



ICAO

International Civil Aviation Organization
**Twenty-Fifth Meeting of the Regional Airspace Safety
Monitoring Advisory Group (RASMAG/25)**
Video Teleconference, 27 - 30 October 2020

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 2019 to 31 December 2019. 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

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 Target Level of Safety (TLS) values for lateral and longitudinal separation standards. The assessment period covered is from 1 January 2019 to 31 December 2019.

2. DISCUSSION

Executive Summary

2.1 **Table 1** provides the South China Sea airspace horizontal risk estimates. **Figure 1** presents the lateral and longitudinal collision risk estimate trends for South China Sea airspace during the assessment period January 2019 until December 2019.

South China Sea Airspace – estimated annual flying hours = 80,299 hours (note: estimated hours based on December 2019 traffic sample data)			
Risk	Risk Estimation	TLS	Remarks
RASMAG 24 Lateral Risk	0.37×10^{-9}	5.0×10^{-9}	Below TLS
RASMAG 24 Longitudinal Risk	0.38×10^{-9}	5.0×10^{-9}	Below TLS
Lateral Risk	0.012×10^{-9}	5.0×10^{-9}	Below TLS
Lateral Risk	0.38×10^{-9}	5.0×10^{-9}	Below TLS

Table 1: South China Sea Airspace Horizontal Risk Estimates

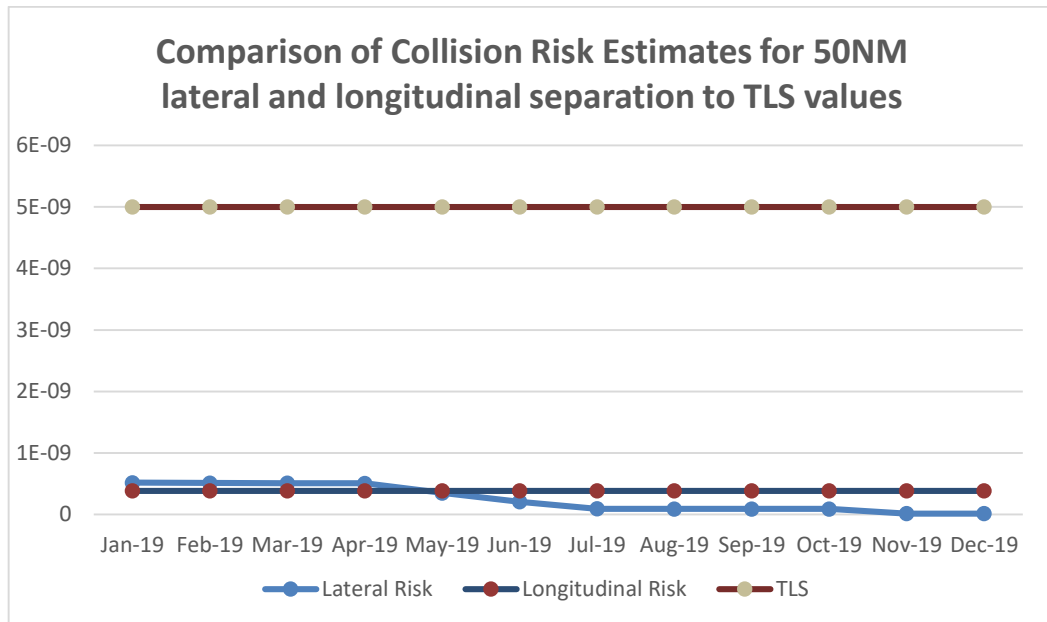


Figure 1: South China Sea Airspace Horizontal Risk Estimates

2.2 Figure 2 provides the geographical location of Non-zero duration Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) within the South China Sea Airspace.

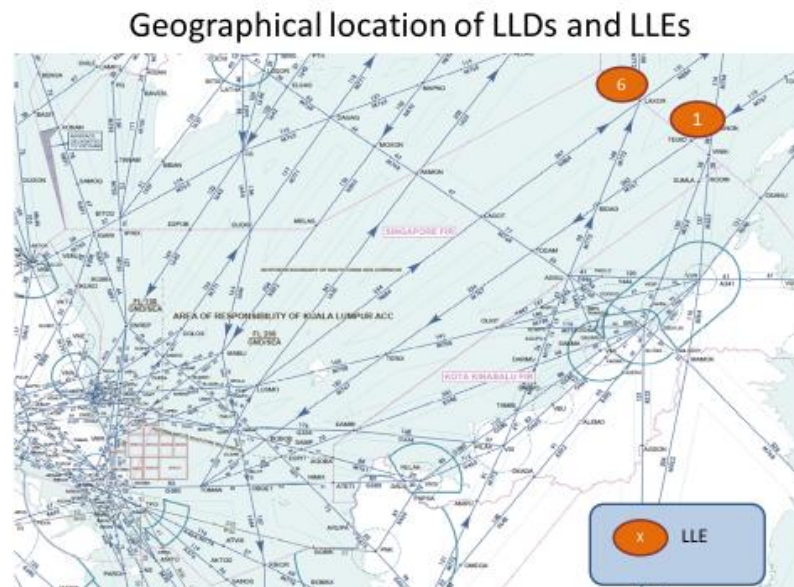


Figure 2: Geographical location of LLDs and LLEs within South China Sea Airspace

2.3 Table 2 contains a summary of LLDs and LLEs received by SEASMA for South China Sea airspace.

Deviation Code	Cause of Deviation	LLDs	Non-zero duration LLDs	LLEs	Non-zero duration LLEs
A	Flight crew deviate without ATC Clearance in the horizontal dimension	0	0	0	0
B	Incorrect estimate or route provide due to incorrect operations or	0	0	1	1

	interpretation of airborne equipment				
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position;	0	0	0	0
D	ATC system loop error (e.g. ATC issues incorrect clearance, Flight crew misunderstands clearance message etc);	0	0	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues	0	0	2	2
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	0	0	4	4
G	Navigation errors due to airborne equipment failure leading to deviation in the Horizontal dimension of which notification was not received by ATC or notified too late for action	0	0	0	0
H	Turbulence or other weather related causes (other than approved);	0	0	0	0
I	Aircraft provided with RHS but did not meet the RNP/RSP/RCP specifications	0	0	0	0
J	Others	0	0	0	0
Total		0	0	7	7

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

2.4 The lateral risk within the South China Sea Airspace has reduced from 0.52×10^{-9} in 2018 to 0.012×10^{-9} in 2019 due to zero LLD occurrence between January to December 2019. The number of LLEs has reduced from 19 in 2018 to 7 in 2019. However, the reduction in the number of LLEs did not reflect any noticeable fluctuations in the longitudinal risk due to the nature of the risk calculation. The various mitigating measures implemented by the States have contributed to the reduction in numbers of errors.

2.5 CAT ‘F’ has replaced CAT ‘E’ LLEs as the top category along the Manila - Singapore FIR boundary. This shift can be attributed to the implementation of Air Traffic Services Inter-facility Data Communication (AIDC) between the two ANSPs which contributed to the reduction of existing CAT ‘E’ errors.

2.6 It is recognised that the continual safety promotion, procedures review and system improvement have positively contributed to the reduction of these errors.

2.7 SEASMA would continue to monitor for any new errors and introduce improvements to maintain the safe performance over the South China Sea airspace.

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 lateral and longitudinal TLS; and
- b) discuss any relevant matters as appropriate.

.....

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:

- i) Air Traffic Service routes L625, N884 and M767 are 50NM lateral separation and 50NM longitudinal separation.
- ii) Air Traffic Service routes L642, M771 and N892 are 40NM lateral separation and 20NM longitudinal separation with ADS-B coverage.

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 to December 2019 is shown in **Table 1**.

Month	Report Received from:		
	Hong Kong, China	Philippines	Singapore
January 2019	Yes	Yes	Yes
February 2019	Yes	Yes	Yes
March 2019	Yes	Yes	Yes
April 2019	Yes	Yes	Yes
May 2019	Yes	Yes	Yes
June 2019	Yes	Yes	Yes
July 2019	Yes	Yes	Yes
August 2019	Yes	Yes	Yes
September 2019	Yes	Yes	Yes
October 2019	Yes	Yes	Yes
November 2019	Yes	Yes	Yes
December 2019	Yes	Yes	Yes

Table 1: Record of ANSP Reporting by Month for Period January 2019 to December 2019

2.2 **Table 2** presents the total traffic counts reported by month transiting all South China Sea monitoring fixes for the period January to December 2019.

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
January 2019	8196	8196
February 2019	7801	15997
March 2019	8062	24059
April 2019	7853	31912
May 2019	8320	40232
June 2019	7835	48067
July 2019	8113	56180
August 2019	8139	64319
September 2019	7973	72292
October 2019	8428	80720
November 2019	7756	88476

December 2019	8276	96752
---------------	------	-------

Table 2: Monthly Count of Monitored Flights Operating on the South China Sea RNAV routes for the period January to December 2019

2.3 **Table 3** presents the cumulative totals of Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period January 2019 to December 2019.

Monitoring Month	Monthly Count of LLDs Reported Over Monitored Fixes	Cumulative 12-Month Count of LLDs Reported Over Monitored Fixes	Monthly Count of LLEs Reported Over Monitored Fixes	Cumulative 12-Month Count of LLEs Reported Over Monitored Fixes
January 2019	0	0	0	0
February 2019	0	0	0	0
March 2019	0	0	1	1
April 2019	0	0	0	1
May 2019	0	0	2	3
June 2019	0	0	0	3
July 2019	0	0	2	5
August 2019	0	0	1	6
September 2019	0	0	0	6
October 2019	0	0	0	6
November 2019	0	0	0	6
December 2019	0	0	1	7

Table 3: Monthly Count of LLDs and LLEs reported on the South China Sea RNAV routes for the period January to December 2019

2.4 **Table 4** presents the cumulative totals of Non-zero duration Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period January to December 2019.

Monitoring Month	Monthly Count of Non-zero duration LLDs Reported Over Monitored Fixes	Cumulative 12-Month Count of Non-zero duration LLDs Reported Over Monitored Fixes	Monthly Count of Non-zero duration LLEs Reported Over Monitored Fixes	Cumulative 12-Month Count of Non-zero duration LLEs Reported Over Monitored Fixes
January 2019	0	0	0	0
February 2019	0	0	0	0
March 2019	0	0	1	1
April 2019	0	0	0	1
May 2019	0	0	2	3
June 2019	0	0	0	3
July 2019	0	0	2	5
August 2019	0	0	1	6
September 2019	0	0	0	6
October 2019	0	0	0	6
November 2019	0	0	0	6
December 2019	0	0	1	7

Table 4: Monthly Count of Non-zero duration LLDs and LLEs reported on the South China Sea RNAV routes for the period January to December 2019

2.5 **Table 5** presents the causes of deviation in the LLE and LLD reports received for the period January to December 2019.

Deviation Code	Cause of Deviation	LLDs	Non-zero duration LLDs	LLEs	Non-zero duration LLEs
A	Flight crew deviate without ATC Clearance in the horizontal dimension	0	0	0	0
B	Incorrect estimate or route provide due to incorrect operations or interpretation of airborne equipment	0	0	1	1
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position;	0	0	0	0
D	ATC system loop error (e.g. ATC issues incorrect clearance, Flight crew misunderstands clearance message etc);	0	0	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues	0	0	2	2
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	0	0	4	4
G	Navigation errors due to airborne equipment failure leading to deviation in the Horizontal dimension of which notification was not received by ATC or notified too late for action	0	0	0	0
H	Turbulence or other weather related causes (other than approved);	0	0	0	0
I	Aircraft provided with RHS but did not meet the RNP/RSP/RCP specifications	0	0	0	0
J	Others	0	0	0	0
Total		0	0	7	7

Table 5: Causes of LLE & LLD 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:

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

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:

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

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:

$$HOP(t|V_1, V_2) = \frac{\pi\lambda_{xy}^2}{16\lambda^2} e^{-|D_x(t)|/\lambda} \left(\frac{|D_x(t)|}{\lambda} + 1 \right)$$

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

3.2.5 **Table 6** 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	0.04 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	0.0399NM	Based on December 2019 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	120NM, equivalent	Arbitrary criterion which

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
	NM, used to count proximate aircraft at adjacent fix for occupancy estimates	to the +/- 15-minute pairing criterion	does not affect the estimated value of lateral collision risk
$E_y(\text{same})$	Same-direction lateral occupancy	0.0	Result of direction of traffic flows on each pair of RNAV routes
$E_y(\text{opp})$	Opposite-direction lateral occupancy	0.124	Based on December 2019 TSD
\bar{V}	Individual-aircraft along-track speed	489.9 knots	Based on December 2019 TSD
$ \bar{y}(S_y) $	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
$ \bar{z} $	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	497knots	Based on December 2019 TSD
V_2	Average ground speed of a/c 2	497knots	Based on December 2019 TSD
λ_{xy}	Average aircraft wingspan or length (whichever is greater)	0.0363NM	Based on December 2019 TSD
λ_z	Aircraft height	0.00101NM	Based on December 2019 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
$ \bar{z} $	Average relative vertical speed of a co altitude aircraft pair assigned to the same route	1 knot	Commonly used in safety assessments
τ	controller intervention buffer	3 cases	Reference 1

Table 6: Summary of Risk Model Parameters Used in the Lateral CRM

3.2.6 **Table 7** 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 8 - 10** 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 within 3 mins	10.5
Case 3: ADS periodic reports takes more than 3 mins	13.5

Table 7: 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 8: Case 1

Case 2: ADS report received & response to CPDLC uplink NOT received within 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 9: 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 10: Case 3

4 Safety Oversight

4.1 **Table 11** summarizes the results of the airspace oversight, as of December 2019.

Type of Risk	Risk Estimation	TLS	Remarks
Lateral Risk	0.012 x 10 ⁻⁹	5 x 10 ⁻⁹	Below TLS
Longitudinal Risk	0.38 x 10 ⁻⁹	5 x 10 ⁻⁹	Below TLS

Table 11: 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 2019.

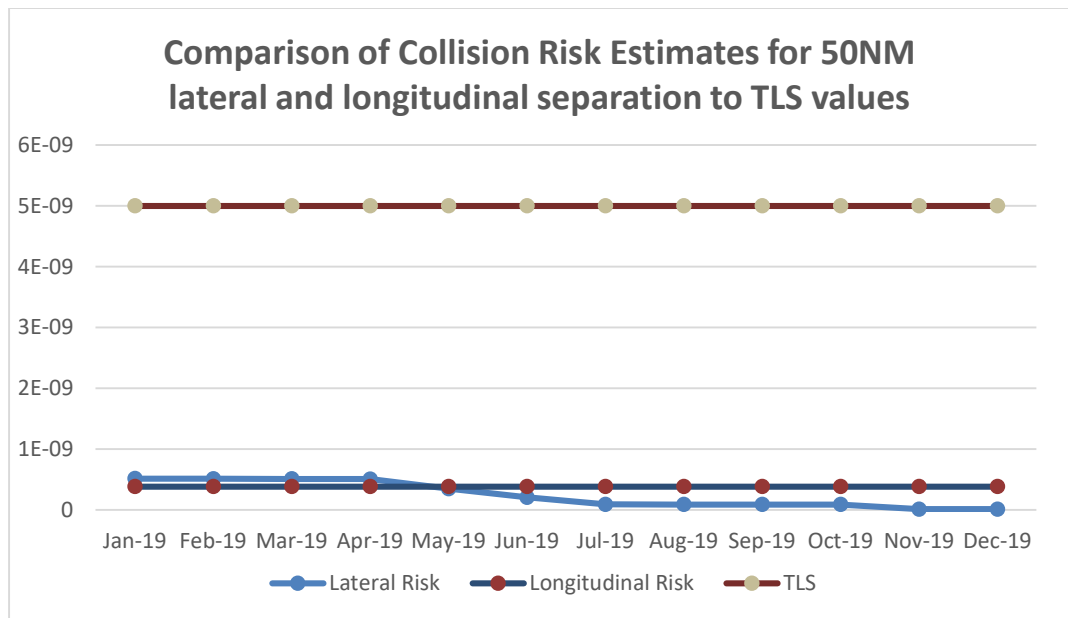


Figure 1 - Assessment of Compliance with Lateral and Longitudinal TLS Values based on Navigational Performance Observed during the South China Monitoring Program

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.