International Civil Aviation Organization

The 17th Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/17)

Bangkok, Thailand, 28 – 31 August 2012

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

JASMA RVSM SAFETY REPORT

(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 May 2011 to 30 April 2012.

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 RVSM in the Fukuoka FIR, as detailed in **Attachment 1**.

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 May 2011 to 30 April 2012 are reported in the Attachment 1. There are a total of 19 large height deviations occurred during this period. The vertical collision risk estimate for the RVSM airspace in the Fukuoka FIR is 4.87×10^{-9} that meets the target level of safety (TLS) but marginal against the 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

- MAY 2011 TO APRIL 2012

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 May 2011 to 30 April 2012. There are a total of 19 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 4.87×10^{-9} that meets the target level of safety (TLS) but marginal against the value of 5.0×10^{-9} fatal accidents per flight hour.

1. Introduction

1.1 The JASMA produces a report 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 2011 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 May 2011 to April 2012.

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.

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

Month-Year	No. of LHD Occurrences	LHD Duration (Minutes)
May 2011	1	0.17
June 2011	1	0.5
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
December 2011	0	0
January 2012	3	5.48
February 2012	0	0
March 2012	2	5.75
April 2012	0	0
Total	**19**	**41.73**

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.

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

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	2	2.88	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.)	3	3.97	3
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)	2	16.5	0
H	Deviation due to airborn equipment failure leading to unintentional or undetected change of flight level	2	2.07	1

I	Deviation due to turbulence or other weather related cause	6	13.0	0
J	Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory	3	1.48	0
TOTAL		19	41.73	13

3.3 Appendix A contains the details of the eight (8) LHDs contributed to the operational risk, which were reported to the JASMA during the reporting period.

3.4 Appendix B contains the details of the twelve (12) LHDs which were not involved in the operational risk. Three (3) of them were reported that the aircraft correctly followed a TCAS or ACAS advisory. Seven (7) were caused by turbulence or bad weather including one icing case below FL290 and the rest of two (2) were caused by aircraft equipment failure.

3.5 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.

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

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 2011 and the LHD reports associated with the airspace during the period from May 2011 to April 2012 are used to produce the risk estimates presented in this report.

4.2 Estimate of the Collision Risk Model (CRM) Parameters are shown in the Table 3. The average size of the aircraft becomes to smaller than the size of aircraft in the December 2010 TSD.

4.2.1 In addition to the typical risk assessment, JASMA asked Electronic Navigation Research Institute (ENRI) to conduct the estimation of $P_y^{RS}(0)$ and $N_x^{RS}(e)$ of the each route segments in Fukuoka FIR by using TSD and radar data of December 2011. The details are shown in Appendix E.

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	0.0719	Using the data of secondary surveillance radar obtained by the Hachinohe Air Route Surveillance radar (domestic RNAV route, 2001-2002) and FDPS data (December 2011).

λx	Average aircraft length	0.0279 nm	FDPS data (December 2011)
λy	Average aircraft width	0.0254 nm	
λz	Average aircraft height	0.0081 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	3.07×10^{-2}	FDPS data (December 2011)
Nx(opp)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	1.39×10^{-1}	FDPS data (December 2011)
$Naz^{technical}$ (cross)	The collision risk for crossing routes (technical dimension)	5.90×10^{-11} [accidents/flight hour]	FDPS data (December 2011) is utilized for the calculation of $E_z(\theta)$.
$Naz^{operational}$ (cross)	The collision risk for crossing routes (operational dimension)	1.49×10^{-9} [accidents/flight hour]	By eq. (12).
H	Total flight hours of aircraft flying on the route segments within airspace under consideration	1025961.24 flight hours	12 times of December 2011
T(0)	LHD duration in hours	0.42flight hours	8 LHD reports received from May 2011 to Apr 2012

4.3 Risk Calculation

4.3.1 Based on the TSD for one month of December 2011 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

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

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

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 0.35 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 4.87 x 10^{-9} fatal accidents per flight hour, which satisfies the globally agreed TLS but marginal against the value of 5.0 x 10^{-9} fatal accidents per flight hour.

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

Fukuoka FIR RVSM Airspace – estimated annual flying hours = 1025961.24 hours *(note: estimated hours based on December 2011 traffic sample data)*			
Source of Risk	Risk Estimation	TLS	Remarks
Technical Risk	0.35 x 10^{-9}	2.5 x 10^{-9}	Below Technical TLS
Operational Risk	4.52 x 10^{-9}	-	-
Total Risk	4.87 x 10^{-9}	5.0 x 10^{-9}	Below Overall TLS

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. Because of the system upgrading, obtained parameters have changed a little. Between May and November 2011, LHD duration is accumulated with the starting month of December 2010, on the other hand after November 2011, LHD duration is accumulated for the past 12 months against the respective ending months.

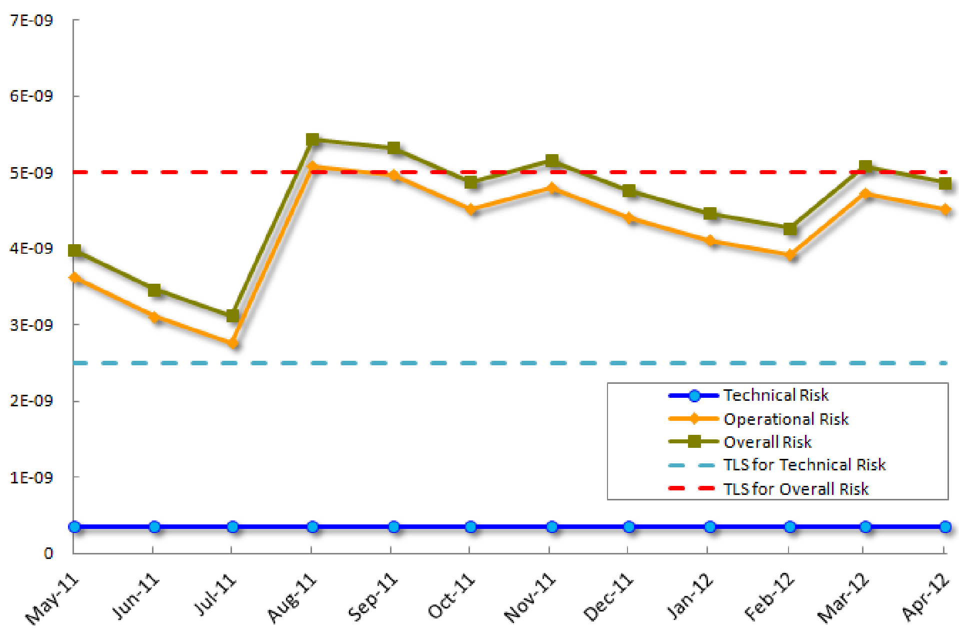

Figure 2: Trends of Risk Estimates for RVSM in the Fukuoka FIR

4.4.3 Even the total risk estimate has met the target level of safety, the transfer errors occurred in August 2011 and March 2012 and the communication error in November 2011 which all happened at the Fukuoka-Manila FIR boundary raised the level of operational risk. It is reported that the ATC facilities concerned discussed these events to mitigate this kind of human errors.

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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
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
17 Jan 12	Tokyo ACC	YULIA (Y57)	3	Pilot's misunderstanding (assigned FL330 but descent to FL300)	D
8 Mar 12	Naha ACC	MEVIN (B462)	5.5	Incorrect flight level not in accordance with agreed parameters	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
18 May 11	Fukuoka ACC	0.17	300	297	Turbulence	I
9 Jun 11	Fukuoka ACC	0.5	340	335	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
20 Dec 11	ATMC	Around 26N138E	240B260	below 290	Icing	I
6 Jan 12	Fukuoka ACC	1.82	320	31600	Transponder malfunctioning	H
17 Jan 12	Tokyo ACC	0.67	300	30500	TCAS resolution advisory; flight crew correctly following the Resolution Advisory	J
5 Mar 12	Operator	0.25	320	31600	Airborne equipment failure (VNAV: Vertical Navigation malfunction)	H

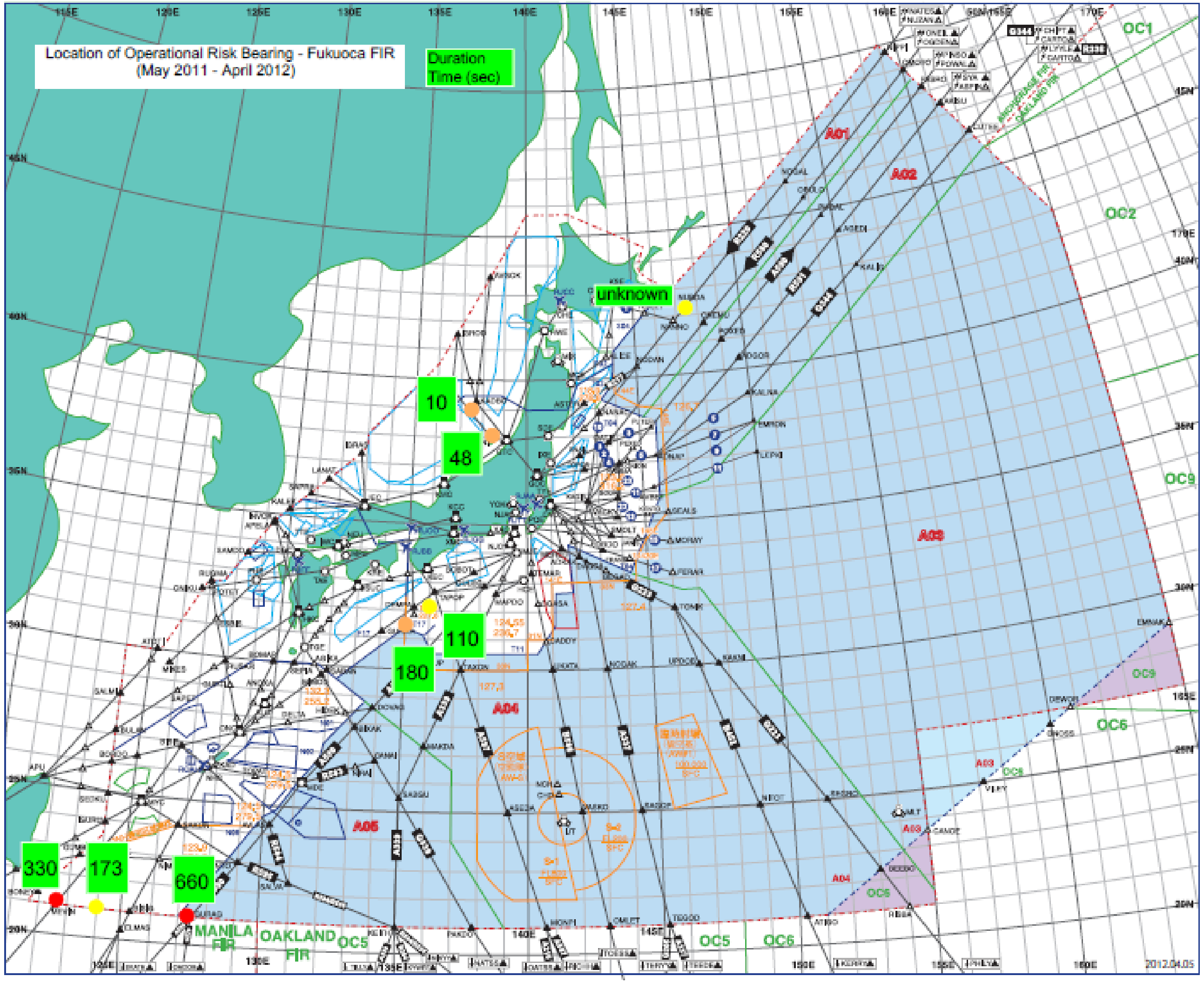
Appendix C

Height Deviations Occurred Outside the Fukuoka FIR during the Reporting Period

Event date	Source	Location of deviation	Expected FL	Observed FL	Cause	Other traffic
18 Jun 11	ATMC PARMO	NIPPI (R220)	360	380	Transfer error	N
21 Jul 11	Naha ACC	MEVIN (B462)	-	380	Non-existent coordination	N
24 Aug 11	ATMC	Around 21N142E	380	365	Engine trouble	N
27 Aug 11	Operator	PUD	390	399	Wind shear, the information has sent to China RMA	N
8 Nov 11	ATMC	GURAG (A590)	400	380	Incorrect flight level not in accordance with agreed parameters	N
13 Dec 11	Fukuoka ACC	SADLI (A593)	290	310	Transfer error (before entering Fukuoka FIR, revised transfer received)	N
30 Dec 11	Fukuoka ACC	SADLI (A593)	300	297	TCAS resolution advisory between unknown target	Y
28 Mar 12	Naha ACC	BISIG (A582)	260	240	Transfer error (bound for Manila FIR, Out of RVSM airspace)	N

Appendix D

Geographical locations where LHDs contributed to the operational risk occurred in the Fukuoka FIR (May 2011~April 2012)



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

Appendix E

Prepared by Electronic Navigation Research Institute (ENRI)

E-1. This appendix provides a detailed estimation of $P_y^{RS}(0)$ and $N_x^{RS}(e)$ for the respective eighty (80) route segments of major thirty one (31) ATS routes within Fukuoka FIR by using TSD and radar data of December 2011. The lateral overlap probability for the non-selected route segments were considered as $P_y^{RS}(0)=0.073$ which is the value often used. Note that $N_x^{RS}(e)$ is the average equivalent passing frequency that two aircraft on the same track are in longitudinal overlap at a certain RS (route segment).

E-2. Some of the prerequisite conditions to estimate the parameters are as follows.

- Even if an aircraft approaching departure and arrival airport, TSD shows an aircraft cruise at assigned flight level. In this estimation, it is considered that an aircraft has cruised between 60 NM after departure airport and 60NM before arrival airport.

- The passing frequency at each FIX of route segments considered as 0.5 times.

- If the flight level of the first FIX and the last FIX of the route segment are different, it is considered that the aircraft has cruised at the flight level recorded in the last FIX. For example, the flight level at the first FIX was FL330 and the last FIX was FL350, it is considered that this aircraft cruised at FL350.

- If a pair of FIXs are adjacent within 4NM, they are considered as a sole FIX.

- If the angle of two diverging route segments was smaller than 5 degrees, and the length of perpendicular line from the first FIX of one diverging route segment to the other route segments was shorter than 6NM, they are considered as the same route segment.

- The size of aircraft is B767-300 which is the most typical aircraft in Fukuoka FIR. This aircraft size is greater than the TSD of December 2011. Same-direction passing frequency N_x^{RS}(same), opposite-direction passing frequency N_x^{RS} (opp) and equivalent opposite-direction passing frequency N_x^{RS} (e) are defined by

$$N_x(e) = N_x(opp) + \frac{K(s)}{K(o)} N_x(same)$$

Where,

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

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

E-3. By using K(o)=1.02, K(s)=1.64, multiple of the equivalent opposite direction passing frequency and lateral overlap probability at each route segment where T_{RS} denotes the flight hours at each route segment as,

$$\sum_{RS}\left[\frac{T_{RS}}{H} N_x{}^{RS}(e) P_y^{RS}(0)\right] = 0.0181\left[\text{Number of aircraft/flight hour}\right]$$

E-4. The largest P_y^{RS} (0) value of all route segment was 0.42. From each route segment, various overlap probability are estimated and applied the largest value in the whole route. Estimate the P_y^{RS} (0) of 31 high passing frequency airways of all, the other airway was used P_y^{RS} (0) which is the value 0.073 often used. It should be noted that if it estimated using the conventional $P_y(0)$=0.073 and $N_x(e)$ as the average value of Fukuoka FIR obtained Nx(e)×Py(0)=0.0172 which is close to the result of above mentioned method. Although the estimation of overlap probability of each route segment could provide more realistic value, it should be considered that is it suitable for safety assessment of whole RVSM airspace and valance of other overlap probability. This may be the continuous challenge.

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