International Civil Aviation Organization

The 21st Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/21)

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

SEASMA SAFETY REPORT

(Presented by Singapore)

SUMMARY

This paper presents the horizontal safety assessment report from the South East Asia Safety Monitoring Agency (SEASMA) for operations on Air Traffic Service routes N892, L625, N884 and M767 within the South China Sea for the period 1 January 2015 to 31 December 2015. This assessment is based on RNP10 performance and concludes that the Asia and Pacific Region Target Level of Safety (TLS) values established for lateral and longitudinal separation standards were satisfied.

This paper relates to –

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

1. INTRODUCTION

1.1 This working paper is a periodic assessment to ascertain if flight operations on Air Traffic Service routes N892, L625, N884 and M767 within the South China Sea meet the APANPIRG-agreed Target Level of Safety (TLS) values for lateral and longitudinal separation standards. The assessment period covered is from 1 January 2015 to 31 December 2015.

2. DISCUSSION

<u>Executive Summary</u>

2.1 **Table 1** provides the South China Sea airspace horizontal risk estimates.

Risk	Risk Estimation	TLS	Remarks
RASMAG 20 Lateral Risk	*0.045×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 20 Longitudinal Risk	*0.34×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Lateral Risk	**0.66×10^{-9}**	5.0×10^{-9}	**Below TLS**
Longitudinal Risk	**0.38×10^{-9}**	5.0×10^{-9}	**Below TLS**

Table 1: South China Sea Airspace Horizontal Risk Estimates

2.2 **Table 2** contains a summary of Large Lateral Deviations (LLD) and Large Longitudinal Errors (LLE) received by SEASMA for the South China Sea airspace.

Code	Deviation Description	No.
E	ATC Coordination errors	1
Total		1

Table 2: Summary of South China Sea Airspace LLD and LLE Reports

2.3 **Figure 1** presents the lateral and longitudinal collision risk estimate trends for the South China Sea airspace during the period January 2015 to December 2015.

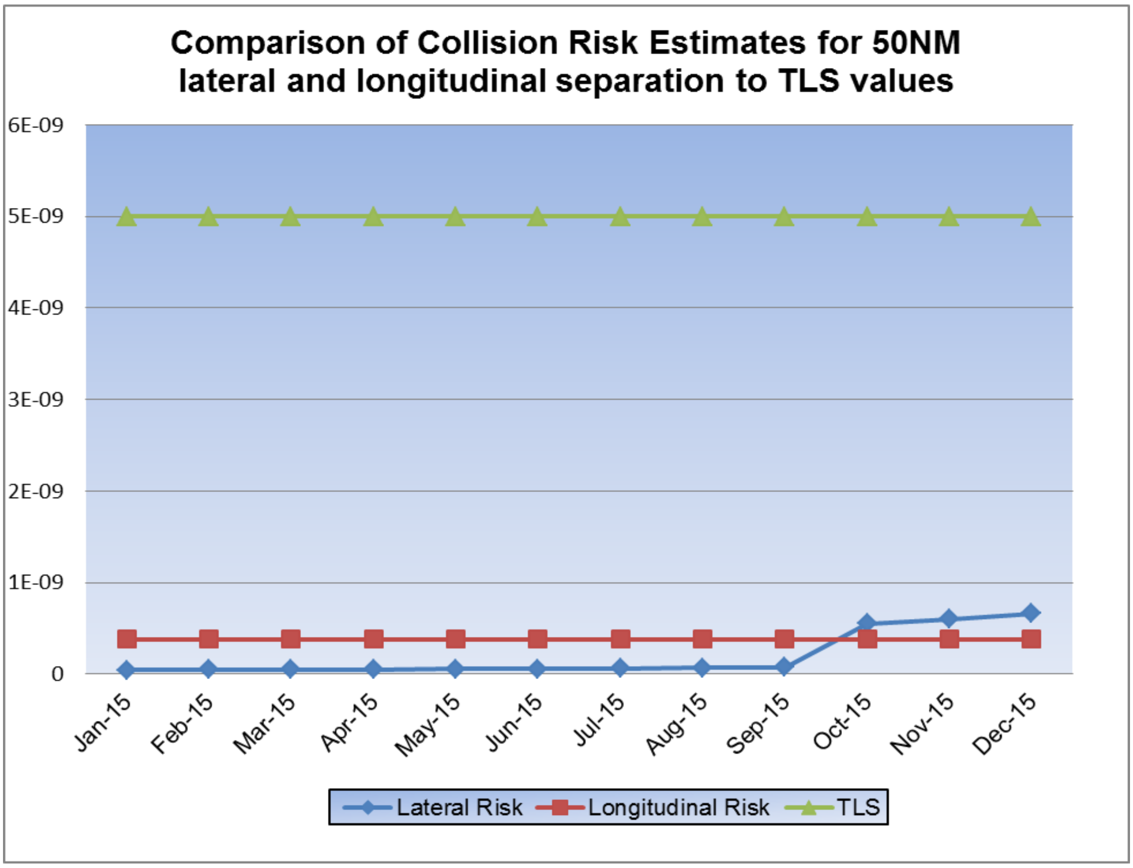

Figure 1: South China Sea Airspace Horizontal Risk Estimates

2.4 **Figure 2** provides the geographical location of LLDs and LLEs within the South China Sea Airspace.

Geographical location of LLDs and LLEs

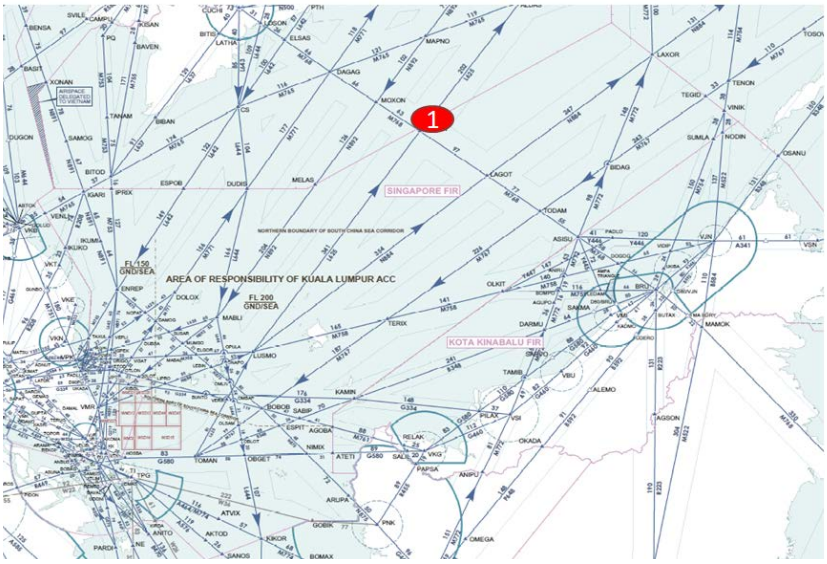

Figure 2: Geographical location of LLDs and LLEs

2.5 There was one LLE for 2015 and in this occurrence, three-party AIDC was in place between the boundary of Ho Chi Minh and Singapore and between Singapore and Kota Kinabalu. However there was negative AIDC transfer carried out at the Ho Chi Minh/Singapore boundary. The two primary contributing factors were Man & Machine. The ATCO did not notice that there was a negative transfer from the electronic strip and the ATC system assigned an incorrect reference number while sending the AIDC EST message and was subsequently rejected by the downstream FIR. Mitigations had been carried out to impress on the Man of the importance of proper and timely coordination and the AIDC trial (Machine) involving all three FIRs has been suspended until the issue is resolved.

2.6 There was an improvement of LLD/LLE reducing from seven occurrences in 2014 to one in 2015 and this could be attributed to the use of technology (AIDC). Nevertheless SEASMA would continue to monitor for any new errors and introduce improvements to maintain safe performance over the South China Sea.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) Note the performance that the South China Sea RNAV routes are compliant with the APANPIRG-agreed lateral and longitudinal TLS;

b) Discuss any relevant matters as appropriate.

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Appendix: SEASMA Safety Report for the South China Sea

1. Background

1.1 The lateral and longitudinal separation standard applied in the South China Sea routes were:

a) Air Traffic Service routes L625, N884 and M767 are 50NM lateral separation and 50NM longitudinal separation.

b) Air Traffic Service routes L642, M771 and N892 were 40NM lateral separation and 40NM longitudinal separation with ADS-B coverage. This was further reduced to 30NM/30NM in July 2014.

1.2 In this report, Air Traffic Service routes L642 and M771 have been excluded as these two routes are fully covered by surveillance systems. Air Traffic Service route N892 will continue to be monitored and assess as it is part of the route pair with Air Traffic Service route L625.

2. Results of Data Collection

2.1 The fidelity of large-error and traffic-count reporting by each responsible Air Navigation Service Provider (ANSP) for the period January 2015 to December 2015 is shown in **Table 1**.

Month	Report Received from:		
	Hong Kong, China	Philippines	Singapore
January 2015	Yes	Yes	Yes
February 2015	Yes	Yes	Yes
March 2015	Yes	Yes	Yes
April 2015	Yes	Yes	Yes
May 2015	Yes	Yes	Yes
June 2015	Yes	Yes	Yes
July 2015	Yes	Yes	Yes
August 2015	Yes	Yes	Yes
September 2015	Yes	Yes	Yes
October 2015	Yes	Yes	Yes
November 2015	Yes	Yes	Yes
December 2015	Yes	Yes	Yes

Table 1: Record of ANSP Reporting by Month for Period January 2015 to December 2015

2.2 **Table 2** presents the total traffic counts reported by month transiting all South China Sea monitoring fixes for the period January 2015 to December 2015.

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
January 2015	5241	123408
February 2015	4816	118154
March 2015	5159	112435
April 2015	5133	106757
May 2015	5255	100984
June 2015	5200	95501

July 2015	5158	89479
August 2015	5170	83338
September 2015	4961	77884
October 2015	5092	71767
November 2015	4987	65809
December 2015	5424	59795

Table 2: Monthly Count of Monitored Flights Operating on the South China Sea RNAV routes for the period January 2015 to December 2015

2.3 **Table 3** presents the cumulative totals of Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period January 2015 to December 2015.

Monitoring Month	Monthly Count of LLDs Reported	Cumulative 12- Month Count of LLDs	Monthly Count of LLEs Reported	Cumulative 12- Month Count of LLEs
January 2015	0	0	0	0
February 2015	0	0	0	0
March 2015	0	0	0	0
April 2015	0	0	0	0
May 2015	0	0	0	0
June 2015	0	0	0	0
July 2015	0	0	0	0
August 2015	0	0	0	0
September 2015	0	0	0	0
October 2015	0	0	1	1
November 2015	0	0	0	1
December 2015	0	0	0	1

Table 3: Monthly Count of LLDs and LLEs reported on the South China Sea RNAV routes for the period January 2015 to December 2015

2.4 **Table 4** presents the cause of deviation in the LLD and LLE reports received for the period January 2015 to December 2015.

Deviation Code	Cause of Deviation	No of Occurrences
E	ATC coordination errors.	1
Total		1

Table 4: Cause of LLE deviation

3. Risk Assessment

3.1 This section presents the results of safety oversight to the lateral and longitudinal separations standards applied in the South China Sea RNAV route structure. Analysis techniques used are in conformance with internationally applied collision risk methodology.

3.2 Estimate of the CRM Parameters

3.2.1 The mathematical formula of the lateral collision risk model used in assessing the safety of operations on the South China Sea RNAV routes:

$$N_{ay} = P_y(S_y)P_z(0)\frac{\lambda_x}{S_x}\left\{E_y(same)\left[\frac{\overline{|\dot{x}|}}{2\lambda_x}+\frac{\overline{|\dot{y}(S_y)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]+E_y(opp)\left[\frac{\overline{V}}{\lambda_x}+\frac{\overline{|\dot{y}(S_y)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]\right\}$$

3.2.2 The mathematical formula of the longitudinal collision risk model used in assessing the safety of operations on the South China Sea RNAV routes:

$$CR(t_0,t_1) = 2NP\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{t_0}^{t_1} HOP(t|V_1,V_2)P_z(h_z)\left(\frac{2V_{rel}}{\pi\lambda_{xy}}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right)f_1(V_1)f_2(V_2)dt\,dV_1\,dV_2$$

3.2.3 The component HOP(t) represents the probability of the pair of aircraft having a horizontal overlap during a given time interval given the speeds of the pair of aircraft. It is based on reliability theory and is evaluated in terms of multiple integrals of the probability density functions for the along and cross track position errors of each aircraft and is stated in [Reference 1] as:

$$HOP(t|V_1V_2) = \frac{\pi\lambda_{xy}^2}{16\lambda^2}e^{-|D_x(t)|/\lambda}\left(\frac{|D_x(t)|}{\lambda}+1\right)$$

3.2.4 The South China Sea route system comprises of four unidirectional non intersecting parallel routes. Thus longitudinal risk assessment will only consider the case of same identical track.

3.2.5 **Table 5** summarizes the value and source material for estimating the values for each of the inherent parameters of the internationally accepted Collision Risk Model (CRM).

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
For Lateral Collision Risk Model			
N_{ay}	Risk of collision between two aircraft with planned 50NM lateral separation	5.0 x 10^{-9} fatal accidents per flight hour	TLS adopted by APANPIRG for changes in separation minima
S_y	Lateral separation minimum	50NM	Current lateral separation minimum in the South China Sea
$P_y(50)$	Probability that two aircraft assigned to parallel routes with 50NM lateral separation will lose all planned lateral separation	2.02 x 10^{-9}	Value required to meet exactly the APANPIRG-agreed TLS value using equation (1), given other parameter values shown in this table.
λ_x	Aircraft length	0.0363NM	Based on December 2015 TSD
λ_y	Aircraft wingspan	0.0350NM	
λ_z	Aircraft height	0.0099NM	
$P_z(0)$	Probability of vertical overlap for airplanes assigned to the same flight level	0.538	Commonly used in safety assessments
S_x	Length of half the interval, in NM, used to count proximate aircraft at adjacent fix for occupancy estimates	120NM, equivalent to the +/- 15-minute pairing criterion	Arbitrary criterion which does not affect the estimated value of lateral collision risk
$E_y(same)$	Same-direction lateral	0.0	Result of direction of

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
	occupancy		traffic flows on each pair of RNAV routes
$E_y(opp)$	Opposite-direction lateral occupancy	0.21207	Based on December 2015 TSD
$\overline{V}$	Individual-aircraft along-track speed	505 knots	Based on December 2015 TSD
$\overline{\lvert\dot{y}(S_y)\rvert}$	Average relative lateral speed of aircraft pair at loss of planned lateral separation of S_y	75 knots	Conservative value based on assumption of waypoint insertion error
$\lvert\dot{z}\rvert$	Average relative vertical speed of a co altitude aircraft pair assigned to the same route	1.5 knots	Conservative value commonly used in safety assessments
For Longitudinal Collision Risk Model			
V_1	Average ground speed of a/c 1	480knots	Reference 1
V_2	Average ground speed of a/c 2	480knots	Reference 1
λ_{xy}	Average aircraft wingspan or length (whichever is greater)	0.0363NM	Based on December 2015 TSD
λ_z	Aircraft height	0.00101NM	Based on December 2015 TSD
λ_v	Scale factor for speed error distribution	5.82	Reference 1
T	ADS periodic report	27mins	ICAO Doc 4444
NP	No. of a/c per hour	1	Reference 1
$P_z(0)$	Probability of vertical overlap for airplanes assigned to the same flight level	0.538	Commonly used in safety assessments
$\overline{\lvert\dot{z}\rvert}$	Average relative vertical speed of a co altitude aircraft pair assigned to the same route	1.5knots	Commonly used in safety assessments
τ	controller intervention buffer	3 cases	Reference 1

Table 5: Summary of Risk Model Parameters Used in the Lateral CRM

3.2.6 **Table 6** shows the summary of the three cases of Controller intervention buffer (τ) [reference 1 and 2] used in the computation of the longitudinal risk. **Tables 7 - 9** present the detailed component of each of the cases as used in Reference 1 & 2. The final collision risk is also stated as:

$$0.95\times(0.95\times CR(\tau=4)+0.05\times CR(\tau=10.5))+0.05\times CR(\tau=13.5)$$

τ	Minutes
Case 1: Normal ADS ops	4
Case 2: ADS report received & response to CPDLC uplink NOT received in 3 mins	10.5
Case 3: ADS periodic reports takes more than 3 mins	13.5

Table 6: 3 cases of τ

Case 1: normal ADS ops	Seconds
Screen update time/controller conflict recognition	30
Controller message composition	15
CPDLC uplink	90
Pilot reaction	30
Aircraft inertia plus climb	75
Total	240

Table 7: Case 1

Case 2: ADS report received & response to CPDLC uplink NOT received in 3 mins	Seconds
Screen update time/controller conflict recognition	30
Controller message composition	15
CPDLC uplink and wait for response	180
HF communication	300
Pilot reaction	30
Aircraft inertia plus climb	75
Total	630

Table 8: Case 2

Case 3: ADS periodic reports takes more than 3 mins	Seconds
Controller wait for ADS report	180
Controller message composition	15
CPDLC uplink & wait for response	180
HF communication	300
Pilot reaction	30
Aircraft inertia plus climb	75
Extra allowance	30
Total	810

Table 9: Case 3

4 Safety Oversight

4.1 **Table 10** summarizes the results of the airspace oversight, as of December 2015.

Type of Risk	Risk Estimation	TLS	Remarks
Lateral Risk	0.66 x 10^{-9}	5 x 10^{-9}	Below TLS
Longitudinal Risk	0.38 x 10^{-9}	5 x 10^{-9}	Below TLS

Table 10: Lateral and Longitudinal Risk Estimation

4.2 **Figure 1** presents the results of the collision risk estimates for each month using the cumulative 12-month LLD and LLE reports since January 2015.

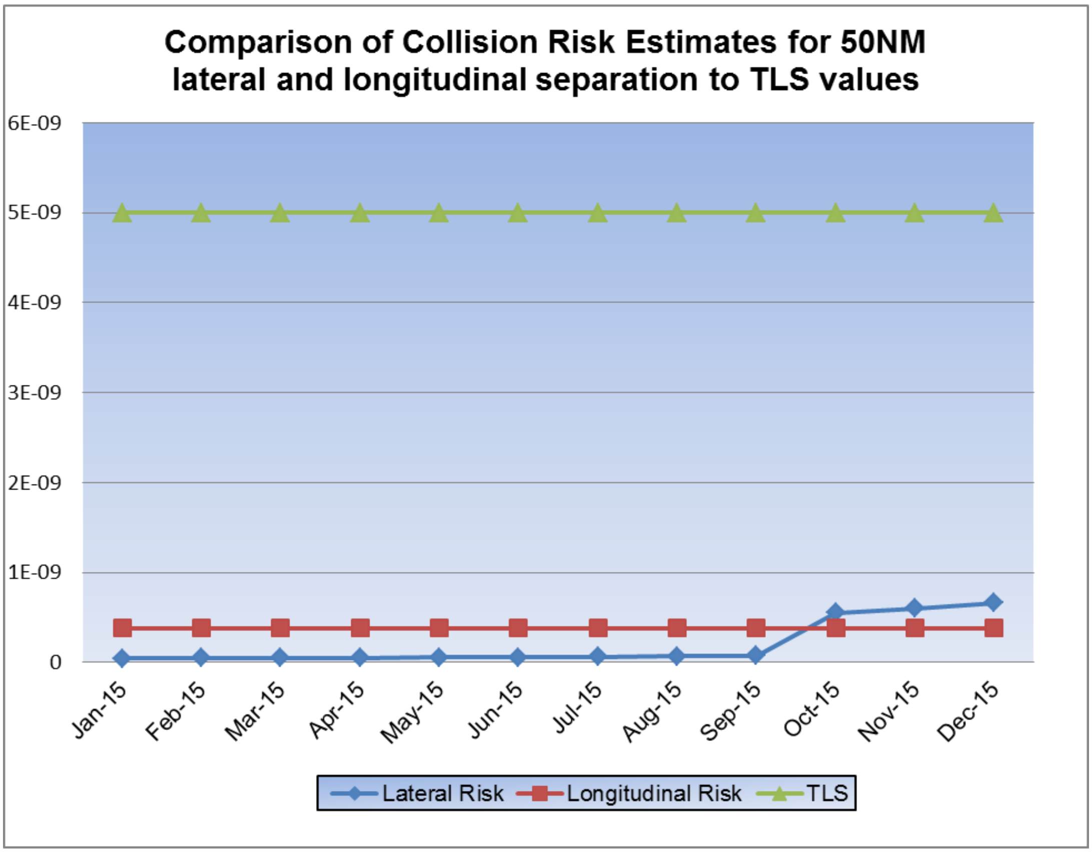

Figure 1 - Assessment of Compliance with Lateral and Longitudinal TLS Values based on Navigational Performance Observed during the South China Monitoring Program

4.3 The estimates of lateral and longitudinal risk show compliance with the corresponding respective TLS values during all months of the monitoring period.

References

1. Anderson, D., “A collision risk model based on reliability theory that allows for unequal RNP navigational accuracy” ICAO SASP-WG/WHL/7-WP/20, Montreal, Canada, May 2005.

2. PARMO, “Safety Assessment to support use of the 50-NM Longitudinal, 30-NM Lateral and 30-NM Longitudinal Separation Standards in New York Oceanic Airspace.” Attachment to MAWG/1 WP/2, Honolulu, USA, Dec 2013.