International Civil Aviation Organization

The Sixteenth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/16)

Bangkok, Thailand, 20 – 24 February 2012

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

SAFETY ASSESSMENT OF RVSM WITHIN THE FUKUOKA FLIGHT INFORMATION REGION

(Presented by Japan)

SUMMARY

This paper presents the results of the airspace safety assessment of the Fukuoka Flight Information Region (FIR) by the Japan Airspace Safety Monitoring Agency (JASMA) for the time period from 1 December 2010 to 30 November 2011.

This paper relates to –

Strategic Objectives:

*A: **Safety** – Enhance global civil aviation safety*

Global Plan Initiatives:

GPI-2 Reduced vertical separation minima

1. INTRODUCTION

1.1 The Japan Airspace Safety Monitoring Agency (JASMA) has produced a periodic airspace safety assessment for the RVSM implementation in the Fukuoka FIR, as detailed in the Attachment 1, which is distributed twice annually to ICAO.

2. DISCUSSION

2.1 A summary of large height deviation reports received by the JASMA and an update of the vertical collision risk for the time period of 1 December 2010 to 30 November 2011 are reported in the Attachment 1. There are a total of 26 large height deviations occurred during this period. The vertical collision risk estimate for the RVSM airspace in the Fukuoka FIR is 4.85×10^{-9} that meets the target level of safety (TLS) value of 5.0×10^{-9} fatal accidents per flight hour.

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

AIRSPACE SAFETY REVIEW FOR THE RVSM IMPLEMENTATION IN THE FUKUOKA FLIGHT INFORMATION REGION - DECEMBER 2010 TO NOVEMBER 2011

(Prepared by JASMA)

SUMMARY

The purpose of this report is to compare actual performance to safety goals related to continued use of reduced vertical separation minimum (RVSM) in the Fukuoka Flight Information Region (FIR). This report contains a summary of large height deviation reports received by the JASMA and an update of the vertical collision risk for the time period of 1 December 2010 to 30 November 2011. There are a total of 26 reported large height deviations that occurred during this period in the Fukuoka FIR. The vertical collision risk estimate for the RVSM airspace in the Fukuoka FIR is 4.85×10^{-9} that meets the target level of safety (TLS) value of 5.0×10^{-9} fatal accidents per flight hour.

1. Introduction

1.1 The JASMA produces two reports each calendar year following the standardized reporting period and format guidelines set forth by the International Civil Aviation Organization's (ICAO's) Asia and Pacific Region Regional Airspace Safety Monitoring Advisory Group (RASMAG).

2. Data Submission

2.1 Traffic Sample Data (TSD)

2.1.1 Traffic Sample data for the month of December 2010 of aircraft operating in the Fukuoka FIR were used to assess the safety of RVSM airspace.

2.2 Large Height Deviation (LHD)

2.2.1 A series of cumulative 12-month of LHD reports were used in this safety assessment starting from December 2010 to November 2011.

3. Summary of LHD Occurrences in the Fukuoka FIR

3.1 Table 1 summarizes the number of LHD occurrences and associated LHD duration (in minutes) by month in the RVSM airspace of the Fukuoka FIR.

Month-Year	No. of LHD Occurrences	LHD Duration (Minutes)
December 2010	2	2.20
January 2011	1	4.65
February 2011	5	3.93
March 2011	2	1.00
April 2011	2	1.50
May 2011	1	0.17
June 2011	1	0.50
July 2011	1	0.17
August 2011	3	12.83
September 2011	3	11.83
October 2011	2	0.65
November 2011	3	4.35
Total	**26**	**43.78**

Table 1: Summary of LHD Occurrences and Duration per Month in the Fukuoka FIR

3.2 The LHD reports are separated by categories based on the details provided for each deviation. Table 2 summarizes the number of LHD occurrences by the cause of the deviation. Duration of respective LHDs and number of flight levels transitioned without clearance associated with the LHDs are also summarized.

LHD Category Code	LHD Category Description	No. of LHD Occurrences	Duration (Min)	No. of Flight Levels Transitioned Without Clearance
B	Flight crew climbing/descending without ATC Clearance	3	3.88	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	1.83	6
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message. Includes situations where ATC delivery of operational information, including as the result of hear back and/or read back errors, is absent, delayed, incorrect or incomplete, and may result in a loss of separation.)	6	8.15	2
E	Coordination errors in the ATC to ATC 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)	3	12.93	0
F	Coordination errors in the ATC to ATC transfer of control responsibility as a result of equipment outage or technical issues	1	0	0

I	Deviation due to turbulence or other weather related cause	6	13	0
J	Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory	6	3.99	0
TOTAL		26	43.78	11

Table 2: Summary of LHD Occurrences, Duration and Level Crossed per Cause in the Fukuoka FIR

3.3 Appendix A contains the details of the fourteen (14) LHDs contributed to the operational risk, which were reported to the JASMA during the reporting period.

3.4 ATC loop errors (Category D) brought the largest number of LHD reports whereas the coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues (Category E) brought the longest duration of LHD during the reporting period. The transfer error occurred at the boundary between the Manila FIR and the Fukuoka FIR on 28 August 2011 caused a deviation for the duration of eleven (11) minutes.

3.5 Figure 1 shows the implementation status of AIDC, ADS-C and/or radar along the boundary of the Fukuoka FIR. The red color dots indicate the location where Category E/F transfer errors occurred during this reporting period. Three (3) transfer errors occurred at the FIR boundary where both AIDC and ADS-C/radar are not introduced. One (1) transfer error occurred at the FIR boundary where AIDC and ADS-C had been implemented but the AIDC was inoperative due to significant earthquake.

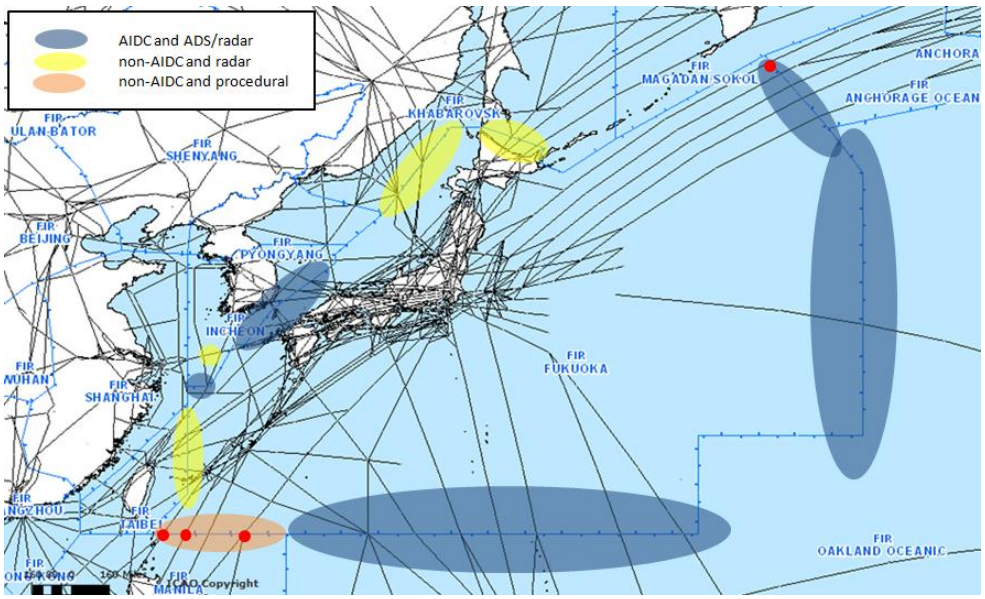

Figure 1: AIDC, ADS-C and/or radar implementation status along the boundary of the Fukuoka FIR

3.6 Appendix B contains the details of the twelve (12) LHDs which were not involved in the operational risk. Six (6) of them were reported that the aircraft correctly followed a TCAS or ACAS advisory. The other six (6) were caused by turbulence or bad weather.

3.7 The JASMA received eight (8) LHDs which occurred outside the Fukuoka FIR. Appendix C contains the details of the LHDs occurred outside the Fukuoka FIR during the reporting period.

3.8 Appendix D shows geographical locations where LHDs contributed to the operational risk occurred.

3.9 The Asia News Network reported in September 2011 that the aircraft flying FL410 in the Fukuoka FIR was on the verge of stalling after nose-diving about 6,300 feet. It was supposed that the pilot mistook a rudder switch for door open switch when the pilot intended to open the cockpit door. The cause of the incident is still under investigation by the Japan Transport Safety Board. The Category C LHD that transitioned six (6) flight levels without clearance in Table 2 indicates this case.

4. Risk Assessment and Safety Oversight

4.1 This section updates the results of safety oversight for the RVSM implementation in the Fukuoka FIR. Accordingly, the internationally accepted collision risk methodology is applied in assessing the safety of the airspace. The Traffic Sample Data (TSD) of December 2010 and the LHD reports associated with the airspace during the period from December 2010 to November 2011 are used to produce the risk estimates presented in this report.

4.2 Estimate of the Collision Risk Model (CRM) Parameters

4.2.1 Table 3 summarizes the value of the parameters used for the risk calculation.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
Pz(1000)	Probability that two aircraft nominally separated by the vertical separation minimum 1000 feet are in vertical overlap	1.7×10^{-8}	Value specified in ICAO Doc. 9574
Pz(0)	Probability that two aircraft at the same nominal level are in vertical overlap	0.54	Value often used (shown in RVSM/TF-9-IP/2)
Py(0)	Probability that two aircraft on the same track are in lateral overlap	0.0733	Using the data of secondary surveillance radar obtained by the Hachinohe Air Route Surveillance radar (domestic RNAV route, 2001-2002)
λx	Average aircraft length	0.0284 nm	FDPS data (December 2010)
λy	Average aircraft width	0.0259 nm	
λz	Average aircraft height	0.0082 nm	
$\overline{\lvert\Delta V\rvert}$	Average along track speed of aircraft pairs	28.9 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC, Apr. 1994)
$\overline{\lvert V\rvert}$	Individual-aircraft along track speed	480 kt	Value often used
$\overline{\lvert\dot{y}\rvert}$	Average cross track speed of aircraft pairs	11.6 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC, Apr. 1994)
$\overline{\lvert\dot{z}\rvert}$	Average vertical speed of aircraft pairs	1.5 kt	Value often used
Nx(same)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	3.56×10^{-2}	FDPS data (December 2010)

Nx(opp)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	1.32×10^{-1}	FDPS data (December 2010)
$Naz^{technical}$ (cross)	The collision risk for crossing routes (technical dimension)	8.79×10^{-11} [accidents/flight hour]	FDPS data (December 2010) is utilized for the calculation of $E_z(\theta)$.
$Naz^{operational}$ (cross)	The collision risk for crossing routes (operational dimension)	1.21×10^{-9} [accidents/flight hour]	By eq. (12).
H	Total flight hours of aircraft flying on the route segments within airspace under consideration	1034175.6 flight hours	12 times of December 2010
T(0)	LHD duration in hours	0.45flight hours	14 LHD reports received from Dec 2010 to Nov 2011

Table 3: Estimates of the Parameters in the CRM

4.3 Risk Calculation

4.3.1 Based on the TSD for one month of December 2010 extracted from the JCAB Flight Data Processing System (FDPS), the numbers of passing events, n_p(same) and n_p(opp), were calculated for each route segment consisting of two fixes.

4.3.2 Using the CRM parameters, such as average size of aircraft and average relative speed of the aircraft pair, contained in Table 3, kinematical coefficients of passing frequencies for the same and opposite direction traffic can be calculated by

$$K(same) = 1 + \frac{\lambda x}{\overline{|\Delta V|}}\left(\frac{\overline{|\dot{y}|}}{\lambda y} + \frac{\overline{|\dot{z}|}}{\lambda z}\right) \quad (1)$$

$$K(opp) = 1 + \frac{\lambda x}{2\overline{|V|}}\left(\frac{\overline{|\dot{y}|}}{\lambda y} + \frac{\overline{|\dot{z}|}}{\lambda z}\right) \quad (2)$$

Same-direction passing frequency N_x(same), opposite-direction passing frequency N_x(opp) and equivalent opposite-direction passing frequency N_x^z(e) are defined by

$$N_x(same) = \frac{2n_p(same)}{H}, \quad (3)$$

$$N_x(opp) = \frac{2n_p(opp)}{H} \text{ and} \quad (4)$$

$$N_x^z(e) = N_x(opp) + \frac{K(same)}{K(opp)} N_x(same), \quad (5)$$

respectively.

Technical Risk is estimated by

$$N_{az}^{technical} = N_{az}^{technical}(o+s) + N_{az}^{technical}(cross) \quad (6)$$

where,

$$N_{az}^{technical}(o+s) = P_z(1000)P_y(0)N_x^z(e)K(o) \quad (7)$$

$$N_{az}^{technical}(cross) = P_z(1000)\sum_{\theta} P_h(\theta)E_z^{cross}(\theta)\left[\frac{2\left|\overline{\dot{h}(\theta)}\right|}{\pi\lambda_{xy}} + \frac{\left|\overline{\dot{z}}\right|}{2\lambda_z}\right] \quad (8)$$

$P_h(\theta)$ was calculated assuming that the distributions of along-track positions and of cross-track deviations follow normal distributions whose standard deviations are $5/\sqrt{6}$ NM and 0.132, respectively. Remark that 5NM is the radar separation standard and $5/\sqrt{6}$ NM is the standard deviation of the uniform distribution with the domain width = 5NM. The value 0.132 is calculated from the Hachinohe radar data collected from August 2001 till July 2002. $P_h(\theta)$, $E_z^{cross}(\theta)$ and $\left|\overline{\dot{h}(\theta)}\right|$ were calculated every ten degrees.

Operational Risk is given by

$$N_{az}^{operational} = N_{az}^{operational}(o+s) + N_{az}^{operational}(cross) \quad (9)$$

where,

$$N_{az}^{operational}(o+s) = \frac{\sum P_z(z)T(z)}{H} P_y(0)N_x^{z}(e)K(opp) \quad (10)$$

$$N_{az}^{operational}(cross) = \frac{\Sigma P_z(z)T(z)}{H}\sum_{\theta} P_h(\theta)E_z^{cross}(\theta)\left[\frac{2\left|\overline{\dot{h}(\theta)}\right|}{\pi\lambda_{xy}} + \frac{\left|\overline{\dot{z}}\right|}{2\lambda_z}\right] \quad (11)$$

equivalently,

$$N_{az}^{operational}(cross) = \frac{\Sigma P_z(z)T(z)}{H} \cdot \frac{N_{az}^{technical}(cross)}{P_z(1000)} \quad (12)$$

4.4 Safety Oversight for the RVSM implementation in the Fukuoka FIR

4.4.1 Table 4 presents the estimates of vertical collision risk for the RVSM airspace of the Fukuoka FIR. The technical risk is estimated to be 0.33 x 10^{-9} fatal accidents per flight hour. The operational risk estimate is 4.52 x 10^{-9} fatal accidents per flight hour. The estimate of the overall vertical collision risk is 4.85 x 10^{-9} fatal accidents per flight hour, which satisfies the globally agreed TLS value of 5.0 x 10^{-9} fatal accidents per flight hour.

Fukuoka FIR RVSM Airspace – estimated annual flying hours = 1034175.6 hours *(note: estimated hours based on December 2010 traffic sample data)*			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.33 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	4.52 x 10^{-9}	-	-
Total Risk	4.85 x 10^{-9}	5.0 x 10^{-9}	Below Overall TLS

Table 4: Risk Estimates for the RVSM Implementation in the Fukuoka FIR

4.4.2 Figure 2 presents the trends of collision risk estimates by type (e.g. technical, operational, and total) for each month using the appropriate cumulative 12-month of LHD reports during reporting period.

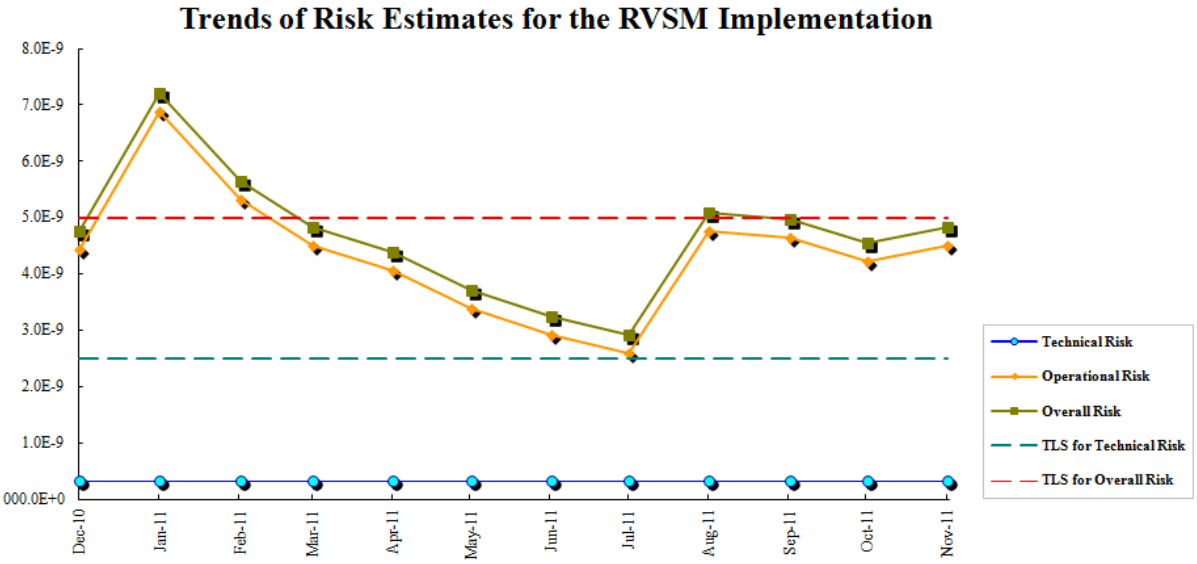

Figure 2: Trends of Risk Estimates for the RVSM Implementation in the Fukuoka FIR

4.4.3 The estimated risk value showed a downward tendency until July 2011, however one transfer error caused a deviation for the duration of eleven (11) minutes reversed a downward trend in August. The total risk estimate has met the target level of safety.

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Appendix A

Height Deviations contributed to Operational Risk in the Fukuoka FIR Reported to the JASMA during the Reporting Period

Event date	Source	Location of deviation	Duration of LHD (min)	Cause	code
23 Dec 10	Naha ACC	MEVIN (B462)	1	Incorrect flight level not in accordance with agreed parameters	E
31 Dec 10	Naha ACC	LEBIX (N884)	1.20	Forgot to input a transfer message on the ATC strip	D
27 Jan 11	Fukuoka ACC	TAE (Y14)	4.65	Pilot's misunderstanding an ATC clearance	D
7 Feb 11	Fukuoka ACC	ONIKU (A593)	0.17	Miscommunications between controller and pilot	D
11 Feb 11	Naha ACC	LEBIX (N884)	0.93	Incorrect flight level not in accordance with agreed parameters	E
11 Mar 11	PARMO	NIPPI (R220)	unknown	AIDC was not operable due to significant earthquake	F
21 Mar 11	Fukuoka ATMC	PASRO (A590)	1	Pilot's careless operation	B
9 Apr 11	Naha ACC	ONC (A586)	1.17	Pilot's misunderstanding an ATC clearance	D
27 Jul 11	Tokyo ACC	CLALA (Y301)	0.17	Pilot's mishearing	D
28 Aug 11	Fukuoka ATMC	GURAG (A590)	11	Incorrect flight level not in accordance with agreed parameters	E
6 Sep 11	Tokyo ACC	SOPHY (Y52)	1.83	Pilot's incorrect operation	C
9 Sep 11	Fukuoka ATMC	NANAC (R220)	Unknown	Climb without ATC clearance	B
20 Nov 11	Naha ACC	ALBAX (N884)	2.88	Descend without ATC clearance	B
25 Nov 11	Tokyo ACC	KADBO (B451)	0.8	Pilot's misread back of clearance and Controller's mishearing	D

Appendix B

Height Deviations which did not contribute to Operational Risk in the Fukuoka FIR Reported to the JASMA during the Reporting Period

Event date	Source	Duration of LHD (min)	Assigned FL	Observed / Reported ft	Cause	Code
11 Feb 11	Tokyo ACC	1.17	360	34900	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
14 Feb 11	Tokyo ACC	0.67	300	30900	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
15 Feb 11	Tokyo ACC	1	290	29500	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
19 Apr 11	Tokyo ACC	0.33	310	31500	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
18 May 11	Fukuoka ACC	0.17	300	29700	Turbulence	I
9 Jun 11	Fukuoka ACC	0.5	340	33500	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
5 Aug 11	Fukuoka ACC	1.83	380	38500	Turbulence	I
20 Aug 11	Fukuoka ATMC	unknown	330	32500	Cumulonimbus	I
10 Sep 11	Fukuoka ATMC	10	380	38500	Bad weather	I
20 Oct 11	Fukuoka ACC	0.32	370	37400	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
21 Oct 11	Operator	0.33	360	36500	Turbulence	I
11 Nov 11	Tokyo ACC	0.67	300	30600	Bad weather	I

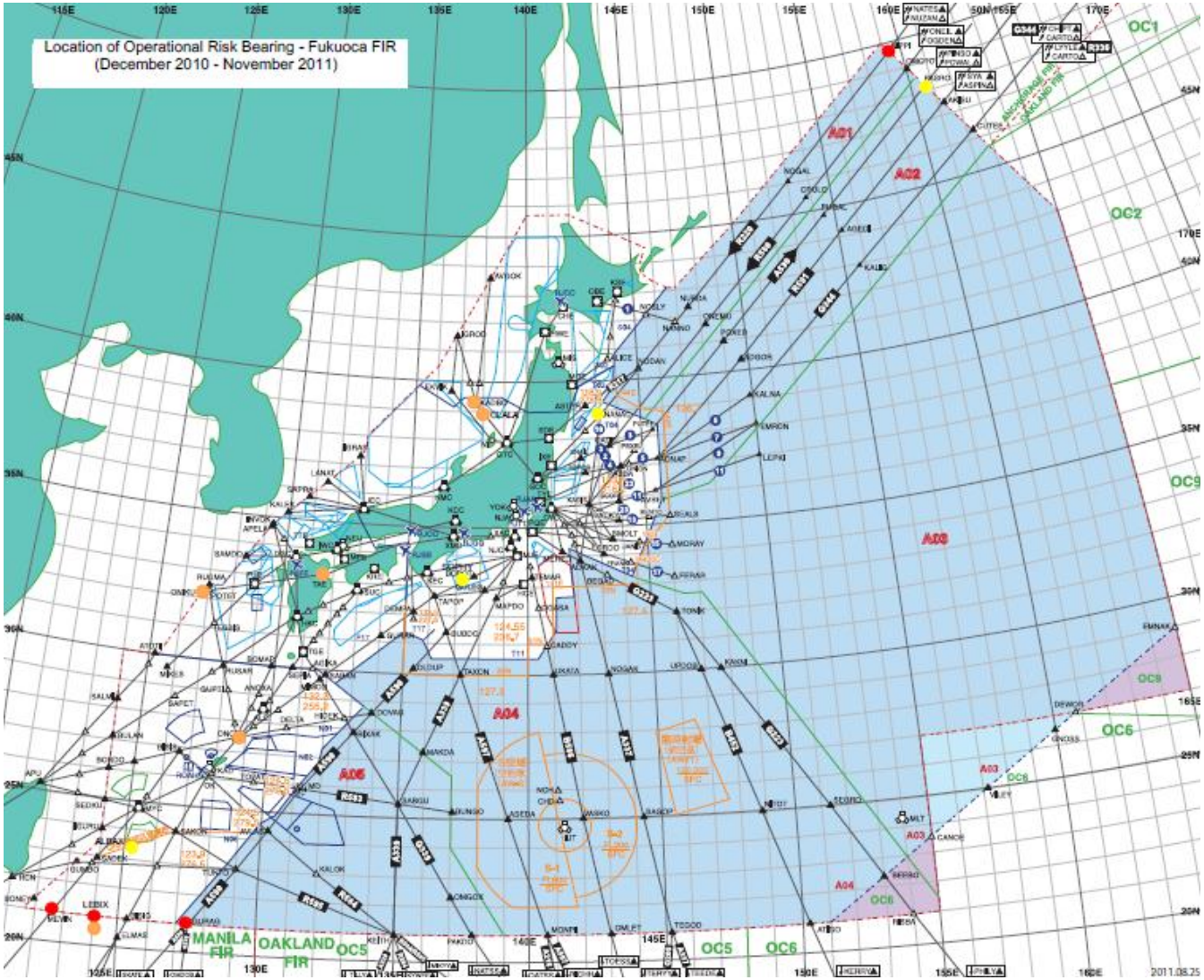
Appendix C

Height Deviations Occurred Outside the Fukuoka FIR during the Reporting Period

Event date	Source	Location of deviation	Expected FL	Observed FL	Cause	Other traffic
30 Dec 10	Fukuoka ATMC	GURAG (A590)	340	340	Non-existent coordination	Nil
15 Mar 11	Fukuoka ACC	SADLI (A593)	290	310	Incorrect flight level not in accordance with agreed parameters	Nil
16 Apr 11	Incheon ACC	SADLI (A593)	-	410	Non-existent prior coordination	Nil
18 Jun 11	PARMO	NIPPI (R220)	360	380	Controller did not obtain positive confirmation of aircraft assigned altitude because of CPDLC problem	Nil
21 Jul 11	Naha ACC	MEVIN (B462)	-	380	Non-existent coordination	Nil
24 Aug 11	Fukuoka ATMC	Around 21N142E	380	365	Engine trouble	Nil
27 Aug 11	Airline	PUD	390	399	Wind shear, the information has sent to China RMA	Nil
8 Nov 11	Fukuoka ATMC	GURAG (A590)	400	380	Incorrect flight level not in accordance with agreed parameters	Nil

Appendix D

Geographical locations where LHDs contributed to the operational risk occurred in the Fukuoka FIR (December 2010~Nobember 2011)



Red color dot ●:
ATC-to-ATC transfer error by human factors

Orange color dot ●:
ATC loop error

Yellow color dot ●:
Incorrect operation by flight crew