” flight. The primary cause of this reported LHD was error in ATC-to-ATC transfer. The transferring ATC unit did not provide information to the receiving ATC unit. This aircraft operated within oceanic airspace without knowledge of the receiving ATC unit, it was radar identified near the destination airport. This event took place in a low traffic area of Pacific airspace, there was no loss of separation recorded. The primary LHD category for this report was ‘F’, error in ATC-to-ATC transfer due to technical issue. The transferring ATC unit was made aware of this occurrence. The reporting ATC units indicated that this is a specific problem associated with “round-robin” flights, which are unique operations. A software fix for the AIDC handling of round-robin flights is now in place along with a verbal procedure to ensure an invalid transfer message is not sent.
- 3.5.3 Another reported LHD had a duration of forty-five minutes. The location for this report was within the North Pacific (NOPAC) area of Pacific airspace, this area contains traffic between North America and Japan. This event involved a data link equipped military operation. The primary cause of this occurrence was no transfer information provided to the receiving ATC unit due to human factors. The receiving ATC unit initiated a system service review (SSR) resulting from this occurrence. This review determined the contributing causes to be ATC not reacting to alert messages. A work group will look at the alert messages to improve effectiveness of system messaging.
- 3.5.4 Another reported LHD ha a duration of forty-four minutes. This event involved a military operation on a “round-robin” flight and was similar to an earlier reported LHD which occurred two month prior to this one (paragraph 3.5.2). This aircraft operated on an unexpected routing within oceanic airspace without knowledge of the receiving ATC unit, it was radar identified near the destination airport. This event took place in a low traffic area of Pacific airspace, there was no loss of separation recorded. The primary LHD category for this report was ‘F’, error in ATC-to-ATC transfer due to technical issue. The reporting ATC units indicated that this is a specific problem associated with “round-robin” flights, which are unique operations. A software fix for the AIDC handling of round-robin flights is now in place along with a verbal procedure to ensure an invalid transfer message is not sent.
- 3.5.5 There was a reported LHD with twenty-three minutes duration. This reported LHD occurred within the Nadi traffic flow in Pacific airspace and involved a commercial operation using High Frequency (HF) radio communications. The primary cause of this occurrence was incorrect transfer information provided to the receiving ATC unit due to human factors. The receiving facility expected the aircraft at flight level (FL) 360, but the aircraft was occupied FL380 over the boundary crossing. The transferring facility was notified of this reported occurrence.

3.6 **Table 6** and **Figure 2** 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 2019 to 31 December 2019 inclusive for Pacific RVSM airspace. **Figure 3** provides a geographic chart with the approximate locations of the non-nil LHD reports.

3.7 **Table 6** and **Figure 2** show categories E and F, errors in ATC-to-ATC transfer are the top contributors to reported LHD occurrences during calendar year 2019. This is a change from previous years where categories A and B, air crew climbing/descending without clearance and not in accordance with clearance, were the top contributors to reported occurrences, Figure 2 provides the observed trend in LHD category over the previous three years.

3.8 All of the long duration LHDs described in paragraph 3.5 were classified as either category E or F. The largest duration reported LHD occurred in the CENPAC traffic flow. This traffic flow is second in terms of flying hours in Pacific airspace; it contains the Pacific Organized Track System (PACOTS) routes. The traffic flow with the highest number of flying hours is the Central East Pacific (CEP) traffic flow.



**Figure 2:** Summary of LHD causes for Pacific RVSM airspace

**Table 6:** 12-month LHD reports by LHD category for Pacific RVSM airspace - 2019

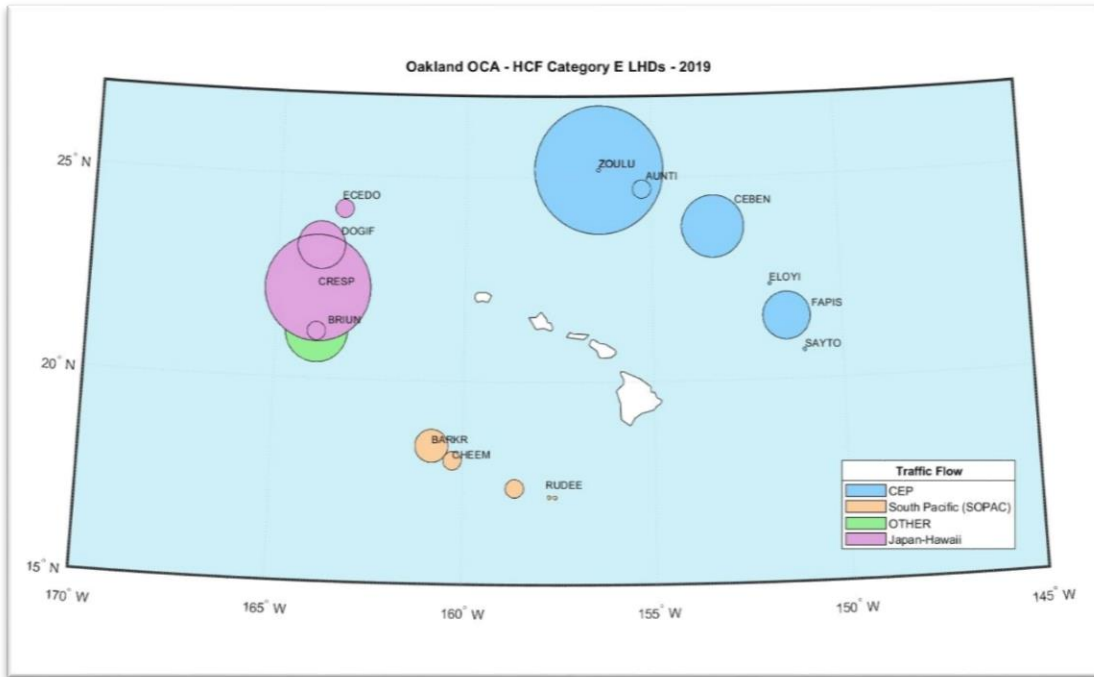
LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
A	Flight crew failing to climb/descend the aircraft as cleared;	5	18	3
B	Flight crew climbing /descending without ATC clearance;	4	15	3
C	Incorrect operation or interpretation 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.)	1	18	0

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message);	0	0	0
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);	67	334	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues;	3	130	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure);	1	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	2	4	10
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
	<b>Totals</b>	<b>83</b>	<b>519</b>	<b>16</b>

3.9 The reported LHDs for 2019 included a large number of reports classified as category E for transfer errors between Honolulu Control Facility (HCF) and Oakland Oceanic FIR. There were sixty-one reported category E LHDs during the period September to November 2019. **Figure 3** provides the general locations for all of the category E LHD reports. 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 CEP traffic are colored in blue. The other traffic flows affected by these transfer errors include Japan – Hawaii, South Pacific (SOPAC), and Other traffic flows.

3.10 The scrutiny review group informed PARMO these occurrences affect the user preferred routes (UPRs) crossing fixed airways within Oakland airspace. These type of events occur frequently and

require significant resources at the ATC facility to investigate underlying causes. The resources needed for this activity were made available during the September to November 2019 period, which helps to explain the inconsistent reporting for these occurrences. During this period, there were pauses in reporting occurrences as real-time improvements were made to both the process for examining the occurrences and the actual ATC-unit to ATC-unit transfer procedure itself. The current status of this work is ongoing; a task force has been established that includes personnel from both facilities.



**Figure 3.** Reported transfer occurrences HCF – Oakland OCA (2019)

3.11 The available system data were examined for each reported occurrence. The subject matter experts from Oakland center and PARMO agreed to the following scheme to determine each associated LHD duration:

- 3.11.1 If there were no observed updates to related messages in the archived sector queue data prior to the aircraft entry into Oakland oceanic airspace, an acceptable time of two minutes was assigned to the reported LHD. The lack of amended sector queue messages indicates the receiving ATC did not recognize the transfer error prior to aircraft entering Oakland oceanic airspace.
- 3.11.2 If there were amendments made to related messages in the archived sector queue data prior to the aircraft entry into Oakland oceanic airspace, a zero duration was assigned to the reported LHD. These updated messages in the sector queue data represent the recognition of the discrepancy by ATC prior to the actual boundary crossing time.
- 3.11.3 After examining the recorded system messages and applying the above scheme, there were thirty-three reported LHDs with zero duration, and twenty-eight reported LHDs each with 2 minutes duration (e.g. 28 reported LHDs with 2 minutes duration (a total of 56 minutes)).

3.12 A few notable mitigations and improvements implemented as a result of the reported occurrences in 2019 are included in the following list:

- 3.12.1 AIDC has now been implemented for aircraft transfers between Anchorage Oceanic and Magadan FIRs. There was a reported LHD with an eighteen-minute duration in January 2019 which occurred prior to the AIDC implementation between the two facilities. This LHD occurrence helped to encourage establishing AIDC between the two facilities.
- 3.12.2 One ATC facility took action to organize a work group to examine “nuisance” messages because of reported occurrences. Here, the term, “nuisance” is used to describe alerts provided to the controller. The scrutiny review team informed PARMO there are, in general, many out-of-conformance alerts delivered to the controller by the automation system. Sometimes, the controllers receiving the out-of-conformance reports believe they already know the information contained in the alert before reading it completely. These “nuisance” alerts are sometimes discarded.
- 3.12.3 An ATC outage in an adjacent FIR and the related reported occurrences caused one ATC facility to initiate a system service review (SSR). A result of the SSR was to retrain controllers on the use of HOLD messages in the automation system. It took more than a month to have all ATC personnel retrained; this training is now part of the annual refresher training at the facility.
- 3.12.4 At least one ATC facility utilizes the ADS-C altitude range change (ARC) event contract. When the altitude range is set to include the cleared flight level, it triggers an ADS-C report when the aircraft is outside of the prescribed altitude range. This ATC unit provided an LHD report with category A, air crew failing to climb/descend as cleared, indicating that the ADS-C ARC message triggered a warning message to the controller.
- 3.12.5 Another ATC facility established a task force to examine repeated occurrences in ATC-to-ATC unit coordination. The current status of the task force work is ongoing, personnel from both facilities are involved in the effort. These occurrences are described in detail in paragraph 3.9.

3.13 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 5**. For example, the CEP traffic flow contains aircraft operations travelling between North America and Hawaii. The CEP traffic flow has 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.

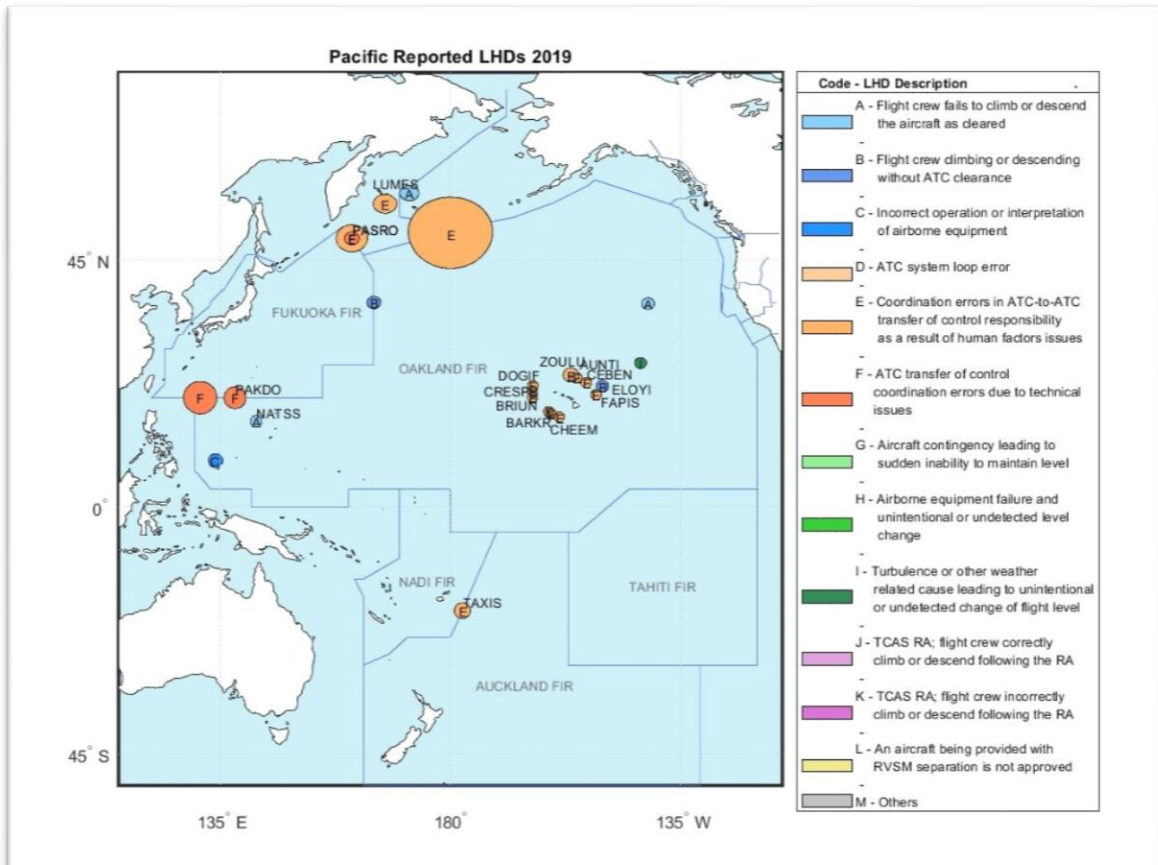
3.14 In 2019, the area of Pacific airspace with the largest reported LHD duration is the CENPAC traffic flow. This is the traffic flow that contains the PACOTS routes and consists of aircraft operations between North America and Asia. **Figure 4** shows the approximate location and cause of all reported LHDs within Pacific airspace. There were two reported LHDs contributing 181 minutes of LHD duration and one levels crossed to the estimated risk. In 2018, the CEP traffic flow had the most reported LHD occurrences.

3.15 **Table 7** provides the LHD summary by Pacific traffic flow. The traffic flows listed in Table 7 are described in Table 5. The values provided in Table 7 include the LHD duration in minutes by

category code for each traffic flow. The third row in Table 7 shows the CENPAC traffic flow has the largest LHD duration for 2019.

**Table 7:** Sum of LHD Duration (minutes) by Pacific Traffic Flow and LHD category - 2019

Traffic Flow	A	B	C	E	F	G	I	Total
NOPAC	7	0	0	63	3	0	0	73
CENPAC	0	6	0	175	0	0	0	181
CEP	3	9	0	33	0	0	4	49
HAWJPN	0	0	0	24	0	0	0	24
JPNGM	0	0	0	0	0	0	0	0
OTH	0	0	0	8	0	0	0	8
AUSNZSP	0	0	0	0	0	0	0	0
NADI	0	0	0	23	0	0	0	23
AUSNZJP	8	0	18	0	127	0	0	153
SOPAC	0	0	0	8	0	0	0	8
<b>Total</b>	<b>18</b>	<b>15</b>	<b>18</b>	<b>334</b>	<b>130</b>	<b>0</b>	<b>4</b>	<b>519</b>



**Figure 4:** Pacific RVSM airspace LHD locations - 2019

### 3.16 North East Asia RVSM Airspace

3.17 **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 2019 to 31 December 2019 inclusive for North East Asia airspace. The data in Table 8 do not include the reported LHDs for the AKARA corridor. The analyses of the AKARA corridor airspace is considered in a separate working paper for this meeting.

**Table 8:** Summary of non-NIL LHD occurrences and duration for North East Asia RVSM airspace

Month-Year	No. of Non-NIL LHD	LHD Duration (min)	No. Levels Crossed
<b>2019</b>			
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	0	0	0
June	1	0.733	1
July	0	0	0
August	2	0	2
September	0	0	0
October	2	0	0
November	0	0	0
December	0	0	0
<b>Total</b>	5	0.733	3

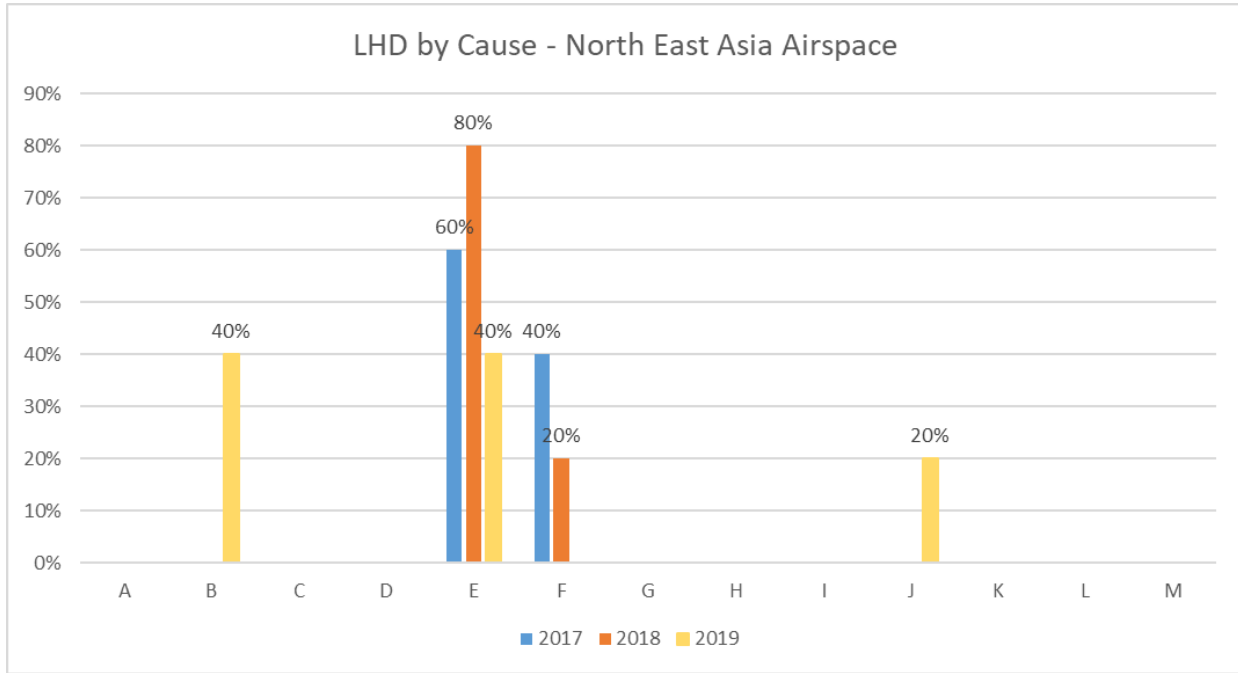
3.18 **Table 9** and **Figure 5** summarize the number of LHD occurrences, the associated LHD duration (in minutes) and number of flight levels crossed without clearance, by LHD category from 1 January 2019 to 31 December 2019 inclusive for North East Asia RVSM airspace. Figure 4 provides the observed trends in reported LHD category codes for the recent three-year period. **Figure 6** provides the geographic locations of the LHDs reported for North East Asia Airspace.

3.19 The reported LHDs for 2019 included errors in the AIDC transfer information or AIDC failures, which were resolved prior to the boundary crossing. Reported LHDs within the AKARA corridor are not included in Table 9, and in Figures 4 and 5.

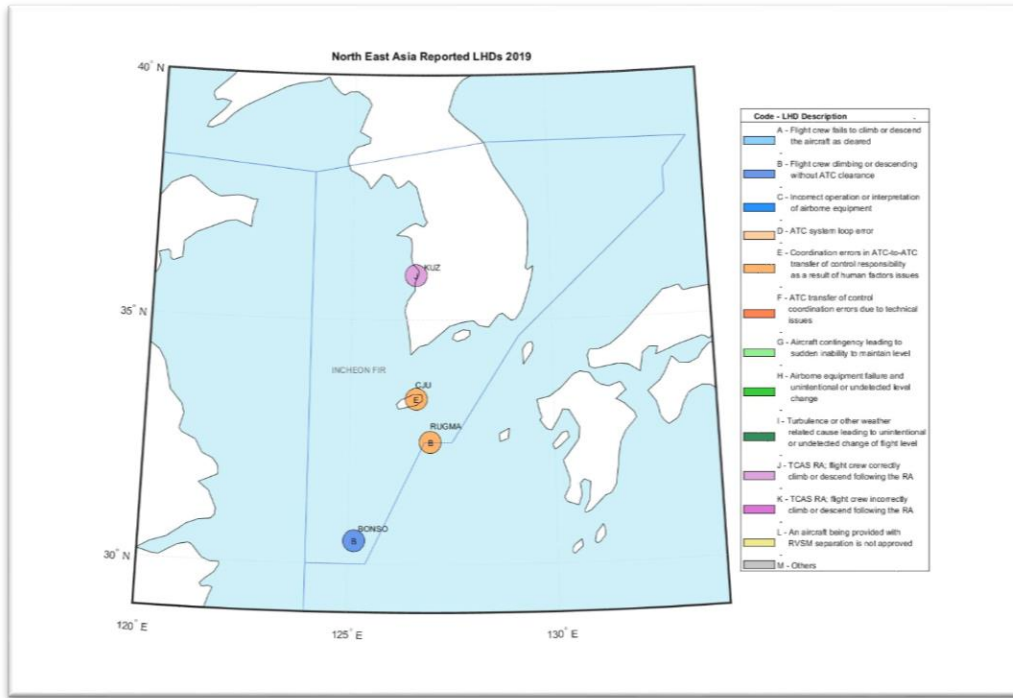
**Table 9: LHD Summary by category for North East Asia RVSM airspace**

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;	0	0	0
B	Flight crew climbing /descending without ATC clearance;	2	0.733	3
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
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	1	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

LHD Category Code	LHD Category Description	No of LHD Occurrences	LHD Duration (Min)	No. of Flight Levels Transitioned Without Clearance
M	Other	0	0	0
	<b>Totals</b>	<b>5</b>	<b>0.733</b>	<b>3</b>



**Figure 5:** Summary of LHD causes for North East Asia RVSM airspace - 2019



**Figure 6:** North East Asia Airspace – Risk Bearing LHD

**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 10**. Other collision risk model parameters that vary by traffic flow include aircraft size, occupancy values, and flying hours. These parameters are shown in **Table 11** by traffic flow. Table 5 contains a listing and description for each traffic flow.

**Table 10:** Estimates of the parameters in the CRM for Pacific RVSM airspace

Parameter	Description	Value
$ \overline{\Delta V} $	Average relative same-direction speed	13 Knots
$ \overline{V} $	Average aircraft speed	480 knots
$ \overline{y} $	Average relative cross-track speed	5 knots
$ \overline{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
$P_z(1000)$	Probability two aircraft nominally separated by 1 000 ft are in vertical overlap	$4.68 \times 10^{-9}$

**Table 11: 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, $E_z(\text{Same})$	Opposite Direction Vertical Occupancy, $E_z(\text{Opp})$
NOPAC	228,621.0	13.03%	0.037	0.034	0.010	0.522	0.000
CENPAC	451,686.8	25.75%	0.037	0.035	0.010	0.645	0.013
CEP	499,785.8	28.49%	0.026	0.022	0.007	0.662	0.183
JPHAWA	101,600.9	5.79%	0.033	0.032	0.009	0.595	0.003
JPGUAM	15,850.4	0.90%	0.027	0.025	0.008	0.039	0.110
OTHER	19,873.1	1.13%	0.026	0.023	0.008	0.035	0.023
AUSNZSP	57,737.9	3.29%	0.025	0.023	0.007	0.013	0.031
NADI	22,603.0	1.29%	0.031	0.030	0.009	0.027	0.013
AUSNZJP	90,884.3	5.18%	0.034	0.034	0.010	0.035	0.006
SOPAC	265,568.1	15.14%	0.035	0.034	0.010	0.133	0.131
<b>TOTAL</b>	<b>1,754,211.1</b>	<b>100.00%</b>	<b>0.032 NM</b>	<b>0.030 NM</b>	<b>0.009 NM</b>		
			<b>195.8 ft</b>	<b>183.7 ft</b>	<b>54.2 ft</b>		

4.4 **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 12**. 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 exceeds the specified TLS value** for these components of  $5.0 \times 10^{-9}$  fapfh.

**Table 12: Pacific Airspace Risk Estimates**

<b>Pacific Airspace – estimated annual flying hours = 1,754,212 hours</b> <i>(note: estimated hours based on Dec 2019 traffic sample data)</i>			
Source of Risk	Risk Estimation	TLS	Remarks
<i>RASMAG 24 Total Risk</i>	$26.46 \times 10^{-9}$	$5.0 \times 10^{-9}$	<i>Above TLS</i>
Technical Risk	$0.17 \times 10^{-9}$	$2.5 \times 10^{-9}$	Below Technical TLS
Operational Risk	$31.24 \times 10^{-9}$	-	-
Total Risk	<b><math>31.41 \times 10^{-9}</math></b>	$5.0 \times 10^{-9}$	<b>Above TLS</b>

4.5 **Figure 7** presents the trends of collision risk estimates for each month using the appropriate cumulative 12-month data set of LHD reports. Although the current vertical collision risk estimate exceeds the TLS, this value is a result of increased reporting for the airspace which is considered to be a positive outcome.

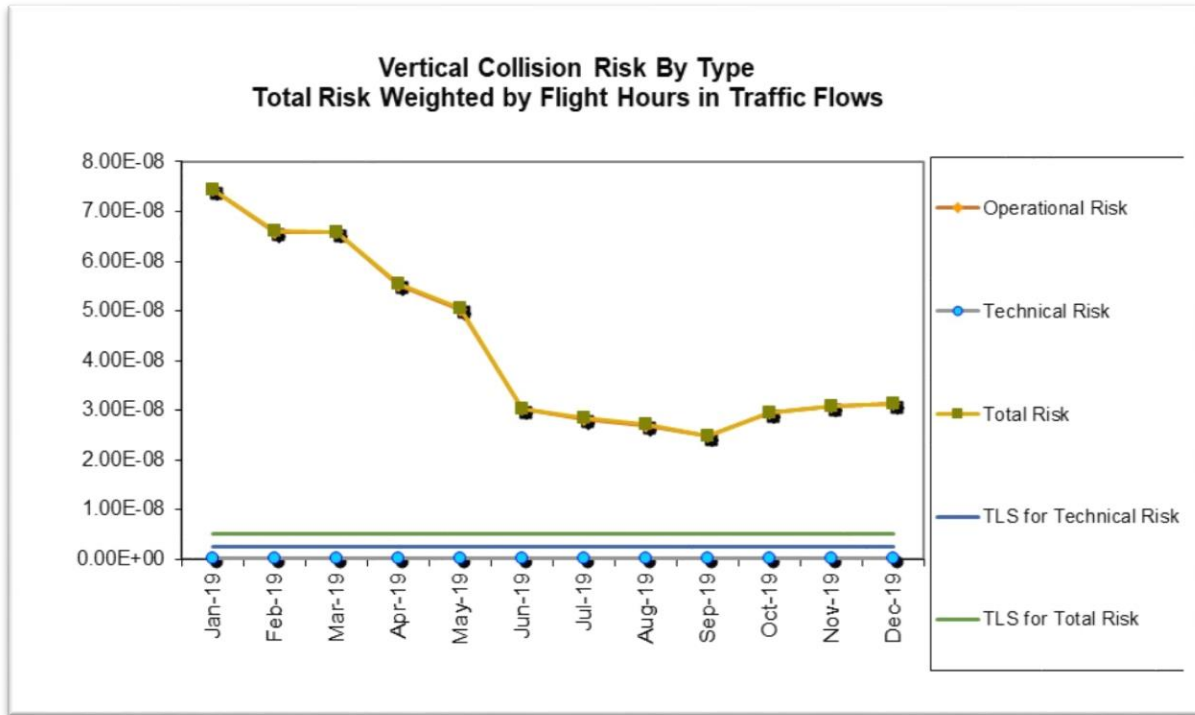


Figure 7: Trends of Risk Estimates for Pacific RVSM Airspace

4.6 North East Asia RVSM airspace

4.7 Collision Risk Model (CRM) Parameters

4.8 The value of the parameters in the CRM used to estimate risk in North East Asia RVSM airspace, are summarized in Table 13.

Table 13: Estimates of the parameters in the CRM for North East Asia RVSM airspace

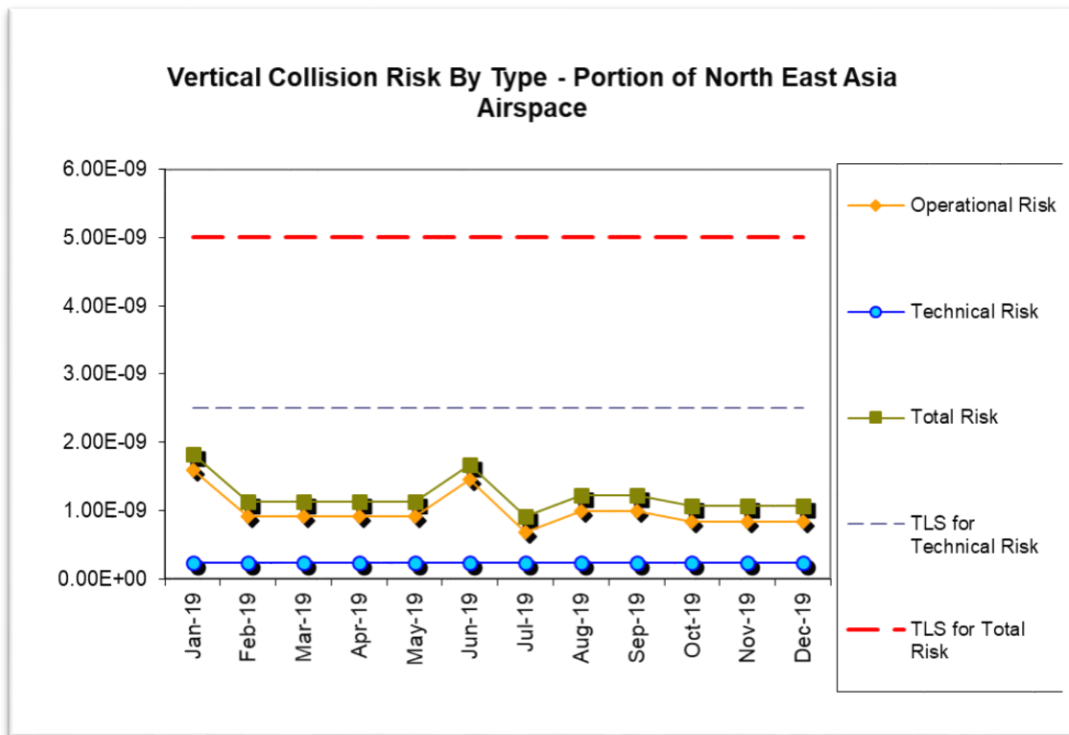
Parameter	Description	Value
$\lambda_x$	Average aircraft length	0.028 NM
$\lambda_y$	Average aircraft wingspan	0.025 NM
$\lambda_z$	Average aircraft height	0.008 NM
$ \Delta V $	Average relative same-direction speed	38.3 Knots
$ V $	Average aircraft speed	480 knots
$ \dot{y} $	Average relative cross-track speed	5 knots
$ \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
$P_z(1000)$	Probability two aircraft nominally separated by 1 000 ft are in vertical overlap	$4.68 \times 10^{-9}$
$E_z(\text{Same})$	Same direction vertical occupancy value	0.9601

Parameter	Description	Value
$E_z(Opp)$	Opposite direction vertical occupancy value	0.0985

4.9 **Risk Estimation Results.** The results for the technical, operational, and total risk for the RVSM implementation are detailed in **Table 14**. 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.

**Table 14:** North East Asia RVSM Airspace Risk Estimates

North East Asia Airspace – estimated annual flying hours = 644,602 hours (note: estimated hours based on Dec 2019 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG 24 Total Risk	$4.06 \times 10^{-9}$	$5.0 \times 10^{-9}$	Below TLS
Technical Risk	$0.23 \times 10^{-9}$	$2.5 \times 10^{-9}$	Below Technical TLS
Operational Risk	$0.84 \times 10^{-9}$	-	-
Total Risk	<b><math>1.07 \times 10^{-9}</math></b>	$5.0 \times 10^{-9}$	<b>Below TLS</b>



**Figure 8:** Trends of Risk Estimates for North East Asia RVSM Airspace