International Civil Aviation Organization

Twenty-Ninth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/29)

Bangkok, Thailand, 19 – 22 August 2024

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

JASMA HORIZONTAL SAFETY REPORT

(Presented by JASMA)

SUMMARY

This paper presents the results of the horizontal safety assessment of the Pacific Ocean airspace in the Fukuoka Flight Information Region (FIR) for the period January 2023 to December 2023.

1. INTRODUCTION

1.1 This paper provides the horizontal risk assessment results of the Pacific Ocean airspace of Fukuoka Flight Information Region (FIR), which was conducted by the Japan Airspace Safety Monitoring Agency (JASMA). In this paper, the risk estimation results of the following three horizontal separation standards are reported.

a) 50 NM lateral separation

b) 10 minutes Time-based longitudinal separation (without Mach number technique)

c) 30 NM Distance-based longitudinal separation (PBCS and RNP4)

2. DISCUSSION

2.1 For the calculation methods and parameters used, please refer to the **Attachment** to this paper.

Executive Summary

2.2 **Table 1** provides the North Pacific Ocean airspace horizontal risk estimates. **Figure 1** presents the lateral and longitudinal collision risk estimate trends for the North Pacific Ocean airspace of Fukuoka FIR during the period January 2023 to December 2023.

Table 1: North Pacific Ocean Airspace Horizontal Risk Estimates

North Pacific Ocean Airspace – estimated annual flying hours = 119,382 hours ***(note: estimated hours based on Dec 2023 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 50 NM Lateral Risk	*0.456×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 28 10 MIN Based-Longitudinal Risk	*1.75×10^{-9}*	*5.0×10^{-9}*	*Below TLS*

North Pacific Ocean Airspace – estimated annual flying hours = 119,382 hours *(note: estimated hours based on Dec 2023 traffic sample data)*			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 28 30 NM Distance-based Longitudinal Risk	*0.008 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
50 NM Lateral Risk	**1.16 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**
10 MIN Time-based Longitudinal Risk	**10.01 x 10^{-9}**	5.0 x 10^{-9}	**Above TLS**
30 NM Distance-based Longitudinal Risk	**0.003 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

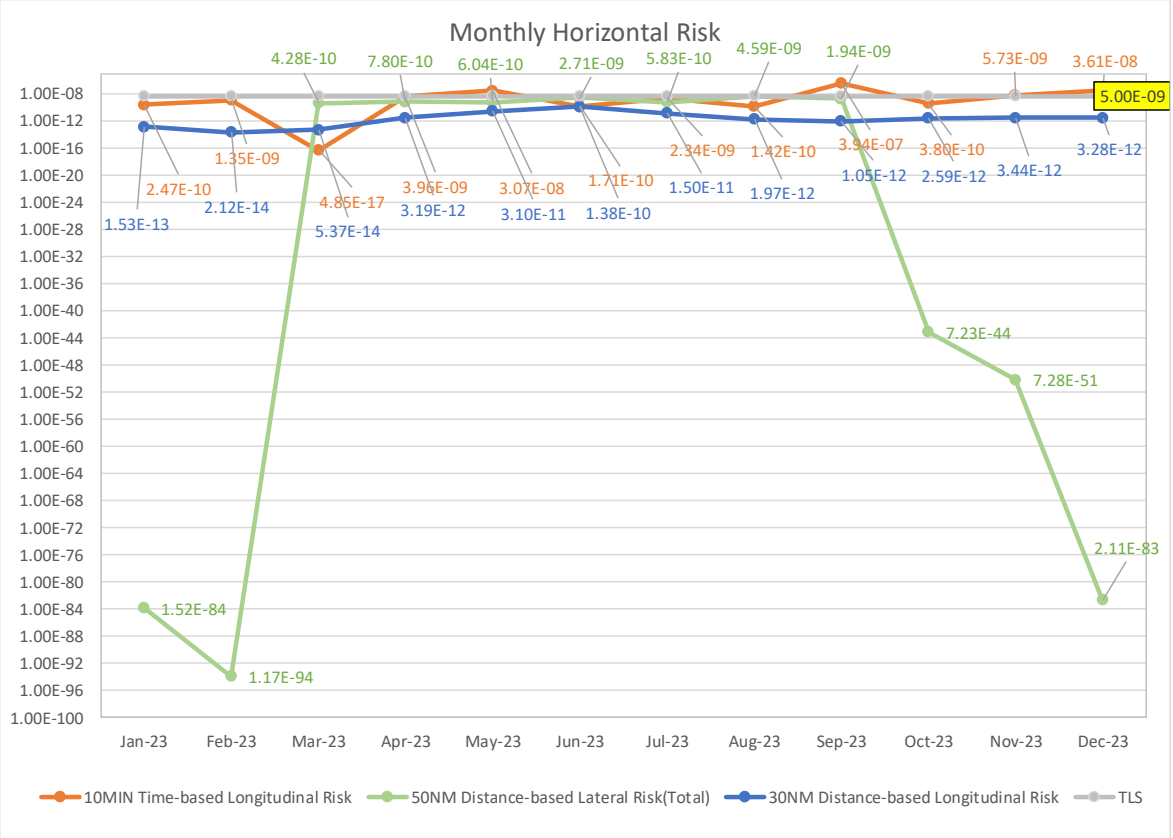

Figure 1: North Pacific Ocean Airspace Horizontal Risk Estimates

2.3 **Table 2** contains a summary of Large Lateral Deviations (LLD) and Large Longitudinal Errors (LLE) received by JASMA for the Pacific Ocean airspace in Fukuoka FIR.

Table 2: Summary of Pacific Ocean Airspace LLD and LLE Reports

Code	Deviation Description	No.
A	Flight crew deviates without ATC clearance in the horizontal dimension	1
B	Flight crew incorrect operation or interpretation of airborne equipment	0
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	1
D	ATC system loop error	1
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues	3
F	Coordination errors in the ATC-to-ATC transfer of control	1

Code	Deviation Description	No.
	responsibility as a result of equipment outage or technical issues	
G	Navigation errors due to airborne equipment failure leading to a deviation in the horizontal dimension of which notification was not received by ATC or notified too late for action	0
H	Turbulence or other weather related causes (other than approved) leading to a deviation in the horizontal dimension;	11
I	An aircraft was provided with reduced horizontal separation minima but did not meet the RNP/RSP/RCP specification	0
J	Others	0
Total		18

2.4 Category H, "Turbulence or other weather related causes" was the top contributor during the calendar year 2023.

2.5 **Figure 2** provides the geographic location of LLD and LLE reports in the Pacific Ocean Airspace within Fukuoka FIR during the assessment period. The filled blue square symbols represent the LLD location within Fukuoka FIR, and the filled green square symbols represent the LLE location within Fukuoka FIR. The circle size means an LLD or LLE duration of 50 seconds or more.

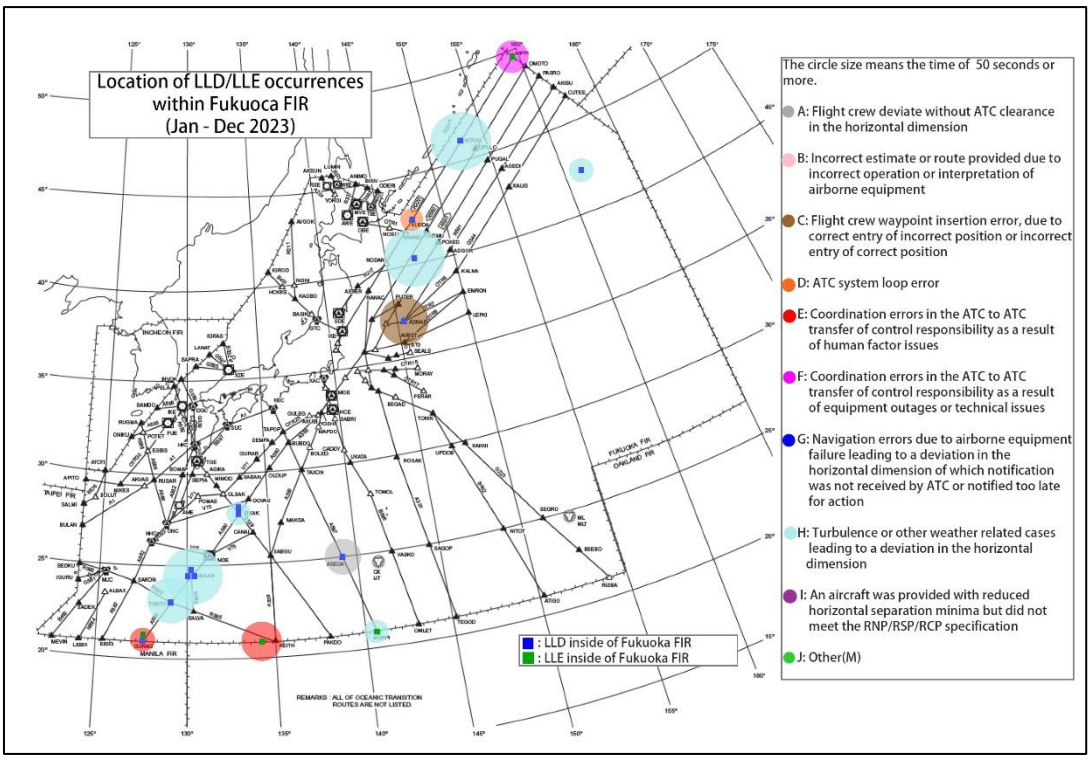

Figure 2: Geographical Location of LLDs &LLEs within Fukuoka FIR

2.6 To enhance airspace capacity in the Pacific Ocean airspace, 23 NM lateral separation minima based on PBCS and RNP4 has already been implemented in the airspace of Fukuoka FIR entirely since 15 June 2023 as an operational trial.

2.7 Current RNAV10 (RNP10) routes and the Pacific Organized Track System (PACOTS) in the airspace are established by using 50 NM lateral distance. A new RNP4 route named M523, which aircraft require PBCS and RNP4, has been established in the North Pacific Ocean airspace since 25 January 2024, and the RNP4 route is separated at least 23 NM from other neighboring ATS routes.

2.8 JASMA is developing and updating the procedures and software to calculate “23 NM Lateral Risk”, and the Risk estimate will be provided to the Thirtieth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/30) next year.

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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Attachment

1. COLLISION RISK FOR 50NM ATC LATERAL SEPARATION

1.1 The North Pacific (NOPAC) Route System was comprised of five Air Traffic Service (ATS) routes that transit the North Pacific between Alaska and Japan until 22 February 2023. Two ATS routes, R591 and G334 were shortened or removed on 23 February 2023. Thus, three ATS routes, R220, R580 and A590 consisted of the NOPAC Route System as of December 2023. Please note that the current route structure and operation of the NOPAC route system are different.

1.2 In 2023, the two northern routes, R220 and R580 were used for westbound traffic. The center route, A590 was used for eastbound traffic. The southern two routes, R591 and G344 were used for eastbound traffic for aircraft crossing the FIR boundary between Anchorage FIR and Fukuoka FIR between 0900UTC and 2100UTC and used for westbound traffic for aircraft crossing the FIR boundary between 0000UTC and 0600UTC until the routes were shortened or removed.

1.3 R591 was shortened until ADGOR on 23 February 2023. However, waypoints, AGEDI and AKISU remain, and aircraft can fly those waypoints as the Pacific Organized Track System (PACOTS) route or the User Preferred Route (UPR).

1.4 G334 was also abolished on 23 February 2023, and waypoints, KALIG and CUTEE are used for PACOTS and UPR as well.

1.5 NOPAC Passing Frequencies are shown in **Table 1**. Since waypoints for former R591 and G344 remain and can be used, the flight hours and passing frequencies are calculated by each segment.

		Flight Hours		Passing Frequencies				Flight Hours		Passing Frequencies		
Airways	Segment	East Bounds	West Bounds	Same East Bounds	Same West Bounds	Opposite Direction	Segment	East Bounds	West Bounds	Same East Bounds	Same West Bounds	Opposite Direction
R220	NUBDA - NOGAL	0.0	27236.8				NOGAL - NIPPI	0.0	26647.4			
				0.0	87.5					0.0	74.5	
R580	ONEMU - OPULO	0.0	8394.0				OPURO - OMOTO		8153.3			
				0.0	0.0	3349.5				0.0	0.0	4575.5
A590	POXED - PUGAL	20811.2	0.0				PUGAL - PASRO	20949.2	0.0			
				14.0	0.0	81.0				12.0	0.0	99.0
(R591)	ADGOR - AGEDI	1506.9	359.5				AGEDI - AKISU	1326.7	317.4			
				0.0	0.0	6.0				0.0	0.0	4.0
(G344)	KALNA - KALIG	1446.3	517.3				KALIG - CUTEE	1392.2	524.1			

Table 1: Flight Hours and Passing Frequencies

1.6 Note that passing frequencies between segments of R220 and R580 were relatively small because R220 and R580 were both westbound only for all the time, passing occurs only when the situation where an aircraft catches up and overtakes another aircraft. On the other hand, the passing frequencies between segments of R580 and A590 were large, because R580 was used for westbound while A590 was used for eastbound.

1.7 The passing frequencies between segments of A590 and former R591 were small because the flight hours of each segment of former R591 were smaller than other northern routes, R220, R580 and A590. Additionally, the passing frequencies between each segment of former R591 and G344 were zero.

1.8 **Table 2** shows the estimated lateral collision risk in the NOPAC area. The total risk estimation was below TLS.

Source of Risk	Risk Estimation
N_{ay} (same)	0.06×10^{-9}
N_{ay} (opposite)	1.10×10^{-9}
N_{ay} (total)	1.16×10^{-9}

Table 2: NOPAC Lateral Collision Risk Estimation

2. Consideration for LLDs and LLEs

Appendix A contains the details of the 17 LLDs/LLEs that occurred in the Pacific Ocean airspace within Fukuoka FIR, which were reported to JASMA during the assessment period.

2.1 **Appendix B** contains the details of the 4 LLEs that occurred in the Pacific Ocean airspace outside of Fukuoka FIR, which were reported to JASMA during the assessment period.

2.2 **Appendix C** provides the geographic location of LLD and LLE reports in the Pacific Ocean airspace within and around Fukuoka FIR during the assessment period. The filled blue square symbols represent the LLD location in Fukuoka FIR, and the hollow blue square symbols represent the LLD location outside of Fukuoka FIR. The filled green square symbols represent the LLE location in Fukuoka FIR, and the hollow green square symbols represent the LLE location outside of Fukuoka FIR. The circle size means an LLD or LLE duration of 50 seconds or more.

3. Risk Assessment

3.1 The calculation methods and parameters used are following;

1) Using the longitudinal overlapping probability, the collision risk is estimated by the following formula (1)

$$N_{ax} = P_y(0) \cdot P_z(0) \cdot \frac{2\lambda_x}{|\dot{x}|T}\left(\frac{\overline{|\dot{x}|}}{2\lambda_x} + \frac{\overline{|\dot{y}(0)|}}{2\lambda_y} + \frac{\overline{|z(0)|}}{2\lambda_z}\right)\sum E_x(t)P_x(t) \qquad (1)$$

The individual parameters for equation (1) and their definitions are given in **Table 4**.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
Py(0)	Probability that two aircraft on the same track are in lateral overlap	0.575	JASMA (2023)
Pz(0)	Probability of vertical overlap in operational risk estimation for the aircraft flying as a same flight level	0.55	Doc 10063 Appendix F Table F-5
$\overline{\lvert\dot{y}(0)\rvert}$	The average relative speed between two aircraft, across track.	1 kt	EMA handbook
$\overline{\lvert\dot{z}(0)\rvert}$	Average vertical speed of aircraft pairs	1.5 kt	ICAO SASP safety assessment
λx	Average aircraft length	0.0367 nm	JASMA (TSD of NOPAC in 2023)
λy	Average aircraft width	0.0341 nm	JASMA (TSD of NOPAC in 2023)
λz	Average aircraft height	0.0098 nm	JASMA (TSD of NOPAC in 2023)

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
T	The average time to fly the segment.	0.69 h	ICAP data (NOPAC)
$E_x(t)$	The proportion of aircraft initial separation		
$P_x(t)$	The probability of the loss of longitudinal separation.		

Table 4: parameters in Equation

2) The formulas of the lateral collision risk model used in assessing the safety of operation on NOPAC routes are:

$$N_{ay}(same) = P_z(0)P_y(S_y)\frac{2\lambda_x}{|\Delta V|}N_x^y(same)\left[\frac{\overline{|\Delta V|}}{2\lambda_x} + \frac{\overline{|\dot{y}|}}{2\lambda_y} + \frac{\overline{|\dot{z}|}}{2\lambda_z}\right] \quad (2)$$

$$N_{ay}(opposite) = P_z(0)P_y(S_y)\frac{2\lambda_x}{2\overline{|V|}}N_x^y(opp)\left[\frac{2\overline{|V|}}{2\lambda_x} + \frac{\overline{|\dot{y}|}}{2\lambda_y} + \frac{\overline{|\dot{z}|}}{2\lambda_z}\right] \quad (3)$$

$$N_{ay} = N_{ay}(same) + N_{ay}(opposite) \quad (4)$$

3) **Table 5** summarizes the value and source material for estimating the parameter values of the following Collision Risk Model (CRM) used to conduct safety oversight for the RNP10 based 50NM lateral separation minimum of NOPAC routes.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
$\overline{\lvert V\rvert}$	Individual-aircraft along track speed	480 kt	Doc 10063 Appendix F Table F-5
$\overline{\lvert \Delta V\rvert}$	Average along track speed of aircraft pairs	28.9 kt	Kushiro Air Route Surveillance Radar data (R220 of NOPAC, Apr. 1994)
$\overline{\lvert \dot{y}\rvert}$	Average cross track speed of aircraft pairs	36 kt	Doc 10063 Appendix F F.2.4
$\overline{\lvert \dot{z}\rvert}$	Average vertical speed of aircraft pairs	1.5 kt	Doc 10063 Appendix F Table F-5
λx	Average aircraft length	0.0367 nm	JASMA (TSD of NOPAC in 2023)
λy	Average aircraft width	0.0341 nm	JASMA (TSD of NOPAC in 2023)
λz	Average aircraft height	0.0098 nm	JASMA (TSD of NOPAC in 2023)
$N_x(same)$	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	3.15×10^{-3}	ICAP data (NOPAC, 2023)
$N_x(opp)$	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	1.36×10^{-1}	ICAP data (NOPAC, 2023)

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
$P_z(0)$	Probability of vertical overlap in operational risk estimation for the aircraft flying as a same flight level	0.55	Doc 10063 Appendix F Table F-5
$P_y(50)$	Probability that two aircraft on the same track are in lateral overlap	1.40×10^{-8}	DDE Normal model (2023)

Table 5: Estimates of the parameters in the CRM

Appendix A

LLDs/LLEs occurred within Fukuoka FIR

	Occurrence Date	LLD/ LLE	Reporter	Location	ACFT Type	ALT	Deviation (NM/MIN)	Duration (Minutes)	Cause	CAT Code	Hot Spot
1	21 Mar 2023	LLD	Fukuoka ATMC	BIXAK	A20N	FL370	20 NM (Left)	3	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
2	3 Apr 2023	LLD	Fukuoka ATMC	NUBDA	P8	FL320	30 NM (Left)	5	ATC system loop error	D	
3	17 May 2023	LLE	Fukuoka ATMC	NIPPI	B77L	FL400	14 MIN (Longitudinal)	11	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
4	19 May2023	LLD	Fukuoka ATMC	BIXAK	A320	FL360	15 NM (Right)	1	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
5	24 May 2023	LLD	Fukuoka ATMC	4240N 16129E	B77W	FL310	60 NM (Right)	5	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
6	16 Jun 2023	LLE	Fukuoka ATMC	GURAG	A20N	FL370	5 MIN (Longitudinal)	1	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	D1
7	17 Jun 2023	LLD	Fukuoka ATMC	ADNAP	B789	FL310	25 NM (Right)	15	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	C	
8	8 Jul 2023	LLD	Fukuoka ATMC	GURAG	B789	FL390	30 NM (Left)	5	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D1
9	9 Aug 2023	LLD	Fukuoka ATMC	NOGAL	B77L	FL400	15 NM (Right)	20	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	

	Occurrence Date	LLD/ LLE	Reporter	Location	ACFT Type	ALT	Deviation (NM/MIN)	Duration (Minutes)	Cause	CAT Code	Hot Spot
10	12 Aug 2023	LLD	Fukuoka ATMC	ASEDA	B38M	FL370	20 NM (Right)	10	Flight crew deviates without ATC clearance in the horizontal dimension	A	
11	13 Aug 2023	LLD	Fukuoka ATMC	4013N 14724E	B744	FL340	20 NM (Left)	18	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
12	16 Aug 2023	LLE	Fukuoka ATMC	MONPI	B738	FL340	5 MIN (Longitudinal)	5	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
13	19 Aug 2023	LLD	Fukuoka ATMC	TUNTO	A21N	FL350	30 NM (Left)	14	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
14	12 Sep 2023	LLD	Fukuoka ATMC	AVLAS	B788	FL410	20 NM (Right)	6	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
15	12 Sep 2023	LLD	Fukuoka ATMC	AVLAS	B763	FL350	10 NM (Right)	6	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
16	12 Sep 2023	LLD	Fukuoka ATMC	AVLAS	B789	FL330	15 NM (Right)	4	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
17	24 Sep 2022	LLD	Oakland ARTCC	2242N 14235E	B738	FL390	50 NM (Right)	16	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
18	13 Dec 2023	LLE	Fukuoka ATMC	2100N 13457E	RQ48	FL460 - FL480	8 MIN (Longitudinal)	11	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	

Appendix B

LLDs/LLEs occurred outside of Fukuoka FIR

	Occurrence Date	LLD/ LLE	Relevant ATC Unit	Location	ACFT Type	ALT	Deviation (NM/MIN)	Duration (Minutes)	Cause	CAT Code	Hot Spot
1	10 May 2023	LLE	Oakland ARTCC	OMLET	C30J	FL280	7 MIN (Longitudinal)	1	Flight crew incorrect operation or interpretation of airborne equipment	B	
2	24 Jun 2023	LLD	Oakland ARTCC	42N160E	B77L	FL320	50 NM (Left)		Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	C	
3	21 Jul 2022	LLE	Oakland ARTCC	OMLET	BE20	FL270	18 MIN (Longitudinal)		Flight crew incorrect operation or interpretation of airborne equipment	B	

Appendix C

Geographical Location of all LDDs & LLEs within and around Fukuoka FIR