International Civil Aviation Organization

Thirty-First Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/31)

Bangkok, Thailand, 29 June – 03 July 2026

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

SEASMA HORIZONTAL SAFETY REPORT

(Presented by SEASMA)

SUMMARY

This paper presents the horizontal safety assessment report by the Southeast Asia Safety Monitoring Agency (SEASMA) for operations on Air Traffic Service (ATS) routes N892, L625, N884 and M767 over the South China Sea for the period 1 January to 31 December 2025.

This paper relates to **Strategic Objectives:**
***Safety** – Enhance global civil aviation safety*

1. INTRODUCTION

1.1 This paper presents the safety assessment to evaluate whether flight operations on ATS routes N892, L625, N884 and M767 over the South China Sea meet the Target Level of Safety (TLS) values for lateral and longitudinal separation standards applicable for RNP 10 and RNP 4 operations for the period 1 January to 31 December 2025.

1.2 ATS Routes M767 and N884 support a hybrid mode of RNP 4 and RNP 10 operations. The lateral and longitudinal safety assessment for RNP 4 operations presented in this paper therefore applies only to these two ATS routes.

2. DISCUSSION

Executive Summary

2.1 **Table 1** below provides the horizontal risk estimates for the airspace over the South China Sea, while **Figure 1** presents the horizontal collision risk estimate trends in the same airspace for the assessment period.

Table 1. Horizontal Risk Estimates

Airspace over the South China Sea – estimated annual flying hours = 54,752 hours ***(note: estimated hours based on December 2025 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
Lateral Risk (RNP 10)	**0.156×10^{-9}**	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 10)	**0.375×10^{-9}**	5.0×10^{-9}	**Meets TLS**
Lateral Risk (RNP 4)	**0.199×10^{-9}**	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 4)	**0.786×10^{-9}**	5.0×10^{-9}	**Meets TLS**

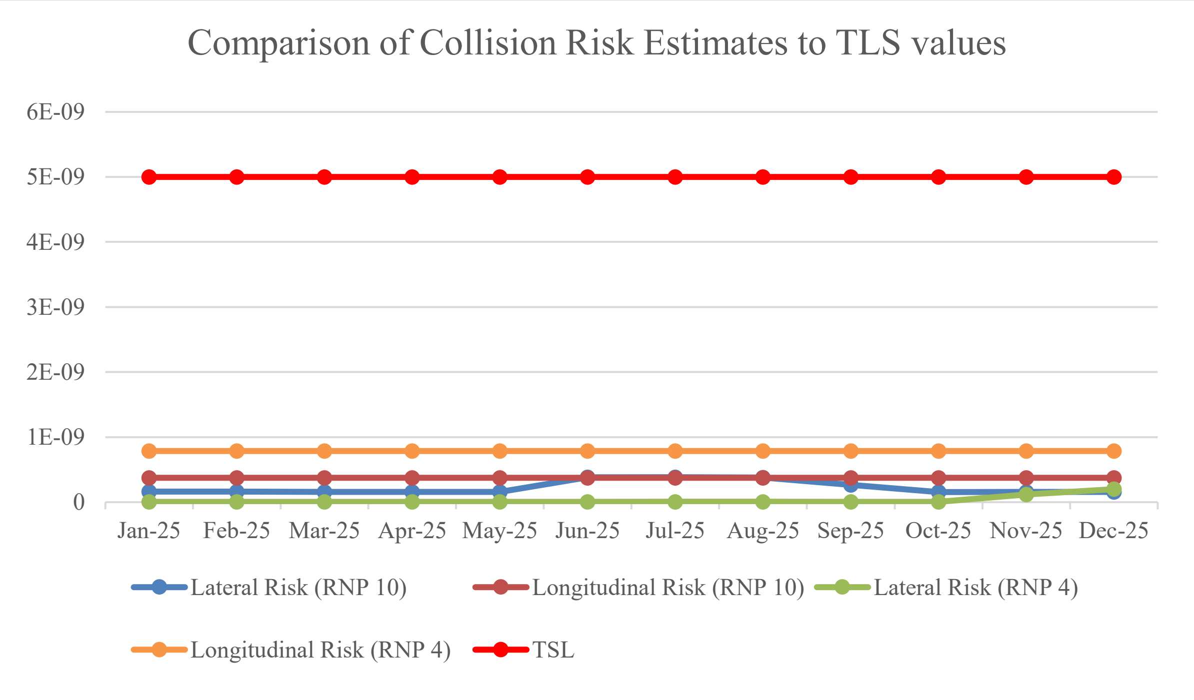

Figure 1. Horizontal Collision Risk Estimates Trends

2.2 **Table 2** contains a summary of Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) received by SEASMA for the airspace over South China Sea in CY2024 and CY2025.

Table 2. Summary of LLD and LLE Reports

Deviation Code	Cause of Deviation	CY 2024		CY 2025	
		No. of LLDs	No. of LLEs	No. of LLDs	No. of LLEs
A	Flight crew deviate without ATC Clearance in the horizontal dimension	0	0	4	0
B	Incorrect estimate or route provided due to incorrect operations or interpretation of airborne equipment	0	0	0	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 route clearance, Flight crew misunderstands route 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	2	1	1	0
F	Coordination errors in the ATC-to-ATC transfer of control	0	0	0	0

Deviation Code	Cause of Deviation	CY 2024		CY 2025	
		No. of LLDs	No. of LLEs	No. of LLDs	No. of LLEs
	responsibility as a result of equipment outage or technical issues				
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) leading to a deviation in the horizontal dimension	0	0	0	0
I	Aircraft provided with reduced horizontal separation minima but did not meet the RNP/RSP/RCP specifications	0	0	0	0
J	Others	0	0	0	0
R	GNSS RFI	0	0	0	0
Total		2	1	5	1

2.3 The number of LLDs increased from 2 in CY2024 to 5 in CY2025, while LLE occurrences remained at one. Most LLDs in CY2025 were classified as Category 'A', due to flight crew deviations without ATC clearance. Analysis of the Category A occurrences indicated that weather avoidance operations were a contributing factor in several events, while the remaining occurrences involved deviations exceeding approved limits or deviations initiated prior to the issuance of the required ATC clearance.

2.4 In contrast, all LLDs and LLEs recorded in CY2024 were classified as Category 'E', due to coordination errors during ATC-to-ATC transfer of control arising from human factors issues. In CY2025, only one Category 'E' deviation was recorded, which may be attributable to increased controller awareness.

2.5 Despite the increase in LLD occurrences, the overall number of LLDs and LLEs in the region remained low, reflecting continued effective collaboration among the responsible ANSPs in maintaining safe and efficient operations.

2.6 SEASMA will continue to monitor for any new and emerging trends, and will recommend improvements to ensure the safety of flight operations over the South China Sea.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the performance of flights on the ATS routes N892, L625, N884 and M767 over the South China Sea are compliant with the lateral and longitudinal TLS; and

b) discuss any relevant matters as appropriate.

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APPENDIX A

SEASMA SAFETY REPORT FOR THE ATS ROUTES OVER THE SOUTH CHINA SEA

1. Background

1.1 The lateral and longitudinal separation standards applied on ATS routes over the South China Sea are:

i) ATS Routes M767 and N884 support a hybrid mode of operations. 50NM lateral and longitudinal separation for RNP 10 compliant aircraft or 30NM lateral and longitudinal separation for RNP 4 compliant aircraft.

ii) ATS Route L625 is 50NM lateral separation and 10 minutes time-based longitudinal separation when applying Mach Number Technique (MNT) between RNAV-equipped aircraft.

1.2 ATS Route N892 will continue to be monitored and assessed as it is part of the route pair with ATS 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 1 January to 31 December 2025 is shown in **Table 1**.

Month	Report Received from:		
	Hong Kong, China	Philippines	Singapore
January 2025	Yes	Yes	Yes
February 2025	Yes	Yes	Yes
March 2025	Yes	Yes	Yes
April 2025	Yes	Yes	Yes
May 2025	Yes	Yes	Yes
June 2025	Yes	Yes	Yes
July 2025	Yes	Yes	Yes
August 2025	Yes	Yes	Yes
September 2025	Yes	Yes	Yes
October 2025	Yes	Yes	Yes
November 2025	Yes	Yes	Yes
December 2025	Yes	Yes	Yes

Table 1: Record of ANSP reporting by month for period from 1 January to 31 December 2025

2.2 **Table 2** presents the reported total monthly traffic counts transiting monitoring fixes over the South China Sea for the period 1 January to 31 December 2025.

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
January 2025	6972	6972
February 2025	6336	13308
March 2025	6885	20193
April 2025	6564	26757
May 2025	6681	33438
June 2025	6473	39911
July 2025	6354	46265
August 2025	6792	53057
September 2025	6429	59486
October 2025	7142	66628

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
November 2025	6133	72761
December 2025	7323	80084

Table 2: Monthly count of monitored flights operating on the ATS routes for the period from 1 January to 31 December 2025

2.3 **Table 3** presents the cumulative totals of Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period 1 January to 31 December 2025.

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 2025	0	2	0	1
February 2025	0	2	0	1
March 2025	0	2	0	1
April 2025	0	2	0	1
May 2025	0	2	0	1
June 2025	2	4	1	2
July 2025	0	4	0	2
August 2025	0	4	0	1
September 2025	0	3	0	1
October 2025	0	2	0	1
November 2025	2	4	0	1
December 2025	1	5	0	1

Table 3: Monthly count of LLDs and LLEs reported on the ATS routes for the period from 1 January to 31 December 2025

2.4 **Table 4** presents the cumulative totals of risk bearing Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period 1 January to 31 December 2025.

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 2025	0	2	0	0
February 2025	0	2	0	0
March 2025	0	2	0	0
April 2025	0	2	0	0
May 2025	0	2	0	0
June 2025	2	4	1	1
July 2025	0	4	0	1
August 2025	0	4	0	1
September 2025	0	3	0	1
October 2025	0	2	0	1
November 2025	2	4	0	1
December 2025	1	5	0	1

Table 4: Monthly Count of LLDs and LLEs reported on the ATS routes for the period from 1 January to 31 December 2025

2.5 **Table 5** presents the causes of deviation in the LLE and LLD reports received for the period 1 January to 31 December 2025.

Deviation Code	Cause of Deviation	No. of LLDs	No. of LLEs
A	Flight crew deviate without ATC Clearance in the horizontal dimension	4	0
B	Incorrect estimate or route provided due to incorrect operations or interpretation of airborne equipment	0	1
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position	0	0
D	ATC system loop error (e.g. ATC issues incorrect route clearance, Flight crew misunderstands route clearance message, etc.)	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues	1	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	0	0
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
H	Turbulence or other weather-related causes (other than approved) leading to a deviation in the horizontal dimension	0	0
I	Aircraft provided with reduced horizontal separation minima but did not meet the RNP/RSP/RCP specifications	0	0
J	Others	0	0
R	GNSS RFI	0	0
Total		5	1

Table 5: Causes of LLE and LLD deviation for the period from 1 January to 31 December 2025

3. Risk Assessment

3.1 This section presents the results of safety oversight on the lateral and longitudinal separations standards applied on the ATS route structure over the South China Sea. The analysis techniques used are in conformance with the internationally applied collision risk methodology.

3.2 Estimate of the Collision Risk Model (CRM) Parameters

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

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

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

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

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 ATS routes structure over the South China Sea comprises 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 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 (RNP 10)	Lateral separation minimum for RNP 10 operation	50NM	Current lateral separation minimum over the South China Sea for RNP 10 operation
S_y (RNP 4)	Lateral separation minimum for RNP 4 operation	30NM	Current lateral separation minimum over the South China Sea for RNP 4 operation
λ_x	Aircraft length	0.0399NM	Based on December 2025 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 occupancy	0.0	Result of direction of traffic flows on each pair of RNP routes

Model Parameter	**Definition**	**Value Used in TLS Compliance Assessment**	**Source for Value**
$E_y(opp)$	Opposite-direction lateral occupancy	0.097	Based on December 2025 TSD
$\overline{V}$ (RNP 10)	Individual-aircraft along-track speed on RNP 10 routes	507.0 knots	Based on December 2025 TSD
$\overline{V}$ (RNP 4)	Individual-aircraft along-track speed on RNP 4 routes	508.3 knots	Based on December 2025 TSD
$\lvert\bar{\dot{y}}(S_y)\rvert$	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
$\lvert\bar{\dot{z}}\rvert$	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 (RNP 10)	Average ground speed of a/c 1 on RNP 10 routes	507.0 knots	Based on December 2025 TSD
V_2 (RNP 10)	Average ground speed of a/c 2 on RNP 10 routes	507.0 knots	Based on December 2025 TSD
V_1 (RNP 4)	Average ground speed of a/c 1 on RNP 4 routes	495.8 knots	Based on December 2025 TSD
V_2 (RNP 4)	Average ground speed of a/c 2 on RNP 4 routes	495.8 knots	Based on December 2025 TSD
λ_{xy}	Average aircraft wingspan or length (whichever is greater)	0.0363NM	Based on December 2025 TSD
λ_z	Aircraft height	0.00101NM	Based on December 2025 TSD
λ_v	Scale factor for speed error distribution	5.82	Reference 1
T (RNP 10)	ADS periodic report for RNP 10 compliant aircraft	27mins	ICAO Doc 4444
T (RNP 4)	ADS periodic report for RNP 4 compliant aircraft	10mins	Based on Singapore FIR
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 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 take 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 airspace oversight as of 31 December 2025.

Type of Risk	Risk Estimation	TLS	Remarks
Lateral Risk (RNP 10)	0.156×10^{-9}	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 10)	0.375×10^{-9}	5.0×10^{-9}	**Meets TLS**
Lateral Risk (RNP 4)	0.199×10^{-9}	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 4)	0.786×10^{-9}	5.0×10^{-9}	**Meets 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 from 1 January to 31 December 2025.

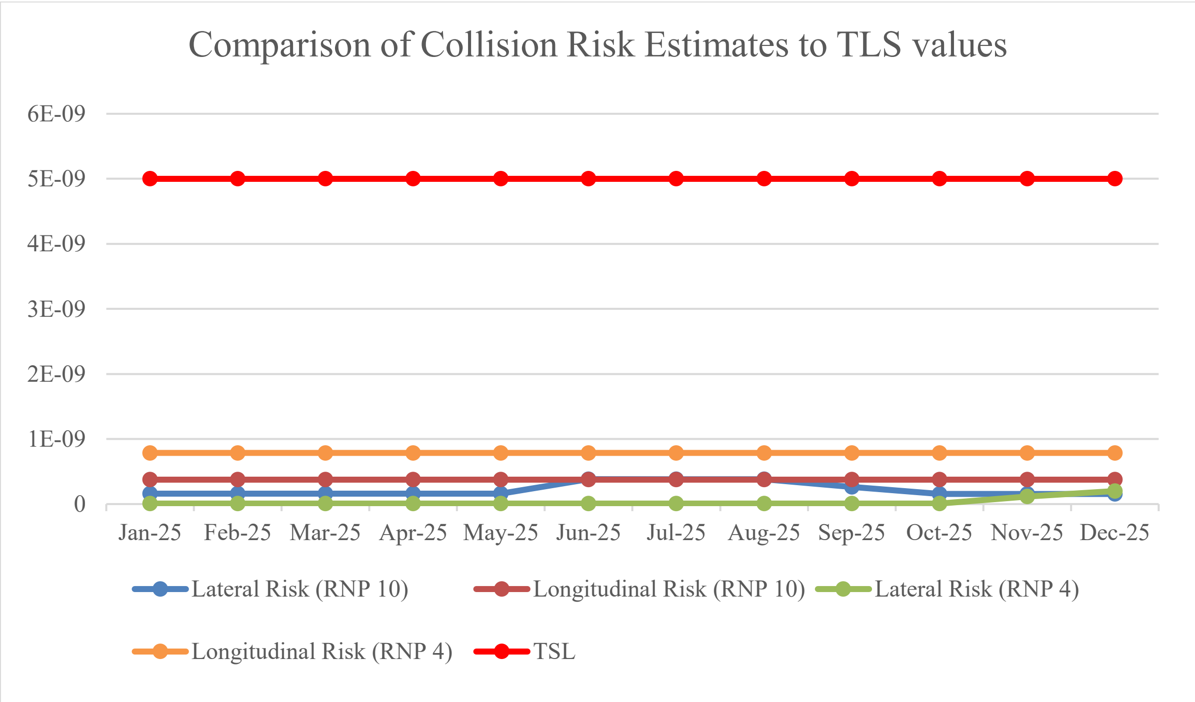

Figure 1 - Assessment of Compliance with Lateral and Longitudinal TLS Values based on Navigational Performance Observed during the South China Monitoring Program

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.

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