International Civil Aviation Organization

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Bangkok Thailand, 21 − 25 February 2011

Agenda Item 5: Airspace Safety Monitoring Activities/Requirements in the Asia/Pacific Region

TECHNICAL TRANSFER OF LATERAL COLLISION RISK ANALYSIS TO JCAB RMA

(Presented by Japan)

SUMMARY

This information paper presents the technical transfer of know-how on Collision Risk Model (CRM) analysis from Electronic Navigation Research Institute (ENRI) to JCAB RMA so that the regular assessment of lateral collision risk by En-route Monitoring Agency (EMA) will become possible in the future.

1. Introduction

1.1 The Electronic Navigation Research Institute (ENRI) is a research institute studying on overall technical aspects of air navigation systems in Japan. The ENRI has long been committed and contributed to the ICAO’s airspace safety monitoring initiatives from its inception. It also acts as a primary technical advisor to the JCAB RMA.

1.2 The technical know-how on collision risk model (CRM) analysis has been transferred from ENRI to JCAB RMA, and the calculation of technical lateral collision risk was carried out on the North Pacific (NOPAC) air traffic service (ATS) routes by JCAB RMA.

2. Background

2.1 Presently JCAB RMA conducts monthly calculation of vertical collision risk of RVSM airspace at the office of Air Traffic Control Association, Japan (ATCA-J) in Tokyo. But JCAB HQ is planning to reinforce the RMA functions by the installation of a ground-based height monitoring unit (HMU) in the Setouchi region and the RVSM analyzing and evaluating system at Air Traffic Management Center (ATMC) in Fukuoka. The new RMA capabilities will start to function from September this year.

2.2 The regular assessment of lateral and longitudinal separations are also planning to be undertaken by JCAB RMA to be approved as one of the APANPIRG EMAs. To establish sustainable framework for the continuing activity as a future EMA, the JCAB RMA requested ENRI for the transfer of technical know-how on horizontal CRM.

2.3 Once a national governmental organization, the ENRI is now an independent administrative institution. One of ENRI's founding ideas is to disseminate its knowledge acquired through research to the public sector. The ENRI scientists who have long been studying CRM, almost completed basic studies and going to shift their priority issue onto other fields than CRM, agreed with the JCAB RMA to use their collision risk calculation programs and know-how's accumulated during their studies.

2.4 The trial calculation of lateral technical collision risk was carried out on NOPAC ATS routes (i.e. R220, R580, A590, R591, and G344) by JCAB RMA with the technical advice by the ENRI.

3. Lateral Collision Risk Calculation Process

3.1 Area Selection

The area for the collision risk calculation was selected on the following three basis.

3.1.1 Representation

The area should represent traffic and airspace characteristic of whole Fukuoka FIR so that from the result of calculation the safety of the Fukuoka FIR is reasonably assumed.

3.1.2 Applicability

The usable CRM and its analysis techniques presently available can be applied to the particular airspace.

3.1.3 Data availability

The flight plan data to calculate passing frequencies and the radar data to define theoretical distribution are large enough to estimate characteristics of the airspace.

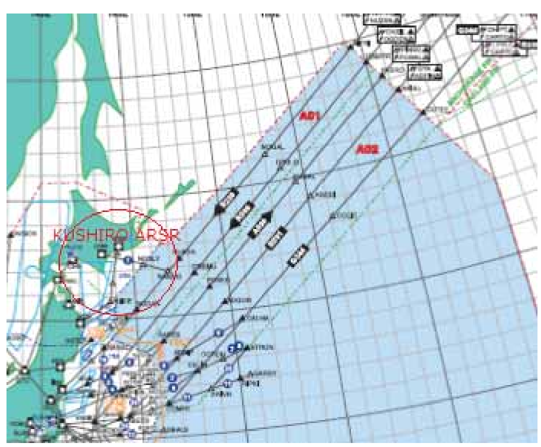

Figure 1: Fukuoka FIR and NOPAC routes

3.2 Characteristics of selected area, NOPAC ATS routes.

3.2.1 NOPAC routes connect west coast of Alaska to east coast of Japan through Fukuoka/Anchorage FIRs. They are utilized by international flights between North America and East Asia. Each NOPAC route is basically unidirectional as shown in **Figure 1** and **Table 1**.

Route	Assignment
R220	One-way west bound at all times
R580	One-Way west bound at all times
A590	One-way eastbound at all times
R591	One-way eastbound unless designated as a westbound PACOTS track
G344	One-way eastbound unless designated as a westbound PACOTS track

Table 1: NOPAC routes and traffic assignment

4. Radar Data Processing

4.1 Radar data to identify the type of theoretical distribution was sampled from the journal of Kushiro Air Route Surveillance Radar (ARSR) in December 2009.

4.2 The original radar position of the aircraft is recorded by range-azimuth format centered at Kushiro ARSR site. This position data is first converted into latitude-longitude coordinate data.

4.3 To calculate deviation from the center of the track (R220), latitude-longitude positions are again converted into X-Y Cartesian data where X-axis identify route R220 and Y-axis measures deviation from the center of route R220. (See **Figure 2**.)

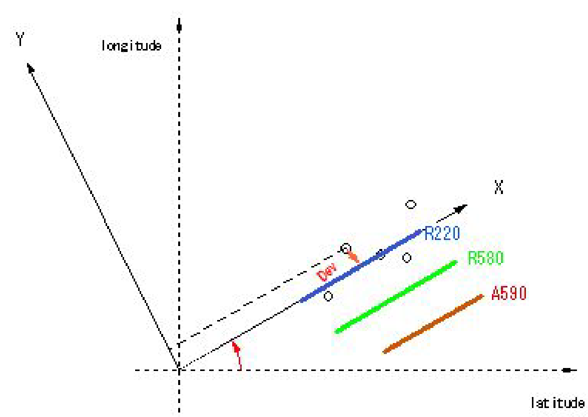

Figure 2: Radar Data Conversion latitude-longitude to X-Y.

4.4 The deviation statistics was compared with theoretical distributions as shown in **Figure 3**. This time the Double Double Exponential distribution was chosen as identified theoretical distribution.

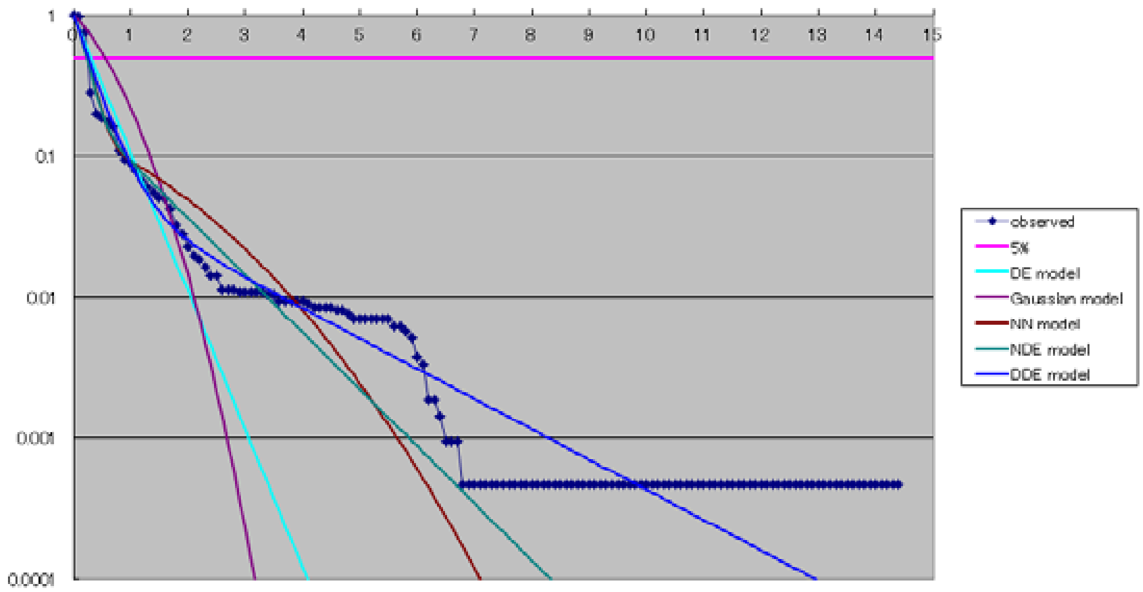

Figure 3: Observed data and Theoretical distributions.

5. Flight Plan Data Processing

5.1 December 2010 Traffic Sample Data acquired from the Flight Data Processing System (FDPS) were used for calculations. The total Number of Flight Hours and Passing Frequencies are shown in **Table 2**.

	Flight Hours		**Passing Frequencies**	
	EAST Bound	WEST Bound	Same Direction	Opp Direction
R220	0	2610.43		
			34	0
R580	0	658.823		
			0	376
A590	2513.64	0		
			11.5	0
R591	437.162	0.817		
			0	0
G344	0	0		

Table 2: Flight Hours and Passing Frequencies

6. Results

6.1 The following are the results of calculation. **Table 3** summarizes the value and source material for estimating parameter values of the following Collision Risk Model (CRM) used to conduct safety oversight for the RNP-10 based 50NM lateral separation minimum of NOPAC routes.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
$\overline{\lvert V\rvert}$	Individual-aircraft along track speed	480 kt	Value often used
$\overline{\lvert \Delta V\rvert}$	Average along track speed of aircraft pairs	28.9 kt	Kushiro Air Route Surveillance Radar data (R220 route, NOPAC,Apr. 1994)
$\overline{\lvert \dot{y}\rvert}$	Average cross track speed of aircraft pairs	42.22 kt	Doc.9689 1st eds. Appendix 13
$\overline{\lvert \dot{z}\rvert}$	Average vertical speed of aircraft pairs	1.5 kt	Value often used
λx	Average aircraft length	0.0393 nm	A380, conservative selection
λy	Average aircraft width	0.0431 nm	
λz	Average aircraft height	0.0132 nm	
Nx(same)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	1.46×10^{-2}	FDPS data (NOPAC, December 2010)
Nx(opp)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	12.01×10^{-2}	FDPS data (NOPAC, December 2010)
Pz(0)	Probability of vertical overlap in operational risk estimation for the aircraft flying as a same flight level	0.54	Value often used (shown in RVSM/TF-9-IP/2)
Py(50)	Probability that two aircraft on the same track are in lateral overlap	4.71×10^{-14}	Using the data of secondary surveillance radar obtained by the Kushiro Air Route Surveillance radar (R220 route, DDE model, December 2009)

Table 3: Estimates of the parameters in the CRM

6.2 The formulas of the lateral collision risk model used in assessing the safety of operations on NOPAC routes are:

$$N_{ay}(same) = P_z(0)P_y(S_y)\frac{2\lambda_x}{\overline{\lvert \Delta V\rvert}}N_x^y(same)\left[\frac{\overline{\lvert \Delta V\rvert}}{2\lambda_x}+\frac{\overline{\lvert \dot{y}\rvert}}{2\lambda_y}+\frac{\overline{\lvert \dot{z}\rvert}}{2\lambda_z}\right]$$

$$N_{ay}(opposite) = P_z(0)P_y(S_y)\frac{2\lambda_x}{2\overline{\lvert V\rvert}}N_x^y(opp)\left[\frac{2\overline{\lvert V\rvert}}{2\lambda_x}+\frac{\overline{\lvert \dot{y}\rvert}}{2\lambda_y}+\frac{\overline{\lvert \dot{z}\rvert}}{2\lambda_z}\right]$$

$$N_{ay} = N_{ay}(same) + N_{ay}(opposite)$$

6.3 **Table 4** shows estimates of lateral collision risk for NOPAC routes. The estimate of the total lateral technical collision risk is 4.13733 x 10^{-15} fatal accidents per flight hour, which satisfies the Asia/Pacific Region agreed TLS value of 2.5 x 10^{-9} fatal accidents per flight hour.

Source of Risk	**Risk Estimation**
N_{ay} (same)	9.25183×10^{-16}
N_{ay} (opposite)	3.21215×10^{-15}
N_{ay} (total)	**4.13733×10^{-15}**

Table 4: Lateral technical collision risk estimates for the NOPAC routes.

7. Future Plan

7.1 For the next step, JCAB RMA is planning to evaluate longitudinal risk on the NOPAC routes.

8. Action by the meeting

8.1 The meeting is invited to note the content of this paper.

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