International Civil Aviation Organization
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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 to 31 December 2020. 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 to 31 December 2020.

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 until December 2020.

South China Sea Airspace – estimated annual flying hours = 27,560 hours ***(note: estimated hours based on December 2020 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 25 Lateral Risk	*0.012×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 25 Longitudinal Risk	*0.38×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
Lateral Risk	**0.012×10^{-9}**	5.0×10^{-9}	**Below TLS**
Longitudinal Risk	**0.375×10^{-9}**	5.0×10^{-9}	**Below TLS**

Table 1: South China Sea Airspace Horizontal Risk Estimates

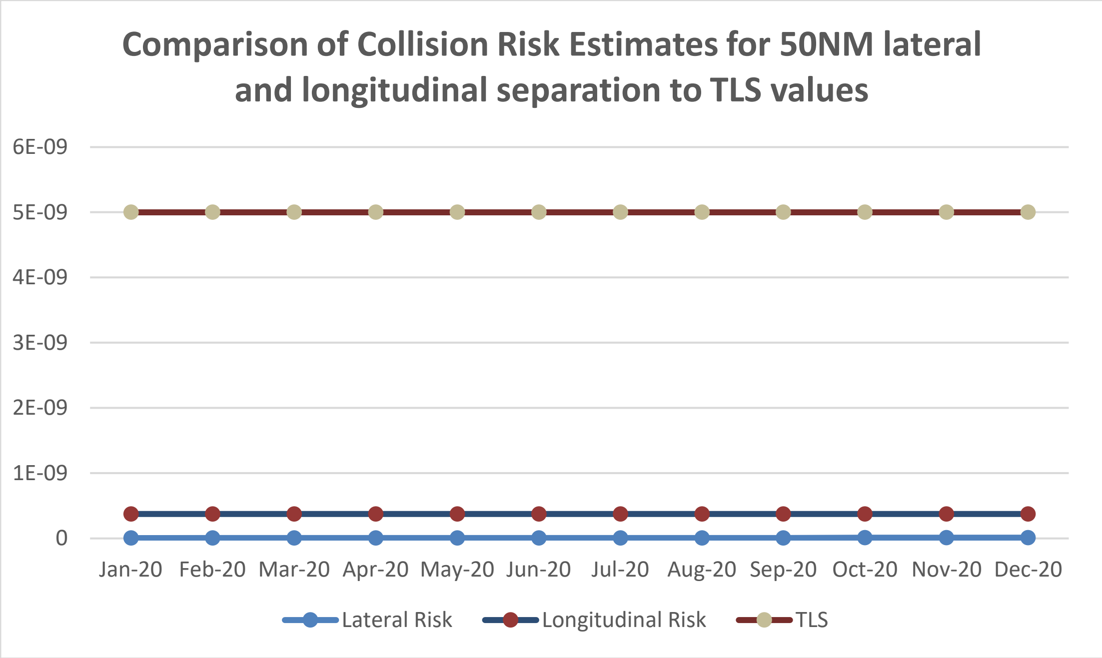

Figure 1: South China Sea Airspace Horizontal Risk Estimates

2.2 **Figure 2** provides the geographical location of risk bearing Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) within the South China Sea Airspace.

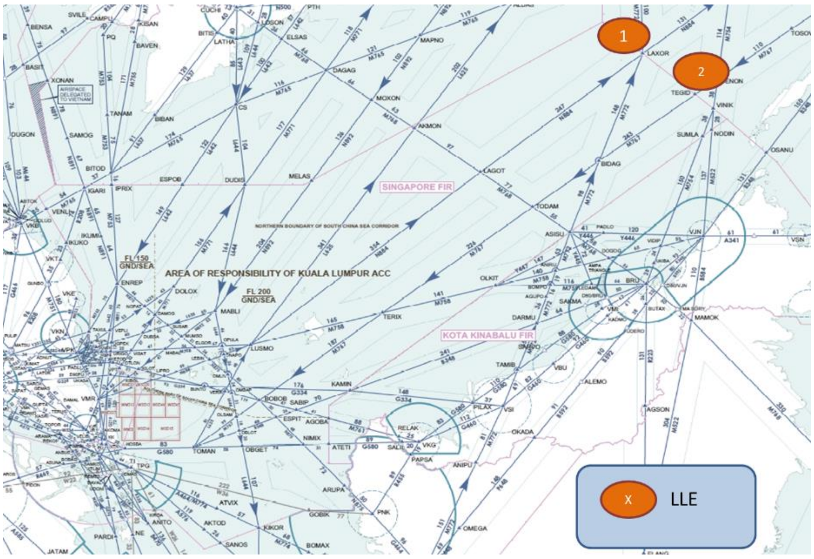

Figure 2: Geographical location of LLDs and LLEs within South China Sea Airspace

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	Risk bearing LLDs	LLEs	Risk bearing 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	0	0

Deviation Code	Cause of Deviation	LLDs	Risk bearing LLDs	LLEs	Risk bearing 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	1	1
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	2	2
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	3	3

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

2.4 The lateral risk within the South China Sea airspace remains nil to zero LLD occurrence between January to December 2020. The number of LLEs has reduced from 7 in 2019 to 3 in 2020. However, the reduction 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 errors.

2.5 The two CAT ‘F’ were due to AIDC failures where the lack of flight plans were found to have contributed to the AIDC transfer failures. However, the CAT ‘D’ error was a unique occurrence where the flight plan differed from the actual flight profile (way-point to way-point) and thus did not “appear” to be entering the appropriate sector. The pilot’s intended route was verified when pilot established contact with ATC. The flight was re-routed to the nearest airway to continue its flight.

2.6 The LLEs reports are reported by both the involved FIRs where the LLEs occurred at the common boundary. This suggests a proactive and continual positive reporting culture by the FIRs involved and continue to learn from such occurrences and implement improvements to prevent similar recurrence.

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

2.8 SEASMA would continue to monitor for any new and emerging 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.

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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:

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 2020 is shown in **Table 1**.

Month	Report Received from:		
	Hong Kong, China	Philippines	Singapore
January 2020	Yes	Yes	Yes
February 2020	Yes	Yes	Yes
March 2020	Yes	Yes	Yes
April 2020	Yes	Yes	Yes
May 2020	Yes	Yes	Yes
June 2020	Yes	Yes	Yes
July 2020	Yes	Yes	Yes
August 2020	Yes	Yes	Yes
September 2020	Yes	Yes	Yes
October 2020	Yes	Yes	Yes
November 2020	Yes	Yes	Yes
December 2020	Yes	Yes	Yes

Table 1: Record of ANSP reporting by month for period from January to December 2020

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 2020.

Monitoring Month	Total Monthly Traffic Count Reported Over Monitored Fixes	Cumulative 12-Month Count of Traffic Reported Over Monitored Fixes Through Monitoring Month
January 2020	6580	76670
February 2020	6137	76521
March 2020	3522	73631
April 2020	1043	68428
May 2020	1213	63045
June 2020	1384	58245
July 2020	1552	53431
August 2020	1532	48518
September 2020	1570	43800
October 2020	1848	39008
November 2020	1726	34673
December 2020	2024	30131

Table 2: Monthly count of monitored flights operating on the South China Sea RNAV routes for the period from January to December 2020

2.3 **Table 3** presents the cumulative totals of Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period January 2020 to December 2020.

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 2020	0	0	1	1
February 2020	0	0	0	1
March 2020	0	0	0	1
April 2020	0	0	1	2
May 2020	0	0	0	2
June 2020	0	0	1	3
July 2020	0	0	0	3
August 2020	0	0	0	3
September 2020	0	0	0	3
October 2020	0	0	0	3
November 2020	0	0	0	3
December 2020	0	0	0	3

Table 3: Monthly count of LLDs and LLEs reported on the South China Sea RNAV routes for the period from January to December 2020

2.4 **Table 4** presents the cumulative totals of risk bearing Large Lateral Deviations (LLDs) and Large Longitudinal Errors (LLEs) for the period January to December 2020.

Monitoring Month	Monthly Count of Risk bearing LLDs Reported Over Monitored Fixes	Cumulative 12-Month Count of Risk bearing LLDs Reported Over Monitored Fixes	Monthly Count of Risk bearing LLEs Reported Over Monitored Fixes	Cumulative 12-Month Count of Risk bearing LLEs Reported Over Monitored Fixes
January 2020	0	0	1	1
February 2020	0	0	0	1
March 2020	0	0	0	1
April 2020	0	0	1	2
May 2020	0	0	0	2
June 2020	0	0	1	3
July 2020	0	0	0	3
August 2020	0	0	0	3
September 2020	0	0	0	3
October 2020	0	0	0	3
November 2020	0	0	0	3
December 2020	0	0	0	3

Table 4: Monthly Count of Risk bearing LLDs and LLEs reported on the South China Sea RNAV routes for the period from January to December 2020

2.5 **Table 5** presents the causes of deviation in the LLE and LLD reports received for the period January to December 2020.

Deviation Code	Cause of Deviation	LLDs	Risk bearing LLDs	LLEs	Risk bearing 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	0	0
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	1	1
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	2	2
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	3	3

Table 5: Causes of LLE and LLD deviation

3. Risk Assessment

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

1.2 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 South China Sea RNAV routes:

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

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

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

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 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	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 2020 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 RNAV routes

Model Parameter	Definition	Value Used in TLS Compliance Assessment	Source for Value
$E_y(opp)$	Opposite-direction lateral occupancy	0.046	Based on December 2020 TSD
$\overline{V}$	Individual-aircraft along-track speed	479.5 knots	Based on December 2020 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	Average ground speed of a/c 1	479.5knots	Based on December 2020 TSD
V_2	Average ground speed of a/c 2	479.5knots	Based on December 2020 TSD
λ_{xy}	Average aircraft wingspan or length (whichever is greater)	0.0363NM	Based on December 2020 TSD
λ_z	Aircraft height	0.00101NM	Based on December 2020 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
$\overline{\|\dot{z}\|}$	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 2020.

Type of Risk	Risk Estimation	TLS	Remarks
Lateral Risk	0.012×10^{-9}	5×10^{-9}	**Below TLS**
Longitudinal Risk	0.38×10^{-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 2020.

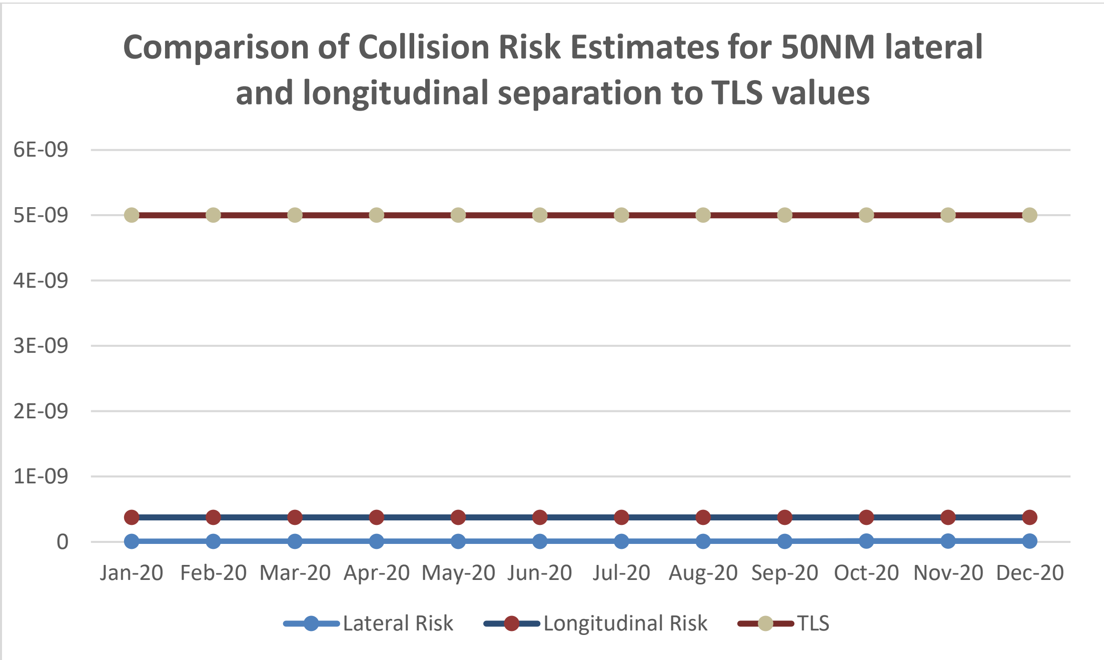

Figure 1 - Assessment of Compliance with Lateral and Longitudinal TLS Values based on Navigational Performance Observed during the South China Monitoring Program

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.