International Civil Aviation Organization

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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 2021 to December 2021.

1. INTRODUCTION

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

a) 50NM lateral separation

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

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

2. DISCUSSION

2.1 For the calculation methods and parameters used, please refer to **Attachment A** 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 during the period January 2021 to December 2021.

North Pacific Ocean Airspace – estimated annual flying hours = 90,811 hours *(note: estimated hours based on Dec 2021 traffic sample data)*			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 26 50NM Lateral Risk	*0.65 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
RASMAG 26 10MIN Time-based Longitudinal Risk	*0.25 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
RASMAG 26 30MIN Distance-based Longitudinal Risk	*0.015 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
50NM Lateral Risk	**0.712 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**
10MIN Time-based Longitudinal Risk	**0.034 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

North Pacific Ocean Airspace – estimated annual flying hours = 90,811 hours *(note: estimated hours based on Dec 2021 traffic sample data)*			
Risk	**Risk Estimation**	**TLS**	**Remarks**
30NM Distance-based Longitudinal Risk	**0.014 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**

Table 1: North Pacific Ocean Airspace Horizontal Risk Estimates

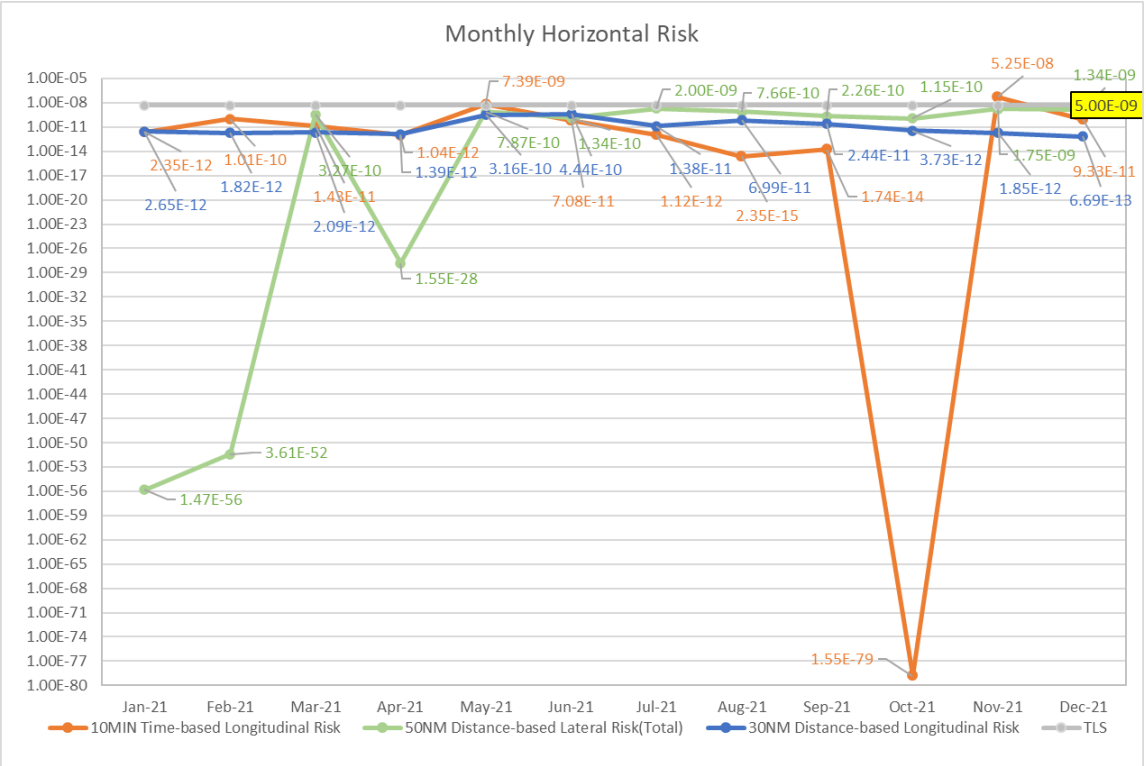

Figure 1: North Pacific Ocean Airspace Horizontal Risk Estimates

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	4
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	0
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	5
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	8
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	1
H	Turbulence or other weather related causes (other than approved) leading to a deviation in the horizontal dimension;	5
I	An aircraft was provided with reduced horizontal separation minima but did not meet the RNP/RSP/RCP specification	0
J	Others	0
Total		24

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, was the top contributor during the calendar year 2021.

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 LLD location within Fukuoka FIR, and the filled green square symbols represent LLE location within Fukuoka FIR. The circle size means an LLD or LLE duration of 50 seconds or more.

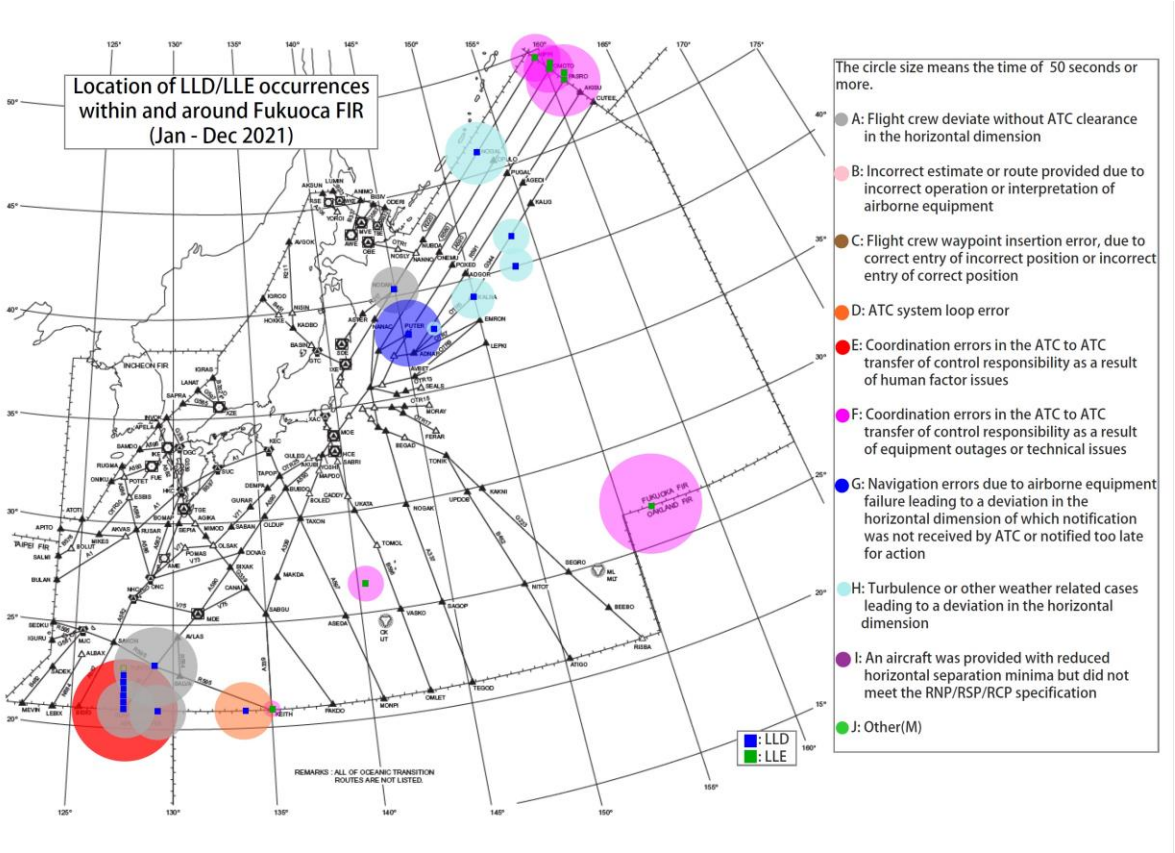

Figure 2: Geographical Location of LLDs &LLEs in the Pacific Ocean Airspace within Fukuoka FIR

2.6 The restructuring of the North Pacific (NOPAC) Route System with implementing 23 NM lateral separation for aircraft approved PBCS and RNP4, which is called “The North Pacific (NOPAC) Redesign Project”, have been considered and discussed by the Federal Aviation Administration (FAA) and JCAB.

2.7 The NOPAC Redesign Project will be conducted with a phased approach. JASMA is keeping up with the consideration and discussion to update procedures and software for the safety assessment as an EMA.

2.8 The updated information for the NOPAC Redesign Project would be provided by FAA and JCAB at the relevant meetings hosted by the ICAO APAC Regional Office (e.g. ATM/SG meeting).

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 A

1. COLLISION RISK FOR 50NM ATC LATERAL SEPARATION

1.1 The North Pacific (NOPAC) Route System is comprised of five Air Traffic Service (ATS) routes that transit the North Pacific between Alaska and Japan.

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 are 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 airway R220 and R580 are relatively small because R220 and R580 are both westbound only for all the time, passing occurs only when catching up occurs. On the other hand, passing frequency between R580 and A590 is large, because R580 is used for westbound while A590 is used for eastbound. The passing frequency between A590 and R591 is small because the flight hours of R591 is small.

	Flight Hours		Passing Frequencies		
Airways	East Bounds	West Bounds	Same East Bounds	Same West Bounds	Opposite Direction
R220	0	40839.6			
			0	55	0
R580	0	9392.8			
			0	0	2289
A590	32434.1	0			
			38	0	35
R591	3592.9	135.6			
			1	0	3
R344	4159.2	257.2			

Table 1: Flight Hours and Passing Frequencies

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

Source of Risk	Risk Estimation
N_{ay} (same)	0.07×10^{-9}
N_{ay} (opposite)	0.64×10^{-9}
N_{ay} (total)	0.71×10^{-9}

Table 2: NOPAC Lateral collision risk estimation

2. Consideration for LLDs and LLEs

Appendix A contains the details of the 24 LLDs/LLEs occurred in the Pacific Ocean airspace within Fukuoka FIR, which were reported to JASMA during the assessment period.

Appendix B contains the details of the 2 LLEs occurred in the Pacific Ocean airspace outside of Fukuoka FIR, which were reported to JASMA during the assessment period.

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 LLD location in Fukuoka FIR, and the hollow blue square symbols represent LLD location outside of Fukuoka FIR. The filled green square symbols represent LLE location in Fukuoka FIR, and the hollow green square symbols represent 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 the 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	0.801	JASMA (2021)
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	0.0368 nm	JASMA (TSD of NOPAC in 2021)
λy	Average aircraft width	0.0340 nm	JASMA (TSD of NOPAC in 2021)
λz	Average aircraft height	0.0098 nm	JASMA (TSD of NOPAC in 2021)
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:

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

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

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

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 RNP-10 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	0.0368 nm	JASMA (TSD of NOPAC in 2021)
λy	Average aircraft width	0.0340 nm	JASMA (TSD of NOPAC in 2021)
λz	Average aircraft height	0.0098 nm	JASMA (TSD of NOPAC in 2021)
N_x(same)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	2.07×10^{-3}	ICAP data (NOPAC, 2021)
N_x(opp)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	5.12×10^{-2}	ICAP data (NOPAC, 2021)
$P_z(0)$	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	2.21×10^{-8}	DDE Normal model (2021)

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 MAR 2021	LLD	Fukuoka ATMC	GURAG	B789	FL390	40NM (Left)	3	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D
2	22 MAR 2021	LLD	Fukuoka ATMC	42N154E	B77W	FL350	70NM (Left)	5	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	-
3	15 APR 2021	LLE	Fukuoka ATMC	OMOTO	C30J	FL200	8MIN (Longitudinal)	3	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-
4	20 APR2021	LLE	Fukuoka ATMC	KEITH	D328	FL300	11MIN (Longitudinal)	2	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-
5	29 MAY 2021	LLE	Fukuoka ATMC	27N157E	C130	FL200-FL240	29MIN (Longitudinal)	25	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-
6	31 MAY 2021	LLD	Fukuoka ATMC	22N133E	K35R	FL320	20NM (Right)	11	ATC system loop error	D	-
7	25 JUN 2021	LLD	Fukuoka ATMC	GURAG	B789	FL410	20NM (Left)	2	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D
8	14 JUL 2021	LLD	Fukuoka ATMC	GURAG	WW24	FL330	25NM (Left)	11	Flight crew deviate without ATC Clearance in the horizontal dimension	A	D
9	20 JUL 2021	LLD	Fukuoka ATMC	NOGAL	C17	FL340	10NM (Right)	13	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	20 JUL 2021	LLD	Fukuoka ATMC	GURAG	B789	FL390	20NM (Left)	8	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D
11	31 JUL 2021	LLD	Fukuoka ATMC	21N129E	B52	FL330	60NM (Right)	12	Flight crew deviate without ATC Clearance in the horizontal dimension	A	-
12	29 AUG 2021	LLD	Fukuoka ATMC	GURAG	B788	FL410	60NM (Right)	12	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D
13	11 SEP 2021	LLD	Fukuoka ATMC	4029N 15394E	B789	FL370	10NM (Left)	4	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	-
14	12 SEP 2021	LLD	Fukuoka ATMC	3353N 14747E	B77W	FL330	20NM (Left)	1	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	-
15	30 SEP 2021	LLE (LHD)	Fukuoka ATMC	PASRO	B744	FL400	8MIN (Longitudinal)	9	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-
16	3 OCT 2021	LLE (LHD)	Fukuoka ATMC	NIPPI	A306	FL340	7MIN (Longitudinal)	8	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-
17	12 OCT 2021	LLD	Fukuoka ATMC	GURAG	B789	FL370	30NM (Left)	2	Coordination errors in the ATC-to-ATC-transfer of control responsibility as a result of human factors issues	E	D
18	21 OCT 2021	LLE	Fukuoka ATMC	OMOTO	B1	FL240	12MIN (Longitudinal)	5	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-
19	17 NOV 2021	LLE	Fukuoka ATMC	27N 14055E	B350	FL260	5MIN (Longitudinal)	5	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-

	Occurrence Date	LLD/ LLE	Reporter	Location	ACFT Type	ALT	Deviation (NM/MIN)	Duration (Minutes)	Cause	CAT Code	Hot Spot
20	22 NOV 2021	LLD	Fukuoka ATMC	TUNTO	A343	FL400	30NM (Right)	21	Flight crew deviate without ATC Clearance in the horizontal dimension	A	-
21	22 NOV 2021	LLD	Fukuoka ATMC	NODAN	B744	FL380	100NM (Right)	8	Flight crew deviate without ATC Clearance in the horizontal dimension	A	-
22	1 DEC 2021	LLD	Fukuoka ATMC	KALNA	B77W	FL340	20NM (Left)	7	Turbulence or other weather related causes leading to a deviation in the horizontal dimension	H	-
23	21 DEC 2021	LLD	Fukuoka ATMC	PUTER	B789	FL350	11NM (Left)	16	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	G	-
24	29 DEC 2021	LLE	Fukuoka ATMC	PASRO	B1	FL250	25MIN (Longitudinal)	10	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	19 MAY 2021	LLE	Manila ACC	GURAG	C30J	Block FL240-260	4MIN (longitudinal)	4	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	D
2	22 OCT 2021	LLE	Oakland ARTCC	OMLET	BE20	FL230	17MIN (Longitudinal)	2	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	F	-

Appendix C

Geographical Location of all LDDs & LLEs in Fukuoka FIR