International Civil Aviation Organization
Twenty-Fifth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/25)

Video Teleconference, 27 – 30 October 2020

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

JASMA VERTICAL SAFETY REPORT

(Presented by JASMA)

SUMMARY

This paper presents the results of the vertical safety assessment of the Reduced Vertical Separation Minimum (RVSM) airspace in the Fukuoka Flight Information Region (FIR) by the Japan Airspace Safety Monitoring Agency (JASMA) for the period from 1 January 2019 to 31 December 2019.

1. INTRODUCTION

The paper provides the executive summary of the airspace safety oversight assessment undertaken by the Japan Airspace Safety Monitoring Agency (JASMA) for the Reduced Vertical Separation Minimum (RVSM) implementations in Fukuoka Flight Information Region (FIR) which is a part of the Pacific Ocean Airspace and North-East Asia Airspace. 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 11.57 x 10^{-9} which exceeds the target level of Safety 5.0 x 10^{-9} (TLS).

Executive Summary

2.2 **Table 1** summarizes Fukuoka FIR RVSM technical, operational, and total risks. **Figure 1** presents collision risk estimate trends during the period from January 2019 to December 2019.

Fukuoka FIR – estimated annual flying hours = 1,598,660 hours *(note: estimated hours based on Dec 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 24 Total Risk	*10.61 x 10^{-9}*	*5.0 x 10^{-9}*	*Above TLS*
Technical Risk	0.53 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	11.04 x 10^{-9}	-	-
Total Risk	**11.57 x 10^{-9}**	5.0 x 10^{-9}	**Above TLS**

Table 1: Fukuoka FIR Airspace RVSM Risk Estimates

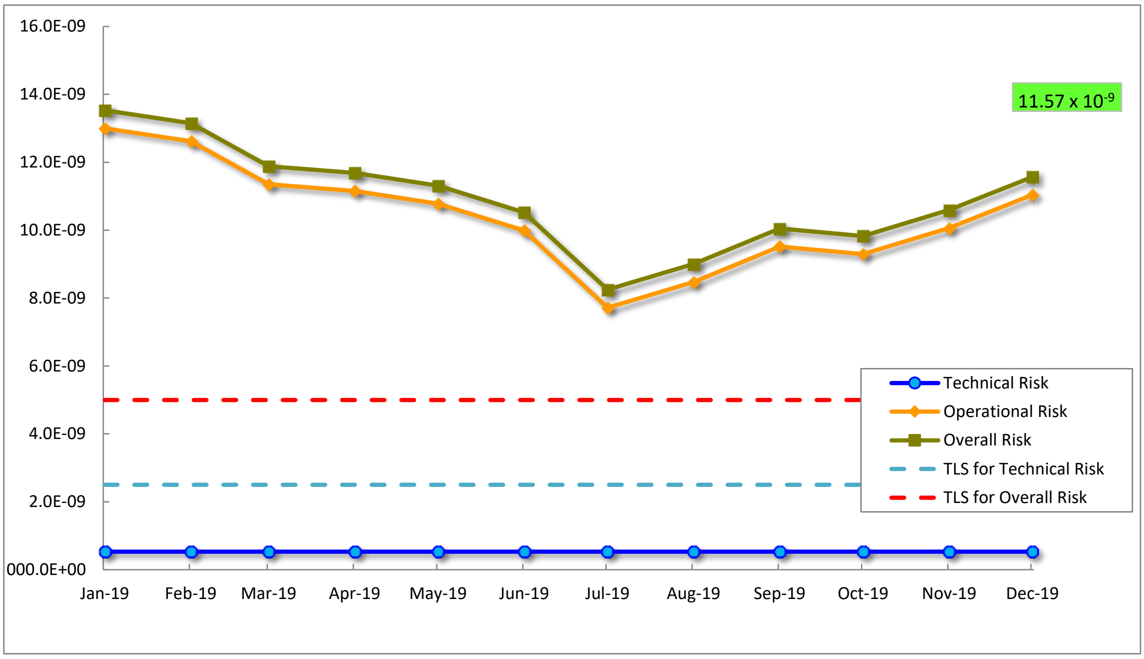

Figure 1: Fukuoka FIR RVSM Risk Estimate Trends

2.3 **Table 2** presents a summary of the LHD causes within Fukuoka FIR from January 2019 until December 2020.

Code	LHD Category Description	No.
A	Flight crew fails to climb or descend the aircraft as cleared	1
B	Flight crew climbing or descending without ATC clearance	0
C	Incorrect operation or interpretation of airborne equipment	1
D	ATC system loop error	10
E	Coordination errors in the ATC -to-ATC transfer of control responsibility as a result of human factors issues	12
F	ATC transfer of control coordination errors due to technical issues	0
G	Aircraft contingency leading to sudden inability to maintain level	2
H	Airborne equipment failure and unintentional or undetected level change	0
I	Turbulence or other weather related cause leading to unintentional or undetected change of flight level	11
J	TCAS resolution advisory; flight crew correctly climb or descend following the resolution advisory	27
K	TCAS resolution advisory; flight crew incorrectly climb or descend following the resolution advisory	0
L	An aircraft being provided with RVSM separation is not RVSM approved	0
M	Others	0
Total		64

Table 2: Summary of LHD Causes within Fukuoka FIR

2.4 **Figure 2** provides the geographic location of non-zero-duration LHD reports within Fukuoka FIR and the Air Traffic Control (ATC) Airspace of the Japan Civil Aviation Bureau (JCAB), e.g. AKARA airspace, during the assessment period. The filled blue square symbols represent LHD location in the RVSM stratum inside of Fukuoka FIR and the hollow blue square symbols represent LHD location reported by the Fukuoka Area control center (ACC) in the Flight Level Allocation Scheme (FLAS) stratum inside of AKARA airspace. The circle size means an LHD duration of 50 seconds or more.

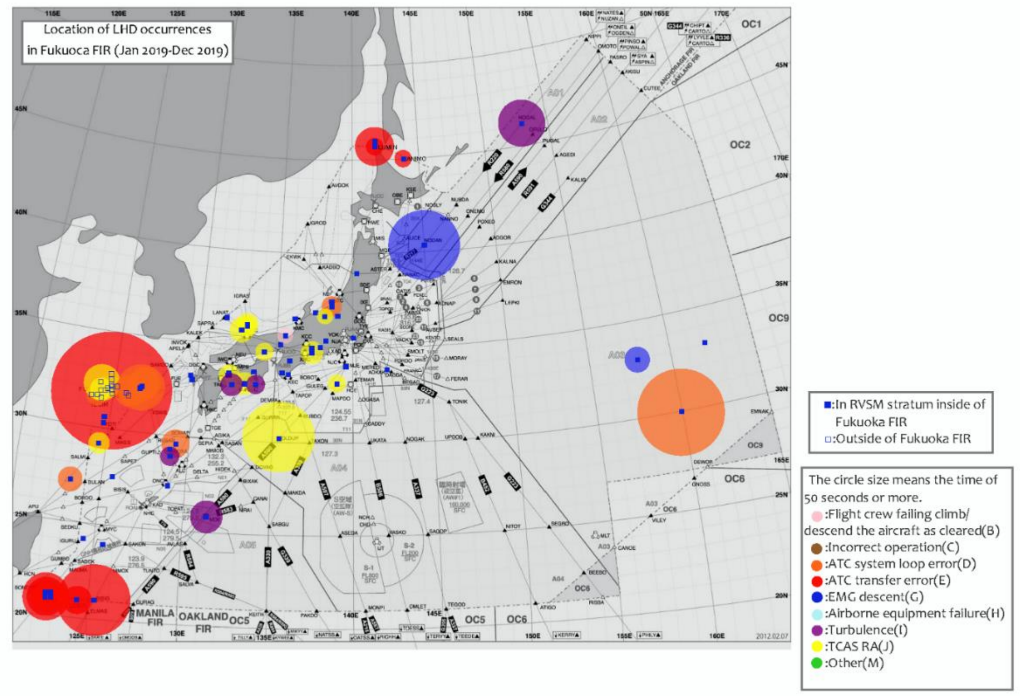

Figure 2: Fukuoka FIR Airspace – None-Zero-Duration LHD

2.5 The estimated overall risk exceeded the TLS. The risk value slightly increased from the previous year.

2.6 **Figure 3** presents the comparing LHDs from the calendar year 2017 to 2019.

- The number of Category D LHD, ATC system loop error, increased to 10.
- The number of Category E LHD, ATC transfer of control coordination errors due to human factors, decreased to 12.
- The number of Category I LHD, Turbulence or other weather related cause, decreased to 11.
- The number of Category J LHD, TCAS resolution advisory and flight crew correctly responds, increased to 27. 19 of the 27 Category J LHDs were caused by nuisance TCAS RA.

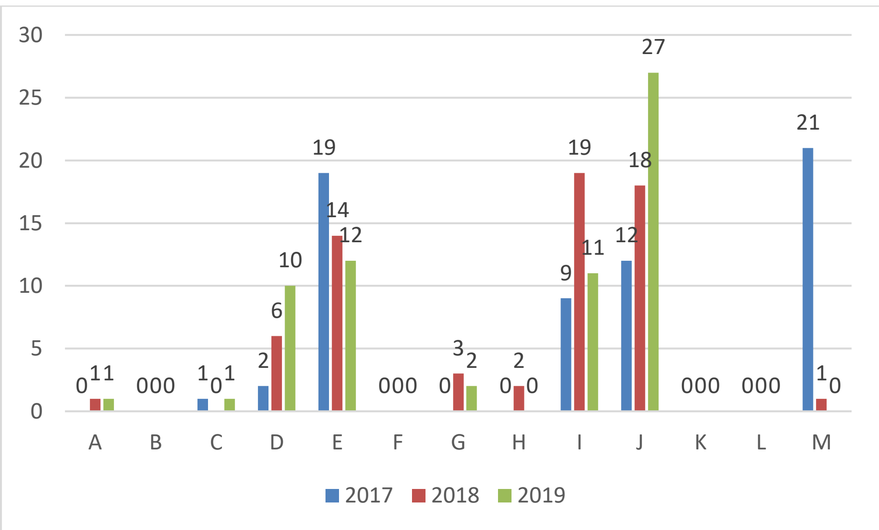

Figure 3: Comparing LHDs from 2017 to 2019

2.7 17 Category M LHDs in 2017 were included transfer error with an incorrect time estimate, which should be counted as a Large Longitudinal Error (LLD).

2.8 **Figure 4** presents LHDs that occurred at the Hot spot D, the FIR boundary between Manila FIR and Fukuoka FIR. There were 6 LHDs occurred at the Hot spot D in 2019, 5 of these LHDs occurred on transfer from Manila ACC to the Kobe ACC, and the rest of 1 LHD occurred on transfer from Kobe ACC to Manila ACC. These LHDs were caused by a lack of the latest transfer information with the revised altitude.

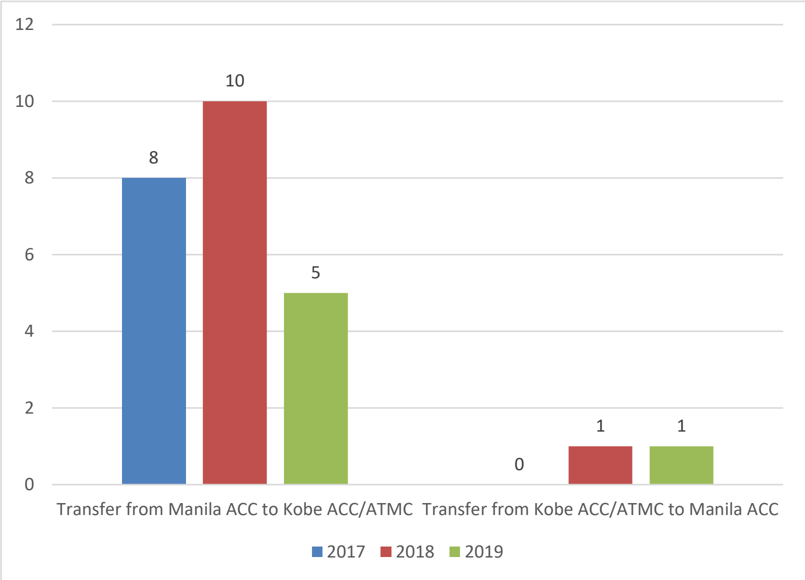

Figure 4: Number of LHDs at Hot spot D between Manila FIR and Fukuoka FIR

2.9 The cases of the LHDs at the FIR boundary between Manila FIR and Fukuoka FIR in 2019 seem to decrease in comparison 2017 and 2018, as the result of the LHD Preventive/Mitigation Measures presented by the Civil Aviation Authority of the Philippines at the RASMAG/24 meeting.

2.10 **Figure 5** presents LHDs that occurred at the Hot spot L, the FIR boundary between Khabarovsk FIR and Fukuoka FIR. 3 LHDs that occurred at the Hot spot L in 2019, these LHDs occurred on transfer from Khabarovsk ACC to Sapporo ACC. There were two factors, one factor was no revised transfer information for altitude change, and the other factor was a misunderstanding of transfer altitude.

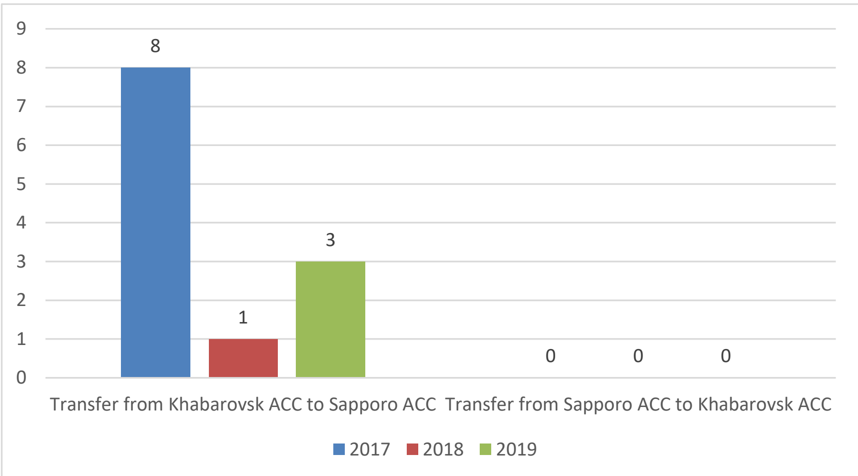

Figure 5: Number of LHDs at Hot spot L between Khabarovsk FIR and Fukuoka FIR

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

AIRSPACE SAFETY REVIEW FOR THE RVSM IMPLEMENTATION

IN FUKUOKA FLIGHT INFORMATION REGION

JAN 2019 to DEC 2019

(Presented by JASMA)

SUMMARY

The purpose of this report is to compare actual performance to safety goals related to the 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 Japan Airspace Safety Monitoring Agency (JASMA) and an update of the vertical collision risk for the period of 1 January 2019 to 31 December 2019. There are a total of 64 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 11.57×10^{-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 period of 1 January 2018 to 31 December 2018.

2. DISCUSSION

2.1 Traffic Sample Data (TSD)

2.1.1 Traffic Sample data for December 2018 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 2019 to December 2019.

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.

Month-Year	No. of LHD Occurrences	LHD Duration (Minutes)
January 2019	5	7.0
February 2019	4	2.7
March 2019	3	0.0
April 2019	2	0.7
May 2019	1	0.0
June 2019	7	9.5

July 2019	4	6.0
August 2019	8	2.0
September 2019	9	5.0
October 2019	1	0.0
November 2019	12	11.0
December 2019	8	10.5
Total	**64**	**54.4**

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

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. 2018 until Dec. 2018 against 2017. The number of LHD reports in 2019 is as same as in 2018.

Code	LHD Category Description	2018	2019
A	Flight crew fails to climb or descend the aircraft as cleared	1	1
B	Flight crew climbing or descending without ATC clearance	0	0
C	Incorrect operation or interpretation of airborne equipment	0	1
D	ATC system loop error	6	10
E	ATC transfer of control coordination errors due to human factors	14	12
F	ATC transfer of control coordination errors due to technical issues	0	0
G	Aircraft contingency leading to sudden inability to maintain level	3	2
H	Airborne equipment failure and unintentional or undetected level change	2	0
I	Turbulence or other weather related cause	19	11
J	TCAS resolution advisory and flight crew correctly responds	18	27
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	0
Total		64	**64**

Table 2: Summary of LHD Causes within Fukuoka FIR.

2.2.5 **Table 3** presents the details of the 24 LHDs that contributed to the operational risk, which were reported to the JASMA during the reporting period.

No.	Date	Time (UTC)	Reporting ACC	Location	ACFT TYPE	Deviation (Levels Crossed)	Duration	CAT
1	3-Jan-2019	09:22	KOBE ACC	BOMAP	K35R	1	0.5 min	D
2	11-Jan-19	13:37	FUKUOKA ACC	MUGUS	A333	0	0 min	E
3	24-Jan-19	04:37	SAPPORO ACC	LUMIN	B789	2	4 min	E
4	7-Feb-19	05:27	TOKYO ACC	KOHAK	A320	0	1 min	D
5	15-Feb-19	19:56	FUKUOKA ACC	MUGUS	B744	0	0 min	E
6	7-Mar-19	03:34	KOBE ACC	MEVIN	B788	0	0 min	E
7	20-Jun-19	02:53	FUKUOKA ACC	OLE	B788	0	0 min	D
8	23-Jun-19	09:01	KOBE ACC	LEBIX	A21N	0	1.5 min	E
9	26-Jun-19	19:24	KOBE ACC	MEVIN	B788	1	3 min	E
10	25-Jul-19	02:46	ATMC	CUTEE	B77W	0	6 min	E
11	30-Jul-19	01:54	FUKUOKA ACC	MOLKA	A333	2	0 min	D
12	12-Aug-19	07:02	FUKUOKA ACC	POTET	B789	1	2 min	D
13	14-Aug-19	11:13	TOKYO ACC	YME	B763	1	0 min	A
14	27-Aug-19	09:18	TOKYO ACC	KMC	B738	0	0 min	D
15	1-Sep-19	11:20	FUKUOKA ACC	RUGMA	A321	2	1 min	D
16	2-Sep-19	21:26	KOBE ACC	MEVIN	B78X	0	0 min	E
17	7-Sep-19	19:22	KOBE ACC	MEVIN	A359	0	4 min	E
18	4-Nov-19	10:52	FUKUOKA ACC	ESBIS	B77W	0	0 min	D

19	5-Nov-19	06:22	SAPPORO ACC	ANIMO	DC3T	0	1 min	E
20	14-Nov-19	23:24	FUKUOKA ACC	OOITA	F35	0	0 min	C
21	17-Nov-19	07:54	SAPPORO ACC	LUMIN	DH8C	0	1 min	E
22	23-Nov-19	08:02	KOBE ACC	BISIG	A320	0	8 min	E
23	14-Dec-19	01:27	FUKUOKA ACC	KRE	A333	0	0 min	D
24	20-Dec-19	16:18	ATMC	30N160E	B77W	1	10 min	D

Table 3: Summary of LHD reports contributed to Operational Risk

2.2.6 **Table 4** contains the details of the 40 LHDs which were not involved in the operational risk.

No.	Date	Time (UTC)	Reporting ACC	Location	ACFT TYPE	Deviation (Levels Crossed)	Duration	CAT
1	14-Jan-19	05:36	TOKYO ACC	MIHOU	B739	1	0.5 min	J
2	30-Jan-19	01:04	ATMC	NODAN	B763	4	2 min	G
3	5-Feb-19	08:49	KOBE ACC	ONC	C560	0	1 min	I
4	7-Feb-19	05:27	TOKYO ACC	KOHAK	E170	0	0.7 min	J
5	20-Mar-19	07:05	FUKUOKA ACC	SUBTA	A320	0	0 min	J
6	31-Mar-19	11:41	FUKUOKA ACC	SUC	A321	0	0 min	J
7	2-Apr-19	03:32	ATMC	OLDUP	B77W	0	0 min	J
8	22-Apr-19	03:20	TOKYO ACC	ADKAK	B738	0	0.7 min	J
9	28-May-19	00:33	TOKYO ACC	MAMRO	E170	0	0 min	J
10	1-Jun-19	03:19	ATMC	NOGAL	B744	2	5 min	I
11	8-Jun-19	05:29	KOBE ACC	IGURU	B772	0	0 min	J
12	14-Jun-19	05:35	TOKYO ACC	NTE	B77W	0	0 min	J
13	29-Jun-19	11:16	TOKYO ACC	ROKKO	B763	0	0 min	J
14	8-Jul-19	14:12	FUKUOKA ACC	NHC	B748	0	0 min	I
15	22-Jul-19	05:45	FUKUOKA ACC	OOITA	A320	0	0 min	J
16	4-Aug-19	01:41	TOKYO ACC	TEKEL	B738	0	0 min	I
17	6-Aug-19	02:59	ATMC	MDE	B763	0	0 min	I
18	9-Aug-19	01:39	KOBE ACC	ALBAX	A320	0	0 min	I
19	11-Aug-19	03:00	ATMC	33N150E	K35R	3	0 min	G
20	20-Aug-19	07:22	TOKYO ACC	KEC	B737	0	0 min	J
21	4-Sep-19	02:33	FUKUOKA ACC	SUC	B762	0	0 min	I
22	7-Sep-19	06:32	TOKYO ACC	KEC	B748	0	0 min	J
23	8-Sep-19	10:28	TOKYO ACC	HAKKA	B738	0	0 min	J
24	20-Sep-19	22:59	FUKUOKA ACC	BOMAP	B744	0	0 min	I
25	21-Sep-19	11:46	TOKYO ACC	BIZEN	B788	0	0 min	J
26	29-Sep-19	03:54	TOKYO ACC	MIHOU	B738	0	0 min	J
27	24-Oct-19	00:59	FUKUOKA ACC	OOITA	A321	0	0 min	J
28	12-Nov-19	20:50	TOKYO ACC	YOSHI	GLEX	1	1 min	J
29	14-Nov-19	05:34	TOKYO ACC	MAUKA	E190	0	0 min	J
30	18-Nov-19	02:01	KOBE ACC	ONC	B738	0	0 min	J
31	22-Nov-19	13:40	ATMC	33N162E	A388	0	0 min	I
32	30-Nov-19	07:33	TOKYO ACC	SINGU	E75L	0	0 min	J
33	30-Nov-19	23:27	TOKYO ACC	KOHWA	B772	0	0 min	J
34	30-Nov-19	23:27	TOKYO ACC	KOHWA	B738	0	0 min	J
35	5-Dec-19	08:21	TOKYO ACC	TENRU	B738	0	0 min	J
36	6-Dec-19	01:44	TOKYO ACC	LANAT	B733	0	0 min	J
37	16-Dec-19	04:37	TOKYO ACC	MOE	B788	0	0 min	J
38	25-Dec-19	02:58	TOKYO ACC	STAGE	A321	0	0 min	J
39	25-Dec-19	07:12	FUKUOKA ACC	DONKY	A320	0	0 min	I
40	25-Dec-19	10:18	FUKUOKA ACC	SABAR	B748	3	0.5 min	I

Table 4: Summary of LHD reports not contributed to Operational Risk

2.2.7 **Figure 1** provides the geographic location of LHD reports during the assessment period. The blue square symbols represent LHD location in RVSM stratum inside of Fukuoka FIR. The circle size means LHD duration of 50 seconds or more.

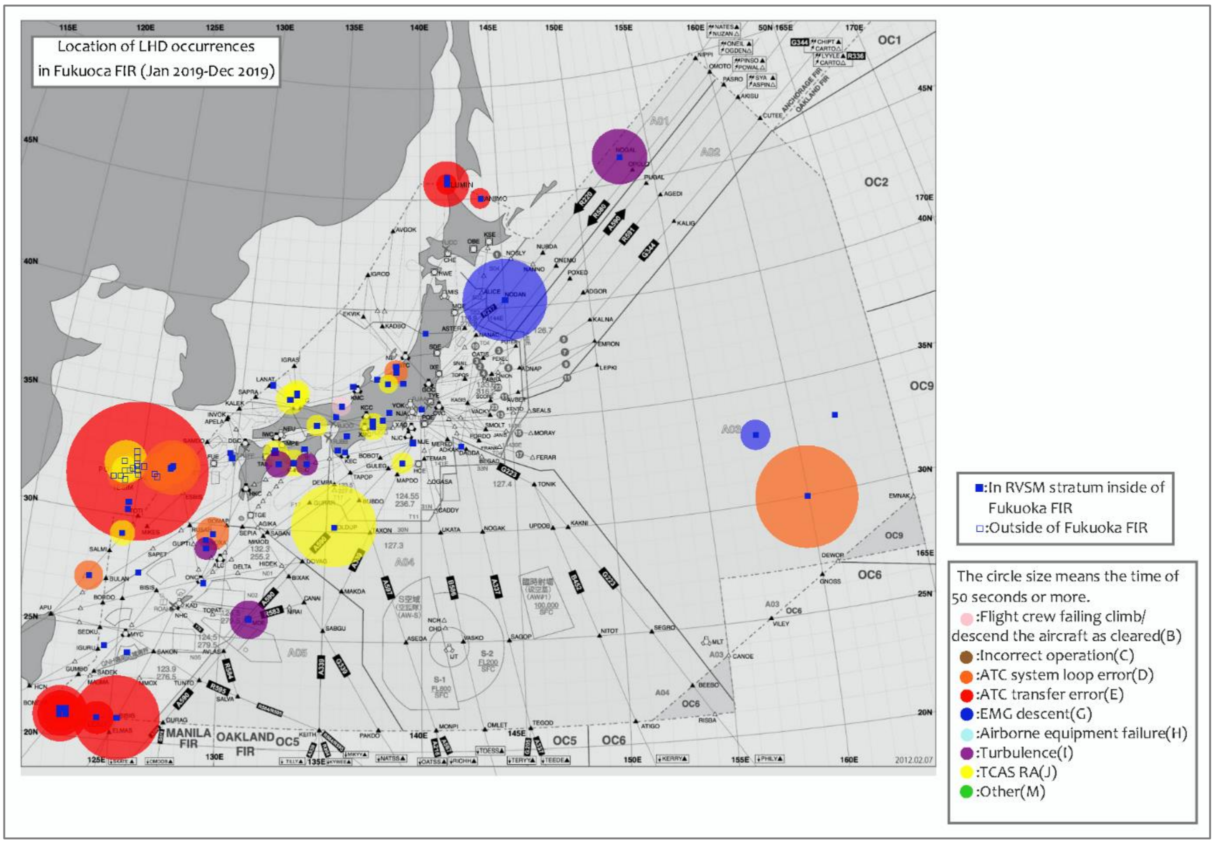

Figure 1: Fukuoka FIR Airspace – None-Zero-Duration LHD

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 5**. The average sizes of aircraft are almost the same as the December 2018 TSD.

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	0.0711	Using the data of secondary surveillance radar obtained by the Hachinohe Air Route Surveillance Radar (domestic RNAV route, 2001-2002) and

			FDPS data (December 2012).
λx	Average aircraft length	0.0273 nm	FDPS data (December 2018)
λy	Average aircraft width	0.0248 nm	
λz	Average aircraft height	0.0079 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	3.50×10^{-3}	FDPS data (December 2019)
Nx(opp)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	1.89×10^{-2}	FDPS data (December 2019)
$Naz^{technical}$ (cross)	The collision risk for crossing routes (technical dimension)	1.51×10^{-10} [accidents/flight hour]	FDPS data (December 2019) is utilized for the calculation of $E_z(\theta)$.
$Naz^{operational}$ (cross)	The collision risk for crossing routes (operational dimension)	3.13×10^{-9} [accidents/flight hour]	By eq. (12).
H	Total flight hours of aircraft flying on the route segments within airspace under consideration	1,332,222 flight hours	12 times of December 2019
T(0)	LHD duration in hours	1.04flight hours	24 LHD reports received from Jan. 2018 to Dec. 2018

Table 5: Summarizes the value of the parameters used for the risk calculation.

3.2 Risk Calculation

3.2.1 Based on the TSD for one month of December 2019 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 the 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 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,

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

Executive Summary

3.3 Safety Oversight for the RVSM implementation in the Fukuoka FIR

3.3.1 **Table 6** presents the estimates of vertical collision risk for the RVSM airspace of the Fukuoka FIR. The technical risk is estimated to be 0.53 x 10^{-9} fatal accidents per flight hour. The operational risk estimate is 11.04 x 10^{-9} fatal accidents per flight hour. The estimate of the overall vertical collision risk is 11.57 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.

Fukuoka FIR – estimated annual flying hours = 1,598,660 hours *(note: estimated hours based on Dec 2019 traffic sample data)*			
Source of Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 24 Total Risk	*10.61 x 10^{-9}*	*5.0 x 10^{-9}*	*Above TLS*
Technical Risk	0.53 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	11.04 x 10^{-9}	-	-
Total Risk	**11.57 x 10^{-9}**	5.0 x 10^{-9}	**Above TLS**

Table 6: Fukuoka FIR RVSM Risk Estimates

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 2019 to December 2019.

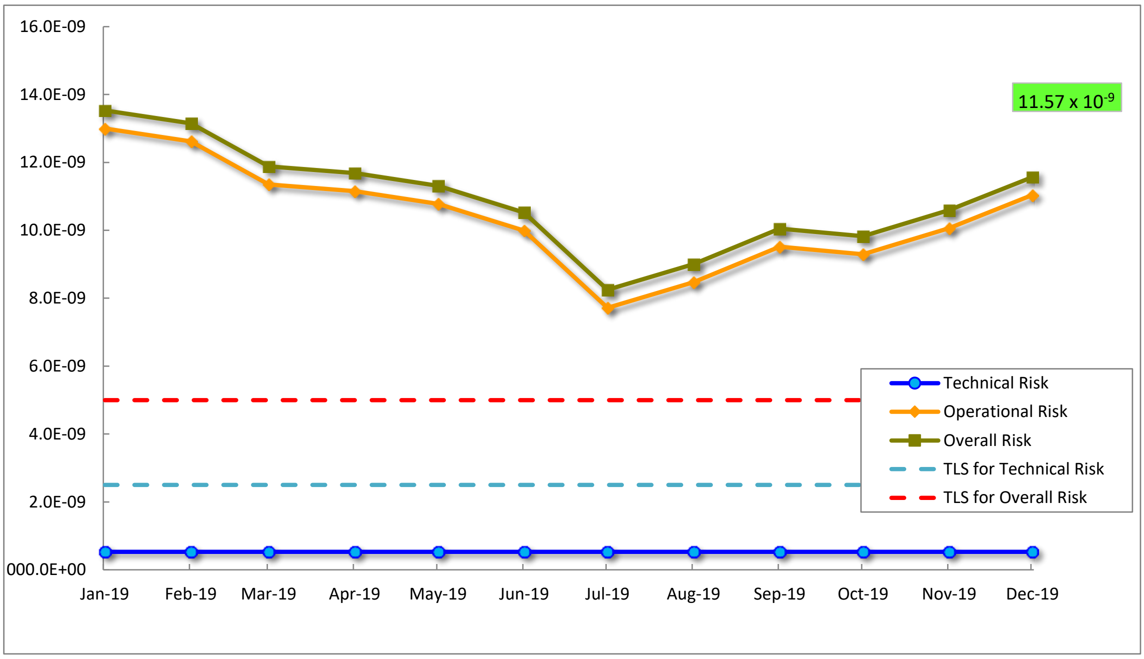

Figure 2: Fukuoka FIR RVSM Risk Estimate Trends

3.3.3 The estimated overall risk exceeded the TLS. The risk value slightly increased from last year.

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