*International Civil Aviation Organization*

**The Twentieth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/21)**

Bangkok, Thailand, 14-17 June 2016

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**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 2015 to 31 December 2015.

## 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 reports is detailed in **Attachment 1**.

## 2. DISCUSSION

2.1 The report shows that for the Fukuoka FIR, the level of risk for the reporting period was 22.11 x $10^{-9}$ which exceeds the target level of Safety 5.0 x $10^{-9}$ (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 2015 to December 2015.

**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** |
| *RASMAG20 Total Risk (PREVIOUS RASMAG)* | *7.17 x $10^{-9}$* | *5.0 x $10^{-9}$* | *Exceed the TLS* |
| Technical Risk | 0.44 x $10^{-9}$ | 2.5 x $10^{-9}$ | Below Technical TLS |
| Operational Risk | 21.67 x $10^{-9}$ | - | - |
| Total Risk | **22.11 x $10^{-9}$** | 5.0 x $10^{-9}$ | **Exceed the TLS** |

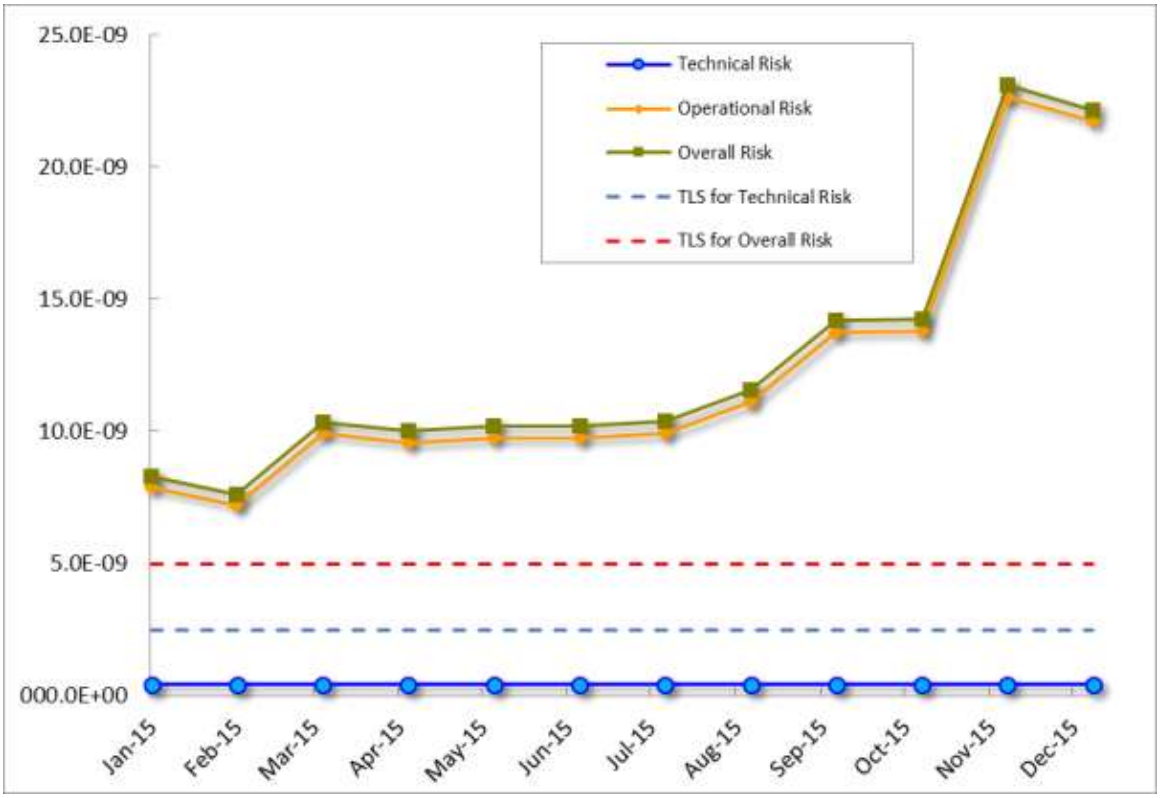


**Figure 1**: Fukuoka FIR RVSM Risk Estimate Trends

2.3 **Table 2** presents as summary of the LHD causes within Fukuoka FIR from 1 January 2015 to 31 December 2015.

**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 | 2 |
| C | Incorrect operation or interpretation of airborne equipment | 1 |
| D | ATC system loop error | 9 |
| E | ATC transfer of control coordination errors due to human factors | 12 |
| F | ATC transfer of control coordination errors due to technical issues | 0 |
| G | Aircraft contingency leading to sudden inability to maintain level | 0 |
| H | Airborne equipment failure and unintentional or undetected level change | 2 |
| I | Turbulence or other weather related cause | 19 |
| J | TCAS resolution advisory and flight crew correctly responds | 3 |
| K | TCAS resolution advisory and flight crew incorrectly responds | 0 |
| L | Non-approved aircraft is provided with RVSM separation | 0 |
| M | Other | 3 |
| Total | | 51 |

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 2015. It is reported that the ATC facilities and aircraft operator concerned are discussing these events to mitigate this kind of human errors.

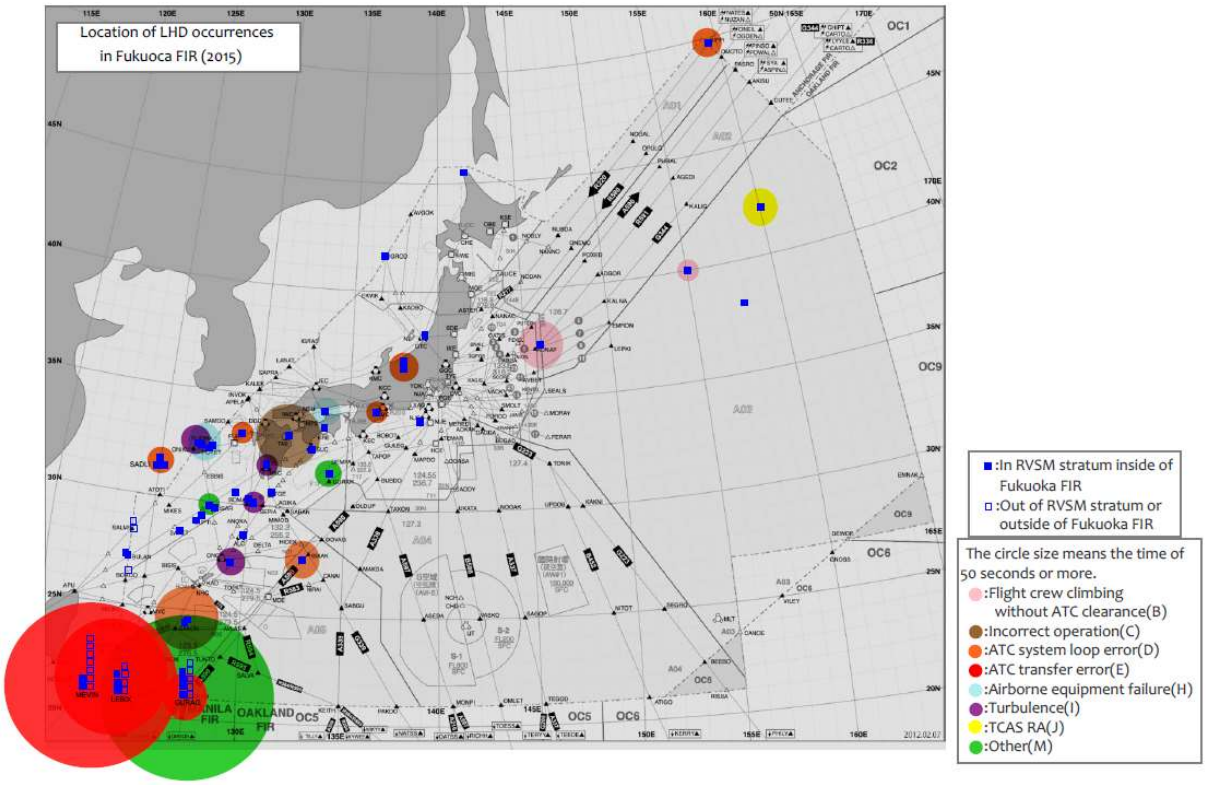


**Figure 2**: Fukuoka FIR – Risk Bearing LHD

## 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.

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**Attachment 1**

**AIRSPACE SAFETY REVIEW FOR THE RVSM IMPLEMENTATION**

**IN FUKUOKA FLIGHT INFORMATION REGION**

JAN 2015 to DEC 2015

(Presented by JASMA)

JASMA の RVSM 安全性検証レポート

**SUMMARY**

The purpose of this repot 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 2015 to 31 December 2015. There are at total of 51 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 22.11 x $10^{-9}$ 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 2015 to 31 December 2015.

## 2. DISCUSSION

2.1 Traffic Sample Data (TSD)

2.1.1 Traffic Sample data for the month of December 2015 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 January 2015 to December 2015.

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 2015 | 3 | 8 |
| February 2015 | 2 | 3 |
| March 2015 | 3 | 16.1 |
| April 2015 | 6 | 10 |
| May 2015 | 3 | 1 |
| June 2015 | 6 | 0 |
| July 2015 | 6 | 1 |
| August 2015 | 6 | 8 |
| September 2015 | 3 | 15.6 |
| October 2015 | 5 | 1.2 |
| November 2015 | 4 | 52.5 |
| December 2015 | 4 | 12.5 |
| **Total** | **51** | **128.7** |

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. 2015 until Dec. 2015 against 2014. The number of LHD reports increased from 34 to 51.

**Table 2**: Summary of LHD Causes within Fukuoka FIR.

| Code | LHD Category Description | 2014 | 2015 |
|---|---|---|---|
| A | Flight crew fails to climb or descend the aircraft as cleared | 0 | 0 |
| B | Flight crew climbing or descending without ATC clearance | 0 | 2 |
| C | Incorrect operation or interpretation of airborne equipment | 0 | 1 |
| D | ATC system loop error | 3 | 9 |
| E | ATC transfer of control coordination errors due to human factors | 9 | 12 |
| F | ATC transfer of control coordination errors due to technical issues | 0 | 0 |
| G | Aircraft contingency leading to sudden inability to maintain level | 1 | 0 |
| H | Airborne equipment failure and unintentional or undetected level change | 0 | 2 |
| I | Turbulence or other weather related cause | 7 | 19 |
| J | TCAS resolution advisory and flight crew correctly responds | 11 | 3 |
| K | TCAS resolution advisory and flight crew incorrectly responds | 0 | 0 |
| L | Non-approved aircraft is provided with RVSM separation | 0 | 0 |
| M | Other | 3 | 3 |
| Total | | 34 | **51** |

2.2.5 **Appendix A** contains the details of the twenty four (24) 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 twenty seven (27) LHDs which were not involved in the operational risk. Nineteen (19) were turbulence or other weather related causes categorized I. Three (3) were TCAS resolution advisory and flight crew correctly responds cases categorized J. Two (2) were airborne equipment failure categorized H. Three (3) were unknown but there is a possibility of TCAS RA and CPDLC malfunctioning cases.

2.2.7 **Appendix C**, **Figure 3** provides the geographic location of LHD reports 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 2014 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 | $1.7\times10^{-8}$ | 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 | 0.0711 | Using the data of secondary surveillance radar obtained by the Hachinohe Air Route Surveillance radar (2011). |
| $\lambda x$ | Average aircraft length | 0.0267 nm | FDPS data (December 2015) |
| $\lambda y$ | Average aircraft width | 0.0245 nm | |
| $\lambda z$ | Average aircraft height | 0.0078 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 | $3.07\times10^{-2}$ | FDPS data (December 2015) |
| Nx(opp) | The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic | $2.03\times10^{-1}$ | FDPS data (December 2015) |
| $Naz^{technical}$ (cross) | The collision risk for crossing routes (technical dimension) | $1.29\times10^{-10}$ [accidents/flight hour] | FDPS data (December 2015) is utilized for the calculation of $E_z(\theta)$. |

| | | | |
|---|---|---|---|
| $Naz^{operational}$ (cross) | The collision risk for crossing routes (operational dimension) | $6.34\times10^{-9}$ [accidents/flight hour] | By eq. (12). |
| H | Total flight hours of aircraft flying on the route segments within airspace under consideration | 1,375,006 flight hours | 12 times of December 2015 |
| T(0) | LHD duration in hours | 2.15flight hours | 24 LHD reports received from Jan. 2015 to Dec. 2015 |

3.2 Risk Calculation

3.2.1 Based on the TSD for one month of December 2015 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.

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

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

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

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,

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

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

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

Operational Risk is given by

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

where,

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

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

equivalently,

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

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 0.44 x $10^{-9}$ fatal accidents per flight hour. The operational risk estimate is 21.67 x $10^{-9}$ fatal accidents per flight hour. The estimate of the overall vertical collision risk is 22.11 x $10^{-9}$ fatal accidents per flight hour, which exceeds the globally agreed TLS value of 5.0 x $10^{-9}$ 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 2015 to December 2015.

**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** |
| *RASMAG20 Total Risk (PREVIOUS RASMAG)* | *7.17 x $10^{-9}$* | *5.0 x $10^{-9}$* | *Exceed the TLS* |
| Technical Risk | 0.44 x $10^{-9}$ | 2.5 x $10^{-9}$ | Below Technical TLS |
| Operational Risk | 21.67 x $10^{-9}$ | - | - |
| Total Risk | **22.11 x $10^{-9}$** | 5.0 x $10^{-9}$ | **Exceed the TLS** |

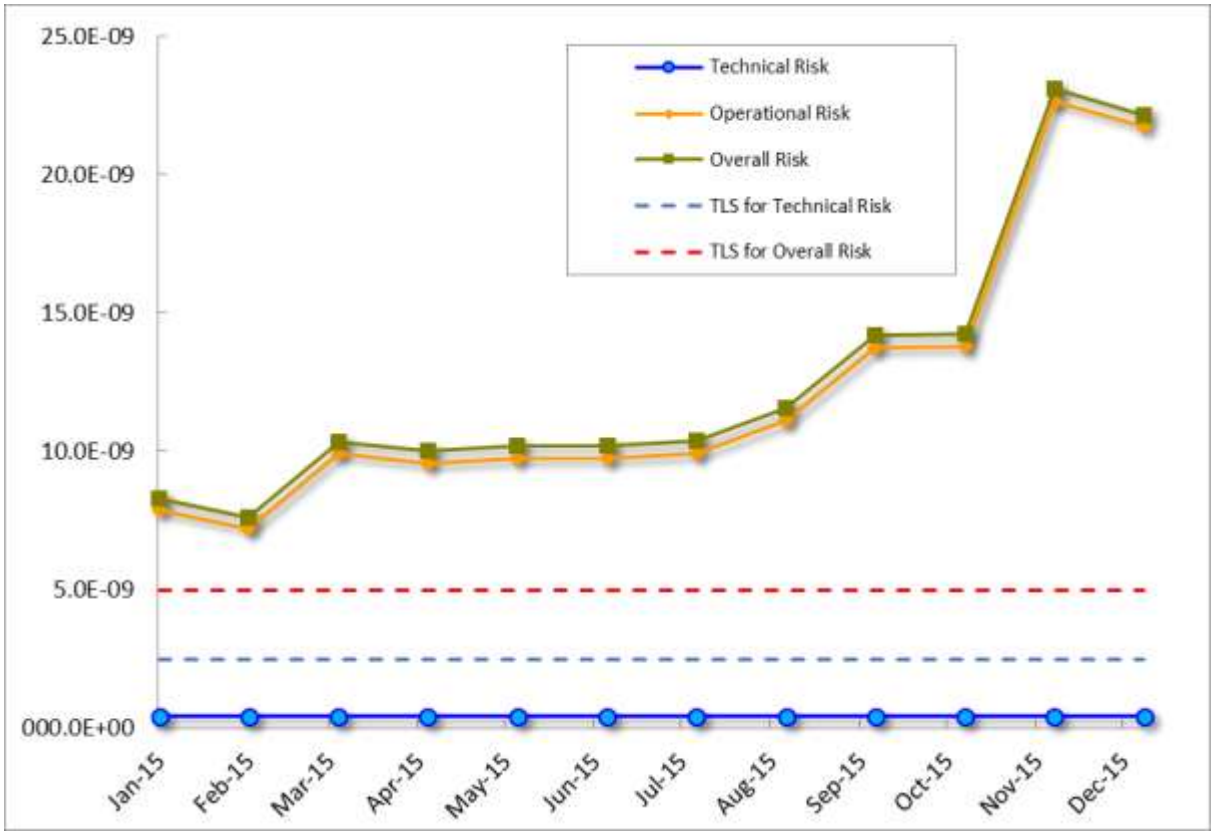


**Figure 2**: Fukuoka FIR RVSM Risk Estimate Trends

3.3.3 The estimated one year Overall risk exceeded the TLS some of transfer errors and ATC system loop errors are above in 2015. 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:

a) note the information contained in this paper; and

b) 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 |
|---|---|---|---|---|---|
| 11 Jan 15 | ATMC | 50NM South West of BIXAK(A590) | 5 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 17 Jan 15 | ATMC | NIPPI(R220) | 3 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 30 Jan 15 | Fukuoka ACC | 15NM North West of SADLI (A593) | 0 | ATC transfer of control coordination errors due to human factors | E |
| 20 Feb 15 | ATMC | GURAG (A590) | 3 | ATC transfer of control coordination errors due to human factors | E |
| 25 Mar 15 | Fukuoka ACC | 10NM East of TAE | 12.3 | Incorrect operation or interpretation of airborne equipment | C |
| 29 Mar 15 | ATMC | GURAG (A590) | 2 | ATC transfer of control coordination errors due to human factors | E |
| 29 Mar 15 | Fukuoka ACC | 10NM South East of SADLI (A593) | 1.8 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 10 Apr 15 | Naha ACC | LEBIX (N884) | 5 | ATC transfer of control coordination errors due to human factors | E |
| 22 Apr 15 | Sapporo ACC | LUMIN(B223) | 0 | ATC transfer of control coordination errors due to human factors | E |
| 25 Apr 15 | Tokyo ACC | 10NM West of OTARI (Y517) | 3 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 27 Apr 15 | ATMC | GURAG(A590) | 2 | ATC transfer of control coordination errors due to human factors | E |
| 23 May 15 | Tokyo ACC | 5NM South East of KOHWA (Y544) | 0.8 | ATC system loop error (Flight crew misunderstands the clearance) | D |

| Event date | Source | Location of deviation | Duration of LHD (min) | Cause | code |
|---|---|---|---|---|---|
| 2 Jul 15 | ATMC | 300NM North East of EMRON | 1 | Flight crew climbing or descending without ATC clearance | B |
| 24 Jul 15 | Fukuoka ACC | 15NM West of SADLI(A593) | 0 | ATC transfer of control coordination errors due to human factors | E |
| 24 Aug 15 | ATMC | ADNAP | 8 | Flight crew climbing or descending without ATC clearance | B |
| 9 Sep 15 | Naha ACC | MEVIN (B462) | 0.6 | ATC transfer of control coordination errors due to human factors | E |
| 25 Sep 15 | Naha ACC | LEBIX(N884) | 15 | ATC transfer of control coordination errors due to human factors | E |
| 29 Oct 15 | Tokyo ACC | 5NM North East of GTC | 0.2 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 30 Oct 15 | Sapporo ACC | IGROD | Unknown | ATC transfer of control coordination errors due to human factors | E |
| 31 Oct 15 | Fukuoka ACC | 40NM North East of FUE (Y60) | 1 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 4 Nov 15 | Naha ACC | MEVIN (B462) | 49 | ATC transfer of control coordination errors due to human factors | E |
| 12 Nov 15 | Naha ACC | LEBIX (N884) | 3.5 | ATC transfer of control coordination errors due to human factors | E |
| 2 Dec 15 | Naha ACC | 25NM North East of SAKON (A582) | 4.5 | ATC system loop error (Flight crew misunderstands the clearance) | D |
| 23 Dec 15 | ATMC | 150NM East of LEPKI | 8 | ATC system loop error (Flight crew misunderstands the clearance) | 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 |
|---|---|---|---|---|---|---|
| 27 Feb 15 | Fukuoka ACC | 0.8 | 370 | 37500 | Other | M |
| 7 Apr 15 | Fukuoka ACC | 0.8 | 360 | 35200 | Severe Turbulence | I |
| 25 Apr 15 | Tokyo ACC | 0.5 | 290 | 28700 | TCAS resolution advisory and flight crew correctly responds | J |
| 20 May 15 | Fukuoka ACC | 0.8 | 330 | 33700 | Severe Turbulence | I |
| 26 May 15 | ATMC | 5 | 390 | 39600 | TCAS resolution advisory and flight crew correctly responds | J |
| 13 Jun 15 | ATMC | 42 | 310 | 35000 | Other (Lost Communications) | M |
| 16 Jun 15 | A/C Operator | 0.1 | 360 | 35688 | Severe Turbulence | I |
| 18 Jun 15 | Fukuoka ACC | 0.3 | 380 | 37500 | Severe Turbulence | I |
| 20 Jun 15 | A/C Operator | 0.1 | 380 | 37640 | Severe Turbulence | I |
| 22 Jun 15 | Fukuoka ACC | 0.5 | 360 | 35540 | Severe Turbulence | I |
| 23 Jun 15 | A/C Operator | 0.5 | 370 | 36400 | Severe Turbulence | I |
| 6 Jul 15 | A/C Operator | 0.2 | 380 | 37620 | Severe Turbulence | I |

| Event date | Source | Duration of LHD (min) | Assigned FL | Observed / Reported(ft) | Cause | Code |
|---|---|---|---|---|---|---|
| 7 Jul 15 | Fukuoka ACC | 5.5 | 360 | 30400 | Airborne equipment failure and unintentional or undetected level change | H |
| 7 Jul 15 | Fukuoka ACC | 2.5 | 380 | 37200 | Weather related cause | I |
| 20 Jul 15 | Naha ACC | 2 | 350 | 33200 | Weather related cause | I |
| 12 Aug 15 | Naha ACC | 0.2 | 390 | 39300 | Weather related cause | I |
| 17 Aug 15 | A/C Operator | 0.2 | 380 | 37640 | Weather related cause | I |
| 18 Aug 15 | A/C Operator | 0 | 350 | 35350 | Weather related cause | I |
| 23 Aug 15 | Fukuoka ACC | 0.3 | 350 | 34500 | Weather related cause | I |
| 29 Aug 15 | A/C Operator | 0.1 | 360 | 35700 | Weather related cause | I |
| 23 Sep 15 | Fukuoka ACC | 1.7 | 380 | 37500 | Other | M |
| 23 Oct 15 | Tokyo ACC | 2 | 300 | 28300 | Airborne equipment failure and unintentional or undetected level change | H |
| 25 Oct 15 | A/C Operator | 0.3 | 320 | 31570 | Weather related cause | I |
| 11 Nov 15 | Fukuoka ACC | 0.2 | 310 | 30400 | Severe Turbulence | I |

| Event date | Source | Duration of LHD (min) | Assigned FL | Observed / Reported(ft) | Cause | Code |
|---|---|---|---|---|---|---|
| 24 Nov 15 | Fukuoka ACC | 0.7 | 310 | 31400 | TCAS resolution advisory and flight crew correctly responds | J |
| 3 Dec 15 | A/C Operator | 0.3 | 310 | 30600 | Weather related cause | I |
| 10 Dec 15 | Fukuoka ACC | 0.5 | 300 | 29700 | Severe Turbulence | I |

## Appendix C

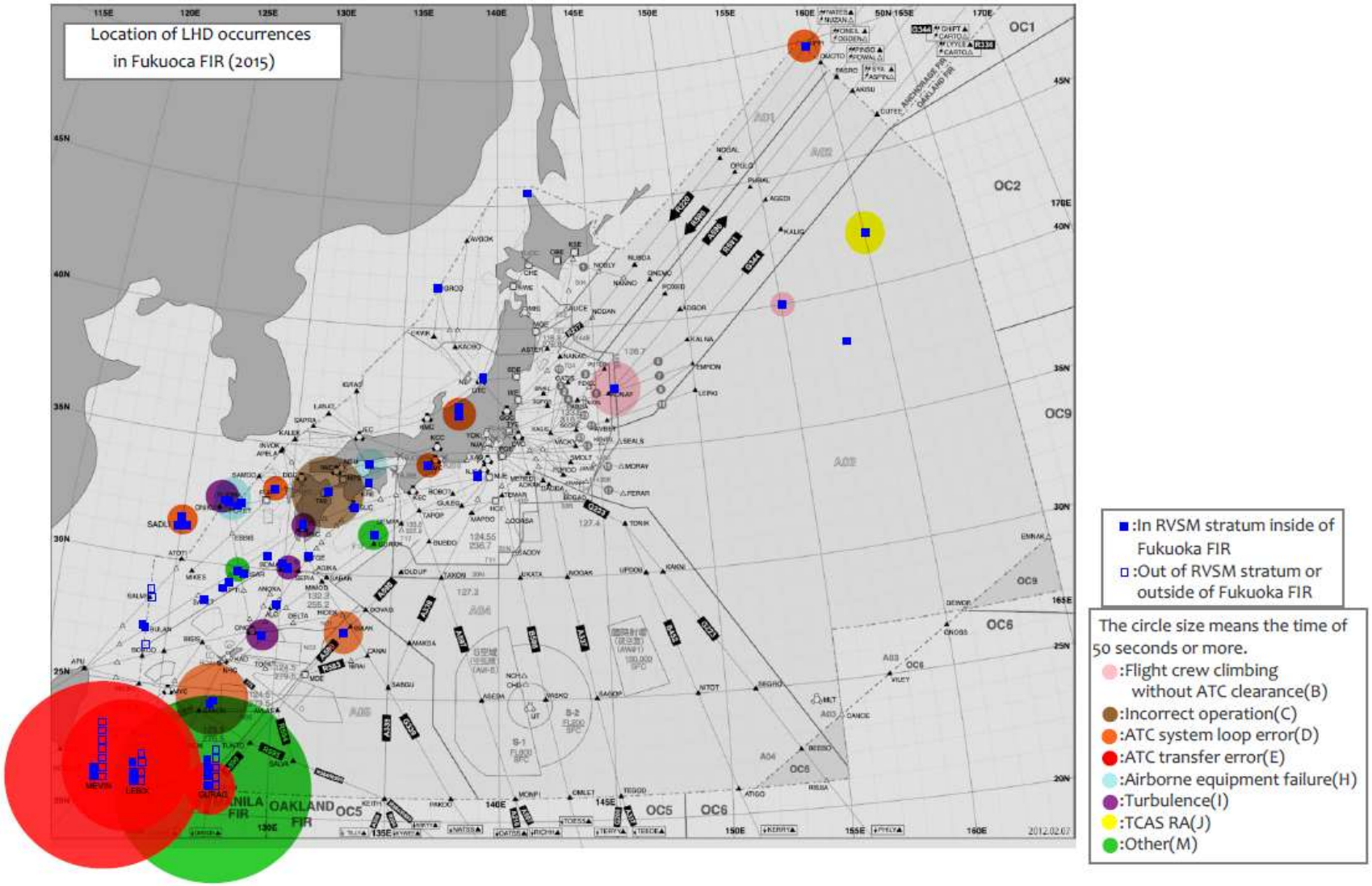


**Figure 3**: Fukuoka FIR – Risk Bearing LHD position and duration