



International Civil Aviation Organization

**The Twentieth Meeting of the Regional Airspace Safety Monitoring
Advisory Group (RASMAG/20)**

Bangkok, Thailand, 26-29 May 2015

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

JASMA RVSM SAFETY REPORT

(Presented by JASMA)

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 January 2014 to 31 December 2014.

1. INTRODUCTION

1.1 The paper provides details of the airspace safety oversight assessment undertaken by the Japan Airspace Safety Monitoring Agency (JASMA) for the RVSM implementations in Fukuoka FIR. The report is detailed in **Attachment A**.

2. DISCUSSION

2.1 The report shows that for the Fukuoka FIR, the level of risk for the reporting period was 7.17×10^{-9} which exceeds the target level of Safety 5.0×10^{-9} (TLS).

2.2 **Table 1** summarizes Fukuoka FIR RVSM technical, operational and total risks. **Figure 1** presents collision risk estimate trends during the period from 1 January 2013 to December 2013.

Table 1: Fukuoka FIR RVSM Risk Estimates

Fukuoka FIR – estimated annual flying hours = 1101469 hours (note: estimated hours based on Dec 2012 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
<i>RASMAG19 Total Risk (PREVIOUS RASMAG)</i>	3.66×10^{-9}	5.0×10^{-9}	<i>Below the TLS</i>
Technical Risk	0.42×10^{-9}	2.5×10^{-9}	Below Technical TLS
Operational Risk	6.75×10^{-9}	-	-
Total Risk	7.17×10^{-9}	5.0×10^{-9}	Exceed the TLS

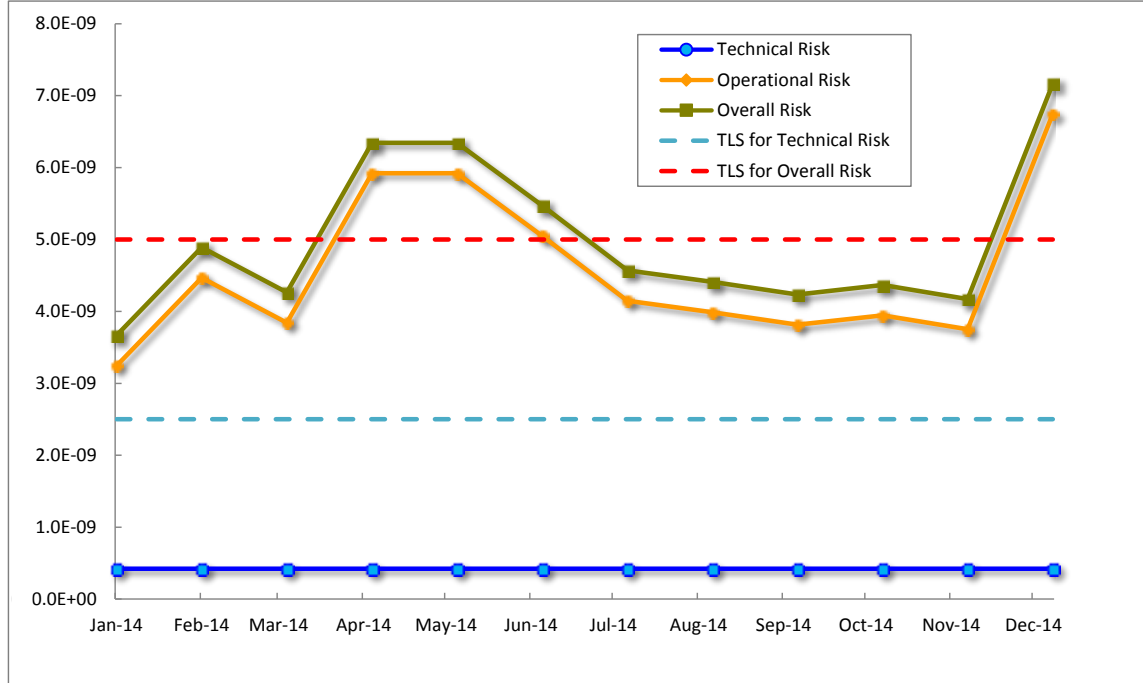


Figure 1: Fukuoka FIR RVSM Risk Estimate Trends

2.3 **Table 2** presents as summary of the LHD causes within Fukuoka FIR from 1 January 2014 to 31 December 2014.

Table 2: Summary of LHD Causes within Fukuoka FIR.

Code	LHD Category Description	No.
A	Flight crew fails to climb or descend the aircraft as cleared	0
B	Flight crew climbing or descending without ATC clearance	0
C	Incorrect operation or interpretation of airborne equipment	0
D	ATC system loop error	3
E	ATC transfer of control coordination errors due to human factors	9
F	ATC transfer of control coordination errors due to technical issues	0
G	Aircraft contingency leading to sudden inability to maintain level	1
H	Airborne equipment failure and unintentional or undetected level change	0
I	Turbulence or other weather related cause	7
J	TCAS resolution advisory and flight crew correctly responds	11
K	TCAS resolution advisory and flight crew incorrectly responds	0
L	Non-approved aircraft is provided with RVSM separation	0
M	Other	3
Total		34

2.4 **Figure 2** provides the geographic location of LHD reports including the information provided from MAAR during the assessment period. The solid square blue symbols represent LHD location in RVSM stratum inside of Fukuoka FIR and the open square blue symbols represent LHD location out of RVSM stratum or outside of Fukuoka FIR. The circle size means the time of 50 seconds or more.

2.5 The estimated one year Overall risk exceeded the TLS some of transfer errors and ATC system loop errors are above in 2014. It is reported that the ATC facilities and aircraft operator concerned are discussing these events to mitigate this kind of human errors.

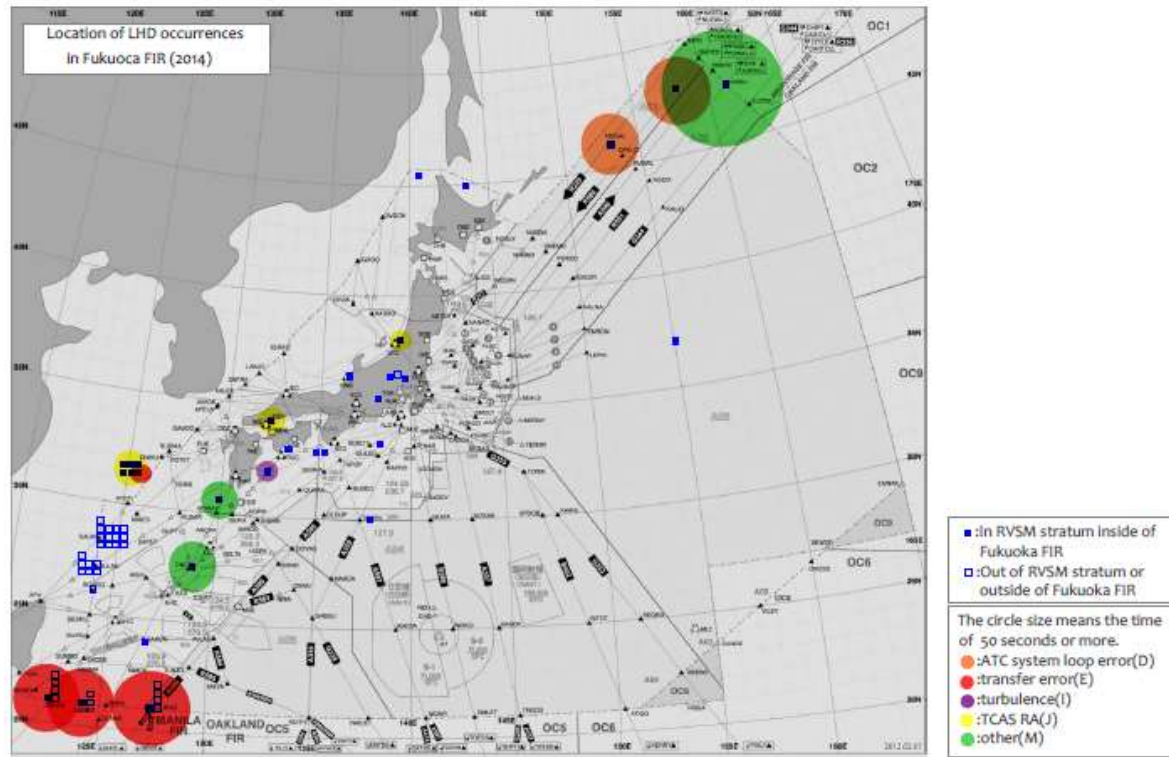


Figure 2: Fukuoka FIR – Risk Bearing LHD

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 A

**AIRSPACE SAFETY REVIEW FOR THE RVSM IMPLEMENTATION
IN FUKUOKA FLIGHT INFORMATION REGION**

JAN 2014 to DEC 2014

(Presented 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 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 January 2014 to 31 December 2014. There are a total of 34 reported large height deviations that occurred during this period in Fukuoka FIR. The vertical collision risk estimate for the RVSM airspace in Fukuoka FIR was 7.17×10^{-9} that exceeds the target level of safety (TLS).

1. INTRODUCTION

1.1 This attachment presents 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 January 2014 to 31 December 2014.

1. DISCUSSION

1.1 Traffic Sample Data (TSD)

2.1.1 Traffic Sample data for the month of December 2014 of aircraft operating in the Fukuoka FIR were used to assess the safety of RVSM airspace.

1.2 Large Height Deviation (LHD)

2.2.1 A series of cumulative 12-month of LHD reports were used in this safety assessment starting from January 2014 to December 2014.

2.2.2 Summary of LHD Occurrences in the Fukuoka FIR

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

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

Month-Year	No. of LHD Occurrences	LHD Duration (Minutes)
January 2014	3	0
February 2014	2	7
March 2014	2	0
April 2014	3	11.9
May 2014	2	0
June 2014	4	0
July 2014	2	0
August 2014	5	1
September 2014	4	0
October 2014	4	0.8
November 2014	1	0
December 2014	2	18
Total	34	38.7

2.2.4 The LHD reports are separated by categories based on the details provided for each deviation. **Table 2** presents a summary of the LHD causes within Fukuoka FIR from Jan. 2014 until Dec. 2014 against 2013. The number of LHD reports decreased from 48 to 34.

Table 2: Summary of LHD Causes within Fukuoka FIR.

Code	LHD Category Description	2013	2014
A	Flight crew fails to climb or descend the aircraft as cleared	1	0
B	Flight crew climbing or descending without ATC clearance	2	0
C	Incorrect operation or interpretation of airborne equipment	0	0
D	ATC system loop error	2	3
E	ATC transfer of control coordination errors due to human factors	15	9
F	ATC transfer of control coordination errors due to technical issues	0	0
G	Aircraft contingency leading to sudden inability to maintain level	2	1
H	Airborne equipment failure and unintentional or undetected level change	0	0
I	Turbulence or other weather related cause	8	7
J	TCAS resolution advisory and flight crew correctly responds	17	11
K	TCAS resolution advisory and flight crew incorrectly responds	0	0
L	Non-approved aircraft is provided with RVSM separation	0	0
M	Other	1	3
Total		48	34

2.2.5 **Appendix A** contains the details of the twelve (12) LHDs contributed to the operational risk, which were reported to the JASMA during the reporting period.

2.2.6 **Appendix B** contains the details of the eighteen (18) LHDs which were not involved in the operational risk. One (1) of them was contingency descend due to fire monitoring system and cabin pressure system alerted cases categorized G. Five (5) were turbulence or other weather related causes categorized I. Nine (9) were TCAS resolution advisory and flight crew correctly responds cases categorized J. Three (3) were unknown but there is a possibility of TCAS RA and CPDLC malfunctioning cases.

2.2.7 The JASMA received Four (4) reports which were occurred outside of Fukuoka FIR. The details are shown in **Appendix C**.

2.2.8 In addition, JASMA has received thirty two (32) transfer error reports occurred in Taipei and Manila FIR from MAAR. JASMA shared these error reports with the ATC facilities concerned. One of the reasons was a short flight leg of southwest bound over flight within Fukuoka FIR. In case of the wind data was not updated, the gap of estimated time of arrival (ETA) at the entering waypoint to adjacent Taipei FIR made a late AIDC send-message that caused the transfer error event even though AIDC has installed. To prevent this kind of event, if the upper wind data is doubtful, Fukuoka ACC controller requests wind data updating to the person in charge of ATMC where receives Met data. And also Fukuoka ACC controller shall be aware of error message and if necessary, send revised ETA and Flight Level (FL) message via AIDC or voice communication line to Taipei ACC. And in ATMC oceanic sector, deputy officer confirms all of the transfers completed using a checklist at the controller table every hour.

2.2.9 **Appendix D, Figure 3** provides the geographic location of LHD reports including the information provided from MAAR during the assessment period. The solid square blue symbols represent LHD location in RVSM stratum inside of Fukuoka FIR and the open square blue symbols represent LHD location out of RVSM stratum or outside of Fukuoka FIR. The circle size means the time of 50 seconds or more.

3. Risk Assessment and Safety Oversight

3.1 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.

3.1.1 Estimate of the Collision Risk Model (CRM) Parameters shown in **Table 3**. The average sizes of aircrafts are a little bit smaller than the December 2013 TSD.

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 (2011).
λ_x	Average aircraft length	0.027 nm	FDPS data (December 2014)
λ_y	Average aircraft width	0.0248 nm	
λ_z	Average aircraft height	0.0079 nm	
$ \Delta V $	Average along track speed of aircraft pairs	28.9 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC, Apr. 1994)
$ \bar{V} $	Individual-aircraft along track speed	480 kt	Value often used

$ \dot{y} $	Average cross track speed of aircraft pairs	11.6 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC, Apr. 1994)
$ \dot{z} $	Average vertical speed of aircraft pairs	1.5 kt	Value often used
$N_x(\text{same})$	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	3.23×10^{-2}	FDPS data (December 2014)
$N_x(\text{opp})$	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	1.81×10^{-1}	FDPS data (December 2014)
$N_{az}^{\text{technical}}(\text{cross})$	The collision risk for crossing routes (technical dimension)	1.26×10^{-10} [accidents/flight hour]	FDPS data (December 2014) is utilized for the calculation of $E_z(\theta)$.
$N_{az}^{\text{operational}}(\text{cross})$	The collision risk for crossing routes (operational dimension)	2.02×10^{-9} [accidents/flight hour]	By eq. (12).
H	Total flight hours of aircraft flying on the route segments within airspace under consideration	1,276,693.4 flight hours	12 times of December 2014
$T(0)$	LHD duration in hours	0.64 flight hours	34 LHD reports received from Jan. 2014 to Dec. 2014

3.2 Risk Calculation

3.2.1 Based on the TSD for one month of December 2014 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.

3.2.2 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

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

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

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

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

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

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

respectively.

Technical Risk is estimated by

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

where,

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

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

$P_h(\theta)$ 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 $|\dot{h}(\theta)|$ were calculated every ten degrees.

Operational Risk is given by

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

where,

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

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

equivalently,

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

Executive Summary

3.3 Safety Oversight for the RVSM implementation in the Fukuoka FIR

3.3.1 **Table 4** presents the estimates of vertical collision risk for the RVSM airspace of the Fukuoka FIR. The technical risk is estimated to be 0.42×10^{-9} fatal accidents per flight hour. The operational risk estimate is 6.75×10^{-9} fatal accidents per flight hour. The estimate of the overall vertical collision risk is 7.17×10^{-9} fatal accidents per flight hour, which exceeds the globally agreed TLS value of 5.0×10^{-9} fatal accidents per flight hour.

3.3.2 **Figure 2** presents collision risk estimate trends by type (technical, operational, and total) for each month using the appropriate cumulative during the period from January 2014 to December 2014.

Table 4: Fukuoka FIR RVSM Risk Estimates

Fukuoka FIR – estimated annual flying hours = 1101469 hours (note: estimated hours based on Dec 2012 traffic sample data)			
Source of Risk	Risk Estimation	TLS	Remarks
RASMAG19 Total Risk (PREVIOUS RASMAG)	3.66×10^{-9}	5.0×10^{-9}	Below the TLS
Technical Risk	0.42×10^{-9}	2.5×10^{-9}	Below Technical TLS
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Total Risk	7.17×10^{-9}	5.0×10^{-9}	Exceed the TLS

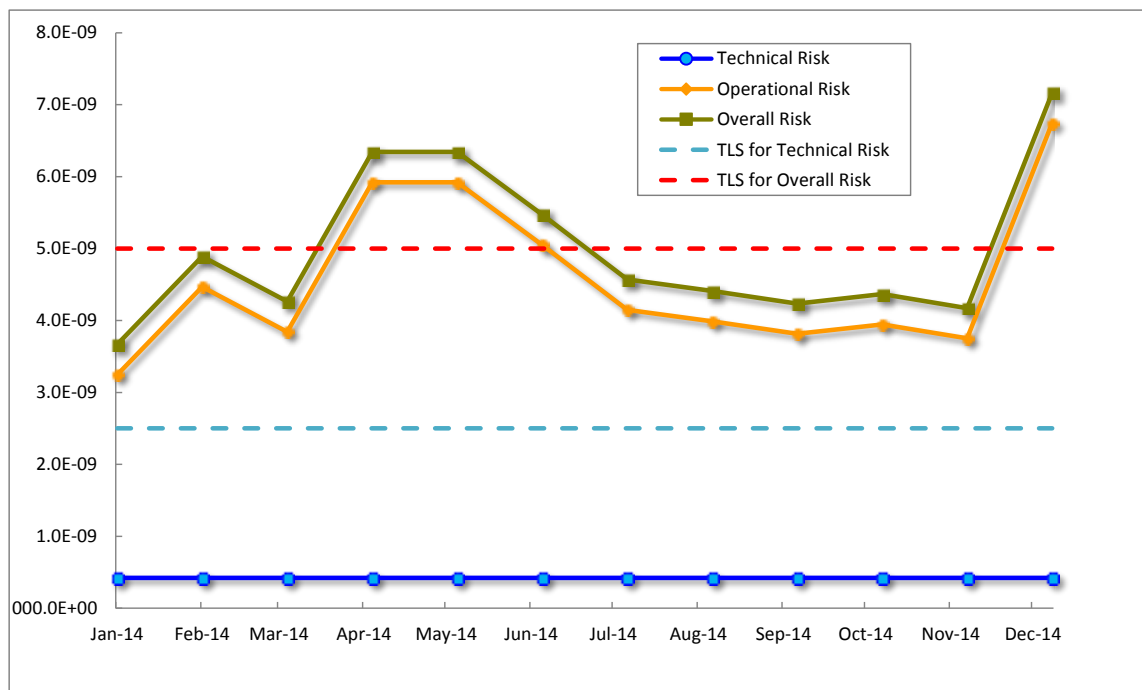


Figure 2: Fukuoka FIR RVSM Risk Estimate Trends

3.3.3 The estimated one year Overall risk exceeded the TLS some of transfer errors and ATC system loop errors are above in 2014. It is reported that the ATC facilities and aircraft operator concerned are discussing these events to mitigate this kind of human errors.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

- note the information contained in this paper; and
- discuss any relevant matters as appropriate.

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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
17 Feb 14	Naha ACC	MEVIN (B462)	7	ATC transfer of control coordination errors due to human factors	E
2 Apr 14	ATMC	NOGAL (R220)	6	ATC system loop error (Flight crew misunderstands the clearance)	D
4 Apr 14	Naha ACC	LEBIX (N884)	5.9	ATC transfer of control coordination errors due to human factors	E
2 Jun 14	Sapporo ACC	AKSUN (A204)	Unknown	ATC transfer of control coordination errors due to human factors	E
15 Jun 14	Fukuoka ACC	20NM West of SADLI (A593)	0	ATC transfer of control coordination errors due to human factors	E
8 Jul 14	Fukuoka ACC	20NM West of SADLI (A593)	0	ATC transfer of control coordination errors due to human factors	E
8 Jul 14	Fukuoka ACC	20NM West of SADLI (A593)	0	ATC transfer of control coordination errors due to human factors	E
19 Aug 14	Fukuoka ACC	20NM West of SADLI (A593)	1	ATC transfer of control coordination errors due to human factors	E
18 Sep 14	Sapporo ACC	ANIMO (B337)	Unknown	ATC transfer of control coordination errors due to human factors	E
30 Oct 14	Naha ACC	10NM South of SAKON (A582)	0.8	ATC system loop error (Flight crew misunderstands the clearance)	D
15 Dec 14	ATMC	OMOTO (R580)	8	ATC system loop error (Flight crew misunderstands the clearance)	D
20 Dec 14	Naha ACC	GURAG (A590)	10	ATC transfer of control coordination errors due to human factors	E

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
19 Jan 14	Tokyo ACC	0.3	300	29200	TCAS resolution advisory and flight crew correctly responds	J
19 Jan 14	Tokyo ACC	0.5	310	31900	TCAS resolution advisory and flight crew correctly responds	J
10 Mar 14	A/C Operator	0.1	290	29350	Severe Turbulence	I
18 Mar 14	Fukuoka ACC	1	330	33500	Weather related cause	I
18 Apr 14	Tokyo ACC	0.3	350	34700	TCAS resolution advisory and flight crew correctly responds	J
3 May 14	ATMC	Unknown	410	10000	Aircraft contingency leading to sudden inability to maintain level	G
9 May 14	A/C Operator	0.2	410	41350	Weather related cause	I
2 Jun 14	ATMC	40	340B380	360	Other (CPDLC related cause)	M
11 Jul 14	Tokyo ACC	0.2	330	33400	Weather related cause	I
2 Aug 14	Fukuoka ACC	1.4	320	32700	TCAS resolution advisory and flight crew correctly responds	J
10 Aug 14	Naha ACC	4.2	370	37300	Other	M
16 Aug 14	Fukuoka ACC	0.3	370	35300	TCAS resolution advisory and flight crew correctly responds	J
Event date	Source	Duration of LHD (min)	Assigned FL	Observed / Reported(ft)	Cause	Code

23 Aug 14	A/C Operator	0.2	360	35600	Weather related cause	I
20 Sep 14	Fukuoka ACC	2.2	370	37300	Other	M
11 Oct 14	Tokyo ACC	0.3	370	36600	TCAS resolution advisory and flight crew correctly responds	J
15 Oct 14	Fukuoka ACC	1.5	290	29900	TCAS resolution advisory and flight crew correctly responds	J
15 Oct 14	Fukuoka ACC	1.9	300	28600	TCAS resolution advisory and flight crew correctly responds	J
7 Nov 14	Tokyo ACC	0.8	310	31500	TCAS resolution advisory and flight crew correctly responds	J

Appendix C

Height Deviations Occurred Outside of Fukuoka FIR and outside of RVSM stratum during the Reporting Period

Event date	Source	Location of deviation	Expected FL	Observed FL	Cause	Other traffic
24 Jan 14	A/C Operator	OMSUN (NCA13)	330	325	Severe Turbulence	N
27 Feb 14	A/C Operator	15NM West of 38N130W (PACOTS)	350	347	Weather related deviation	N
4 Sep 14	Tokyo ACC	MAUKA (Y517)	250	255	TCAS RA (Out of RVSM airspace)	Y
17 Sep 14	Tokyo ACC	YAGAN (Y517)	250	260	TCAS RA (Out of RVSM airspace)	Y

Appendix D

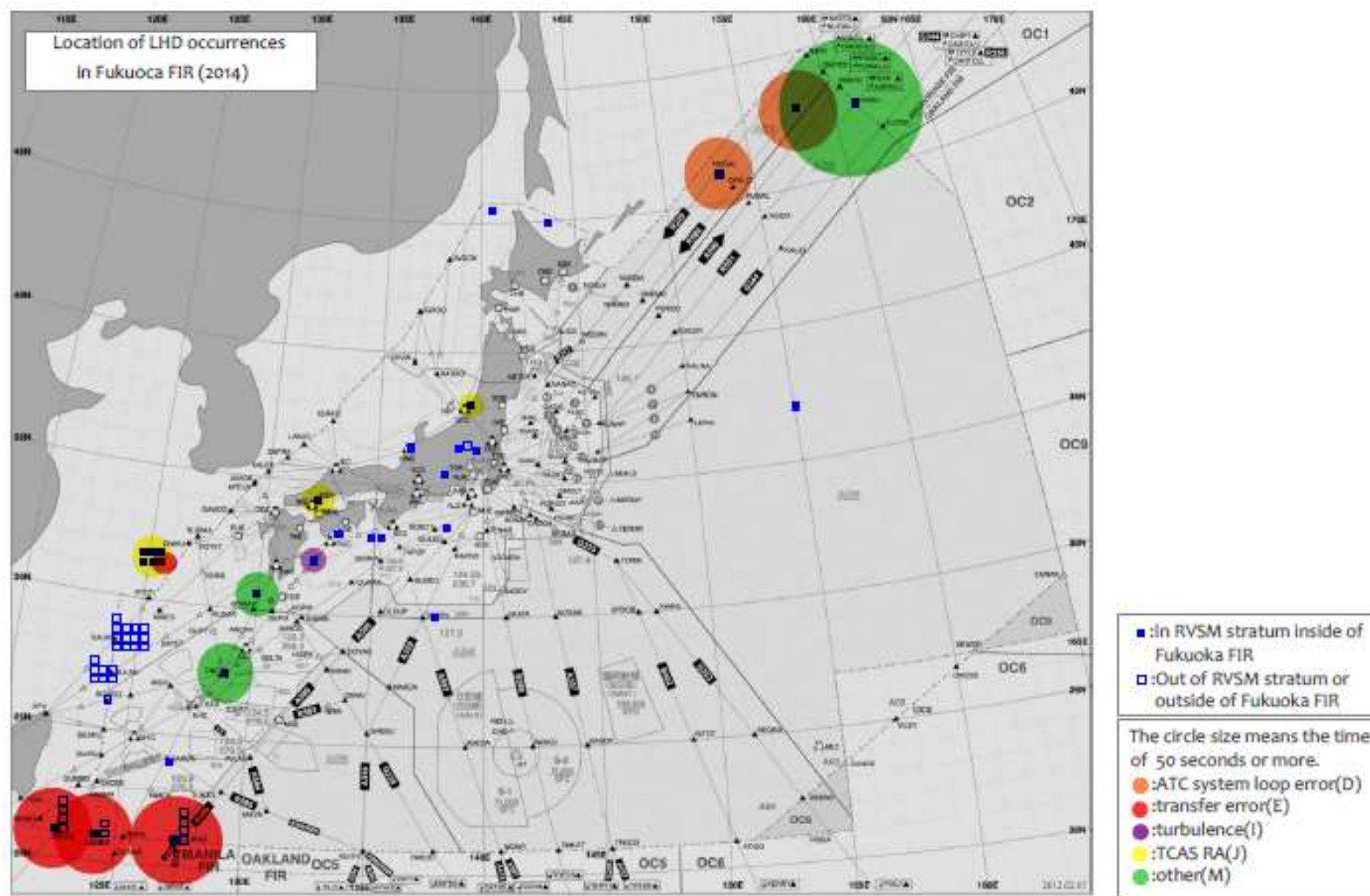


Figure 3: Fukuoka FIR – Risk Bearing LHD position and duration