



International Civil Aviation Organization

**The Nineteenth Meeting of the Regional Airspace Safety Monitoring
Advisory Group (RASMAG/19)**

Pattaya, Thailand, 27-30 May 2014

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

SAFETY ASSESSMENT OF RNAV ATS ROUTES Y711 AND Y722

(Presented by Republic of Korea)

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SUMMARY

This paper presents the lateral safety assessment analysis for the newly implemented RNAV routes Y711 & Y722 which are operated above FL140 from 16:00(UTC) on the 27th of June 2012. The estimated lateral collision risk with TSD for the time period from 1st January to 31st December 2013 meets the agreed TLS value of 5.0×10^{-9} fatal accidents per flight hour.

1. INTRODUCTION

1.1 The Republic of Korea has established the PBN implementation roadmap according to ICAO's PBN implementation plan. PBN based on the instrument flight procedures will be implemented to all airports and ATS routes in Incheon FIR by 2016. The SID/STAR procedures around Jeju International Airport, Muan Airport, Yeosu Airport, and Ulsan Airport have been implemented in 2013 according to Korean PBN implementation plan. This year, the SID/STAR procedures around Sacheon Airport and Gwangju Airport will be implemented.

1.2 For the implementation of PBN in the most congested route B576 in Incheon FIR, the Korea Transport Institute (KOTI), an independent institute funded by the government, has performed the preliminary analysis of ATS route B576 for safety assessment (RASMAG/16-WP10), and has performed the safety assessment of the new parallel routes Y711 & Y722 above FL140 of B576 with TSD of the six months of 1st July to 31st December 2012 (RASMAG/17-WP19, RASMAG/18-WP11).

1.3 The lateral collision risk of the parallel routes Y711 and Y722 with TSD covering July to December 2012 with 8NM lateral separation distance has been evaluated, and the level of collision risk of the routes Y711 & Y722 been evaluated as 4.33×10^{-12} (Y711) and 1.45×10^{-12} (Y722) respectively. Thereby, their levels of the lateral collision risk have been satisfied with the TLS of no more than 5×10^{-9} fatal accidents per flight.

1.4 In this paper, the quantitative lateral risk analysis has been performed to monitor the safety of the newly implemented parallel routes Y711 and Y722 with 8NM lateral separation distance with the traffic sample data of the period from 1st January to 31st December 2013.

2. DISCUSSION

Airspace Description

2.1 In Incheon FIR, there were a total of 37 routes including 11 international routes, 8 domestic routes, and 18 RNAV routes.

2.2 Considering air traffic in Incheon FIR, the total number of the air flights in Incheon FIR was 622,033 in 2013 and the rate of total air traffic has been increased at about 6 % compared to the previous year. The amount of the monthly air traffic is shown in **Figure 1**. The largest amount of the air traffic is 55,554 flights in August, and the second largest one is in October.

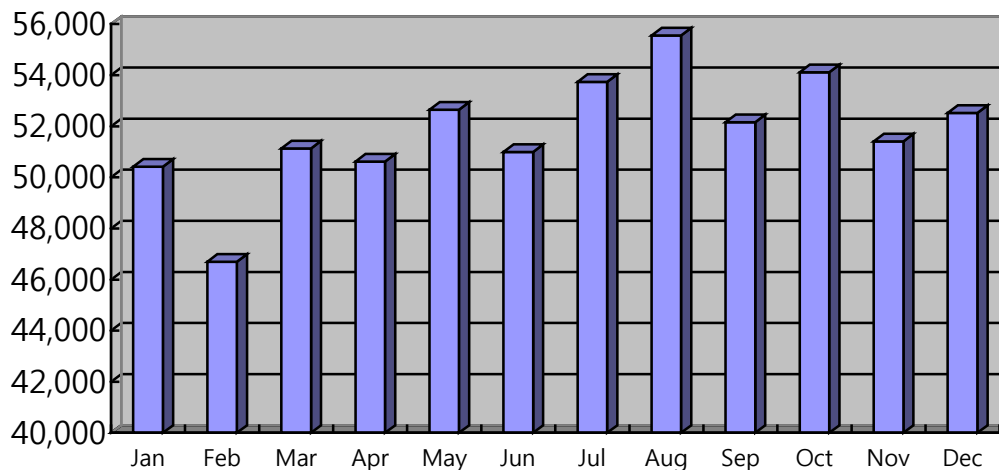


Figure 1: Monthly Air Traffic in Incheon FIR in 2013 (Flights)

2.3 The busiest air routes in Incheon FIR are Y711 and Y722 with around 37% of the total air traffic in Korea. The air routes Y711 and Y722 are the newly PBN implemented routes with RNAV2 navigation requirement in 2012 as shown in Table 1 and Figure 2. They are served for the domestic routes between Seoul and Jeju, and for the international routes between Seoul/Busan/Jeju and South-East Asia.

Regions of Routes	Upper Region MONSI~PANSI (Y711) SOT ~SOSDO (Y722)	Lower Region PANSI~ATOTI (Y711) SOSDO~ATOTI(Y722)
Navigation Requirement	RNAV2	RNAV5
Separation Distance between Y711 and Y722	8NM	12NM
Acceptable Equipments	DME/DME, DME/DME/IRU, GNSS	INS or IRS, GNSS

Table 1: Characteristics of Air routes Y711&Y722

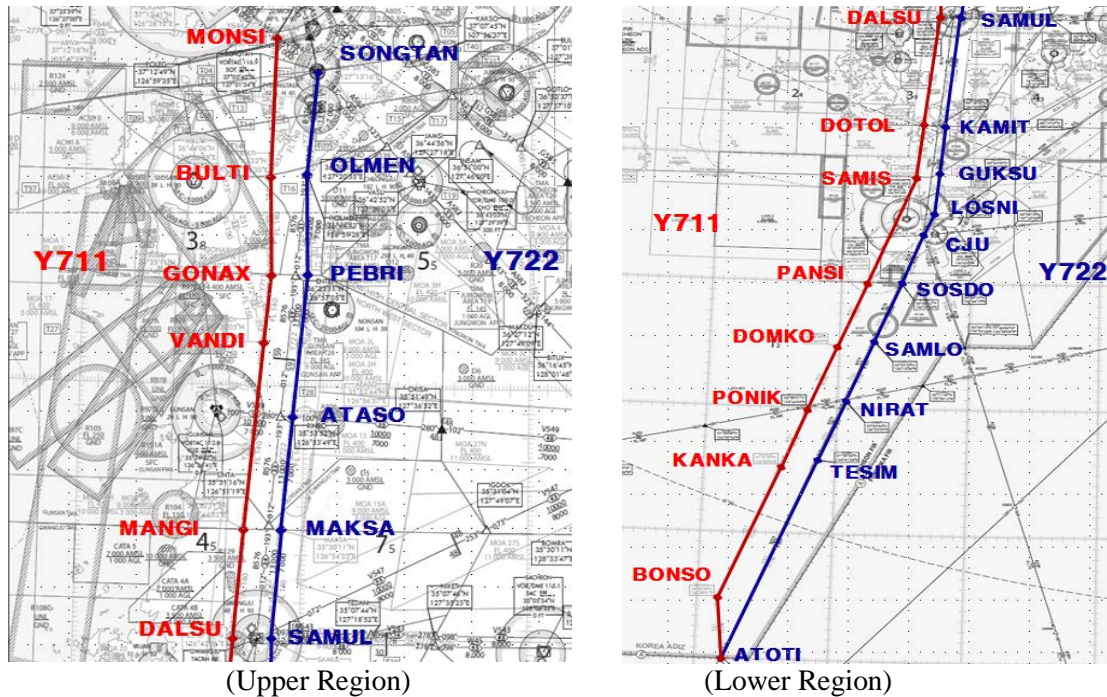


Figure 2: Newly Implemented PBN Routes of Y711 and Y722

Traffic Sample Data(TSD)

2.4 Traffic sample data for the 12 months from 1st January to 31st December 2013 of aircrafts operating in Y711 & Y722 were used to assess the lateral safety of the parallel routes as shown in **Table 2**.

Item		Details
Target	Period of Traffic Sample Data	1 st January 2013 ~ 31 st December 2013
	Altitude	Above FL140 (total 170,530 flights)
	Basic Analysis	Aircraft types, Number of flight, Aircraft characteristics, traffic distribution (distribution over direction, day, time and altitude)

Table 2: Traffic Sample Data of Y711 and Y722

2.5 For the safety assessment of the lateral collision risk for Y711 and Y722, the traffic sample data satisfying the following conditions were used.

- Aircraft operated above FL140 (Y711&722) except below FL130 (B576)
- All data were RNAV approved
- Aircrafts in linear segments separated by 8NM or more. (excluded the terminal area)
 - Aircrafts in the segments between VANDI and SAMIS for route Y711
 - Aircrafts in the segments between PEBRI and KAMIT for route Y722

2.6 The most common aircraft types, the number of flights per type and the percentage of these types over the total flights during the given period for Y711 and Y722 have been analyzed. The population is dominated by the large aircrafts such as B737, B738, A321 and A333. The percentage of these 4 types is nearly 70 % among the total number of flights. Details of percentage of aircraft types are shown in **Figure 3**.

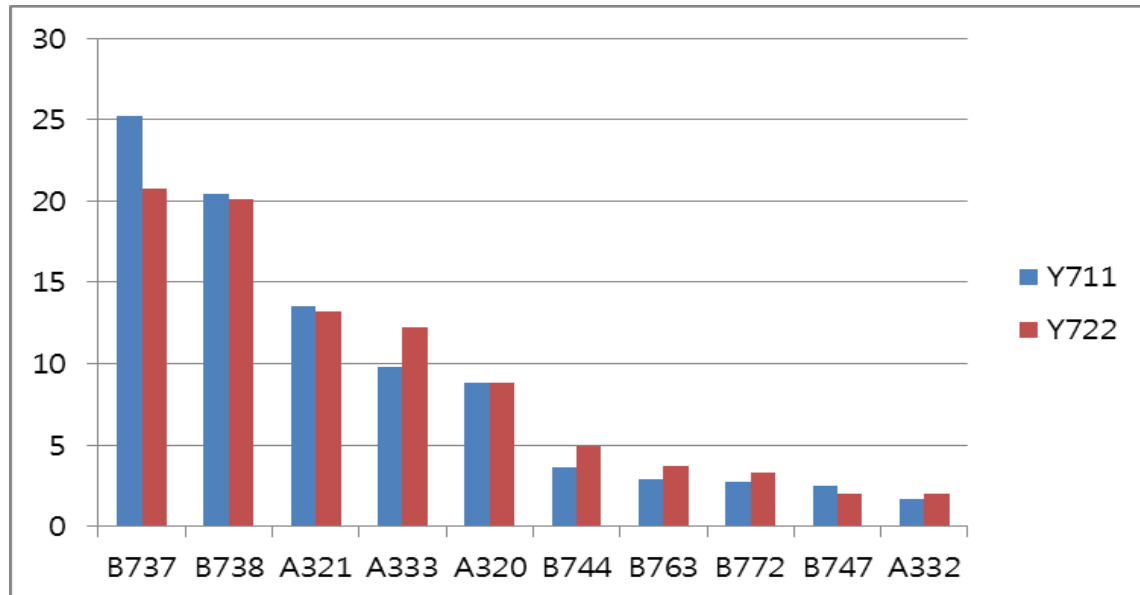


Figure 3: Percentage of aircraft type on routes Y711&Y722 (Left: Y711, Right : Y722)

2.7 The total traffic distribution based on flight level in routes Y711 and Y722 is shown in **Figure 4**. The busiest altitude in these routes is between FL260 and FL290. Y711 is for the southbound and Y722 is for the northbound, respectively.

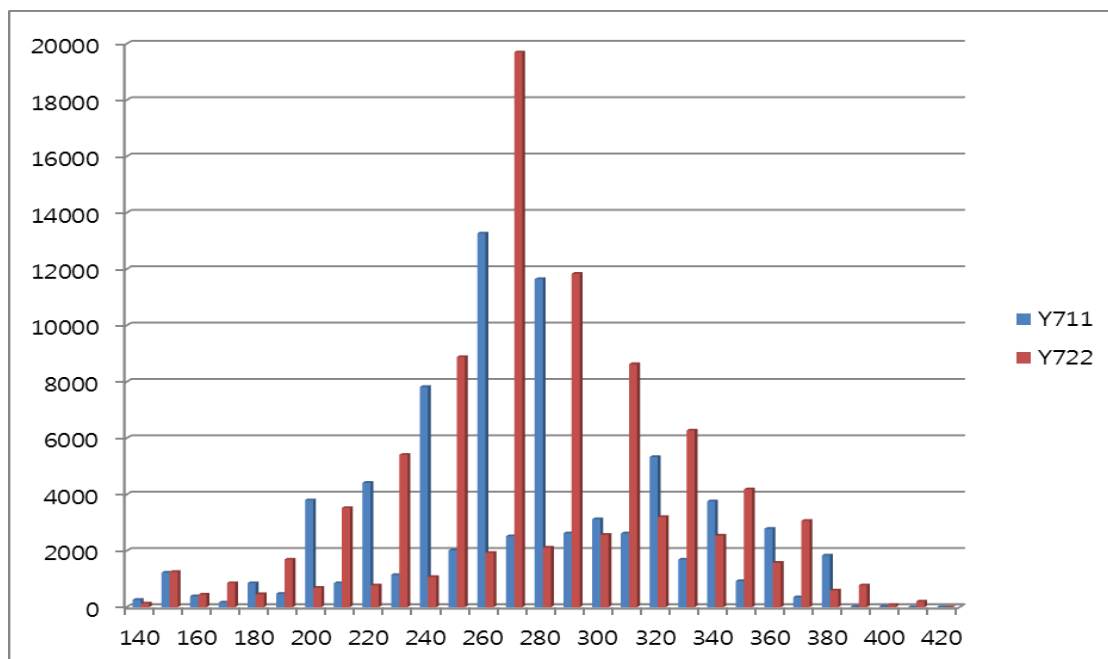


Figure 4: Air Traffic Distribution at Different Flight Levels in Routes Y711&Y722

Lateral Collision Risk Model

2.8 The Reich model of quantitative collision risk assessment has been used for monitoring the lateral safety of the parallel routes Y711 & Y722. The model is as follows:

$$N_{ay} = P_y(S_y) \cdot P_z(O) \cdot \frac{\lambda_x}{S_x} \cdot \left\{ E_{y(same)} \cdot \left[\frac{|\Delta v|}{2\lambda_x} + \frac{|\dot{y}|}{2\lambda_y} + \frac{|\dot{z}|}{2\lambda_z} \right] + E_{y(opp)} \cdot \left[\frac{2|\bar{v}|}{2\lambda_x} + \frac{|\dot{y}|}{2\lambda_y} + \frac{|\dot{z}|}{2 \cdot \lambda_z} \right] \right\}$$

Estimate of Lateral Collision Risk

2.9 The distribution of aircraft population in the TSD from Incheon FIR for 2013 is shown in **Figure 3**. The average aircraft dimension has been evaluated using the dimensions of each aircraft type weighted by their proportions (see in **Table 3**).

Aircraft	λ_x , length(x)		λ_y , wingspan(y)		λ_z , height(z)	
	M	NM	M	NM	M	NM
A306	54.08	0.029201	44.84	0.024212	16.62	0.008974
A320	37.58	0.020292	33.86	0.018283	12.13	0.006550
A321	44.51	0.024033	33.86	0.018283	11.81	0.006377
A332	59.00	0.031857	60.30	0.032559	17.88	0.009654
A333	63.58	0.034330	60.30	0.032559	16.84	0.009093
B737	33.6	0.018143	35.8	0.019330	12.5	0.006749
B738	39.5	0.021328	35.8	0.019330	12.5	0.006749
B739	42.1	0.022732	35.7	0.019276	12.5	0.006749
B744	70.6	0.038121	64.4	0.034795	19.4	0.010481
B763	54.9	0.029644	47.6	0.025702	15.8	0.008531
B772	63.7	0.034395	60.9	0.032883	18.5	0.009989
B773	73.9	0.039903	60.9	0.032883	18.5	0.009989

Table 3: Aircraft dimensions on Y711 & Y722 routes

2.10 The values of the length, of the wingspan, of the height of the average aircraft are shown in **Table 4**.

	Y711	Y722
λ_x	0.024749	0.025487
λ_y	0.022823	0.023402
λ_z	0.007487	0.007612

Table 4: Average Aircraft dimensions on Y711 & Y722 routes

2.11 The value of the lateral occupancy parameter, $E_y(opp)$, has been evaluated using the data on heavy-traffic air routes DALSU-DOTOL of Y711 and SAMUL-KAMIT of Y722 as shown in **Table 5**.

Total number	Proximate pair	$E_y(opp)$
170,530	19,639	0.115164

Table 5: $E_y(opp)$ value

2.12 The average ground speed in the opposite direction was evaluated by multiplying with the average flight speed of the aircrafts flying in the routes Y711 & Y722. The values are shown in **Table 6**.

Route	Y711 route	Y722 route
Object Segments	DALSU-DOTOL	SAMUL-KAMIT
Average Flying Speed (knots)	432.1713	437.3816

Table 6: Average Ground Speed of an Aircraft

2.13 The lateral collision risk was estimated in order to determine whether the target level of safety (TLS) is met in the parallel routes Y711 and Y722. **Table 7** presents the estimate of lateral collision risk for the routes Y711 and Y722 separated by 8NM. This estimate meets the agreed TLS value of 5.0×10^{-9} fatal accidents per flight hour.

Parameter	Y711 (VANDI-SAMIS)	Y722 (PEBRI-KAMIT)	Source of the Estimate	Unit
S_y	8	8	Current minimum lateral separation	NM
$P_y(S_y)$	8.17E-12	3.79E-12	Estimated using a mixture of Gaussian	-
$P_z(0)$	0.538	0.538	Estimated from the TSD	-
λ_x	0.0247	0.0255	Estimated from the TSD	NM
λ_y	0.0228	0.0234	Estimated from the TSD	NM
λ_z	0.0075	0.0076	Estimated from the TSD	NM
S_x	80	80	Equivalent to ± 10 minutes of longitudinal separation.	NM
$E_y(opp)$	0.115164	0.115164	Estimated from the TSD	-
\bar{V}	431.6687	437.6346	Value obtained from TSD	Knot
$ \bar{z} $	1.5	1.5	Conservative value taken from EMA Handbook	Knot
$ \bar{y} $	75	75	Conservative value taken from EMA Handbook	Knot
N_{ay}	0.00301×10^{-9}	0.00141×10^{-9}		-

Table 7: Estimated Lateral Collision Risk for Routes Y711 and Y722

2.14 The values of the collision risk are shown in Figure 5. The estimated lateral collision risk with TSD for the time period from 1st January to 31st December 2013 meets the agreed TLS value of 5.0×10^{-9} fatal accidents per flight hour, and it shows that the lateral safety is being stabilized as well.

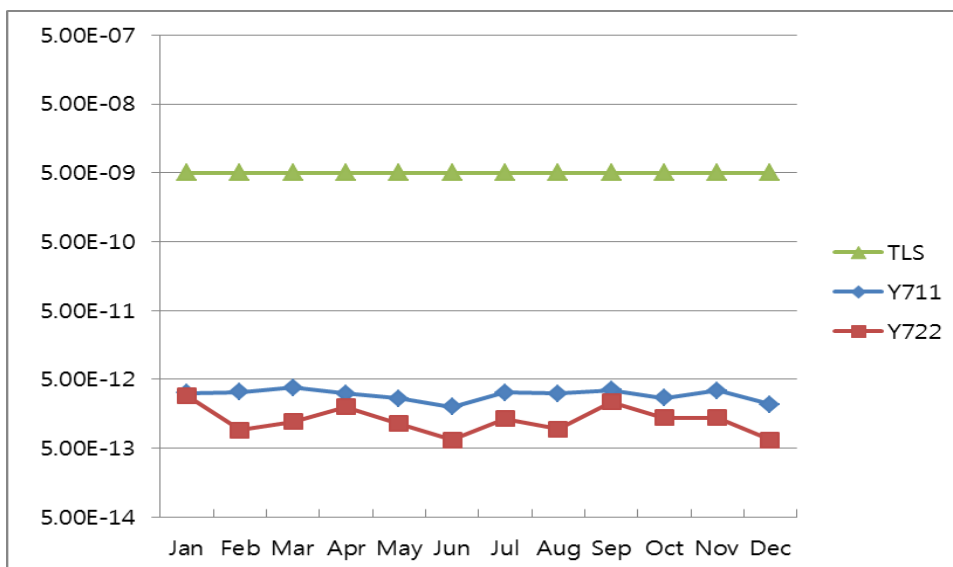


Figure 5: Distribution of Monthly Nays for Routes Y711 and Y722

2.15 These values in 2013 are similar to those initial six months results in 2012, and meet the agreed TLS. Thereby, it seems that the operation in the parallel routes Y711 and Y722 has been reached at the stabilized stage.

Summary and Future Plan

2.16 In this study, the lateral safety assessment for the newly implemented routes Y711&Y722 with RNAV has been analyzed. The estimated lateral collision risk with TSD of the 12 months of 2013 meets the agreed TLS value of 5.0×10^{-9} fatal accidents per flight hour. It means that the operation of the parallel routes Y711 and Y722 is safe. However, it is necessary to keep to monitor for the safe operation of these routes.

2.18 In addition, KOTI will analyze the related collision risk continuously for the newly implemented PBN routes. The results will be presented in the next meeting of RASMAG.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) Present the information contained in this paper; and
- b) Discuss any relevant matters as appropriate.

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REFERENCES

1. 「Asia/Pacific EMA Handbook」 - Version 2.0, August 2010
2. 「EUR/SAM: "Double Unidirectionality" Post-Implementation Risk Assessment」
3. 「Air Traffic Management」, Doc 4444, ATM/501, Fifteenth Edition, 2007, ICAO
4. The 15th Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG /15) Bangkok, Thailand, 1-5 August 2011
5. The 16th Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG /15) Bangkok, Thailand, 20-23 February 2012
6. 「Collision Risk Model」, ENRI, Japan
7. PBN Korea Website (<http://pbn.mir9.co.kr>)
8. 「A Basic Study for Development of Safety Technologies in Aviation - Focusing on Development of Airspace Safety Assessment Model」 , KOTI, 2011.11.
9. 「Preliminary Analysis of Airspace Characteristics in the Incheon FIR and of ATS route B576 for Safety Assessment」, RASMAG/15–IP/02, 2011.8
10. 「Preliminary Analysis of ATS routes B576 for Safety Assessment」, RASMAG/16–WP/10, 2012.2
11. 「Safety Assessment of RNAV ATS Routes Y71 AND Y72」, RASMAG/17–WP/19, 2012.8
12. 「Safety Assessment of RNAV ATS Routes Y711 and Y722 July 2012 – December 2012」, RASMAG/18–WP/11, 2013.4