International Civil Aviation Organization

The 17th Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/17)

Bangkok, Thailand, 28 – 31 August 2012

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

PARMO HORIZONTAL SAFETY MONITORING REPORT

(Presented by United States/Pacific Approvals Registry and Monitoring Organization (PARMO))

SUMMARY

This paper presents the horizontal safety monitoring report from the Pacific Approvals Registry and Monitoring Organization (PARMO) for the time period 1 May 2011 to 30 April 2012. This report contains a summary of large longitudinal errors and large lateral deviations received by the PARMO for that time period and the related performance monitoring activities for the Anchorage and Oakland Flight Information Regions.

This paper relates to –

Strategic Objectives:

*A: **Safety** – Enhance global civil aviation safety*

Global Plan Initiatives:

GPI-9 Situational awareness
GPI-16 Decision support systems and alerting systems
GPI-17 Data link applications
GPI-21 Navigation systems
GPI-22 Communication infrastructure

1. INTRODUCTION

1.1 The Pacific Approvals Registry and Monitoring Organization (PARMO), a service provided by the U.S. Federal Aviation Administration's Technical Center, serves as the En-route Monitoring Agency (EMA) for the Anchorage and Oakland Oceanic Flight Information Regions (FIRs). The report presented in this paper fulfills the ICAO emphasis on safety management systems; such reporting for international airspace is a component of safety management systems.

1.2 This report covers the current reporting period 1 May 2011 to 30 April 2012 in the PARMO's ongoing process of providing periodic updates of information relevant to the continued safe use of the reduced lateral and longitudinal separation standards in the Anchorage and Oakland FIRs. This report follows the standardized reporting period and format guidelines set forth by the ICAO's Asia and Pacific Region Regional Airspace Safety Monitoring Advisory Group (RASMAG). These guidelines are stated in reference 1, paragraph 5.34.

1.3 Within this report, the reader will find the large lateral deviation and large longitudinal error reports received by the PARMO during the reporting period and a discussion of the monitoring activities conducted by the PARMO. There were a total of 4 such reports submitted to the PARMO during the reporting period.

2. DISCUSSION

Lateral Separation Standards

2.1 The lateral separation standard applied in the Anchorage and Oakland FIR varies. The 50-NM lateral separation standard is applied to RNP10 aircraft. However, the airspace is not exclusionary and non-RNP10 aircraft are permitted to operate within the airspace as ATC will apply another form of aircraft separation (either longitudinal or vertical) for non-RNP10 aircraft.

2.2 In the Oakland FIR, the 30-NM lateral separation standard can be applied to suitably equipped RNP4 operations. The application of the 30-NM lateral separation in the Oakland FIR is accomplished ad hoc between pairs of suitably equipped aircraft; this means that the application of the separation minima is not planned prior to oceanic entry. In the near future, the FAA intends to implement the 30-NM lateral separation standard in the same manner within the Anchorage FIR.

Longitudinal Separation Standards

2.3 The longitudinal separation standard applied in the Anchorage and Oakland FIR can vary. The 10-minute longitudinal separation can be applied with or without mandatory assignment of Mach number. The 50-NM longitudinal separation standard can be applied to RNP10 aircraft using ADS-C for position reporting and Controller Pilot Data Link Communication (CPDLC) for ATC communications. A 27 minute interval for ADS-C periodic reports is assigned to aircraft eligible for the 50-NM longitudinal separation. The application of the 50-NM longitudinal separation in the Anchorage and Oakland FIRs is accomplished ad hoc between pairs of suitably equipped aircraft; this means that the application of the separation minima is not planned prior to oceanic entry.

2.4 In the Oakland FIR, the 30-NM longitudinal separation standard can be applied to suitably equipped RNP4 operations. A 14 minute interval for ADS-C periodic reporting is assigned to aircraft eligible for the 30-NM longitudinal separation standard. The application of the 30-NM longitudinal separation in the Oakland FIR is also done ad hoc between pairs of suitably equipped aircraft. In the near future, the FAA intends to implement the 30-NM longitudinal separation standard in the same manner within the Anchorage FIR using a 10-minute periodic interval for RNP4 aircraft using ADS-C.

Data Sources

2.5 Monthly large lateral deviation (LLDs) and large longitudinal errors (LLEs) are forwarded to the PARMO from the Anchorage and Oakland oceanic FIRs. In addition, the FAA's Air Traffic Quality Assurance (ATQA) database provides access to several principal aviation safety data and information sources. The PARMO scans this database periodically in search of incidents occurring in Pacific airspace. These data are supplement the large lateral and longitudinal deviation reports received from the ATS providers.

2.6 Additional reports of large height deviations are occasionally received from various operators. The PARMO reviews these reports and includes them, as appropriate, with the reports received from the ATS providers in estimating the overall risk for the airspace.

2.7 Traffic movement data are archived through the FAA's Ocean21 automation system. These data encompass position reports, filed flight plans, and communication messages between the pilots and air traffic controllers.

2.8 Data link transmission data obtained from operations conducted within the Anchorage and Oakland oceanic FIRs are obtained daily at the FAA Technical Center. In the future, these data collections will be part of the data archiving process through the FAA ATC automation system. These data include the required time stamps from data link messages to measure performance as described in the ICAO GOLD (reference 3). Specific pilot-controller CPDLC message sets are used to estimate the actual communication performance (ACP), actual communication technical performance (ACTP), and pilot operational response time (PORT). In addition, ADS-C surveillance performance is measured. Appendix D to the GOLD (reference 3) provides the post implementation modeling and corrective action details for use of ADS-C and CPDLC data link in airspace.

Data Submission

2.9 The most recent annual one-month traffic movement samples for December 2011 were received from both the Oakland and Anchorage FIRs. These traffic movement samples are used to update the horizontal risk estimates and related monitoring activities described in this report.

2.10 Monthly reports of LLDs and LLEs were also received from both the Anchorage and Oakland FIRs for the time period May 2011 through April 2012. Additional event data were available through the FAA ATQA database.

Large Lateral Deviation and Large Longitudinal Error Report Summary

2.11 **Table 1** contains a summary of the number of risk-bearing LLD and LLE occurrences during the time period 1 May 2011 to 30 April 2012 in the Anchorage and Oakland oceanic FIRs. There were a total of four reports received during the time period.

Month-Year	**No. of LLDs and LLEs Occurrences**
May-11	2
Jun-11	0
Jul-11	0
Aug-11	0
Sep-11	1
Oct-11	0
Nov-11	0
Dec-11	0
Jan-12	1
Feb-12	0
Mar-12	0
Apr-12	0
Total	4

Table 1: Anchorage and Oakland Oceanic Airspace LLD and LLE Summary

2.12 The LLD and LLE reports are separated by categories based on the details provided for each event. These categories are defined in the ICAO Asia Pacific Region EMA Handbook (reference 2). **Table 2** lists the categories for LLDs and LLEs for use in the Asia/Pacific region.

Deviation Code	**Cause of Deviation**
Operational Errors	
A	Flight crew deviate without ATC Clearance;
B	Flight crew incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.);
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position;
D	ATC system loop error (e.g. ATC issues incorrect clearance, Flight crew misunderstands clearance message etc.);
E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility;
Deviation due to navigational errors	
F	Navigation errors, including equipment failure of which notification was not received by ATC or notified too late for action;
Deviation due to Meteorological Conditions	
G	Turbulence or other weather related causes (other than approved);
Others	
H	An aircraft without PBN approval;
I	Other

Table 2: Asia/Pacific Region LLD and LLE Deviation Codes and Category Descriptions

2.13 A summary of the LLD and LLE reports received by the PARMO is contained in Table 3. All of the reports listed in Table 3 are all LLD events. Three of these events were caused by the flight crew following portions of the filed flight plan rather than the ATC cleared flight plan.

2.14 One of the reports listed in **Table 3** with an assigned deviation code 'A' is a LLD report. In this case, the air crew did deviated without ATC clearance from their expect route.

Deviation Code	**Cause of Deviation**	**Number of Occurrences**
A	Flight crew deviate without ATC Clearance;	1
B	Flight crew incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.)	3

Table 3: Summary of LLD and LLE Reports Received by the PARMO

2.15 **Figure 1** shows the approximate locations of the reported LLD events.

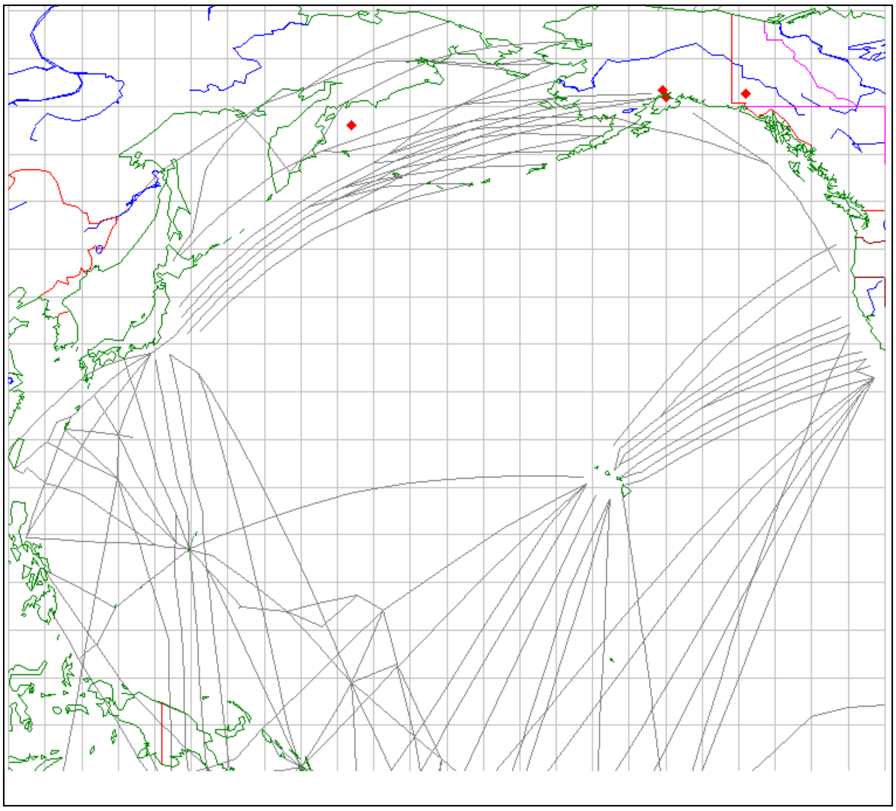

Figure 1: Approximate locations of the LLD event reports

Monitoring of the Application of the Reduced Horizontal Separation Standards

2.16 The PARMO regularly monitors the application of the reduced horizontal separation standards through the available archived data. The monitoring activities are performed in conjunction with a scrutiny group established to review the performance of the systems supporting the reduced separation standards. The scrutiny group was established prior to the first introduction of the reduced horizontal separation standards in the Oakland FIR in 2005. The scrutiny group consists of representatives from the Flight Standards Services office, Anchorage and Oakland ARTCC, Aircraft Certification Service, En-route and Oceanic Air Traffic Procedures office, and the FAA Technical Center.

2.17 The PARMO monitoring activities include an examination of the filed RNP4 status from operations conducted within the airspace and comparisons of the RNP4 status to the RNP4 approval records. The PARMO has formally established RNP4 and RNP10 approval records for operators/aircraft types contained within the PARMO RVSM approvals database.

2.18 Other monitoring activities include evaluation of weather deviations requests, overdue ADS-C periodic reports, longitudinal speed error, communication and surveillance system performance, and reported LLD and LLE occurrences. The evaluation of weather deviation requests and missing ADS-C periodic reports includes the verification of certain automation features of the decision-support tools within Ocean21.

2.19 The data accumulated from monitoring of the longitudinal speed error is used to estimate this distribution for use in the collision risk model. Archived ADS-C position reports are used to examine the longitudinal speed error. This is done by matching the actual waypoint position report to each aircraft-provided position estimate. The speed error is computed from the difference between the actual position time and the estimated position time.

<u>Observed Application of Reduced Horizontal Separation Standards</u>

2.20 The application of the reduced longitudinal separation minima (30-NM and 50-NM) within the Anchorage and Oakland oceanic FIRs are examined through archived ADS-C position reports. The proportions of aircraft operations with the distance-based longitudinal separation applied are presented in Figures 2 and 3.

2.21 Figure 2 contains the proportion of aircraft operations within the North Pacific (NOPAC) traffic flow observed with the 50-NM distance-based longitudinal separation applied. These data are presented by month for the time period September 2010 – May 2012. Figure 2 also shows the total proportion of operations using ADS-C for position reporting within the Anchorage oceanic FIR. The ADS-C data are presented because ADS-C periodic reporting is one of the requirements aircraft operations need to be eligible for the 50-NM longitudinal separation standard.

2.22 Figure 3 contains the observed proportions of aircraft operations within the Oakland oceanic FIR with the 30-NM and 50-NM distance-based longitudinal separations applied. These data are presented by month for the time period September 2010 – May 2012. The proportions of operations utilizing ADS-C periodic reporting are also presented in Figure 3. Aircraft operations eligible for the 30-NM and 50-NM longitudinal separation standards must utilize ADS-C for position reporting.

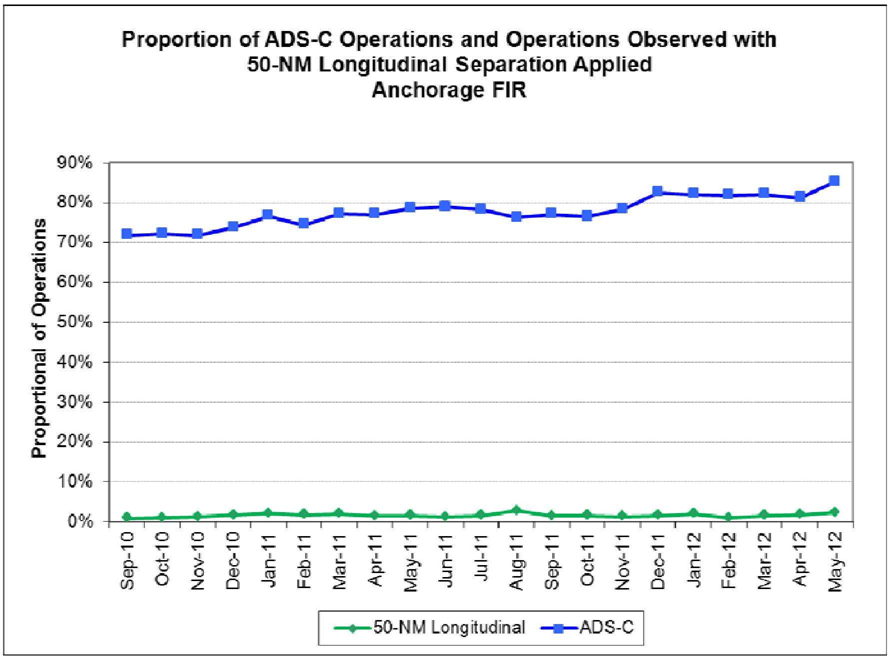

Figure 2: Proportion of Aircraft Operations Observed with the 50-NM Longitudinal Separation Applied in the Anchorage Oceanic FIR by Month

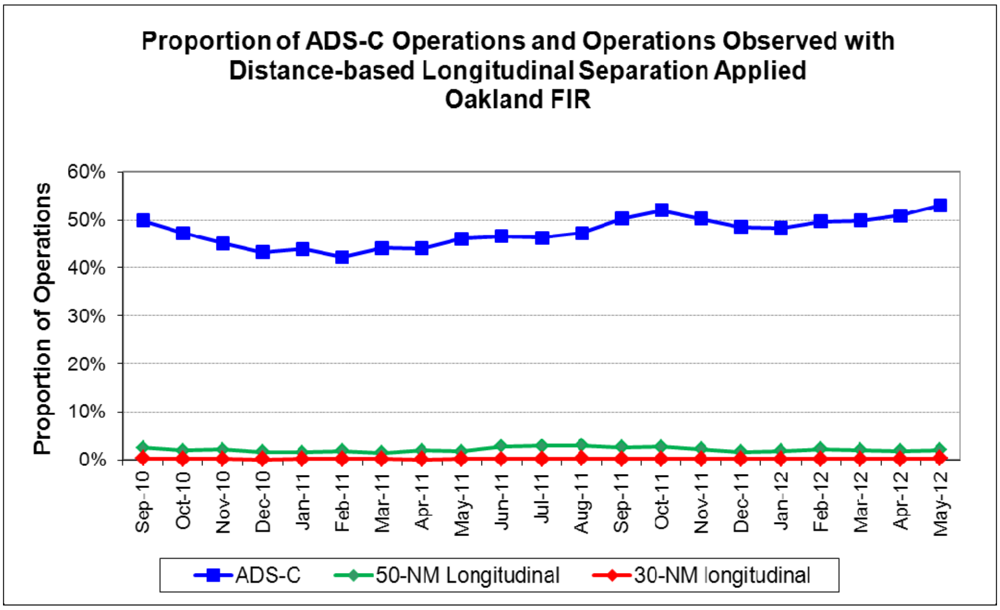

Figure 3: Proportions of Aircraft Operations Observed with the Distance-based Longitudinal Separation Applied in the Oakland Oceanic FIR

2.23 **Figures 2 and 3** show relatively small proportions of operations were observed with the distance-based longitudinal separation standards applied. This result is partially due to the application of the reduced separation standards ad hoc between pairs of suitably equipped aircraft. Other contributing factors are the traffic volume and proportions of RNP10/RNP4 operations. The data in Figures 2 and 3 show that there are operations conducted within both Anchorage and Oakland airspace which are not utilizing ADS-C and therefore not eligible for the reduced longitudinal separation standards. The observed proportions of RNP4 and RNP10 operations are not shown in Figures 2 and 3.

<u>Observed Data Link Performance</u>

2.24 The PARMO examines the aircraft ADS-C periodic reports in the archived data and identifies cases of overdue reports. Figures 4 and 5 contain the proportion of missing ADS-C reports in Anchorage and Oakland airspace, respectively.

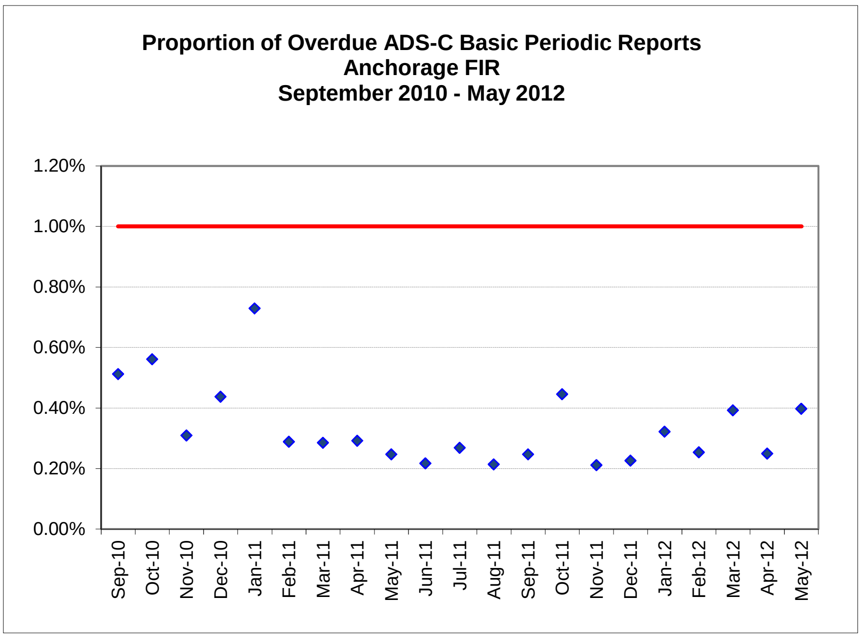

Figure 4. Anchorage Airspace Proportion of Overdue ADS-C Periodic Reports

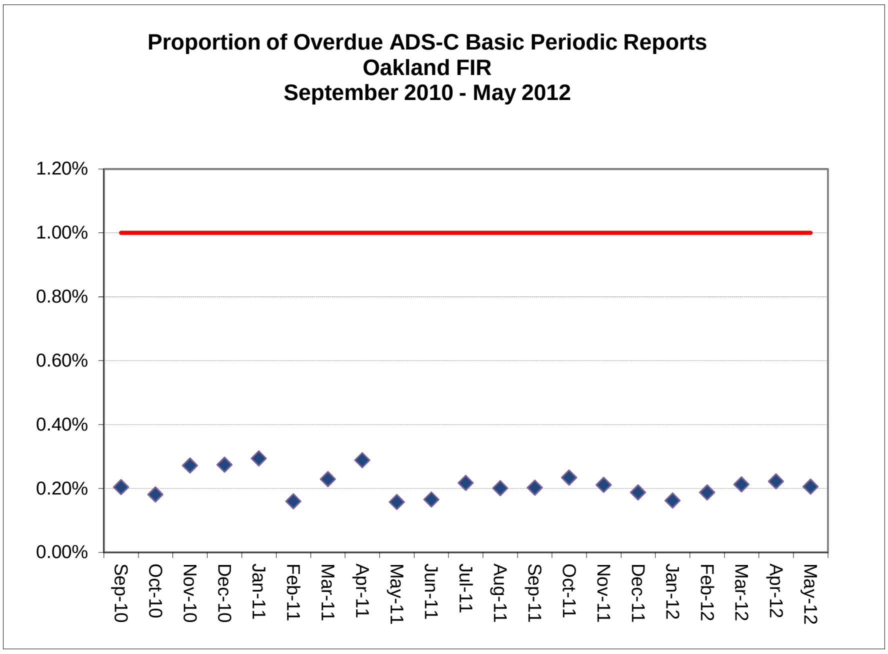

Figure 5: Oakland Airspace Proportion of Overdue ADS-C Periodic Reports

2.25 The data in Figure 4 shows that the average proportion of missing ADS-C reports in the Anchorage FIR is 0.27 percent for the current reporting period. A spike in the proportion of overdue ADS-C reports was observed in January 2011 and October 2011. There was a significant outage reported in October 2011 that affected all data link communications through the INMARSAT satellite. There were no reported communication outages during the month of January 2011. However, several of the observed overdue ADS-C reports were expected around the same time. These data might indicate a degradation or unreported outage within the communication infrastructure. The data in Figure 5 shows that the average proportion of missing ADS-C reports in the Oakland FIR is 0.20 percent for the current reporting period.

2.26 Appendix A provides a summary of the observed performance of the operational data link system at Anchorage and Oakland Oceanic Centers. The purpose is to compare the measured performance obtained from analysis of the operational data to the criteria specified in the Global Operational Data Link Document (GOLD) (reference 3). The data link performance analysis for the Anchorage and Oakland FIRs uses data collected for the time period December 2011 through May 2012.

2.27 These data are relevant to the application of the reduced horizontal separation standards in oceanic airspace because both the communication and surveillance systems which are necessary to support these separations rely on data link.

2.28 The data in **Appendix A** show that the observed data link performance in both Anchorage and Oakland for the top 90 percent of operators meets the 95 percent criteria for the ACP, ACTP, and ADS-C latency established in the GOLD. In addition, several operators are meeting the 99.9 percent criterion for some of the parameters.

Estimate of Horizontal Collision Risk

2.29 The estimation of the lateral risk takes into account the various traffic flows in the Anchorage and Oakland FIRs. The various traffic flows are described in Table 4. The proportions of eligible RNP10 and RNP4 operations vary within each traffic flow as does the aircraft operators, aircraft type populations, fixed or user-defined airways, and traffic volumes. The fixed airways in the North Pacific (NOPAC), Central Pacific (CENPAC) – which includes the Pacific Organized Track System (PACOTS), and the Central East Pacific (CEP) routes have relatively higher lateral occupancy values.

Sub-Region of Pacific	**Flow**	**Description of Flow**
North Pacific	NOPAC	North America west to Japan/Korea/beyond plus Japan/Korea to and from Alaska and beyond
	Central Pacific (CENPAC)	Japan/Korea/other Asian origins east to North America
	Central East Pacific (CEP)	North American mainland to and from Hawaii
	Hawaii/Japan	Japan/Korea to and from Hawaii
	Japan/Guam	Japan/Korea to and from Guam/Saipan/other proximate destinations
	Other	All other North Pacific flights not covered above
South Pacific and Pacific trans-equatorial	SOPAC	Australia to and from airports in northern hemisphere; New Zealand to and from airports in northern hemisphere

Table 4: Traffic Flows Used in Anchorage and Oakland Lateral Collision Risk Estimate

2.30 The lateral collision risk for the 30-NM lateral separation minima is estimated for operations conducted within Oakland oceanic airspace. The lateral collision risk for the 50-NM lateral separation minima is estimated for aircraft operations conducted in both Oakland and Anchorage oceanic airspace.

2.31 The form of the lateral collision risk model applicable to assessing the risk, for the 30-NM and 50-NM lateral separation standards from Appendix 15 of reference 4 is:

$$N_{ay} = P_y(S_y)P_z(0)\frac{\lambda_x}{S_x}\left\{E_y(same)\left[\frac{\overline{|\dot{x}|}}{2\lambda_x}+\frac{\overline{|\dot{y}(S_y)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]+E_y(opp)\left[\frac{\overline{|V|}}{\lambda_x}+\frac{\overline{|\dot{y}(S_y)|}}{2\lambda_y}+\frac{\overline{|\dot{z}|}}{2\lambda_z}\right]\right\} \quad (1)$$

2.32 **Table 5** provides the lateral collision risk model parameter definitions and values used in the estimation of lateral risk.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
$\overline{\lvert\dot{x}\rvert}$	Average absolute relative along track speed between aircraft on same direction routes	17 knots	Estimated from ADS-C reports in traffic sample, (reference 5, section 14.1)
$\overline{\lvert V\rvert}$	Average absolute aircraft air speed	480 knots	Value used in vertical safety assessment
$\overline{\lvert\dot{y}(30)\rvert}$	Average absolute relative cross track speed	60 knots for 50-NM lateral separation minimum, 36 knots for 30-NM lateral separation minimum	Conservative value based on speed required to commit waypoint insertion error
$\overline{\lvert\dot{z}\rvert}$	Average absolute relative vertical speed of an aircraft pair that have lost all vertical separation	1.5 knots	Value used in vertical safety assessment
S_x	Length of longitudinal window used to calculate occupancy	120-NM	Value used in vertical safety assessment
λ_x	Average aircraft length	0.0363-NM	Weighted average based on Dec 2011 traffic sample
λ_y	Average aircraft wing-span	0.0333-NM	Weighted average based on Dec 2011 traffic sample
λ_z	Average aircraft height with undercarriage retracted.	0.0100-NM	Weighted average based on Dec 2011 traffic sample
$P_z(0)$	Probability that two aircraft which are nominally at the same level are in vertical overlap.	0.538	Value used in vertical risk estimates
N_{ay}	Number of fatal accidents per flight hour due to loss of lateral separation.	*Calculated*	-
S_y	Lateral separation minimum	30-NM / 50-NM	-
$P_y(S_y)$	Probability that two aircraft which are nominally separated by the lateral separation minimum are in lateral overlap.	5.87×10^{-8}	Determined from the RNP requirement and the observed frequency of lateral errors modeled with a DDE density
$E_y(same)$	Same direction lateral occupancy	0.1431	Average value estimated from December 2011 traffic sample
$E_y(opp)$	Opposite direction lateral occupancy	0.0346	Average value estimated from December 2011 traffic sample

Table 5: Parameter Values for the Lateral Collision Risk Estimates

2.33 The generalized form of the longitudinal collision risk model applicable to assessing the risk, the number of accidents per flight hour, N_{ax}, associated with a 30-NM longitudinal separation standard is given in references 6 and 7. Assuming that the aircraft pair are on the same ground track, the collision risk during a time interval $[t_0, t_1]$ is given by:

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

2.34 In equation (2) the speeds, V_1 and V_2, of the two aircraft are assumed to follow the same double exponential distribution with known means and the same scale parameter, λ_v. The integral over V_1 and V_2 with their respective probability distributions $f_1(V_1)$ and $f_2(V_2)$ accounts for the variation in aircraft speed around the nominal speed.

2.35 The term for the horizontal overlap probability (HOP) considers the along-track and cross-track position errors of two longitudinally separated aircraft. An equation for HOP for operations on the same ground track (e.g. angle of zero degrees) is given in reference 6 as:

$$HOP(t \mid V_1 V_2) = \frac{\pi\lambda_{xy}^2}{16\lambda^2} e^{-|D_x(t)|/\lambda} \left(\frac{|D_x(t)|}{\lambda} + 1 \right) \qquad (3)$$

2.36 The time integral is evaluated over $t \in [0, T+\tau]$ where T is the ADS reporting period and τ is the controller intervention buffer. Reference 6 considers three cases under an ADS environment and provides the components for τ for each case. The components for each of the three cases are replicated here for clarity:

- under normal ADS operation, an allowance of 4 minutes is assumed for τ;
- in the case where the periodic ADS reports are received and a response to the CPDLC uplink is not received in 3 minutes, an allowance of 10 ½ minutes is assumed for the value of τ; and
- when the ADS periodic report is lost or takes longer than 3 minutes, and allowance of 13 ½ minutes is assumed for the value of τ.

2.37 All of the components for τ used in this collision risk estimation conform to those provided in reference 6 except for the CPDLC uplink time. Reference 6 assigns a static value of 90 seconds to the CPDLC uplink transit time. This document uses an empirical distribution for the CPDLC uplink transit time based on observed performance in Anchorage and Oakland oceanic airspace.

2.38 **Table 6** provides the longitudinal collision risk parameters used in the safety assessment for the ongoing use of the 30NM and 50NM longitudinal separation minima.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
V_1	Assumed average ground speed of aircraft 1	480 knots	Value used in vertical risk estimates
V_1	Assumed average ground speed of aircraft 2	480 knots	Value used in vertical risk estimates
λ_{xy}	Average aircraft wingspan or length	0.0363-NM	Estimated from December 2011 traffic sample data
λ	Scale parameter for speed error distribution	5.82 knots	Reference 6
T	ADS-C periodic report rate	10, 14, and 27 minutes	Reference 5 and 6

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
τ	Controller intervention buffer.	3 cases with empirical CPDLC Uplink Data	Reference 6 and archived CPDLC data – reference 5
NP	Number of aircraft pairs per hour	1	Conservative estimate (see Figures 2 and 3)

Table 6: Parameter Values for the Longitudinal Collision Risk Estimates

2.39 **Figure 6** presents the lateral collision risk estimates by month for the Oakland and Anchorage oceanic airspace.

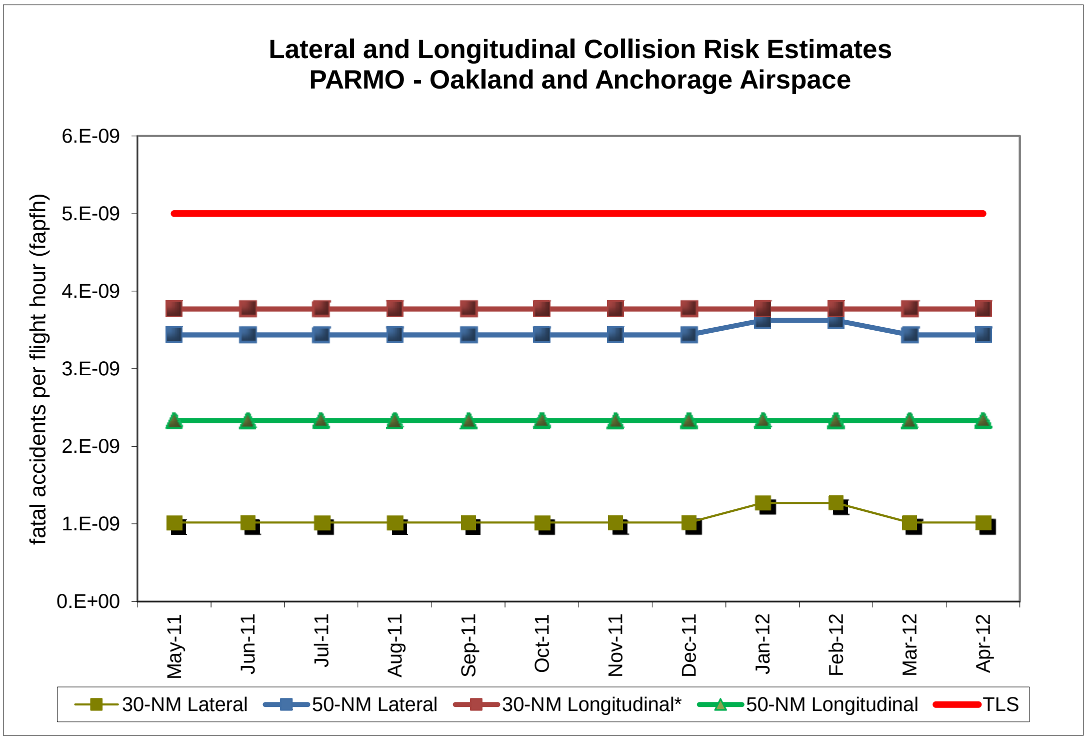

Figure 6: Anchorage and Oakland Oceanic Airspace Horizontal Collision Risk Estimates

* The estimate of collision risk for the 30-NM longitudinal separation standard uses the RNP 4 type for the assumed navigation performance. The Separations and Airspace Safety Panel (SASP) is undertaking a re-evaluation of this assumption for GNSS aircraft. A collision risk value which exceeds the Target level of Safety (TLS) is realized if better navigation performance is assumed. To meet the TLS, a more frequent ADS-C reporting interval is needed.

2.40 The data in Figure 6 show that the estimated lateral and longitudinal collision risk values satisfies the TLS applicable to judging the safety of the appropriate separation standards, 5.0×10^{-9} fatal accidents per flight hour due to the loss of planned separation. **Table 7** provides a summary of the data. (see * note above)

***Portions of Pacific Airspace** – estimated number of traffic movements= 281,928 operations, number of annual flying hours =773,519 hours (note: estimates are based on the December 2011 TSD)*			
Source of Risk	**Lower Bound Risk Estimation**	**TLS**	**Remarks**
30-NM Lateral Risk	1.018×10^{-9}	5.0×10^{-9}	Below Overall TLS
50-NM Lateral Risk	3.439×10^{-9}	5.0×10^{-9}	Below Overall TLS
30-NM Longitudinal Risk	3.773×10^{-9} (* see note above)	5.0×10^{-9}	Below Overall TLS
50-NM Longitudinal Risk	2.333×10^{-9}	5.0×10^{-9}	Below Overall TLS

Table 7: Horizontal Collision Risk Estimates for Pacific Airspace

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

References

1. "Report of the Seventh Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/7)," International Civil Aviation Organization, Bangkok, Thailand, June 2007.
2. *ICAO Asia Pacific Region En-Route Monitoring Agency (EMA)*, ICAO Asia Pacific Office, Version 2, August 2010 Edition, Bangkok, Thailand.
3. *Global Operational Data Link Document (GOLD)*, ICAO, 1st Edition, 14 June 2010.
4. *Manual on Airspace Planning Methodology For the Determination of Separation Minima*, First Edition, Doc 9689-AN/953, International Civil Aviation Organization, Montreal, 1998.
5. PARMO, "Safety Assessment to Support the Use of the 30-NM Lateral and 30-NM Longitudinal Separation Standards in Anchorage Oceanic and Offshore Airspace", WP/24, RASMAG/16, Bangkok, Thailand, February 2012.
6. 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.
7. *A Unified Framework for Collision Risk Modelling in Support of the Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)*, ICAO Circular 319 AN/181, 2009.

Appendix A

A. Observed Data Link Performance

A.1. This section provides a summary of the observed performance of the operational data link system at Anchorage and Oakland Oceanic Center. The purpose is to compare the measured performance obtained from analysis of the operational data to the criteria specified in the Global Operational Data Link Document (GOLD) (reference 3).

A.2. The performance data observed from the CPDLC system is assessed against the Required Communication Performance (RCP) 240 specification when sent via satellite or VHF and against the RCP 400 specification when sent via HF. The latency performance data observed from the Automatic Dependent Surveillance - Contract (ADS-C) system is measured against the Type 180 specification when sent via satellite or VHF and the Type 400 specification when sent via HF. The purpose of this analysis is to demonstrate that safety objectives which rely on the communications infrastructure can be met by the aircraft and ground systems. The sample period of December 2011 through May 2012 was examined for the Anchorage and Oakland FIRs.

A.3. The GOLD provides the guidance material describing the required data points from the FANS 1/A aircraft communications addressing and reporting system (ACARS) messages. The GOLD also describes the calculation process for the actual communication performance (ACP), actual communication technical performance (ACTP), pilot operational response time (PORT), and ADS-C surveillance latency.

A.4. Table A-1 provides the ACP, ACTP, PORT and ADS-C surveillance latency performance, respectively, during the time period December 2011 through May 2012 for the Oakland oceanic FIR. The data presented include data link communications through all available media types; satellite, VHF, and HF. Table A-1 also provides a summary of the observed data link usage by media type for the Oakland FIR.

Table A-1. Observed Data Link Performance by Media Type – Oakland FIR

Media Type	ADS-C			CPDLC					
	Count of ADS-C Downlink Messages	ADS-C 95%	ADS-C 99.9%	Count of CPDLC Transactions	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
SAT	1,250,751 (87.7%)	98.8%	99.6%	93,999 (97.9%)	99.6%	99.7%	99.3%	99.6%	97.4%
VHF	170,136 (11.9%)	99.4%	99.7%	1,518 (1.6%)	100%	100%	99.7%	99.8%	96.6%
HF*	5,154 (0.4%)	91.3%	93.7%	79 (0.1%)	--	--	--	--	--
Total	1,426,041	98.7%	99.5%	96,013**	99.5%	99.7%	99.3%	99.5%	97.3%

* HF performance is assessed against RSP400/RCP400 criteria.

** 0.4% of RCP transactions occur over mixed media

A.5. Table A-2 provides the ACP, ACTP, PORT, and ADS-C surveillance latency performance, respectively, during the time period December 2011 through May 2012 for the Anchorage oceanic FIR. The data presented include data link communications through all available media types; satellite, VHF, and HF. Table A-2 also provides a summary of the observed data link usage by media type for the Anchorage FIR.

Table A-2. Observed Data Link Performance by Media Type – Anchorage FIR

Media Type	ADS-C			CPDLC					
	Count of ADS-C Downlink Messages	**ADS-C 95%**	**ADS-C 99.9%**	**Count of CPDLC Transactions**	**ACTP 95%**	**ACTP 99.9%**	**ACP 95%**	**ACP 99.9%**	**PORT 95%**
SAT	292,473 (68.1%)	97.7%	99.4%	12,588 (78.0%)	99.4%	99.7%	99.3%	99.5%	96.4%
VHF	135,246 (31.5%)	99.7%	99.8%	3,267 (20.2%)	99.9%	99.9%	99.6%	99.7%	97.9%
HF*	1,688 (0.4%)	89.0%	92.7%	7(<0.1%)	--	--	--	--	--
Total	429,407	98.2%	99.4%	16,136**	99.4%	99.7%	99.2%	99.5%	96.5%

* HF performance is assessed against RSP400/RCP400 criteria.
** 1.7% of RCP transactions occur over mixed media

A.6. The data shown in Table A-2 that is highlighted in green indicates that the specific criterion has been met. Table A-2 shows that the data link transactions made using satellite and VHF meet the 95 percent criteria for RCP240 ACP, ACTP, PORT and RSP180 ADS-C surveillance over the six-month period. The data also shows that HF data link performance does not meet the RSP400 95 percent criteria for ADS-C surveillance during the six-month period. The data provided in Table A-1 show that the majority of the data link communication messages are sent via satellite data link in the Anchorage Oceanic FIR.

A.7. The top 90 percent of operators in the Oakland FIR in terms of number of CPDLC and ADS-C data link messages are presented in Table A-3. The operator information is de-identified in the Table. Values that appear in **green** indicate that the 99.9 percent target level was attained. Values that appear in **red** indicate that the 95 percent target level was not reached.

Table A-3. RCP240 and RSP180 Performance Observed in the Oakland FIR by Operator

Operator	ADS-C			CPDLC					
	% of Total ADS-C	ADS-C 95%	ADS-C 99.9%	% of Total CPDLC	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
A	17.0%	98.2%	99.5%	14.0%	99.1%	99.4%	98.9%	99.3%	95.5%
D	8.5%	98.7%	99.6%	5.9%	99.5%	99.6%	99.6%	99.8%	98.2%
B	7.5%	99.2%	99.6%	7.0%	99.6%	99.6%	99.4%	99.6%	98.2%
L	7.3%	98.8%	99.6%	7.8%	99.6%	99.6%	98.8%	99.3%	95.2%
Q	5.9%	98.8%	99.6%	5.8%	99.5%	99.8%	99.5%	99.8%	98.3%
G	5.6%	99.7%	**99.9%**	10.6%	99.9%	**99.9%**	99.8%	**99.9%**	99.1%
NNN	5.5%	97.1%	99.0%	5.1%	98.8%	99.1%	97.4%	97.9%	**92.5%**
E	4.3%	99.2%	99.6%	4.1%	99.7%	99.8%	99.6%	99.7%	98.6%
J	3.2%	99.7%	**99.9%**	4.9%	99.9%	**99.9%**	99.8%	**99.9%**	99.1%
O	3.1%	99.3%	99.8%	2.7%	99.8%	**99.9%**	99.7%	**99.9%**	98.5%
F	2.7%	99.5%	**99.9%**	4.3%	99.8%	99.8%	99.6%	99.8%	98.8%
N	2.7%	99.5%	99.6%	2.1%	99.4%	99.4%	99.4%	**99.9%**	98.6%
S	2.5%	98.6%	99.4%	2.1%	99.5%	99.7%	99.6%	99.8%	98.1%
H	2.5%	99.5%	99.8%	3.8%	99.8%	**100%**	100%	**100%**	99.3%
T	2.3%	99.5%	99.7%	2.6%	99.6%	99.7%	99.4%	99.5%	98.5%
Y	2.2%	97.2%	98.4%	0.8%	98.4%	99.0%	97.9%	98.2%	95.9%
R	2.2%	98.8%	99.6%	2.4%	99.5%	99.6%	99.5%	99.7%	97.5%
K	2.2%	98.2%	99.0%	2.6%	99.0%	99.2%	99.3%	99.6%	98.0%
ZZZZ	1.4%	99.1%	99.5%	1.0%	99.8%	99.8%	97.2%	98.2%	**88.5%**
P	1.4%	98.8%	99.6%	1.7%	99.7%	**99.9%**	99.8%	**99.9%**	98.3%

A.8. The data in Table A-3 show 20 operators contributing to 90 percent of the ADS-C position reports received at Oakland ARTCC. All of the operators presented in Table A-3 meet the 95 percent criterion for RSP180 ADS-C downlink latency and RCP240 ACTP and ACP. Eighteen of the twenty operators meet the 95 percent criteria for PORT within 60 seconds. A few of the operators meet the 99.9 percent criterion for RSP180 ADS-C downlink latency, RCP240 ACTP and ACP; these are indicated with the color **green** in Table A-3.

A.9. The top 90 percent of operators in the Anchorage FIR in terms of number of CPDLC and ADS-C data link messages are presented in Table A-4. The operator information is de-identified in the Table. Values that appear in **green** indicate that the 99.9 percent target level was attained. Values that appear in **red** indicate that the 95 percent target level was not reached.

Table A-4. RCP240 and RSP180 Performance Observed in the Anchorage FIR by Operator

Operator	ADS-C			CPDLC					
	% of Total ADS-C	ADS-C 95%	ADS-C 99.9%	% of Total CPDLC	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
A	12.6%	97.4%	99.4%	10.8%	99.4%	99.7%	99.3%	99.7%	94.9%
D	11.1%	98.1%	99.6%	7.3%	99.3%	99.7%	99.2%	99.5%	96.8%
Q	9.2%	98.0%	99.4%	8.5%	98.7%	99.4%	99.2%	99.5%	95.2%
L	8.1%	98.6%	99.6%	8.2%	99.5%	99.6%	98.5%	98.9%	**93.6%**
S	7.4%	97.7%	99.6%	6.1%	99.3%	99.6%	98.6%	99.1%	96.9%
H	6.7%	98.9%	99.5%	8.6%	99.6%	99.8%	99.4%	99.5%	97.3%
F	6.2%	99.2%	99.8%	8.8%	99.0%	99.4%	99.2%	99.6%	98.2%
Y	6.2%	95.5%	97.5%	2.4%	98.2%	98.4%	98.4%	99.0%	**94.3%**
G	4.3%	99.5%	**99.9%**	7.5%	100%	**100%**	99.9%	**99.9%**	98.9%
J	4.1%	99.8%	**99.9%**	6.4%	99.9%	**99.9%**	99.9%	**99.9%**	99.2%
R	3.7%	96.3%	99.6%	3.4%	99.5%	99.6%	99.6%	**100%**	97.4%
QQQ	2.3%	99.2%	99.4%	2.7%	99.1%	99.5%	98.6%	98.8%	98.2%
T	2.0%	99.4%	99.8%	2.4%	99.7%	99.7%	99.7%	99.7%	97.9%
O	1.9%	99.3%	**99.9%**	2.0%	100%	**100%**	100%	**100%**	98.8%
P	1.9%	98.4%	99.5%	2.1%	98.8%	99.4%	99.4%	99.4%	97.6%
KKK	1.6%	98.9%	99.7%	1.1%	100%	**100%**	100%	**100%**	98.3%
B	1.4%	99.4%	99.7%	1.7%	100%	**100%**	100%	**100%**	97.8%

A.10. The data in Table A-4 show 17 operators contributing to 90 percent of the ADS-C position reports received at Oakland ARTCC. All of the operators presented in Table A-4 meet the 95 percent criterion for RSP180 ADS-C downlink latency and RCP240 ACTP and ACP. Fifteen of the seventeen operators meet the 95 percent criteria for PORT within 60 seconds. A few of the operators meet the 99.9 percent criterion for RSP180 ADS-C downlink latency, RCP240 ACTP and ACP; these are indicated with the color **green** in Table A-3.

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