International Civil Aviation Organization

The Twentieth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/20)

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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 the six major air traffic service routes within the South China Sea for the period 1 January 2014 through 31 December 2014. The assessment is based on RNP10 performance. The assessment concludes that the Asia and Pacific Region Target Level of Safety (TLS) values established for lateral and longitudinal separation standards were satisfied for the six-route system with high statistical confidence during the 12-month period examined for RNP10 operations.

1. INTRODUCTION

1.1 This working paper is a periodic assessment to ascertain if flight operations on the six major South China Sea routes (L642, M771, N892, L625, N884 and M767) meet with the APANPIRG-agreed Target Level of Safety (TLS) values for lateral and longitudinal separation standards. The examination period covered is from 1 January 2014 till 31 December 2014.

1.2 L642, M771 and N892 were included in this airspace safety assessment as part of the South China Sea routes RNAV structure as ADS-B Operations were only implemented for L642, M771 and N892 in December 2013. In subsequent reports, L642 and M771 will be excluded as it is not necessary to conduct airspace safety assessment for airways with surveillance coverage. N892 will continue to be monitored and assess as it is part of the route pair with L625.

2. DISCUSSION

Executive Summary

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

Risk	Risk Estimation	TLS	Remarks
RASMAG 19 Lateral Risk	*0.055 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
RASMAG 19 Longitudinal Risk	*1.18 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
Lateral Risk	**0.045 x 10^{-9}**	5.0 x 10^{-9}	**Below TLS**
Longitudinal Risk	**0.034 x 10^{-9}**	5.0 x 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	7
Total		7

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 South China Sea airspace during the period January 2014 to December 2014.

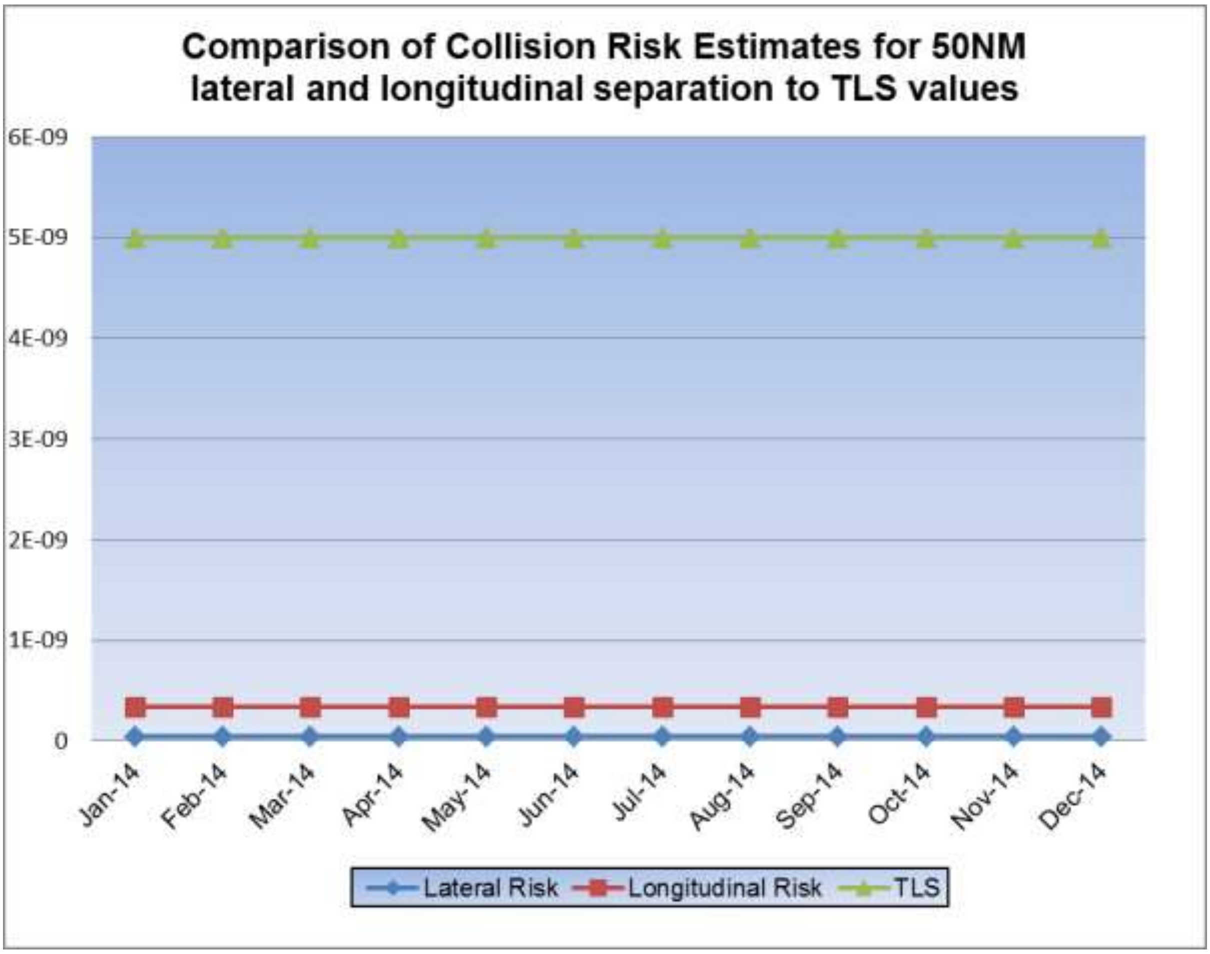

Figure 1: South China Sea Airspace Horizontal Risk Estimates

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

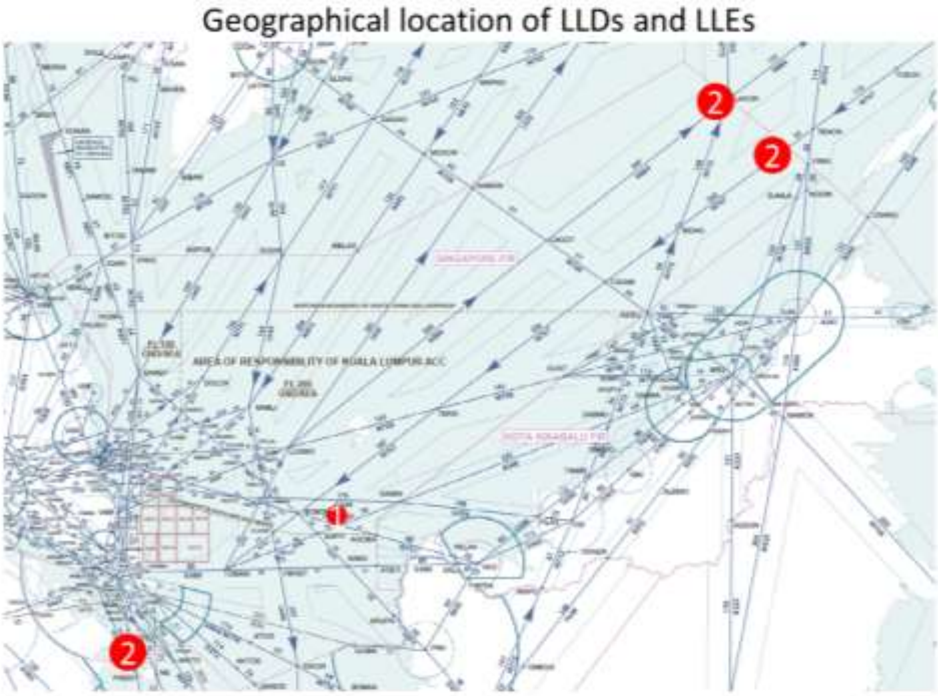

Figure 2: Geographical location of LLDs and LLEs

2.5 The main concern for the South China Sea Airspace is ATC coordination error. All seven occurrences were due to a result of Human Error. Five occurrences were due to incomplete actions by ATC and the other two occurrences were readback error not detected by ATC. Actions had been taken to remind ATC on the importance of passing estimate to adjacent FIR and to be more vigilant on hearback/readback.

2.6 As the seven reports received were also reported as Large Height Deviations (LHDs), this showed that the clarification of the definitions of LHD/LLD and LLE done in 2014 were a success.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

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

b) Note that L642 and M771 will be excluded from subsequent airspace safety assessment; and

c) 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) L625, N884 and M767 are 50NM lateral separation and 50NM longitudinal separation.

b) 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 L642, M771 and N892 were included in this airspace safety assessment as part of the South China Sea routes RNAV structure as ADS-B Operations were only implemented for L642, M771 and N892 in December 2013. In subsequent reports, L642 and M771 will be excluded as it is not necessary to conduct airspace safety assessment for airways with surveillance coverage. N892 will continue to be monitored and assess as it is part of the route pair with 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 2014 through December 2014 is shown in **Table 1**.

Month	Report Received from:		
	Hong Kong, China	Philippines	Singapore
Jan 2014	Yes	Yes	Yes
February 2014	Yes	Yes	Yes
March 2014	Yes	Yes	Yes
April 2014	Yes	Yes	Yes
May 2014	Yes	Yes	Yes
June 2014	Yes	Yes	Yes
July 2014	Yes	Yes	Yes
August 2014	Yes	Yes	Yes
September 2014	Yes	Yes	Yes
October 2014	Yes	Yes	Yes
November 2014	Yes	Yes	Yes
December 2014	Yes	Yes	Yes

Table 1: Record of ANSP Reporting by Month for Period January 2014 through December 2014

2.2 **Table 2** presents the total traffic counts reported by month transiting all South China Sea monitoring fixes for the period January 2014 through December 2014.

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
January 2014	10705	127080
February 2014	10070	127484
March 2014	10878	127629
April 2014	10811	127729

May 2014	11028	127610
June 2014	10683	127549
July 2014	11180	127962
August 2014	11311	128449
September 2014	10415	128592
October 2014	11209	128662
November 2014	10945	128918
December 2014	11438	128872

Table 2: Monthly Count of Monitored Flights Operating on South China Sea RNAV Routes for the period January 2014 through December 2014

2.3 **Table 3** presents the cumulative totals of Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) LLDs and LLEs for the period January 2014 until December 2014.

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 2014	0	0	1	1
February 2014	0	0	2	3
March 2014	0	0	1	4
April 2014	0	0	0	4
May 2014	0	0	0	4
June 2014	0	0	0	4
July 2014	0	0	0	4
August 2014	0	0	1	5
September 2014	0	0	0	5
October 2014	0	0	2	7
November 2014	0	0	0	7
December 2014	0	0	0	7

Table 3: Monthly Count of LLDs and LLEs Reported on South China Sea RNAV Routes for the period January 2014 through December 2014

2.4 **Table 4** presents the cause of deviation in the LLD and LLE reports received for the period January 2014 through December 2014.

Deviation Code	Cause of Deviation	No of Occurrences
E	ATC coordination errors.	7
Total		7

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 the internationally applied collision risk methodology.

3.2 Estimate of the CRM Parameters

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

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

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

$$CR(t_0,t_1) = 2NP\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{t_0}^{t_1} HOP(t|V_1,V_2)P_z(h_z)\left(\frac{2V_{rel}}{\pi\lambda_{xy}}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right)f_1(V_1)f_2(V_2)dtdV_1dV_2$$

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 six 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	0.0399NM	Based on December 2014 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	0.21254	Based on December 2014 TSD
$\overline{V}$	Individual-aircraft along-track speed	507 knots	Based on December 2014 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
$\lvert \bar{\dot{z}} \rvert$	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	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)	0.0399NM	Based on December 2014 TSD
λ_z	Aircraft height	0.0099NM	Based on December 2014 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 Controllers 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

3.2.7 In the model, the value for CPDLC uplink is stated as 90 sec [Reference1]. To better model the actual Communication Navigation and Surveillance (CNS) component, an operational value of CPDLC uplink delivery time could be derived from the actual uplink delivery time database. Further collaboration is needed to collect useful data for analysis. The current ADS CPDLC data collection is shown in **Table 10**.

Uplink Message Delivery Time	30 s	40 s	60 s	120 s	180 s	360 s	>360 s	Total No. of CPDLC Uplink Messages
Jan-14	87.88%	89.72%	92.91%	98.45%	99.39%	99.91%	100.00%	19,878
Feb-14	87.21%	89.53%	93.18%	98.30%	99.23%	99.90%	100.00%	20,594
Mar-14	84.81%	87.50%	91.71%	97.62%	98.92%	99.81%	100.00%	21,409
Apr-14	85.21%	87.74%	92.06%	97.54%	98.77%	99.71%	100.00%	23,435
May-14	86.12%	88.45%	92.54%	97.89%	99.09%	99.83%	100.00%	24,398
Jun-14	86.00%	88.37%	92.59%	97.78%	99.01%	99.85%	100.00%	23,750
Jul-14	86.08%	88.37%	92.56%	97.94%	99.00%	99.76%	100.00%	25,632
Aug-14	86.50%	89.06%	93.12%	98.00%	98.99%	99.83%	100.00%	26,108
Sep-14	86.30%	88.83%	92.87%	98.01%	99.20%	99.84%	100.00%	25,485
Oct-14	88.01%	89.91%	93.40%	98.10%	99.23%	99.84%	100.00%	20,552
Average %	86.41%	88.75%	92.69%	97.96%	99.08%	99.83%	100.00%	23,124

Table 10: ADS CPDLC uplink message delivery time

4 Safety Oversight

4.1 **Table 11** summarizes the results of the airspace oversight, as of December 2014.

Type of Risk	Risk Estimation	TLS	Remarks
Lateral Risk	0.045×10^{-9}	5×10^{-9}	Below TLS
Longitudinal Risk	0.034×10^{-9}	5×10^{-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 2014.

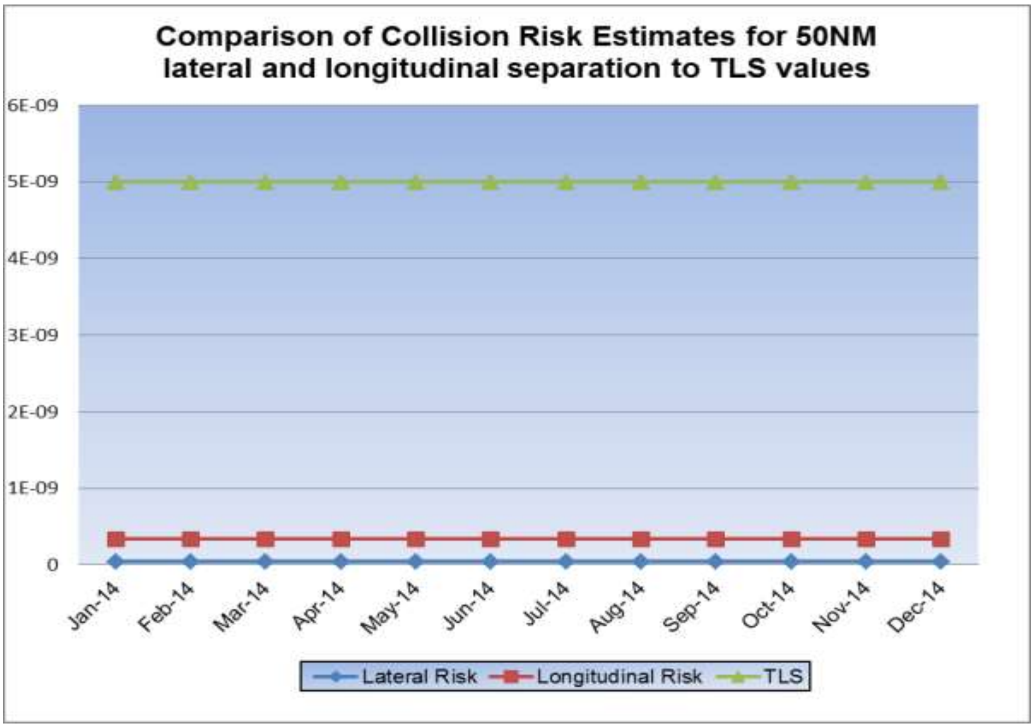

Figure 1 - Assessment of Compliance with Lateral and Longitudinal TLS Values Based on Navigational Performance Observed During South China Monitoring Program

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.