International Civil Aviation Organization

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Bangkok, Thailand, 01 – 04 April 2013

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

JASMA HORIZONTAL SAFETY REPORT

(Presented by Japan)

SUMMARY

This paper presents the results of the horizontal airspace safety assessment of the oceanic airspace of the Fukuoka Flight Information Region (FIR) by the Japan Airspace Monitoring Agency (JASMA). Those are the calculation results of time-based longitudinal, distance-based longitudinal and lateral collision risk in the NOPAC route. This report also refers to the LLD reports received by the FMC for the year 2012.

This paper relates to –

Strategic Objectives:

*A: **Safety** – Enhance global civil aviation safety*

1. INTRODUCTION

1.1 This paper provides the horizontal risk assessment of the FUKUOKA FIR airspace safety undertaken by the JASMA. The report is detailed in **Attachment 1.**

2. DISCUSSION

2.1 The report shows that for the oceanic airspace of Fukuoka, the target level of safety of lateral and longitudinal (TLS) were met for the reporting period of Dec. 2012. But as for the operational risk it is well above TLS, and this is partly because of the practical difficulties for assessing the risk value.

2.2 The JASMA will continue to assess horizontal risk regularly and try to device the improved method to evaluate the operational error and the accuracy of traffic sample data.

<u>Executive Summary</u>

2.3 **Table 1** provides NOPAC routes time based longitudinal risk estimates.

NOPAC Routes – estimated annual flying hours = 65936.04hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 Longitudinal Risk	*$1.79 x 10^{-9}$*	*$2.5 x 10^{-9}$*	*Below TLS*
RASMAG 15Longitudinal Risk	*$1.78 x 10^{-11}$*	*$2.5 x 10^{-9}$*	*Below TLS*

Table 1: NOPAC time separation Risk Estimates

2.4 **Table 2** provides airway R220 in the NOPAC routes distance based longitudinal risk estimates.

R220 in NOPAC Routes ADS-C aircraft – estimated annual flying hours = 26226hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 Longitudinal Risk	$1.73x10^{-12}$	2.5×10^{-9}	*Below TLS*
RASMAG 17Longitudinal Risk	$3.68x10^{-13}$	2.5×10^{-9}	*Below TLS*

Table 2: R220 distance separation Risk Estimates

2.5 **Table 3** provides NOPAC routes lateral risk estimates.

NOPAC Routes – estimated annual flying hours = 65936.04hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 Longitudinal Risk	3.90081×10^{-15}	2.5×10^{-9}	*Below TLS*
RASMAG 17Longitudinal Risk	4.13733×10^{-15}	2.5×10^{-9}	*Below TLS*

Table 3: NOPAC lateral separation Risk Estimates

2.6 **Table 4** provides operational risk estimates.

NOPAC Routes – estimated annual flying hours = 65936 hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
Operational Risk	1.78×10^{-3}	2.5×10^{-9}	*Over TLS*
Total Risk	4.37×10^{-7}	5.0×10^{-9}	*Over TLS*

Table 4: Operational Risk Estimates

2.7 **Figure 1** provides the airways within the FUKUOKA FIR.

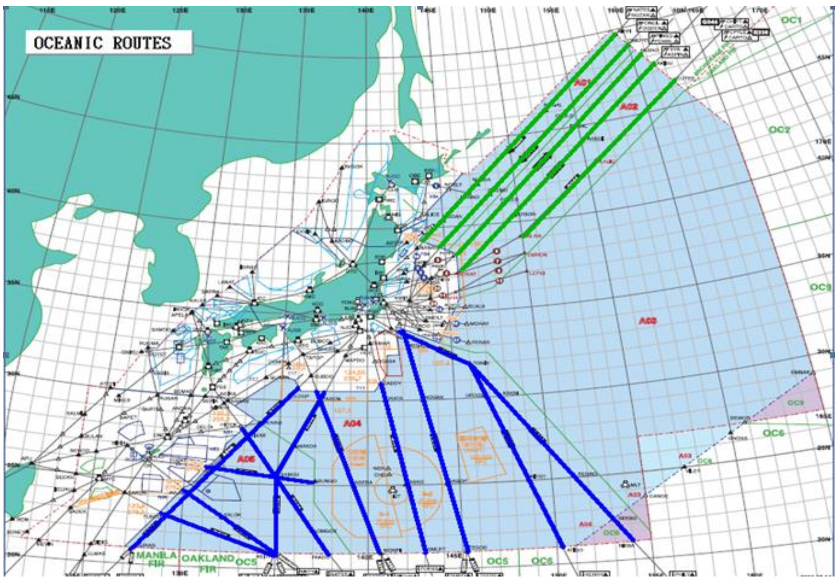

Figure 1: FUKUOKA FIR oceanic routes.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) Discuss the results of the airspace safety oversight presented in this working paper and the attached documentation.

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HORIZONTAL RISK ASSESSMENT OF OCEANIC AIRSPACE OF FUKUOKA FLIGHT INFORMATION REGION

1. INTRODUCTION

1.1 In the Oceanic airspace, there are two types of ATS routes. One is the fixed routes and the other is the flexible routes. The ATC separation standards applicable for these routes also can be categorized into two types, namely time-based separation and distance-based separation. Since flight in the oceanic tends to be a long haul the reduction in the ATC separation and optimal route setting have vital importance to curb fuel burn. On the other hand coexistence of various applicable separations and routing systems poses complex problems to assess the safety of the airspace.

Fixed Oceanic Routes

2. DISCUSSION

2.1 Five oceanic ATS routes colored in green are called NOPAC (North PACific) route. (**Figure 1**) The NOPAC route consists of 5 routes, namely R220, R580, A590, R591 and G344. They link Japan with Alaskan and northern American cities through Anchorage. Because of the booming economy in the East Asian region the traffic volume is rapidly expanding. Another significant feature is the increasing number of flights which fly directory from US to the major East Asian hub airports. Each NOPAC route is basically unidirectional except airway R591 and G344. These two routes are also used as the part of PACOTS track. (**Table 1**)

Route	Assignment
R220	One-way westbound at all times
R580	One-way westbound 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

Table1: NOPAC traffic Assignment

2.2 Ten southern oceanic ATS routes colored in blue link Japan with Southeast Asia/South Pacific through Oakland/Manila FIRs. (i.e. A590 south of MJE (Miyakejima VOR), R595, R584, A339, G339, A597, B586, A337, B452 and G223) (**Figure 1**).

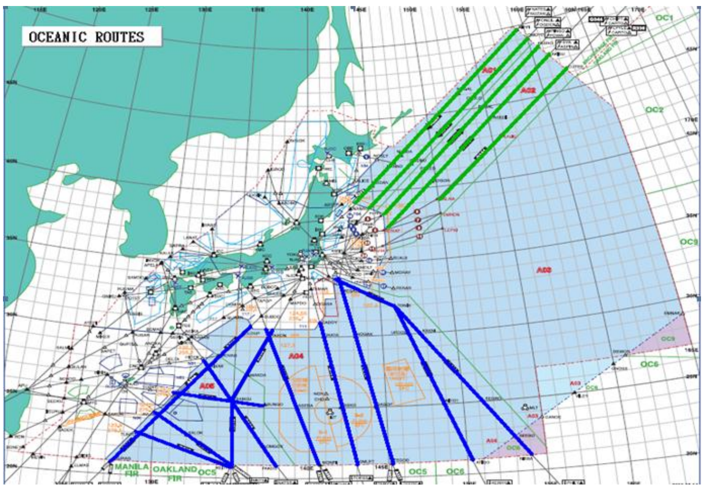

Figure1: Fixed Oceanic Routes

Flexible oceanic tracks

2.3 The PACOTS (Pacific Organized Track System) will be designed daily by mainly considering weather conditions along the track. (**Figure2, 3**) East bound track is numbered like 1, 2, 3… while west bound track is named by alphabetic order like A, B, C. To maximize the use of airspace eastbound and west bound track have their operational hours. User Preferred Routes (UPR) is also a flexible track but, they designed by the operators to optimize the individual flight. The UPRs have been introduced into the airspace where the volume of traffic was relatively low. (**Figure 4, 5**)

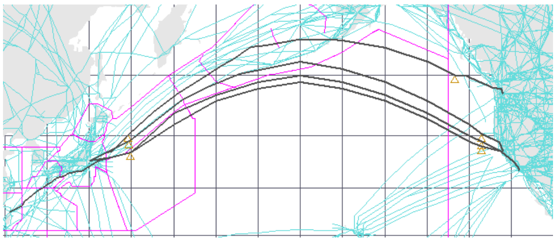

Figure2. East bound PACOTS (Start gate KALNA, one day in Jul.: Provided by ENRL)

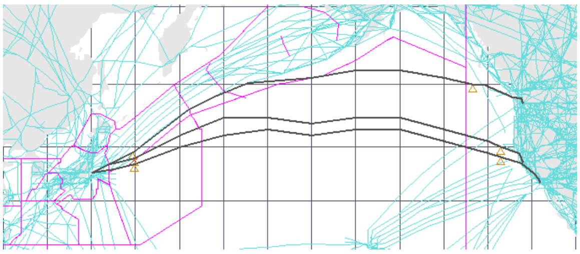

Figure3. East bound PACOTS (Start gate EMRON, one day in Apr.: Provided by ENRI)

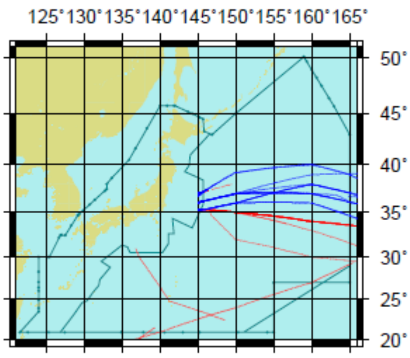

Figure4. (UPR 2011,one day in Nov, PHNL/PHKO Departure and Arrival flight: Provided by ENRI)

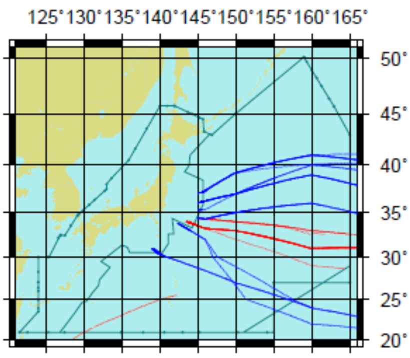

Figure5. (UPR 2012,one day in Jan. PHNL/PHKO Departure and Arrival flight: Provided by ENRI)

The UPRs have been in service since 2010 and their usage has rapidly expanded among operators. The UPRs can be designed by the operator but there are rules to be followed. For instance, for Track 1 UPR, it must remain 50NM north of PACOTS Track2. PACOTS Track UPRs also must remain in the Fukuoka, Anchorage and Oakland Oceanic Control Areas. The operators must utilize acceptable gateways and fixed routes within Fukuoka FIR, applicable to the particular PACOTS track UPR being flown. These UPR guidelines are published in Japan AIP and CHART SUPPLIMENT PACIFIC of FAA. These flexible routes systems are expected to reduce greatly the consumption of fuel and curtail Co2 emission by shortening the flight distance. But the flexibilities in the track designing causes a difficulties assessing collision risk. The other problem is these routes are not well recorded in the ATC system journals. Some of the UPRs are shares their route segment with PACOT tracks. (A590 UPR after POWAL. R591 UPR after ASPIN) And presently there is no easy way to identify daily changing flexible route systems from the system journal. This poses a difficult problem to calculate the collision risk with consideration of the route structure.

Traffic characteristics of NOPAC

2.4 **Table 2** shows traffic statistics of the NOPAC routes. The R220 handles major volume of west bound traffic, while A590 is the major caterer for the east bound traffic.

Route	Count	Proportion	Cumulative Count	Cumulative Proportion
R220	1604	38.34%	1604	38.34%
R580	434	10.37%	2038	48.71%
A590	1628	38.91%	3666	87.62%
R591	256	6.12%	3922	93.74%
G344	262	6.26%	4184	100.00%
NOPAC Total	4184	100.00%	–	–

Table2. Traffic counts on NOPAC routes.

2.5 **Table 3** shows altitude preference of the aircraft. The preferred altitude usually become higher as the flight progresses, because aircraft usually climbs to the higher altitude for the more economical fuel burn when it's weight become lighter. The altitude in table 3 is a snap shot of the certain fix. For instance altitude preference for R220 is the snap shot value at position NIPPI. **Figure 6** is a graphical depicts of the Table 3.

FL \ Route (Fix)	R220 (NIPPI)	R580 (OMOTO)	A590 (PASRO)	R591 (AKISU)	G344 (CUTEE)
410	19	4	18	1	0
400	84	27	0	0	0
390	56	23	15	1	4
380	216	78	5	1	3
370	161	39	57	9	20
360	359	119	34	9	21
350	229	50	291	51	66
340	265	61	298	16	27
330	85	10	508	105	62
320	101	17	210	16	19
310	5	0	144	38	30
300	14	5	15	3	4
290	0	0	8	1	4
280	4	0	5	1	0
270	0	0	5	1	2
260	0	0	1	1	0
250	0	0	7	0	0
Other	6	1	7	2	0

Table3. Traffic counts on NOPAC routes.

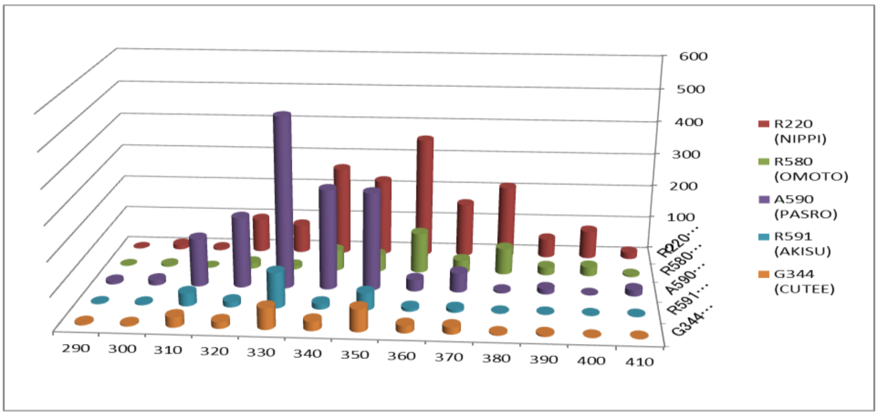

Figure6. Traffic counts on NOPAC routes.

2.6 The total Number of Flight Hours and Passing Frequencies are shown in **Table 4**. Note that "0" value of G344 column. This does not mean no traffic on G344. As shown in table 2 we had 262 traffic on G344 during the 2012 Dec. The "0" value means there was no passing traffic between R591 and G344 during the period. Both R591 and G344 are basically for east bound only, so to be more precisely, this means no catching up had occurred during the period. While the value "34 between the row "R220" and "R580" under column "Same Direction" means there was 34 times catching-up. These values will be used to calculate risk values of lateral collision at section 2.10.

	Flight Hours		Passing Frequencies		
	EASTBound	WEST Bound	Same E-Bound	Same W-bound	Opp Direction
R220	0	2474.49			
			0	21.5	0
R580	0	672.288			
			0	0	325
A590	2023.57	0			
			7	0	3
R591	312.415	11.916			
			0	0	0
G344	0	0			

Table 4: Flight Hours and Passing Frequencies

2.7 **Table5** shows the proportion of over flight. Booming economy in the East Asian countries and long flight capabilities reflected in the increase in the number of over flight. The main destination airports for the over flights are Inchon International Airport (near soul), Shenzhen International Airport (Guangdong), Taiwan Taoyuan International Airport (Taipei). Table 6 shows all the city pairs in the NOPAC during the November 2012.

	N of flights	%
Inbound to Japan	909	32%
Out bound from Japan	258	9%
Over Flight	1700	59%
SUM	2867	

Table 5: Proportion of over flight.

Number	City Pair	Count	Proportion
1	VHHH-ANC	303	7.24%
2	RKSI-PANC	293	7.00%
3	RCTP-PANC	226	5.40%
4	KLAX-RJAA	214	5.11%
5	ZSPD-PANC	188	4.49%
6	PANC-RJAA	155	3.70%
7	PANC-RCTP	125	2.99%
8	RJAA-PANC	116	2.77%
9	PANC-RJBB	96	2.29%
10	KSFO-RJAA	86	2.06%
11	KSEA-RJAA	83	1.98%
12	KORD-RJAA	75	1.79%
13	KLAX-RKSI	71	1.70%
14	KLAX-ZSPD	71	1.70%
15	PANC-RKSI	66	1.58%
16	KLAX-RCTP	61	1.46%
17	KDFW-RJAA	59	1.41%
18	KSFO-RKSI	58	1.39%
19	CYVR-RJAA	56	1.34%
20	RJBB-PANC	54	1.29%
21	RJAA-KJFK	53	1.27%
22	RKSI-KJFK	51	1.22%
23	KLAX-RJTT	49	1.17%
24	KSFO-RCTP	40	0.96%
25	KSEA-RKSI	39	0.93%
26	ZGSZ-PANC	37	0.88%
27	PANC-HHH	36	0.86%
28	KJFK-RJAA	36	0.86%
29	RJAA-KORD	35	0.84%
30	CYVR-ZSPD	35	0.84%

Table 6: City pairs in NOPAC routes.

Applicable ATC Separations

2.8 Separation minima

Table 7 shows the longitudinal separation minima applied to the aircraft-pairs in the oceanic ATS routes in Fukuoka FIR.

Longitudinal separation minima			
	RNP4 aircraft (ADS-C/CPDLC)	RNP10 aircraft (ADS-C/CPDLC)	Other aircraft
RNP4 aircraft (ADS-C/CPDLC)	30NM	50NM	10min*
RNP10 aircraft (ADS-C/CPDLC)	50NM	50NM	10min*
Other aircraft	10min*	10min*	10min*

Table 7: Longitudinal separation minima in the oceanic airspace of Fukuoka FIR
* Not applicable on PACOTS/UPR without MNT.
(Require position reports every 40 minutes.)

The applicable longitudinal separation can vary depending on the applicable separations of the receiving ATCs. For aircraft-pairs entering Anchorage/Oakland FIRs, the applicable longitudinal separation at the FIR boundary is 50NM for RNP10 or 4/ADS-C/CPDLC-based aircraft or 10 minutes with MNT. For aircraft-pairs entering Manila FIR, the applicable longitudinal separation at the FIR boundary is 10 minutes with MNT. The longitudinal separation had long been meant time-based separation. Only recently distance-based separation to shorten the longitudinal separation was introduced for the aircraft with a certification of RNAV 10 or RNP 4. At present the minimum longitudinal separation of 30 NM is applicable when an aircraft pair both has the certification of RNP 4 and ADS system. The aircraft with ADS system automatically sends information about current position at a specific time interval (usually about 27 minutes), which is referred to by the air traffic controllers to secure the longitudinal separation. It is very important to get the accurate aircraft position update within a certain time interval. That is the reason why oceanic route fixes are reviewed to satisfy the position report intervals. So the increase in number of aircraft with RNAV or RNP capabilities will expected to be greatly conduces reducing longitudinal separation. However, there are still a large number of aircraft flying without an ADS system. Since it is required that both aircraft have the ADS system installed for distance-based separation to be applied, the percentage of aircraft pare for which distance-based separation applicable are further limited. Because of this time based separation is still widely used to secure the longitudinal separation. The time separation can be reduced to 10 minutes by applying Mach number technique. But this is rarely applied because of the rather cumbersome procedure to be taken. The 10 minutes separation without Mach number technique was introduced after the October 2010 within FUKUOKA FIR except PACOTS routes.

2.9 **Table 8** shows number of aircraft with RNAV/RNP certified during the December 2012. "NOT" means no entry in the PBN/ column. The aircraft with multiple certificates are all counted. So the total number exceeds the total number of aircraft. Note that the aircraft pair with, say RNP4 does not always flying with the 30NM separation.

PBN		N of Flights	PBN		N of Flights
RNAV5	B1	3541	RNP10	A1	4079
	B2	302	RNP4	L1	2531
	B3	462	Basic RNP1	O1	2267
	B4	425		O2	19
	B5	468		O3	8
	B6	1		O4	10
RNAV2	C1	3750	RNP APCH	S1	1420
	C2	16		S2	2049
	C3	71	RNP AR APCH	T1	395
	C4	263		T2	0
RNAV1	D1	3819	Not		7
	D2	54			
	D3	104			
	D4	304			

Table 8: RNAV/RNP certified aircraft in NOPAC.

Risk value estimates of three different separation standards. (Time, Distance and Lateral)

2.10 Time-based longitudinal collision risk estimates
*Refer to the more detailed explanation on the calculation method to RASMAG/15-WP/22 and RASMAG/16-WP/03

2.10.1 This is a risk calculation result of 10-minutes longitudinal separation minimum without mandatory MNT in the NOPAC routes.

The probability that the longitudinal separation is infringed when the initial time separation is equal to *t* (defined *p(t)*) is calculated using the following expression. (1)

$$P_x(t)=\int_t^{\infty} l_m(\blacklozenge)\,d\blacklozenge \qquad (1)$$

Considering a three dimensional collision, the expected risk of collision *Nix*, which is defined as the expected number of accidents per flight hour due to loss of assigned longitudinal separation, is calculated by the following expression. (2)

$$N_{ax}=P_y(0)P_z(0)\frac{2\lambda_x}{|\dot{x}|T}\left[\frac{|\dot{x}|}{2\lambda_x}+\frac{\overline{|\dot{y}(0)|}}{2\lambda_y}+\frac{\overline{|\dot{z}(0)|}}{2\lambda_z}\right]\sum E_x(t)P_x(t) \qquad (2)$$

	Parameter Definition	Parameter Value	Source for Value
Py(0)	Probability that two aircraft on the same track are in lateral overlap	0.0196	SASP-WG/WHL/13-IP/08
Pz(0)	Probability of vertical overlap in operational risk estimation for the aircraft flying as a same flight level	0.5380	ICAO SASP safety assessment
$\overline{\lvert\dot{y}(0)\rvert}$	The average relative speed between two aircraft, across track.	1kt	EMA handbook
$\overline{\lvert\dot{z}(0)\rvert}$	Average vertical speed of aircraft pairs	1.5 kt	ICAO SASP safety assessment
λx	Average aircraft length	0.0274 nm	JASMA Dec.2012
λy	Average aircraft width	0.00251nm	JASMA Dec.2012
λz	Average aircraft height	0.0081nm	JASMA Dec.2012
T	The average time to fly the segment.	0.69h	FDPS data (NOPAC)
Ex(t)	The proportion of aircraft initial separation	----	----
P_x(t)	The probability of the loss of longitudinal separation.	----	----

Table 9: Parameters for Time based risk calculation model.

Executive Summary

2.10.2 **Table 10** provides the NOPAC routes time based longitudinal risk estimates.

NOPAC Routes – estimated annual flying hours = 65936 hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Technical Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 Longitudinal Risk	*$1.79 x 10^{-9}$*	*$2.5 x 10^{-9}$*	*Below TLS*
RASMAG 15Longitudinal Risk	*$1.78 x 10^{-11}$*	*$2.5 x 10^{-9}$*	*Below TLS*

Table 10: NOPAC routes time based longitudinal risk estimates.

2.11 Distance-based longitudinal collision risk estimates.
*Refer to the more detailed explanation on the calculation method to the RASMAG/17-WP/33.

2.11.1 This is a risk calculation result of 50 NM longitudinal separation minimum with RNP4 and ADS-C capability on R220 in the NOPAC routes. The airway R220 is the busiest airway in the oceanic routes system. If the risk estimates satisfy the TLS within the airway we can safely assume that the TLS in the whole oceanic will meet TLS.

This Risk estimation was done under following assumptions.

1. Aircraft under consideration is the Flights on R220 with 50NM longitudinal separation. (The relative frequency Ex(x) is estimated by analyzing Flight on R220)
2. GPS non GPS mixed environment is not considered.)
3. The position errors of the aircraft are estimated by comparison of ADS-C position estimate and actual reported position. These position errors are converted to the speed errors.
4. Uplink times are collected by analyzing ODP's DLCS data.
5. Time required for collision resolution is 150 seconds.

2.11.2 Let $f_x(d;v_1,v_2,t,\Delta T,T)$ be the probability density function of position error "d". The values of v_1, v_2, t, ΔT and T are constants in this formula. The longitudinal overlapping probability of a typical aircraft pair is given by the following formula (3).

$$P_x(x;\tau) = \frac{1}{T(T+\tau)} \int_0^T \int_0^{T+\tau} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{x-\lambda x}^{x+\lambda x} f_d(x;v_1,v_2,t,\Delta T) f_v(v_1) f_v(v_2) dx dv_1 dv_2 dt d(\Delta T) \tag{3}$$

The individual parameters for the equation (3) and their definitions are given in **Table 11**.

Parameter	Description	Parameter Value	Source for Value
$P_x(x;\tau)$	Longitudinal overlap probability. Mean probability that a typical aircraft pair which is nominally x NM separated on the same route at the same flight level overlaps in the longitudinal dimension.	----	----
$f_v(V)$	Probability density function of longitudinal speed prediction errors. (Prediction is done by ODP using the ADS-C message down linked from the aircraft) It is determined by the accuracy of position prediction by the aircraft, the performance of the ground ATC system interpolation/extrapolation function and so on.	----	----
$f_x(d;v_1,v_2,t,\Delta T,T)$	Probability density function of longitudinal position errors d at the given v_1 v_2, t and ΔT. It is calculated by means of equation (1).	----	----
T	Reporting interval of ADS position report.	1600sec	Standard Oceanic ADS-C Reporting Interval
τ	Time required for the resolution of a potential collision.	----	0.004-0.080
λ_x	Average aircraft length	0.0274NM	Estimated from TSD Dec. 2012

Table 11: Parameters in Equation (2)

Using the longitudinal overlapping probability, the collision risk is estimated by the following formula (4).

$$N_{ax}(x;\tau) = 2 \cdot P_y(0) \cdot P_z(0) \cdot P_x(x;\tau) \cdot \left(\frac{V_{rx}}{2\lambda_x} + \frac{V_{ry}}{2\lambda_y} + \frac{V_{rz}}{2\lambda_z} \right) \quad (4)$$

The individual parameters for the equation (4) and their definitions are given in **Table12**.

Parameter	Description	**Parameter Value**	**Source for Value**
$N_{ax}(x;\tau)$	Collision risk of a typical aircraft pair on the same route at the same flight level whose nominal separation is x (NM). Remember that τ is the time required for the resolution of a potential collision.	----	----
$P_y(0)$	Lateral overlap probability. Probability that an aircraft pair on the same route overlaps in the lateral dimension.	0.0196	SASP-WG/WHL/13-IP/08
$P_z(0)$	Vertical overlap probability. Probability that an aircraft pair at the same flight level overlaps in the vertical dimension.	0.54	RVSM/TF-9-IP/2
$V_{rx}(x)$	Average longitudinal relative velocity of aircraft pairs which are about losing their longitudinal separation in spite of the nominal x NM separation.	----	Assumption $V_{rx} = \frac{x}{T+\tau}$
V_{ry}	Average lateral relative velocity of aircraft pairs on the same route.	1knot	EMA HAND BOOK
V_{rz}	Average vertical relative velocity of aircraft pairs at the same flight level.	1.5knot	ICAO SASP
λ_y	Average aircraft length	0.0251NM	Estimated from TSD Dec. 2012
λ_z	Average aircraft height	0.0080NM	Estimated from TSD Dec. 2012

Table 12: Parameters in Equation (3)

In the previous equation, the distribution of nominal separation is fixed. When relative frequency for the aircraft pair that are flying on the same route and same altitude with the nominal (the displayed separation of the aircraft on the ODP consoles) separation of x(s) are given, collision estimation with resolution time is estimated by equation (5).

$$N_{ax}(\tau) = \sum_{x=0}^{\infty} N_{ax}(x;\tau) E_x(x) \quad (5)$$

The individual parameters for the equation (4) and their definitions are given in **Table 3**.

Parameter	Description	**Parameter Value**	**Source for Value**
$N_{ax}(x,\tau)$	Collision risk value. Where τ is the time required for the resolution of a potential collision.	----	----
$E_x(x)$	The relative frequency for the aircraft pair that are flying on the same route and same altitude with the nominal separation of x.	----	Estimated from flight Plan data and ADS-C position reports

Table 13: Parameters in Equation (5)

2.11.3 Finally CPDLC uplink time is taken into consideration. The average collision risk with respect to this parameter is given by

$$N_{ax} = \sum_{\tau=0}^{\infty} N_{ax}(\tau) E_{\tau}(\tau) \qquad (6)$$

The individual parameters for the equation (5) and their definitions are given in **Table1 4**.

Parameter	Description	**Parameter Value**	**Source for Value**
N_{ax}	Collision risk in the considered ADS-Environment.	----	----
$E_{\tau}(\tau)$	The relative frequency of time required to resolve a potential collision.	----	Estimated from processing Flight Plan data and ADS-C position reports.

Table 14: Parameters in Equation (6)

For the time to collision avoidance operation by the controller, we used the value 150 seconds provided by AAMA. The total time for collision avoidance instructions will be estimated by value X shown in **Table 15**.

DATE	2011 Dec		
N of msg.	27,707		
X<=10(sec)	18674	67.40%	67.40%
10(sec)<X<= 20(sec)	6813	24.59%	91.99%
20(sec)<X<= 30(sec)	983	3.55%	95.54%
30(sec)<X<= 60(sec)	831	3.00%	98.53%
60(sec)<X<= 90(sec)	215	0.78%	99.31%
90(sec)<X<=120(sec)	143	0.52%	99.83%
120(sec)<X<=180(sec)	24	0.09%	99.91%
180(sec)<X	24	0.09%	100.00%

Table 15: CPDLC Up link time.

2.11.4 This distance-based longitudinal collision risk was estimated in order to determine whether the TLS is met on airway R220. The technical risk is estimated to be $3.68*10^{-11}$. This estimate meets the TLS value of $5.0*10^{-9}$.

R220 in NOPAC Routes ADS-C aircraft – estimated annual flying hours = 26226hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 Longitudinal Risk	$1.73x10^{-12}$	2.5×10^{-9}	*Below TLS*
RASMAG 17Longitudinal Risk	$3.68x10^{-13}$	2.5×10^{-9}	*Below TLS*

Table 16: Distance-based risk estimates.

2.12 Lateral collision risk estimates.

*Refer to the more detailed explanation on the calculation method to RASMAG/17-WP/33

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

$$N_{ay}(same) = P_z(0)P_y(S_y)\frac{2\lambda_x}{\overline{|\Delta V|}}N_x^y(same)\left[\frac{\overline{|\Delta V|}}{2\lambda_x}+\frac{\overline{|\dot{y}|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right] \quad (7)$$

$$N_{ay}(opposite) = P_z(0)P_y(S_y)\frac{2\lambda_x}{2\overline{|V|}}N_x^y(opp)\left[\frac{2\overline{|V|}}{2\lambda_x}+\frac{\overline{|\dot{y}|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right] \quad (8)$$

$$N_{ay} = N_{ay}(same) + N_{ay}(opposite) \quad (9)$$

2.12.2 T**able 17** summarizes the value and source material for estimating the 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 knot	Value often used
$\overline{\lvert\Delta V\rvert}$	Average along track speed of aircraft pairs	28.9 knot	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 knot	Doc.9689 1st eds. Appendix 13
$\overline{\lvert\dot{z}\rvert}$	Average vertical speed of aircraft pairs	1.5 knot	Value often used
λx	Average aircraft length	0.0274 nm	JASMA(December 2012)
λy	Average aircraft width	0.0251 nm	JASMA(December 2012)
λz	Average aircraft height	0.0080nm	JASMA(December 2012)
Nix(same)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the same direction traffic	1.04×10^{-2}	FDPS data (NOPAC, December 2012)
Nix(opp)	The passing frequency of aircraft pair assigned to the adjacent flight levels under the opposite direction traffic	11.83×10^{-2}	FDPS data (NOPAC, December 2012)
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 17: Estimates of the parameters in the CRM

Executive Summary

2.12.3 The estimates of the technical lateral collision risk is $3.90081\text{x}10^{-15}$ fatal accidents per flight hour, which satisfies the Asia and Pacific Region agreed TLS value.

NOPAC Routes – estimated annual flying hours = 65936.04hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 Longitudinal Risk	3.90081×10^{-15}	2.5×10^{-9}	*Below TLS*
RASMAG 17Longitudinal Risk	4.13733×10^{-15}	2.5×10^{-9}	*Below TLS*

Table 18: NOPAC lateral risk estimates.

LLD consideration

2.13 RNP Deviation Reports

2.13.1 Five cases of RNP deviations were reported to ATMC (Air Traffic Management Center) during the 2012.

NO.	DATE	to	POSITION	UTC	TYPE	A-ALT	DEV(MAX)	DURATION	CATEGORY
1	2012/3/21	ATMC	40N160E-41N170E	10:34	B77L	FL310	—	—	C
2	2012/7/4	ATMC	KALNA G344 CUTEE	8:20	B772	FL330	26NM (Right)	38min	G/A
3	2012/7/4	ATMC	EMRON 44N160E	10:19	B77W	FL310	20NM (Right)	29min	G/D
4	2012/8/17	ATMC	4026N14830E (A590)	23:41	A332	FL330	10.5NM (right)	—	G/A
5	2012/10/24	ATMC	AVBET-EMRON-152E	18:00	B77L	FL310	30NM (Left)	14min	G/A

Table19: RNP Deviation reports.

No1. Original flight plan was filed 40N160E-43N170E, but the aircraft proceeded to 41N165E after 40N160E. Corrected clearance to the original route was issued while deviating. How far and how long are unknown.

No2. ADS report indicated a deviation. The deviation without ATC clearance was confirmed through CPDLC. The pilot reported the deviation of 10NM right of the course, but actually deviated 25NM maximum.

No3. The aircraft requested deviation 20NM right of course, then granted by ATC accordingly. After a while requested deviation 20NM left of course, and also granted. The aircraft remained right side of the course. To the ATC confirmation the pilot requested deviation either 20NM R/L of course and again granted.

No4. To avoid weather area the aircraft deviated 10.5NM right of course without ATC clearance.

No5. To avoid weather area the aircraft deviated 30NM left of course.

2.13.2 With following supposition operational estimate is calculated.

*All LLD occurred in the NOPAC system which is the busiest track in the oceanic area.

*$P_y(0)$=0.0196 This means when lateral deviation occurred the aircraft is deviating as far as adjacent airways.

The supposition of $P_y(0)$ is a conservative value. The value is very big but and it is deciding factor.(0.0196/non-GPS pairs SASP-WG/WHL/13-IP/08) We need more realistic alternatives for this value. The collision risk differs according to the environment where deviation had occurred. It depends on the traffic volume and it's characteristics. The complex of route configuration and non-uniform traffic volume in the oceanic area makes reasonable assumption difficult. Operational Risk is a very big value and does not satisfy TLS. The Technical risk is well below TLS, but operational risk value is so big that total risk also exceeds TLS.

NOPAC Routes – estimated annual flying hours = 65936 hours ***(note: estimated hours based on Dec 2012 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
Operational Risk	*1.78×10^{-3}*	*2.5×10^{-9}*	*Over TLS*
Total Risk	*4.37×10^{-7}*	*5.0×10^{-9}*	*Over TLS*

Table20: Operational Risk and Total risk.

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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