International Civil Aviation Organization

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

Bangkok, Thailand, 21 – 24 August 2023

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

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 2022 to December 2022.

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 2022 to December 2022.

North Pacific Ocean Airspace – estimated annual flying hours = 103,253 hours *(note: estimated hours based on Dec 2022 traffic sample data)*			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 27 50 NM Lateral Risk	*0.712×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 27 10 MIN Based-Longitudinal Risk	*0.034×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 27 30 NM Distance-based Longitudinal Risk	*0.014×10^{-9}*	*5.0×10^{-9}*	*Below TLS*

North Pacific Ocean Airspace – estimated annual flying hours = 103,253 hours *(note: estimated hours based on Dec 2022 traffic sample data)*			
Risk	**Risk Estimation**	**TLS**	**Remarks**
50 NM Lateral Risk	**0.46 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**
10 MIN Time-based Longitudinal Risk	**1.75 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**
30 NM Distance-based Longitudinal Risk	**0.008 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

Table 1: North Pacific Ocean Airspace Horizontal Risk Estimates

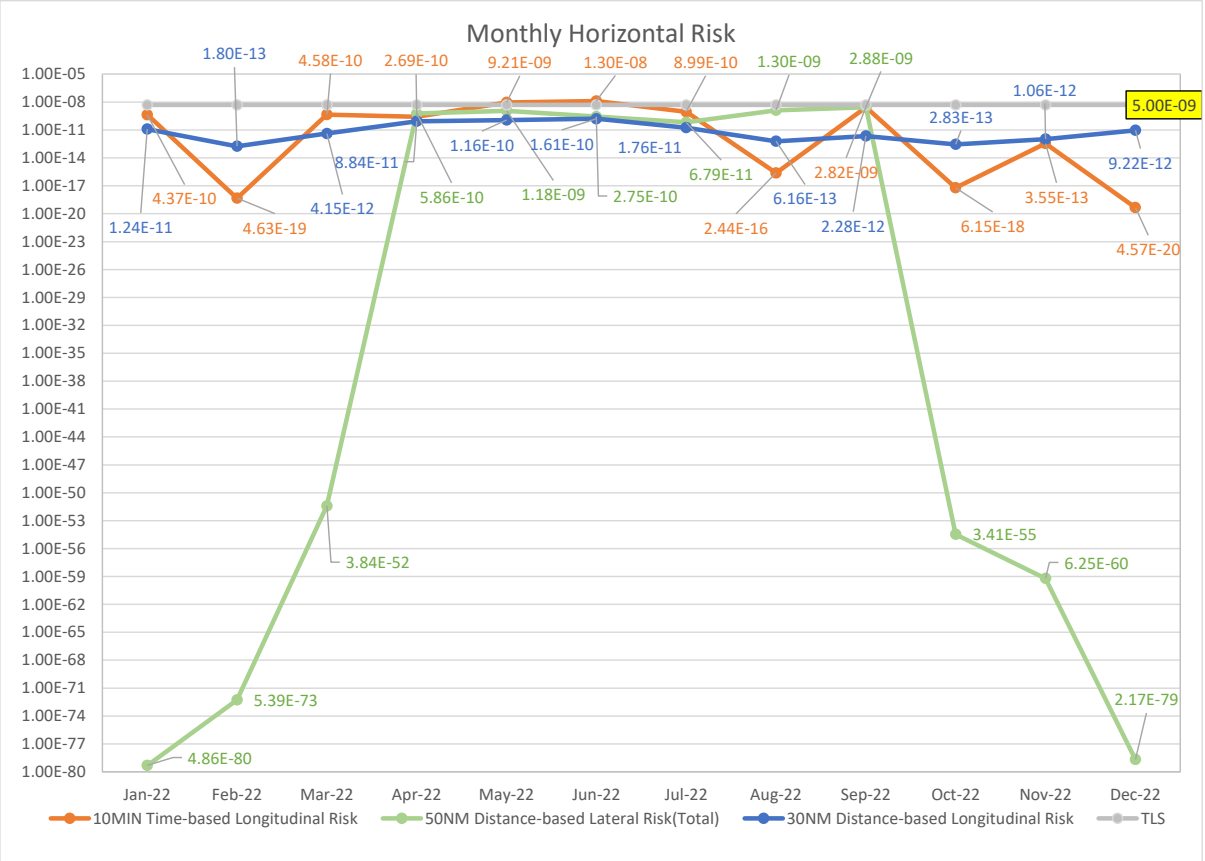

Figure 1: North Pacific Ocean Airspace Horizontal Risk Estimates

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.

Code	Deviation Description	No.
A	Flight crew deviates without ATC clearance in the horizontal dimension	0
B	Flight crew incorrect operation or interpretation of airborne equipment	4
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	2
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	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	6
G	Navigation errors due to airborne equipment failure leading to a	1

Code	Deviation Description	No.
	deviation in the horizontal dimension of which notification was not received by ATC or notified too late for action	
H	Turbulence or other weather related causes (other than approved) leading to a deviation in the horizontal dimension;	6
I	An aircraft was provided with reduced horizontal separation minima but did not meet the RNP/RSP/RCP specification	0
J	Others	0
Total		21

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

2.4 Category F, "Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues," and Category H, "Turbulence or other weather related causes" were the top contributor during the calendar year 2022.

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.

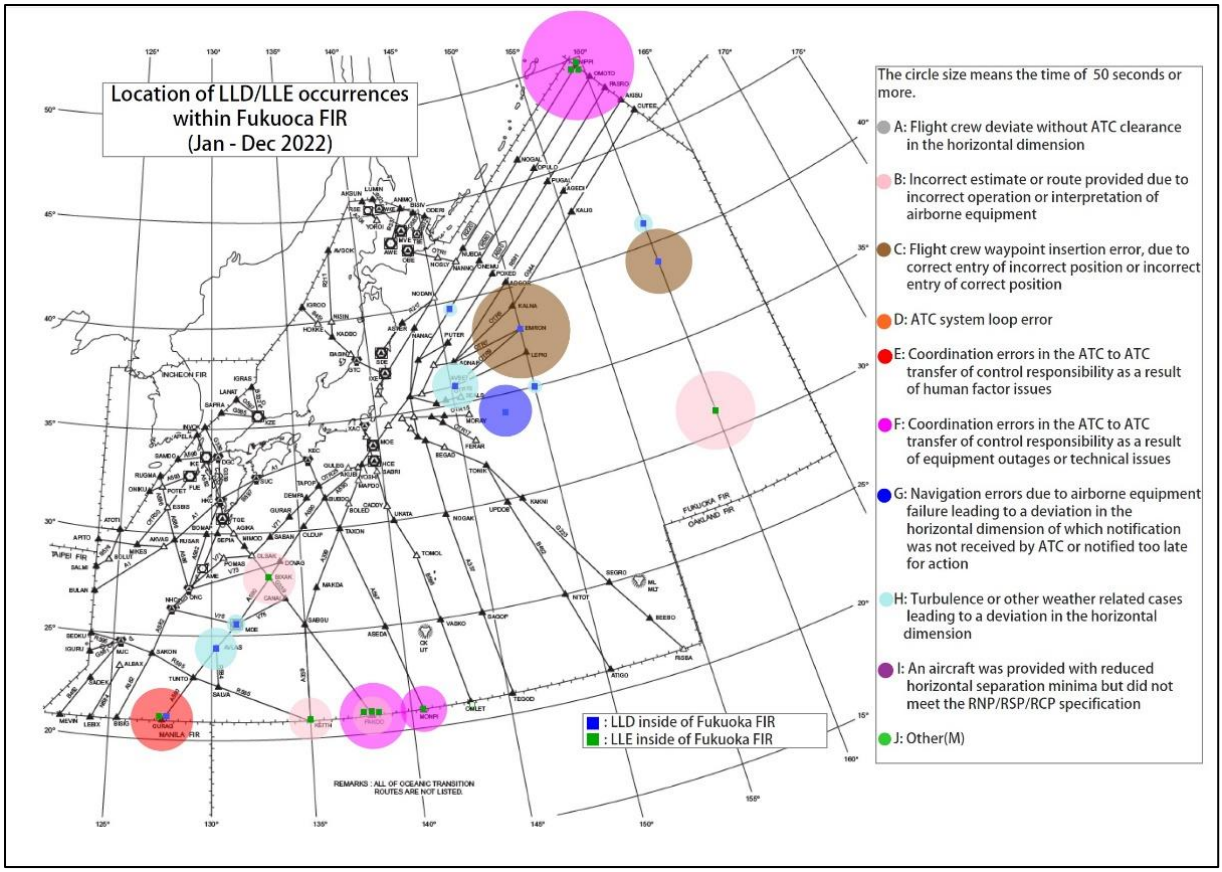

Figure 2: Geographical Location of LLDs &LLEs within Fukuoka FIR

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 still established by using 50 NM lateral distance. However, new RNP4 routes, which aircraft are required PBCS and RNP4, are planning to be established in the North Pacific Ocean airspace in 2024, and the RNP4 routes would be separated at least 23 NM from other ATS routes.

2.8 JASMA has started developing and updating procedures and software to calculate “23 NM Lateral Risk.”

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.

…….

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 as of 2022. Please note that the current route structure and operation of the NOPAC route system is different.

1.2 The two northern routes, R220 and R580 are used for westbound traffic. The center route, A590 is used for eastbound traffic. The southern two routes, R591 and G344 were used for eastbound traffic that aircraft crossing the FIR boundary between Anchorage FIR and Fukuoka FIR between 0900UTC and 2100UTC and used for westbound traffic that aircraft crossing the FIR boundary between 0000UTC and 0600UTC.

1.3 NOPAC Passing Frequencies are shown in **Table 1**. Note that passing frequencies between airways R220 and R580 were relatively small because R220 and R580 were both westbound only for all the time, passing occurs only when catching up occurs. On the other hand, the passing frequency between R580 and A590 was large, because R580 was used for westbound while A590 was used for eastbound. The passing frequency between A590 and R591 was small because the flight hours of R591 were small.

	Flight Hours		Passing Frequencies		
Airways	East Bounds	West Bounds	Same East Bounds	Same West Bounds	Opposite Direction
R220	0	47258.4			
			0	94	0
R580	0	12533.63			
			0	0	4520.5
A590	36377.9	0			
			22.5	0	88
R591	3005.37	479.672			
			1	0	13
R344	2964.21	633.871			

Table 1: Flight Hours and Passing Frequencies

1.4 **Table 2** shows the estimated lateral collision risk on NOPAC routes. The total risk estimation was below TSL.

Source of Risk	Risk Estimation
N_{ay} (same)	0.03×10^{-9}
N_{ay} (opposite)	0.43×10^{-9}
N_{ay} (total)	0.46×10^{-9}

Table 2: NOPAC Lateral collision risk estimation

2. Consideration for LLDs and LLEs

Appendix A contains the details of the 21 LLDs/LLEs 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 6 LLEs 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 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	0.583	JASMA (2022)
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 2022)
λy	Average aircraft width	0.0341 nm	JASMA (TSD of NOPAC in 2022)
λz	Average aircraft height	0.0098 nm	JASMA (TSD of NOPAC in 2022)
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:

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

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

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

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 2022)
λy	Average aircraft width	0.0341 nm	JASMA (TSD of NOPAC in 2022)
λz	Average aircraft height	0.0098 nm	JASMA (TSD of NOPAC in 2022)
$N_x(same)$	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	2.28×10^{-3}	ICAP data (NOPAC, 2022)
$N_x(opp)$	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	8.95×10^{-2}	ICAP data (NOPAC, 2022)
$P_z(0)$	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	8.34×10^{-9}	DDE Normal model (2022)

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	16 Jan 2022	LLE	Fukuoka ATMC	NIPPI	B789	FL400	14 MIN (Longitudinal)	4	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
2	2 Feb 2022	LLE	Fukuoka ATMC	31N160E	B77W	FL590 - FL610	27 MIN (Longitudinal)	13	Flight crew incorrect operation or interpretation of airborne equipment	B	
3	5 Mar 2022	LLE	Fukuoka ATMC	GURAG	C30J	FL270	8 MIN (Longitudinal)	13	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D
4	20 Mar2022	LLE	Fukuoka ATMC	KEITH	B20	FL280	10 MIN (Longitudinal)	7	Flight crew incorrect operation or interpretation of airborne equipment	B	
5	9 Apr 2022	LLD	Fukuoka ATMC	3435N 14734E	C17	FL330	23 NM (Left)	9	Navigation errors due to airborne equipment failure	G	
6	19 May 2022	LLE	Fukuoka ATMC	PAKDO	B738	FL340	5 MIN (Longitudinal)	8	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
7	19 May 2022	LLE	Fukuoka ATMC	NIPPI	C130	FL300	6 MIN (Longitudinal)	10	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
8	24 May 2022	LLD	Fukuoka ATMC	39N160E	K35R	FL380	30 NM (Right)	11	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	C	
9	3 Jun 2022	LLD	Fukuoka ATMC	GURAG	A20N	FL390	30 NM (Right)	3	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D

	Occurrence Date	LLD/ LLE	Reporter	Location	ACFT Type	ALT	Deviation (NM/MIN)	Duration (Minutes)	Cause	CAT Code	Hot Spot
10	4 Jul 2022	LLD	Fukuoka ATMC	35N150E	B77L	FL410 - FL430	20 NM (Left)	1	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
11	7 Jul 2022	LLD	Fukuoka ATMC	AVBET	B789	FL350	15 NM (Left)	8	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
12	29 Jul 2022	LLE	Fukuoka ATMC	MONPI	A321	FL320	10 MIN (Longitudinal)	8	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
13	29 Jul 2022	LLE	Fukuoka ATMC	BIXAK	A20N	FL360	8 MIN (Longitudinal)	9	Flight crew incorrect operation or interpretation of airborne equipment	B	
14	2 Aug 2022	LLD	Fukuoka ATMC	AVLAS	B789	FL380	10 NM (Left)	7	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
15	19 Aug 2022	LLD	Fukuoka ATMC	41N160E	B789	FL330	10 NM (Right)	2	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
16	21 Aug 2022	LLE	Fukuoka ATMC	PAKDO	B738	FL340	8 MIN (Longitudinal)	6	Flight crew incorrect operation or interpretation of airborne equipment	B	
17	1 Sep 2022	LLD	Fukuoka ATMC	3937N 14552E	B77L	FL370	20 NM (Left/Right)	1	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
18	5 Sep 2022	LLE	Fukuoka ATMC	PAKDO	C30J	FL210	11 MIN (Longitudinal)	3	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
19	21 Sep 2022	LLD	Fukuoka ATMC	EMRON	B77L	FL310	10 NM (Left)	22	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	C	

	Occurrence Date	LLD/ LLE	Reporter	Location	ACFT Type	ALT	Deviation (NM/MIN)	Duration (Minutes)	Cause	CAT Code	Hot Spot
20	21 Sep 2022	LLD	Fukuoka ATMC	MDE	B77W	FL400	20 NM (Left)	2	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	
21	19 NOV 2022	LLE (LHD)	Fukuoka ATMC	NIPPI	B77L	FL380	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	

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	15 Jan 2022	LLE	Manila ACC	MEVIN	A359	FL390	6 MIN (longitudinal)	0	Unidentified	B / E	D
2	6 Feb 2022	LLE	Manila ACC	GURAG	C30J	FL180	6 MIN (longitudinal)	10	Unidentified	B / E	D
3	19 Feb 2022	LLE	Oakland ARTCC	OMLET	B190	FL230	27 MIN (Longitudinal)		Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	
4	27 Feb 2022	LLE	Oakland ARTCC	PAKDO	B738	FL370	46 MIN (Longitudinal)		Flight crew incorrect operation or interpretation of airborne equipment	B	
5	4 Jun 2022	LLE	Oakland ARTCC	PAKDO	A321	FL350	13 MIN (Longitudinal)		Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	
6	12 Aug 2022	LLE	Manila ARTCC	GURAG	C30J	FL250	20 MIN (Longitudinal)		Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D

Appendix C

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