



International Civil Aviation Organization

**The Thirteenth Meeting of the Regional Airspace Safety Monitoring
Advisory Group (RASMAG/13)**

Bangkok Thailand, 02 - 05 August 2010

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 working paper presents the results of the airspace safety assessment of the Fukuoka Flight Information Region (FIR) by the Japan Regional Monitoring Agency (Japan RMA) for the time period from 1 May 2009 to 30 April 2010. This report contains a summary of large height deviation reports received by the Japan RMA for that time period and an update of the vertical collision risk for the Japanese RVSM airspace is presented.

1. Introduction

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

2. Action by the Meeting

2.1 The meeting is invited to note the results of the airspace safety oversight presented in this working paper.

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ATTACHMENT 1**AIRSPACE SAFETY REVIEW FOR THE RVSM IMPLEMENTATION
IN THE JAPANESE AIRSPACE - MAY 2009 to APR 2010**

**Prepared by:
Japan Regional Monitoring Agency (Japan RMA)**

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 Japanese airspace (i.e. the airspace of Fukuoka FIR). This report contains a summary of large height deviation reports received by the Japan RMA and an update of the vertical collision risk for the time period of 1 May 2009 to 30 April 2010. There are a total of 34 reported large height deviations that occurred during this period in Japanese airspace. The vertical collision risk estimate for Japanese RVSM airspace meets the target level of safety (TLS) value of 5.0×10^{-9} fatal accidents per flight hour.

1. Introduction

1.1 The Japan Regional Monitoring Agency (Japan RMA) 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 2009 of aircraft operating in the Japanese airspace 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 May 2009 to April 2010.

3. Summary of LHD Occurrences in the Japanese Airspace

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

Month-Year	No. of LHD Occurrences	LHD Duration (Minutes)
May 2009	3	10
June 2009	5	0.083
July 2009	2	1
August 2009	1	6.667
September 2009	5	1.767
October 2009	4	1.25
November 2009	2	0.5
December 2009	3	0.333
January 2010	4	0.833
February 2010	1	0.083
March 2010	3	1
April 2010	1	2.583
Total	34	26.1

Table 1: Summary of LHD Occurrences and Duration per Month in the Japanese RVSM airspace

3.2 The LHD reports are separated by categories based on the details provided for each deviation. **Table 2** below summarizes the number of LHD occurrences by the cause of the deviation and the duration of respective LHDs.

LHD Category Code	LHD Category Description	No. of LHD Occurrences	LHD Duration (Min)
B	Flight crew climbing/descending without ATC clearance	1	10
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)	21	12.166
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	1	0
H	Airborne equipment failure leading to unintentional or undetected change of flight level (e.g. altimetry errors)	2	0.166
J	TCAS resolution advisory; flight crew correctly following the resolution advisory	9	3.76

Table 2: Summary of LHD Occurrences and Duration per Cause in the Japanese RVSM airspace

3.3 **Table 3** summarizes the number and duration of LHD occurrences classified according to the contributors to the technical risk or the contributors to the operational risk.

No. of LHD Occurrences / LHD Duration (min)		
Occurring within the Japanese airspace (34 / 26.1min)	Technical risk (11 / 3.9min)	TCAS resolution advisory (9 / 3.77min)
		Auto pilot trouble (2 / 0.17min)
	Operational risk (23 / 22.2min)	Coordination errors in the ATC- ATC transfer of control - human factors (21 / 12.2min)
		Coordination errors in the ATC -ATC transfer of control -equipment outage (1 / 0min)
		Flight crew climbing without ATC clearance (1 / 10min)

Table 3: Summary of LHD occurrences classified whether technical risk contributors or operational risk contributors.

3.4 **Appendix A** contains the details of LHDs contributed to the technical risk. Nine of them were reported that the aircraft correctly followed a TCAS or ACAS advisory and are considered to be non-risk bearing. The cause of two deviations was reported as airborne equipment failure which led to unintentional or undetected change of flight level (autopilot trouble).

3.5 **Appendix B** contains the details of the twenty-three LHDs contributed to the operational risk, which were reported to the Japan RMA during the reporting period. Main contributor to the operational risk for Japanese airspace is coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility as a result of human factors issues.

3.6 In addition to thirty-four LHDs which occurred within the Japanese airspace, Japan RMA received twelve (12) LHDs which occurred outside of the Japanese airspace. **Appendix C** contains the details of the twelve LHDs occurred outside of the Japanese airspace during the reporting period.

3.7 **Appendix D** shows geographical locations where LHDs contributed to the operational risk occurred. Transfer errors tended to happen over the South West boundary of Fukuoka FIR.

3.8 **Appendix E** provides the number of LHD occurrences caused by ATC-to-ATC coordination errors on aircraft flying ATS route B576 between Japan and Republic of Korea (ROK). The Japanese Area Control Center which provides ATC services on B576 has been changed from Naha ACC to Fukuoka ACC since 11th February 2010. There have been no LHDs at ATOTI (B576) since this February.

4. Risk Assessment and Safety Oversight

4.1 This section updates the results of safety oversight for the RVSM implementation in the Japanese airspace. Accordingly, the internationally accepted collision risk methodology is applied in assessing the safety of the airspace. The Traffic Sample Data (TSD) of December 2009 and the LHD reports associated with the airspace during the period from May 2009 to April 2010 are used to produce the risk estimates presented in this report.

4.2 Estimate of the CRM Parameters

4.2.1 **Table 4** summarizes the value and source material for estimating values for each of the inherent parameters of the internationally accepted Collision Risk Model (CRM) used to conduct the safety oversight for the RVSM airspace.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
V _{ry}	Average cross track speed of aircraft pairs	11.6 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC, Apr. 1994)
V _{rz}	Average vertical speed of aircraft pairs	1.5 kt	Value often used
λ_x	Average aircraft length	0.0288 nm	FDPS data (December 2009)
λ_y	Average aircraft width	0.0263 nm	
λ_z	Average aircraft height	0.0083 nm	
V _{rx(same)}	Average same direction along track speed	28.9 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC, Apr. 1994)
V _{rx(opp)}	Average opposite direction along track speed	960 kt	Value often used
N _{x(same)}	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	3.25×10^{-2}	FDPS data (December 2009)
N _{x(opp)}	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	1.462×10^{-1}	FDPS data (December 2009)
P _{z(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
P _{z(0)}	Probability of vertical overlap in operational risk estimation for the assigned vertical separation $z=1000$ ft	0.54	Value often used (shown in RVSM/TF-9-IP/2)
P _{y(0)}	Probability that two aircraft on the same track are in lateral overlap	0.0745	Using the data of secondary surveillance radar obtained by the Hachinohe Air Route Surveillance radar (domestic RNAV route, 2001-2002)
N _{az^{technical}} (cross)	The collision risk for crossing routes (technical dimension)	5.90×10^{-11} [accidents/flight hour]	FDPS data (December 2009) is utilized for the calculation of $E_z(\theta)$.
N _{az^{operational}} (cross)	The collision risk for crossing routes (operational dimension)	7.23×10^{-10} [accidents/flight hour]	By eq. (12).
H	Total flight hours of aircraft flying on the route segments within airspace under consideration	957711.25 flight hours	12 times of December 2009
T(0)	LHD duration in hours	0.3694 flight hours	23 LHD reports received from May 2009 to Apr 2010

Table 4: Estimates of the Parameters in the CRM

4.3 Risk Calculation

4.3.1 Based on the Traffic Sample Data (TSD) for one month of December 2009 extracted from the JCAB Flight Data Processing System (FDPS), the numbers of passing events, $n_p(\text{same})$ and $n_p(\text{opp})$, 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 4**, kinematical coefficients of passing frequencies for the same and opposite direction traffic can be calculated by

$$K(\text{same}) = 1 + \frac{\lambda_x}{V_{rx}(\text{same})} \left(\frac{V_{ry}}{\lambda_y} + \frac{V_{rz}}{\lambda_z} \right) \quad (1)$$

$$K(\text{opp}) = 1 + \frac{\lambda_x}{V_{rx}(\text{opp})} \left(\frac{V_{ry}}{\lambda_y} + \frac{V_{rz}}{\lambda_z} \right) \quad (2)$$

4.3.3 Same-direction passing frequency $N_x(\text{same})$, opposite-direction passing frequency $N_x(\text{opp})$ and equivalent opposite-direction passing frequency $N_x^z(e)$ are defined by

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

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

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

respectively.

4.3.4 Technical Risk is estimated by

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

where,

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

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

$P_h(\)$ 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 $h(\theta)$ 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,

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

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

equivalently,

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

4.4 Safety Oversight for the RVSM implementation in Japanese airspace

4.4.1 **Table 5** presents the estimates of vertical collision risk for the Japanese airspace. The technical risk is estimated to be 0.31×10^{-9} fatal accidents per flight hour. The operational risk estimate is 3.85×10^{-9} fatal accidents per flight hour. The estimate of the overall vertical collision risk is 4.16×10^{-9} fatal accidents per flight hour, which satisfies the globally agreed TLS value of 5.0×10^{-9} fatal accidents per flight hour.

Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.31×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	3.85×10^{-9}		
Total Risk	4.16×10^{-9}	5.0×10^{-9}	Meets Overall TLS

Table 5: Risk Estimates for the RVSM Implementation in the Japanese airspace

4.4.2 **Figure 1** 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.

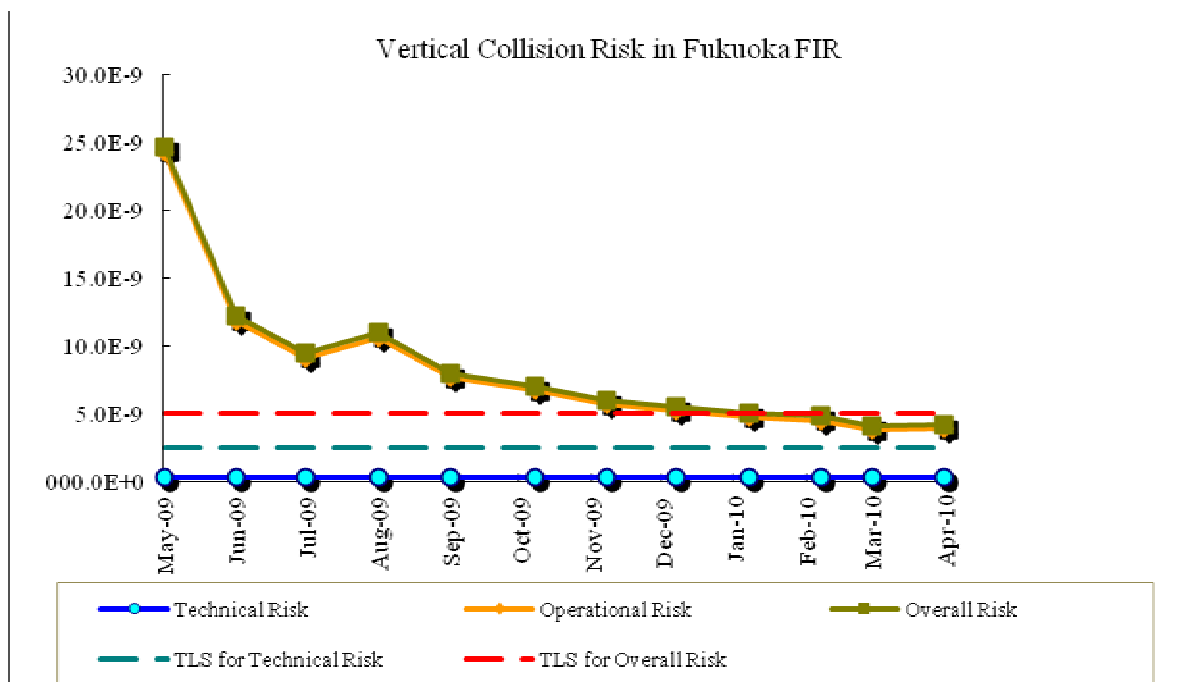


Figure 1: Trends of Risk Estimates for the RVSM Implementation in the Japanese airspace

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Appendix A

Height Deviations Contributed to Technical Risk in the Japanese Airspace Reported to the Japan RMA during the Reporting Period

Event date	Source	Duration of LHD (min)	Assigned FL	Observed / Reported ft	Cause	Code
27 Jun 09	Operator	0.083	300	30320	Airborne equipment failure leading to unintentional or undetected change of flight level (auto pilot trouble)	H
19 Sep 09	Tokyo ACC	0.5	360	35500	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
21 Sep 09	Fukuoka ACC	1.267	390	40175	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
20 Oct 09	Tokyo ACC	0.167	300	29700	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
28 Oct 09	Sapporo ACC	0.333	340	33700	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
10 Nov 09	Tokyo ACC	0.333	330	32700	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
11 Nov 09	Tokyo ACC	0.167	360	35700	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
30 Jan 10	Tokyo ACC	0.5	310	31400	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
28 Feb 10	Operator	0.083	330	32500	Airborne equipment failure leading to unintentional or undetected change of flight level (auto pilot trouble)	H
9 Mar 10	Tokyo ACC	0.167	360	35700	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J
23 Mar 10	Tokyo ACC	0.333	290	29500	TCAS resolution advisory; flight crew correctly following the resolution Advisory	J

Appendix B

Height Deviations Contributed to Operational Risk in the Japanese Airspace Reported to the Japan RMA during the Reporting Period

Event date	Source	Location of deviation	Duration of LHD (min)	Cause	code
24 May 09	Naha ACC	MOLKA (M750)	0	Non-existent coordination	E
25 May 09	Naha ACC	ATOTI (B576)	0	Incorrect flight level not in accordance with agreed parameters	E
28 May 09	Fukuoka ATMC	NANNO (R220)	10	Flight crew climbing without ATC clearance	B
9 Jun 09	Naha ACC	ATOTI (B576)	0	Incorrect flight level not in accordance with agreed parameters	E
11 Jun 09	Naha ACC	MOLKA (M750)	0	Non-existent coordination	E
11 Jun 09	Naha ACC	MOLKA (M750)	0	Non-existent coordination	E
20 Jun 09	Fukuoka ATMC	GURAG (A590)	0	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of mishearing	E
21 Jul 09	Naha ACC	ATOTI (B576)	1	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	E
22 Jul 09	Naha ACC	MOLKA (M750)	0	Non-existent coordination	E
5 Aug 09	Naha ACC	LEBIX (N884)	6.7	Incorrect flight level not in accordance with agreed parameters	E
9 Sep 09	Naha ACC	MOLKA (M750)	0	Incorrect flight level not in accordance with agreed parameters	E
13 Sep 09	Naha ACC	LEBIX (N884)	0	Communication equipment in Manila was out of service due to technical trouble	F
21 Sep 09	Naha ACC	ATOTI (B576)	0	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	E
1 Oct 09	Naha ACC	ATOTI (B576)	0.75	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	E

12 Oct 09	Naha ACC	MOLKA (M750)	0	Non-existent coordination	E
3 Dec 09	Naha ACC	SALMI (B576)	0	Non-existent coordination	E
4 Dec 09	Naha ACC	MEVIN (B462)	0.333	Incorrect flight level not in accordance with agreed parameters	E
7 Dec 09	Naha ACC	ATOTI (B576)	0	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	E
4 Jan 10	Naha ACC	MEVIN (B462)	0.333	Incorrect flight level not in accordance with agreed parameters	E
21 Jan 10	Naha ACC	ATOTI (B576)	0	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	E
26 Jan 10	Naha ACC	ATOTI (B576)	0	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	E
24 Mar 10	Naha ACC	LEBIX (N884)	0.5	Incorrect flight level not in accordance with agreed parameters	E
13 Apr 10	Naha ACC	LEBIX (N884)	2.583	Incorrect flight level not in accordance with agreed parameters	E

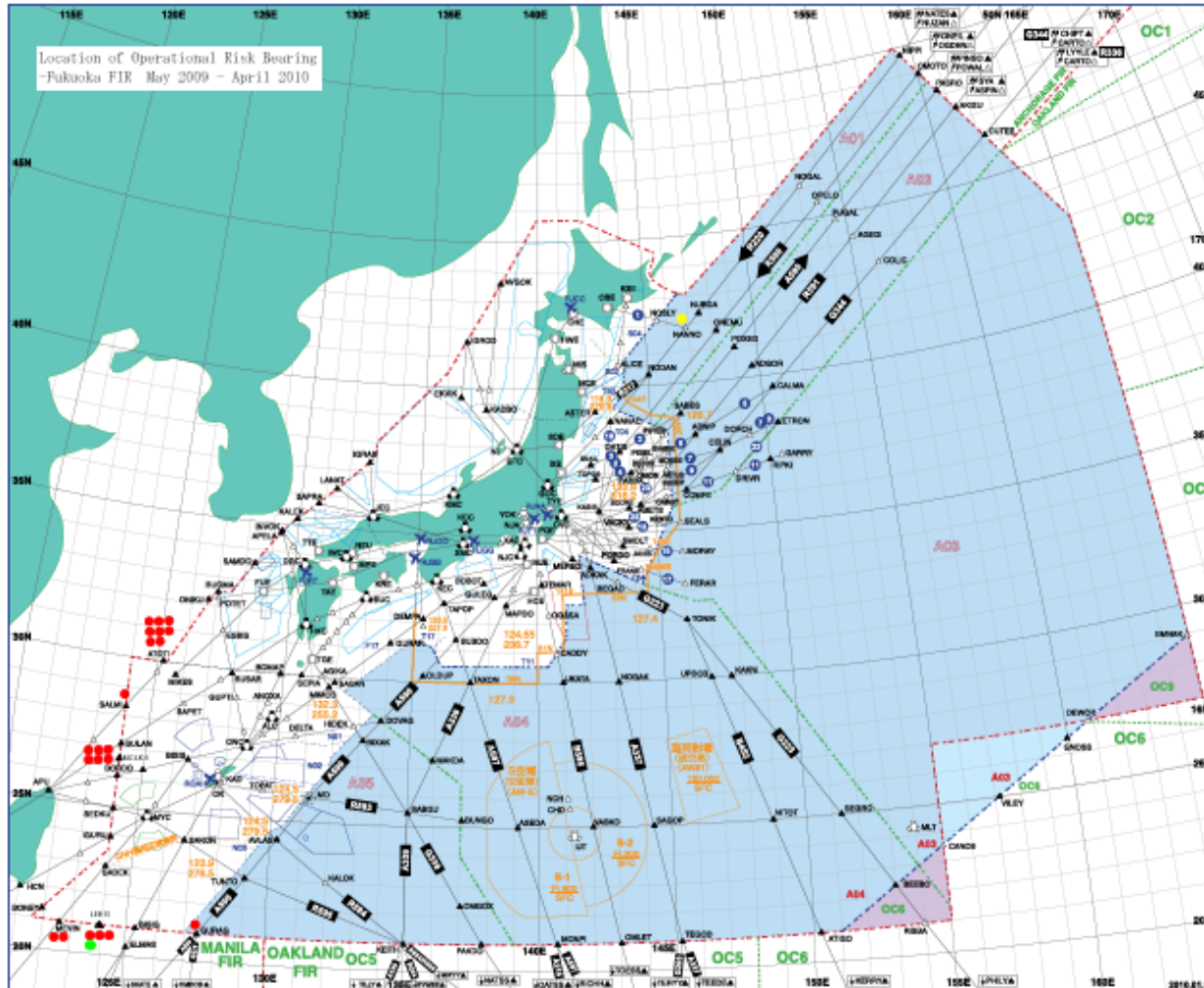
Appendix C

Height Deviation Incidents Occurred Outside of Japanese Airspace during the Reporting Period

Event date	Source	Location of deviation	Expected FL	Observed FL	Cause	Other traffic
31 May 09	Naha ACC	ATOTI (B576)	350	370	Incorrect flight level not in accordance with agreed parameters	Nil
20 Jun 09	Naha ACC	BISIG (A582)	340	340	Incorrect time not in accordance with agreed parameters	Nil
15 Aug 09	Fukuoka ACC	NIRAT (A593)	300	303	TCAS resolution advisory; flight crew correctly following the resolution advisory	yes
19 Aug 09	Incheon ACC	SADLI (A593)	270	330	Incorrect flight level not in accordance with agreed parameters	Nil
23 Aug 09	Incheon ACC	ATOTI (B576)	350	330	Incorrect flight level not in accordance with agreed parameters	Nil
28 Aug 09	Fukuoka ATMC	GURAG (A590)	400	380	Incorrect flight level not in accordance with agreed parameters	Nil
7 Oct 09	Fukuoka ATMC	GURAG (A590)	400	400	Non-existent coordination	Nil
24 Oct 09	Naha ACC	BULAN (A1)	340	380	Incorrect flight level not in accordance with agreed parameters	Nil
28 Oct 09	Fukuoka ATMC	GURAG (A590)	340	320	Incorrect flight level not in accordance with agreed parameters	Nil
8 Nov 09	Naha ACC	BISIG (A582)	340	360	Incorrect flight level not in accordance with agreed parameters	Nil
8 Nov 09	Naha ACC	SALMI (B576)	380	380	Non-existent coordination	Nil
15 Nov 09	Naha ACC	ATOTI (B576)	350	350	Non-existent coordination (AIDC was in operation, but the information of this aircraft was not processed by AIDC due to technical issue)	Nil

Appendix D

Geographical locations where LHDs contributed to the operational risk occurred



Red color dot :
 Coordination errors in the ATC- ATC transfer
 of control - human factors

Green color dot :
 Coordination errors in the ATC -ATC transfer
 of control -equipment outage

Yellow color dot :
 Flight crew climbing without ATC clearance

Appendix E

Number of LHD occurrences caused by ATC-to-ATC coordination errors on aircraft flying ATS route B576 between Japan and ROK

May, 2009	Jun, 2009	Jul, 2009	Aug, 2009	Sep, 2009	Oct, 2009	Nov, 2009	Dec, 2009	Jan, 2010	Feb, 2010	Mar, 2010	Apr, 2010
2	1	1	1	1	1	1	1	2	0	0	0