International Civil Aviation Organization

Twenty-Ninth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/29)

Bangkok, Thailand, 19 – 22 August 2024

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 from 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 2023. This assessment is based on RNP 10 and RNP 4 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 paper presents the periodic assessment to ascertain that flight operations on Air Traffic Service (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. The assessment period covered is from 1 January to 31 December 2023.

1.2. ATS routes M767 and N884 support a hybrid mode of RNP 4 and RNP 10 operations. The lateral and longitudinal collision risk estimate trends for RNP 4 operation presented in this paper is the risk assessment of these two ATS routes.

2. DISCUSSION

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 = 52,044 hours (note: estimated hours based on December 2023 traffic sample data)			
Risk	**Risk Estimation**	**TLS**	**Remarks**
Lateral Risk (RNP 10)	**0.569×10^{-9}**	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 10)	**0.384×10^{-9}**	5.0×10^{-9}	**Meets TLS**
Lateral Risk (RNP 4)	**0.123×10^{-9}**	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 4)	**0.786×10^{-9}**	5.0×10^{-9}	**Meets TLS**

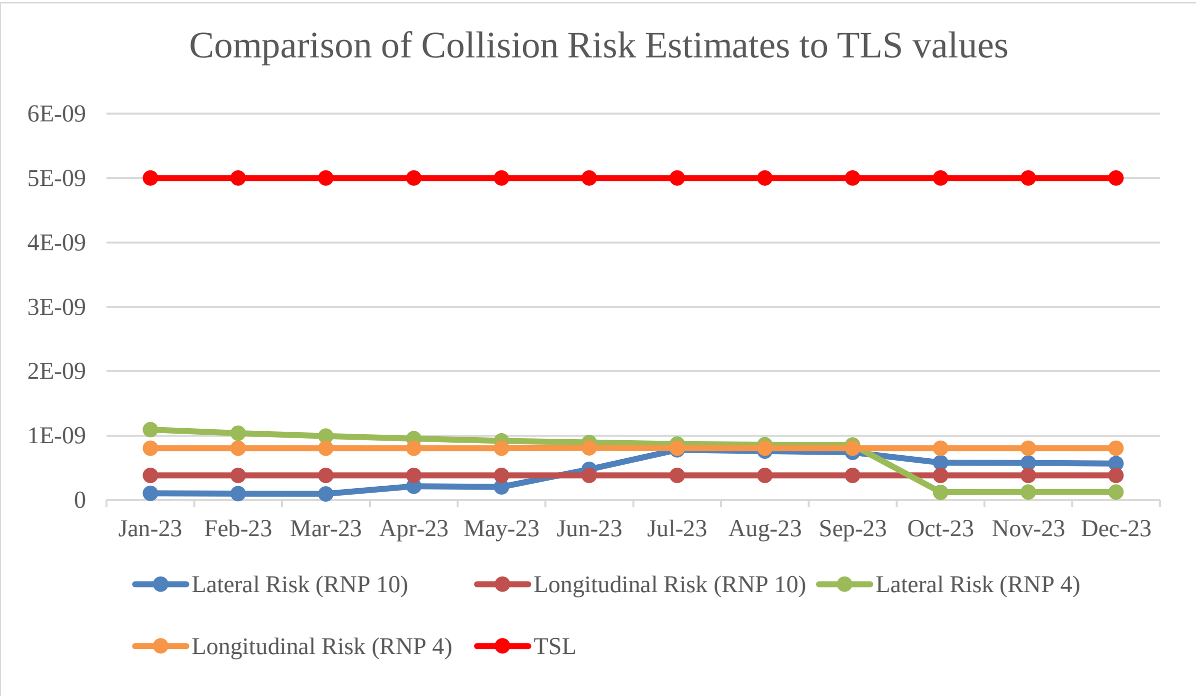


Figure 1: Horizontal Collision Risk Estimates Trends

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 CY2022 and CY2023.

Table 2: Summary of LLD and LLE Reports

Deviation Code	**Cause of Deviation**	**CY 2022**		**CY 2023**	
		No. of LLDs	**No. of LLEs**	**No. of LLDs**	**No. of LLEs**
A	Flight crew deviate without ATC Clearance in the horizontal dimension	1	0	5	0
B	Incorrect estimate or route provide due to incorrect operations or interpretation of airborne equipment	0	0	0	1

Deviation Code	Cause of Deviation	CY 2022		CY 2023	
		No. of LLDs	No. of LLEs	No. of LLDs	No. of LLEs
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	0	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues	0	0	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	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		1	0	5	1

2.3 The number of LLDs increased from one in CY2022 to five in CY2023, while LLEs increased from zero in CY2022 to one in CY2023. All LLDs reported in CY2023 were categorized as Category ‘A’ LLDs, where the flight crew deviated in the horizontal dimension without receiving ATC clearance. The LLE reported in CY2023 was a Category ‘B’ LLE, attributed to an incorrect estimate provided by the flight crew.

2.4 The lateral and longitudinal risk within the airspace over South China Sea remained low, indicating that the continued efforts of the responsible ANSPs were effective in ensuring safe and efficient operations.

2.5 SEASMA would continue to monitor for any new and emerging trends, and would recommend improvements to ensure the safe performance for the airspace 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.

…………………………….

Appendix: 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 N884 and M767 are 50NM lateral separation and 50NM longitudinal separation.

ii) ATS routes L642, M771 and N892 are 50NM lateral separation and 20NM longitudinal separation with ADS-B coverage.

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

1.3 For ATS routes N884 and M767, 30NM lateral separation and 30NM longitudinal separation minima can be applied to RNP 4 compliant aircraft.

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 2023 is shown in **Table 1**.

Table 1: Record of ANSP reporting by month for period from 1 January to 31 December 2023

Month	Report Received from:		
	Hong Kong, China	Philippines	Singapore
January 2023	Yes	Yes	Yes
February 2023	Yes	Yes	Yes
March 2023	Yes	Yes	Yes
April 2023	Yes	Yes	Yes
May 2023	Yes	Yes	Yes
June 2023	Yes	Yes	Yes
July 2023	Yes	Yes	Yes
August 2023	Yes	Yes	Yes
September 2023	Yes	Yes	Yes
October 2023	Yes	Yes	Yes
November 2023	Yes	Yes	Yes
December 2023	Yes	Yes	Yes

2.2 **Table 2** presents the total traffic counts reported by month transiting monitoring fixes over the South China Sea for the period 1 January to 31 December 2023.

Table 2: Monthly count of monitored flights operating on the ATS routes for the period from 1 January to 31 December 2023

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
January 2023	5543	5543
February 2023	5493	11036
March 2023	5572	16608
April 2023	5767	22375
May 2023	5823	28198
June 2023	5703	33901
July 2023	6057	39958
August 2023	6143	46101
September 2023	5955	52056
October 2023	6164	58220
November 2023	5910	64130
December 2023	6474	70604

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 2023.

Table 3: Monthly count of LLDs and LLEs reported on the ATS routes for the period from 1 January to 31 December 2023

Monitoring Month	Monthly Count of LLDs Reported Over	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 2023	0	1	0	0
February 2023	0	1	0	0
March 2023	0	1	0	0
April 2023	1	2	0	0
May 2023	0	2	0	0
June 2023	2	4	1	1
July 2023	2	6	0	1
August 2023	0	6	0	1
September 2023	0	6	0	1
October 2023	0	5	0	1
November 2023	0	5	0	1
December 2023	0	5	0	1

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 2023.

Table 4: Monthly Count of LLDs and LLEs reported on the ATS routes for the period from 1 January to 31 December 2023

Monitorin g Mont h	Monthly Count of LLDs Reported Over	Cumulative 12-Month Count of LLDs Reported Over Monitored Fixes	Monthly Count of LLEs Reported Over	Cumulative 12-Month Count of LLEs Reported Over Monitored Fixes
January 2023	0	1	0	0

Monitorin g Mont h	Monthly Count of LLDs Reported Over	Cumulative 12-Month Count of LLDs Reported Over Monitored Fixes	Monthly Count of LLEs Reported Over	Cumulative 12-Month Count of LLEs Reported Over Monitored Fixes
February 2023	0	1	0	0
March 2023	0	1	0	0
April 2023	1	2	0	0
May 2023	0	2	0	0
June 2023	2	4	1	1
July 2023	2	6	0	1
August 2023	0	6	0	1
September 2023	0	6	0	1
October 2023	0	5	0	1
November 2023	0	5	0	1
December 2023	0	5	0	1

2.5 **Table 5** presents the causes of deviation in the LLE and LLD reports received for the period 1 January to 31 December 2023.

Table 5: Causes of LLE and LLD deviation for the period from 1 January to 31 December 2023

Deviation Code	Cause of Deviation	No. of LLDs	No. of LLEs
A	Flight crew deviate without ATC Clearance in the horizontal dimension	5	0
B	Incorrect estimate or route provide 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 clearance, Flight crew misunderstands clearance message etc);	0	0
E	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues	0	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

Deviation Code	Cause of Deviation	No. of LLDs	No. of LLEs
H	Turbulence or other weather-related causes (other than approved);	0	0
I	Aircraft provided with RHS but did not meet the RNP/RSP/RCP specifications	0	0
J	Others	0	0
Total		5	1

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:

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

3.2.2 The mathematical formula of the longitudinal collision risk model used in assessing the safety of operations on the 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:

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

3.3 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.

3.4 **Table 6** summarizes the value and source material for estimating the values for each of the inherent parameters of the internationally accepted CRM.

Table 6: Summary of Risk Model Parameters Used in the Lateral 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
l_x	Aircraft length	0.0399NM	Based on December 2023 TSD
l_y	Aircraft wingspan	0.0350NM	
l_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
E_y(opp)	Opposite-direction lateral occupancy	0.081	Based on December 2023 TSD
$\overline{V}$ (RNP 10)	Individual-aircraft along-track speed on RNP 10 routes	508.8 knots	Based on December 2023 TSD
$\overline{V}$ (RNP 4)	Individual-aircraft along-track speed on RNP 4 routes	497.8 knots	Based on December 2023 TSD
$\left\|\overline{\dot{y}(S_y)}\right\|$	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
$\|\bar{\dot{z}}\|$	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 (RNP 10)	Average ground speed of a/c 1 on RNP 10 routes	508.8 knots	Based on December 2023 TSD
V_2 (RNP 10)	Average ground speed of a/c 2 on RNP 10 routes	508.8 knots	Based on December 2023 TSD
V_1 (RNP 4)	Average ground speed of a/c 1 on RNP 4 routes	497.8 knots	Based on December 2023 TSD
V_2 (RNP 4)	Average ground speed of a/c 2 on RNP 4 routes	497.8 knots	Based on December 2023 TSD

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
λ_{xy}	Average aircraft wingspan or length (whichever is greater)	0.0363NM	Based on December 2023 TSD
λ_z	Aircraft height	0.00101NM	Based on December 2023 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

3.5 **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:

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

Table 7: 3 cases of τ

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 8: Case 1

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 9: Case 2

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 10: Case 3

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

4. Safety Oversight

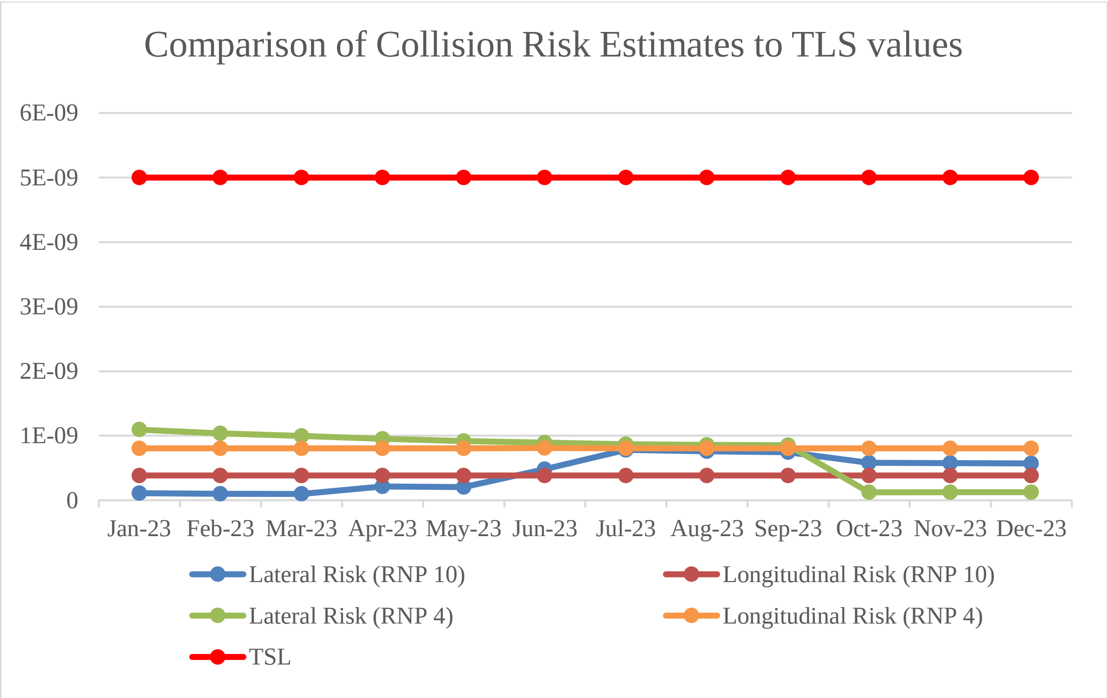
4.1 **Table 11** summarizes the results of the airspace oversight, as of 31 December 2023.

Table 11: Lateral and Longitudinal Risk Estimation

Type of Risk	Risk Estimation	TLS	Remarks
Lateral Risk (RNP 10)	0.569×10^{-9}	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 10)	0.384×10^{-9}	5.0×10^{-9}	**Meets TLS**
Lateral Risk (RNP 4)	0.123×10^{-9}	5.0×10^{-9}	**Meets TLS**
Longitudinal Risk (RNP 4)	0.786×10^{-9}	5.0×10^{-9}	**Meets TLS**

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 2023.

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.