International Civil Aviation Organization

The Nineteenth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/19)

Pattaya, Thailand, 27-30 May 2014

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

PARMO HORIZONTAL SAFETY MONITORING REPORT

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

SUMMARY

This paper presents the horizontal safety monitoring report from the Pacific Approvals Registry and Monitoring Organization (PARMO) for the time period 1 January to 31 December 2013. 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 (FIRs).

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), 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 January to 31 December 2013 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 the report, the reader will find the large lateral deviation and large longitudinal error reports received by the PARMO during the reporting period, as well as relevant data link performance. There were a total of four (4) such reports submitted to the PARMO during the reporting period.

2. DISCUSSION

2.1 **Attachment A** contains the PARMO Horizontal Safety Monitoring Report for January to December 2013.

Executive Summary

2.2 **Table 1** provides the Anchorage and Oakland oceanic airspace horizontal risk estimates. **Figure 1** presents the lateral and longitudinal collision risk estimate trends for the Anchorage and Oakland oceanic airspace during the period 1 January 2013 to 31 December 2013.

Anchorage and Oakland Oceanic Airspace – estimated annual flying hours = 918,873 hours ***(note: estimated hours based on Dec 2013 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 18 30NM Lateral Risk	*0.45 x 10*$^{-9}$	*5.0 x 10*$^{-9}$	*Below TLS*
RASMAG 18 50NM Lateral Risk	*4.33 x 10*$^{-9}$	*5.0 x 10*$^{-9}$	*Below TLS*
RASMAG 18 30NM Longitudinal Risk	*3.73 x 10*$^{-9}$	*5.0 x 10*$^{-9}$	*Below TLS*
RASMAG 18 50NM Longitudinal Risk	*2.32 x 10*$^{-9}$	*5.0 x 10-9*	*Below TLS*
30NM Lateral Risk	**0.26 x 10**$^{-9}$	5.0 x 10^{-9}	**Below TLS**
50NM Lateral Risk	**0.97 x 10**$^{-9}$	5.0 x 10^{-9}	**Below TLS**
30NM Longitudinal Risk	**3.74 x 10**$^{-9}$	5.0 x 10^{-9}	**Below TLS**
50NM Longitudinal Risk	**2.32 x 10**$^{-9}$	5.0 x 10^{-9}	**Below TLS**

Table 1: Anchorage and Oakland Oceanic Airspace Horizontal Risk Estimates

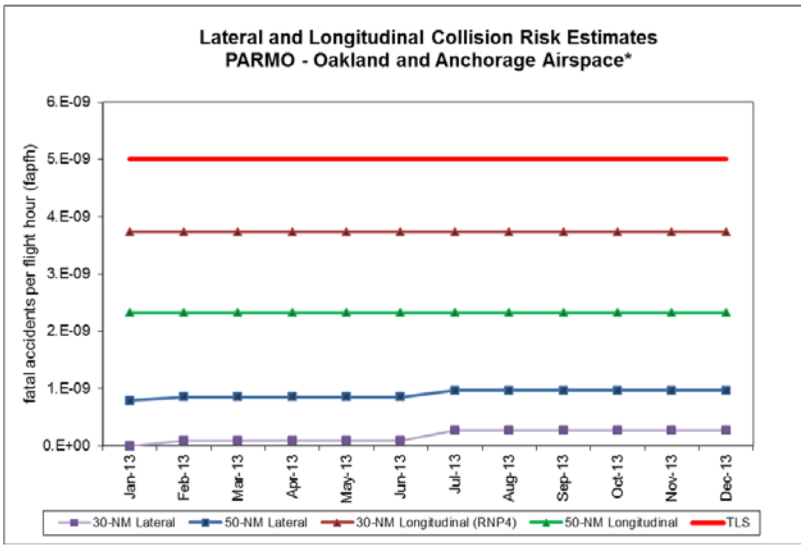

Figure 1: Anchorage and Oakland Oceanic Airspace Horizontal Risk Estimates

2.3 **Table 2** contains a summary of Large Lateral Deviations (LLD) and Large Longitudinal Errors (LLE) received by PARMO for Anchorage and Oakland Oceanic airspace.

Deviation Code	**Cause of Deviation**	**Number of Occurrences**
A	Flight crew deviate without ATC Clearance;	2

Deviation Code	Cause of Deviation	Number of Occurrences
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.)	1
D	ATC system loop error (e.g. ATC issues incorrect clearance, Flight crew misunderstands clearance message etc)	0
E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility	1
F	Navigation errors, including incorrect position estimate or equipment failure of which notification was not received by ATC or notified too late for action	See 2.4 below

Table 2: Summary of Anchorage and Oakland Oceanic Airspace LLD and LLE Reports

2.4 In November 2013, Oakland ARTCC initiated a pro-active safety management process to identify aircraft operations that had not provided ATC with an updated forward position estimate. The goal of this activity is to reduce time errors which will help to improve airspace safety. To accomplish this, the Oakland ARTCC has automated time error tracking and reporting. During the first month of the automated tracking, 109 time error events were identified and reported as having not provided an updated forward estimate of position. Most, if not all, of these events involved operations using HF radio for communication and are not eligible for the reduced longitudinal separation minima. Therefore, these reports are included to inform the RASMAG of this activity, and are not incorporated into the PARMO collision risk estimates for reduced longitudinal separation.

2.5 As a result of this activity, noticeable improvement has been observed with a few operators. New procedures were initiated which include HF radio read-backs. The FAA is now collecting data resulting from this new process.

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.

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WP08 Attachment A

Horizontal Safety Monitoring report for Anchorage and Oakland Flight Information Regions (FIRs) January to December 2013

Prepared by:
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 January to 31 December 2013. 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 (FIRs).

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 Anchorage and Oakland oceanic airspace.

1.2. This report covers the current reporting period 1 January to 31 December 2013 in the PARMO's ongoing process of providing periodic updates of information relevant to the continued safe use of the reduced horizontal separation minima 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.

2. Discussion

2.1. Lateral Separation Standards

2.1.1. The lateral separation minima applied in the Anchorage and Oakland FIR varies. The 50-NM lateral separation minimum 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.

2.1.2. The 30-NM lateral separation minimum can be applied to suitably equipped RNP4 operations. The application of the 30-NM lateral separation 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. On 27 November 2012, the FAA implemented the 30-NM lateral separation minimum in the Anchorage FIR.

2.2. Longitudinal Separation Standards

2.2.1. The longitudinal separation minima applied in the Anchorage and Oakland FIR varies. The 10-minute longitudinal separation can be applied with or without mandatory assignment of Mach number. The 50-NM longitudinal separation minimum 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.

2.2.2. On 27 November 2012, the FAA implemented the 30-NM longitudinal separation minimum in the Anchorage FIR. The 30-NM longitudinal separation minimum can be applied to suitably equipped RNP4 operations. The ADS-C periodic report interval is 10 minutes in the Anchorage FIR and 14 minutes in the Oakland FIR for operations eligible for the 30-NM longitudinal separation minimum. The application of the 30-NM longitudinal separation minimum is also done ad hoc between pairs of suitably equipped aircraft.

2.3. Data Sources

2.3.1. Monthly large lateral deviation (LLDs) and large longitudinal errors (LLEs) are forwarded to the PARMO from the Anchorage and Oakland oceanic FIRs. The FAA has recently changed the event reporting system for the oceanic facilities. The PARMO is currently working with the organizations within the FAA to obtain access to these data. It is expected that the new data source will be similar to the previous source which provided to aviation safety data. These data are supplement the large lateral and longitudinal deviation reports received from the ATS providers.

2.3.2. 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.

2.3.3. Data link transmission data obtained from operations conducted within the Anchorage and Oakland oceanic FIRs are obtained at the FAA Technical Center. 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.

2.4. Data Submission

2.4.1. The most recent annual one-month traffic movement samples for December 2013 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.

2.4.2. Monthly reports of LLDs and LLEs were also received from both the Anchorage and Oakland FIRs for the time period January through December 2013.

2.5. Large Lateral Deviation and Large Longitudinal Error Report Summary

2.5.1. Table 1 contains a summary of the number of risk-bearing LLD and LLE occurrences during the time period 1 January to 31 December 2013 in the Anchorage and Oakland oceanic FIRs. There were a total of four (4) reports received during the time period.

Table 1. Summary of LLD and LLE Occurrences in Anchorage and Oakland Oceanic Airspace

Month-Year	No. of LLDs and LLEs Occurrences
Jan-13	0
Feb-13	1
Mar-13	0
Apr-13	0
May-13	0
Jun-13	1
Jul-13	2
Aug-13	0

Month-Year	No. of LLDs and LLEs Occurrences
Sep-13	0
Oct-13	0
Nov-13	0 (109)
Dec-13	0 (135)
Total	4

2.5.2. 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.

Table 2. LLD and LLE Deviation Codes and Category Descriptions for 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 incorrect position estimate or 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

2.5.3. A summary of the LLD and LLE reports received by the PARMO is contained in Table 3. Three (3) of the reports listed in Table 3 are LLD events, one is a LLE event.

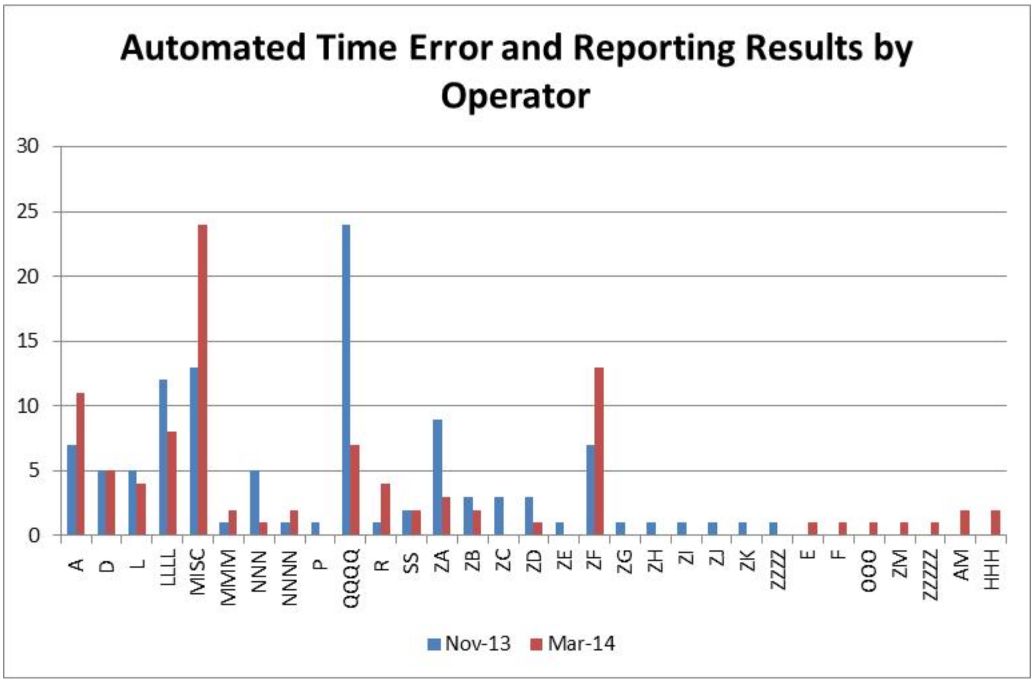
Table 3. Summary of LLD and LLE Reports Received by the PARMO

Deviation Code	Cause of Deviation	Number of Occurrences
A	Flight crew deviate without ATC Clearance;	2
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.)	1
D	ATC system loop error (e.g. ATC issues incorrect clearance, Flight crew misunderstands clearance message etc)	0

E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility	1
F	Navigation errors, including incorrect position estimate or equipment failure of which notification was not received by ATC or notified too late for action	(244) see paragraph 2.5.4

2.5.4. In addition to the four reported LLE and LLD events, the PARMO is in receipt of many incorrect position estimate events from Oakland ARTCC. In November 2013, Oakland ARTCC initiated a pro-active safety management process to identify aircraft operations that had not provided ATC with an updated forward position estimate. The goal of this activity is to reduce time errors and improve airspace safety. To accomplish this, the Oakland ARTCC has automated time error tracking and reporting. During the first month of the automated tracking, 109 time error events were identified and reported as having not provided an updated forward estimate of position. Most, if not all, of these events involved operations using HF radio for communication and are not eligible for the reduced longitudinal separation minima. Therefore, these reports are included to inform the RASMAG of this activity, and are not incorporated into the PARMO collision risk estimates for reduced longitudinal separation.

2.5.5. Figure 1 shows a comparison of the automated time error results by operator, the operator information is de-identified.



2.5.6. The data in Figure 1 compares the number of automated time errors reported for the listed operators in November 2013 and March 2014. Noticeable improvements in the operators labeled ‘QQQQ’, ‘LLLL’, and ‘ZA’ and shown in Figure 1. Recently, it was determined that a significant number of these errors were the result of a lack read-backs performed by the third party communication agent, ARINC. In April 2014, the FAA and ARINC initiated new procedures which include HF radio read-backs. The FAA is now collecting data resulting from this new process.

2.5.7. Figure 2 shows the approximate locations of the four (4) reported LLE and LLD events.

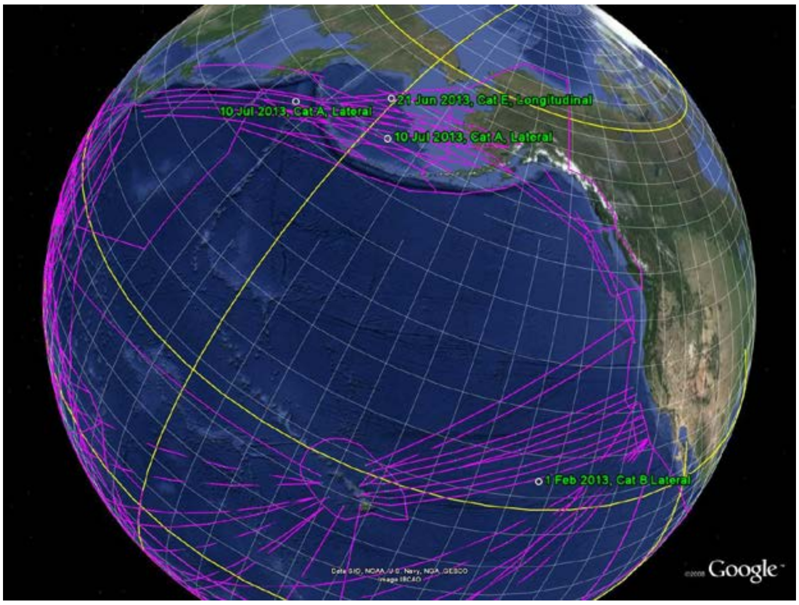


Figure 2. Approximate locations of the four (4) LLD and LLE event reports

2.6. Performance Monitoring Related to the Application of the Reduced Horizontal Separation Standards

2.6.1. 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. Figures 3 and 4 provide the numbers of flights, data link operations, proportions of RNP4 and RNP10 observed by month for Anchorage and Oakland oceanic airspace, respectively.

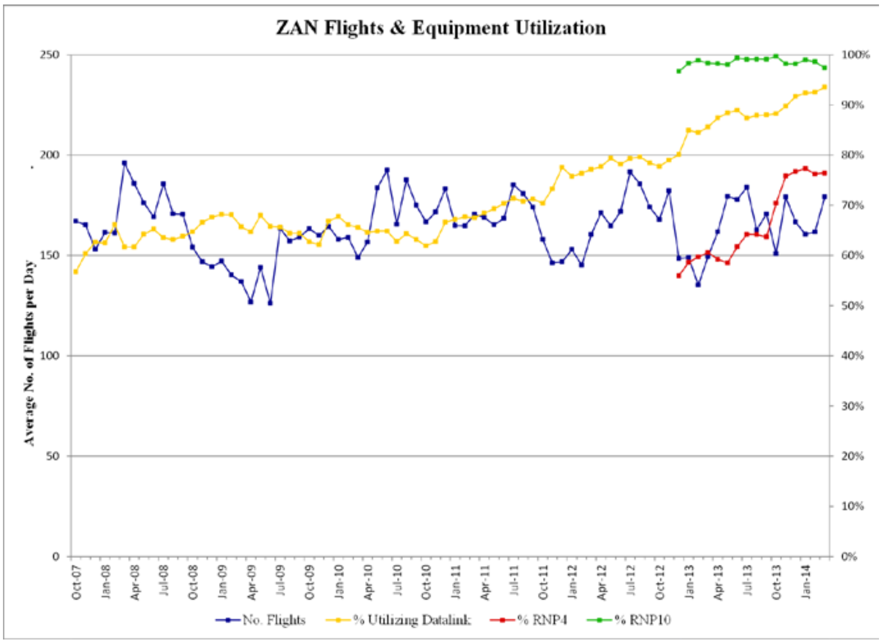


Figure 3. Number of data link flights and proportion of RNP observed in Anchorage oceanic airspace

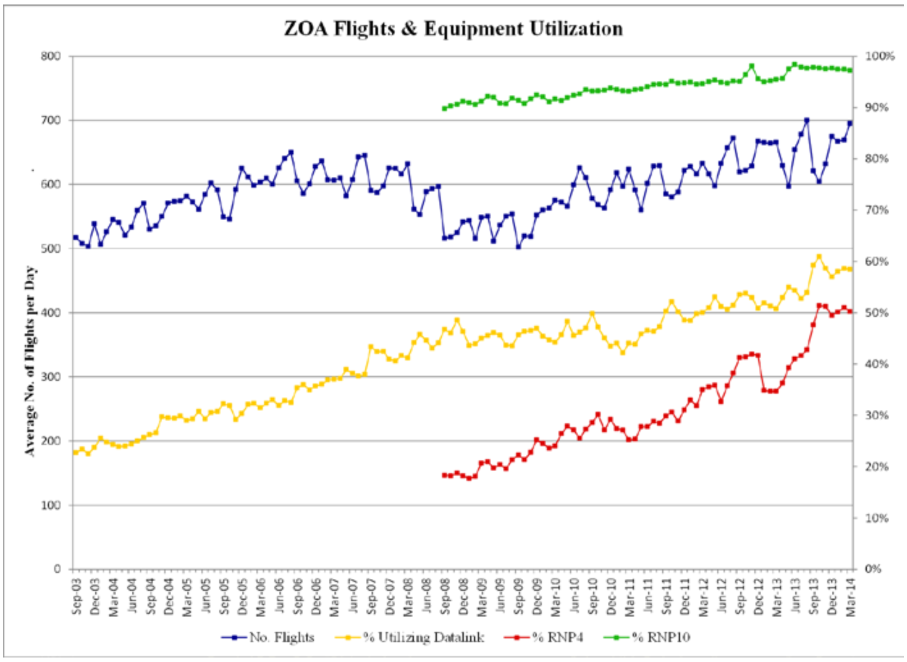


Figure 4. Number of data link flights and proportion of RNP observed in Oakland oceanic airspace

2.7. Longitudinal Monitoring

2.7.1. The observed speed data were obtained from ADS-C operations in the Oakland FIR from traffic data collected for the period of June – November 2013. The data used in this paper were available in the Ocean21 data archives that contain amongst other items, filed flight plans and ADS-C reports.

2.7.2. An ADS-C aircraft in the Oakland FIR is assigned two contracts; a periodic and an event contract. The event contract consists of two elements - the Waypoint Change Event (WPC) and the Lateral Deviation Event (LDC). The ADS-C periodic contract is established with a specific reporting rate and an indication that the following information is requested: predicted route group information, earth reference, meteorological reference, and air reference information. The predicted route group information provides the next waypoint latitude and longitude, expected flight level at the next waypoint, time of arrival estimate (ETA) for the next waypoint to be sequenced. It also provides the next plus one waypoint latitude and longitude along with the expected altitude at the next plus one waypoint.

2.7.3. The coupled ETA information and the actual time of arrival at the waypoint from ADS-C reports are used to estimate along track speed error. The results of this analysis and empirical data fit are shown in Figure 5.

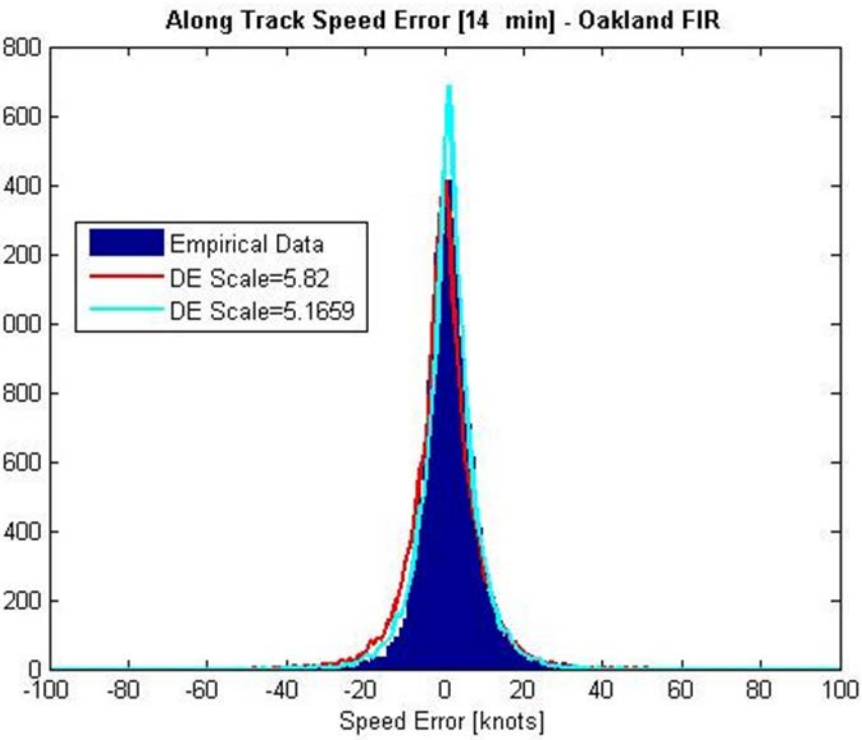


Figure 5. Comparison of Double Exponential Distributional Fit to the Along Track Speed Error Data from the Oakland FIR [14 minute interval]

2.7.4. The results from this analyses show the original estimated double exponential distribution with zero mean and scale parameter of 5.82 knots provides a good estimate to the observed speed error data in the Oakland FIR.

2.8. Observed Data Link Performance

2.8.1. The PARMO examines the aircraft ADS-C periodic reports in the archived data and identifies cases of overdue reports. Figures 6 and 7 contain the proportion of missing ADS-C reports in Anchorage and Oakland airspace, respectively.

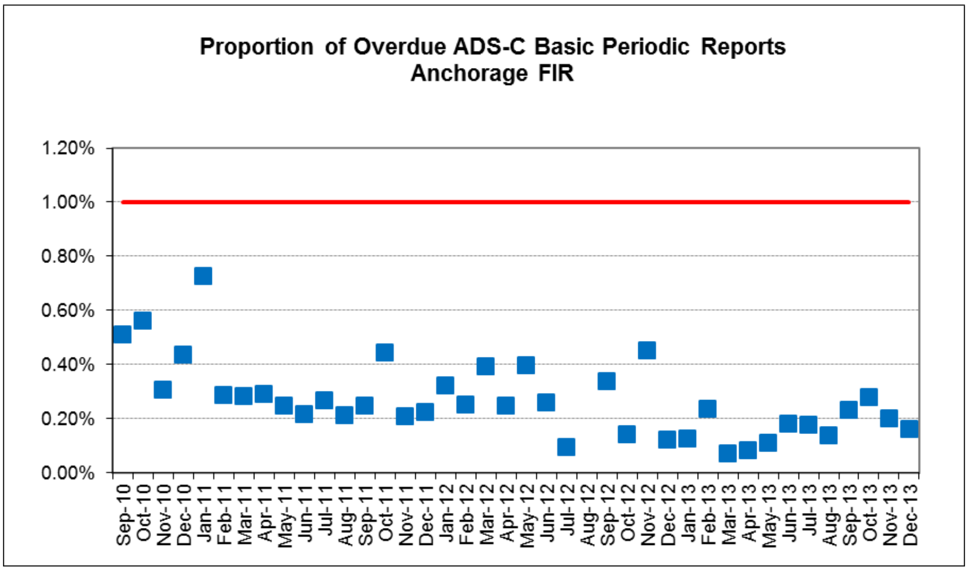


Figure 6. Proportion of Overdue ADS-C Periodic Reports Observed in Anchorage Airspace

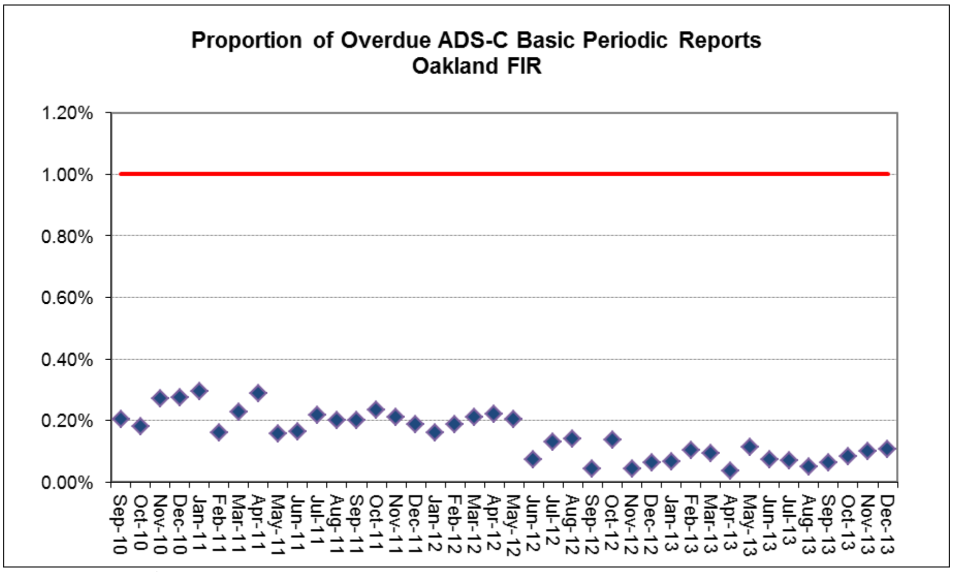


Figure 7. Proportion of Overdue ADS-C Periodic Reports Observed in Oakland Airspace

2.8.2. The data in Figures 6 and 7 show the average proportions of missing ADS-C reports in the Anchorage and Oakland FIRs are well below the target established by the scrutiny group.

2.8.3. 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 July 2013 through December 2013.

2.8.4. The data link performance data are relevant to the monitoring of the reduced horizontal separation standards in oceanic airspace because the communication and surveillance systems necessary to support the reduced separation minima rely on data link.

2.8.5. 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.

2.9. Estimate of Horizontal Collision Risk for Pacific Airspace

2.9.1. Estimation of lateral collision risk

2.9.2. 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.

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

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

Sub-Region of Pacific	Flow	Description of Flow
	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	South Pacific States to and from States in northern hemisphere

2.9.3. 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:

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

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

Table 5. Parameter Values for the Lateral Collision Risk Estimates

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	59.5 knots for 50-NM lateral separation minimum, 35.9 knots for 30-NM lateral separation minimum	Conservative value based on speed required to commit waypoint insertion error
$\overline{\lvert\dot{\mathrm{z}}\rvert}$	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 2013 traffic sample
λ_y	Average aircraft wing-	0.0333-NM	Weighted average based

Parameter Symbol	**Parameter Definition**	**Parameter Value**	**Source for Value**
	span		on Dec 2013 traffic sample
λ_z	Average aircraft height with undercarriage retracted.	0.0100-NM	Weighted average based on Dec 2013 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.	9.24×10^{-9} for 30NM lateral separation / 3.04×10^{-8} for 50NM lateral separation	Determined from the RNP requirement and the observed frequency of lateral errors modeled with a DDE density
$E_y(same)$	Same direction lateral occupancy	0.0508	Average value estimated from December 2013 traffic sample
$E_y(opp)$	Opposite direction lateral occupancy	0.0095	Average value estimated from December 2013 traffic sample

2.9.5. The lateral navigation performance is modeled as a Double Double Exponential (DDE) distribution. The core portion of the DDE represents the typical lateral deviations from the route center line. The mathematical modeling uses the RNP type value to determine the shape of the core density. The reported LLDs are used to determine the shape of the tail portion of the distribution.

2.10. Estimation of longitudinal collision risk

2.10.1. 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 distance-based 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:

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

2.10.2. 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.

2.10.3. 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:

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

2.10.4. Similar to the estimate of lateral collision risk, the required navigation performance is used in estimating the longitudinal risk. The mathematical modeling uses the RNP type value (either RNP 10 or RNP 4) to determine the shape of the navigational performance distribution.

2.10.5. 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.

2.10.6. Under normal ADS operation, an allowance of 4 minutes is assumed for the value of τ.

2.10.7. 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.

2.10.8. 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.

2.10.9. 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.

2.10.10.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.

Table 6. Parameter Values for the Longitudinal Collision Risk Estimates

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 2013 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
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)

2.11. Collision risk estimates

2.11.1. Figure 8 presents the collision risk estimates by month for Oakland and Anchorage oceanic airspace. In all cases, the estimates are made using the RNP Type required for the application of the separation. Significant differences are observed in the results when observed navigation performance is used in longitudinal risk estimates. For example, the 30-NM lateral separation with a 14 minute

ADS-C periodic report rate and an Observed Navigation Performance of 0.3, yields an estimate of longitudinal collision risk of 28.2 x 10^{-9} fapfh when all other CRM parameters remain the same. The Separations and Airspace Safety Panel (SASP) is undertaking a re-evaluation of the effect on the risk under observed navigation performance and the RNP type for GNSS aircraft. A value which exceeds the Target level of Safety (TLS) is realized for longitudinal risk if better navigation performance is assumed rather than the required performance; in order to meet the TLS, a more frequent ADS-C reporting interval is needed. Conversely, lower risk values are realized for lateral risk if better navigation performance is assumed rather than the required performance.

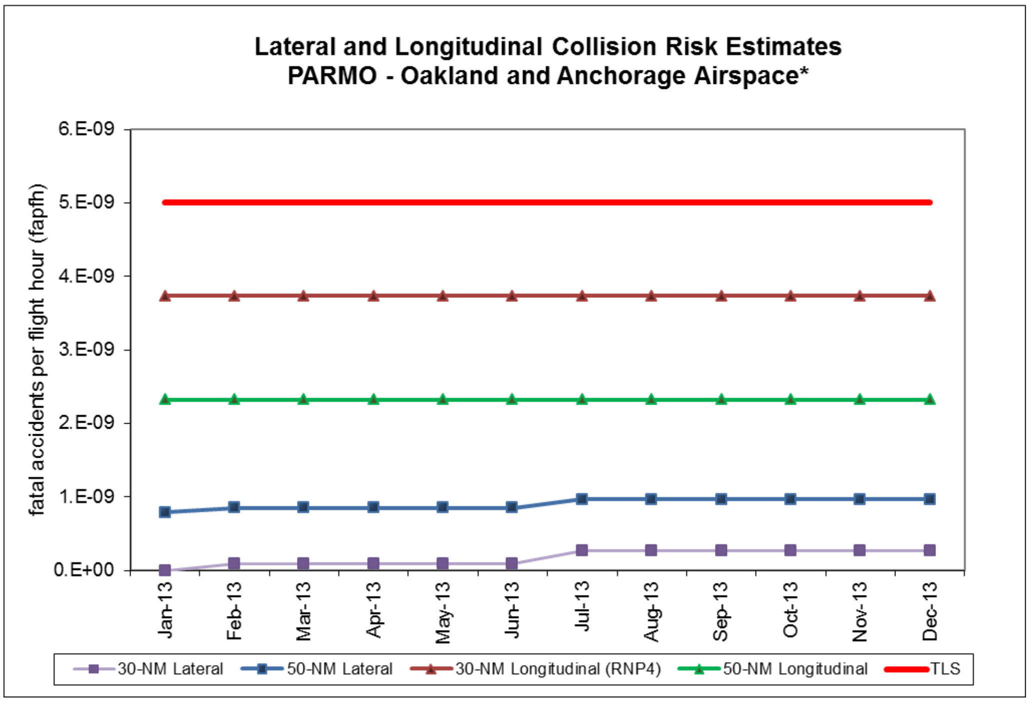


Figure 8. Horizontal Collision Risk Estimates for Anchorage and Oakland Oceanic Airspace

* The estimate of collision risk uses the Required Navigation Performance (RNP) for each separation minima.

2.11.2. The data in Figure 8 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 x 10^{-9} fatal accidents per flight hour due to the loss of planned separation.

2.11.3. Table 4 provides a summary of the data. (see * note above) For most aircraft operating in the Oakland and Anchorage airspace 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.

Table 7. Horizontal Collision Risk Estimates for Pacific Airspace

Portions of Pacific Airspace *– estimated number of traffic movements= 266,820 operations, number of annual flying hours =918,873 hours (note: estimates are based on the December 2013 TSD)*			
Source of Risk	**Lower Bound Risk Estimation**	**TLS**	**Remarks**
30-NM Lateral Risk	0.26 x 10^{-9}	5.0 x 10^{-9}	Below Overall TLS
50-NM Lateral Risk	0.97 x 10^{-9}	5.0 x 10^{-9}	Below Overall TLS
30-NM Longitudinal Risk	3.74 x 10^{-9}	5.0 x 10^{-9}	Below Overall TLS
50-NM Longitudinal Risk	2.32 x 10^{-9}	5.0 x 10^{-9}	Below Overall TLS

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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 July 2013 through December 2013 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 July 2013 through December 2013 for the Oakland oceanic FIR. There were 67.292 flight operations in the Oakland FIR using data link during this time period. 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%
Performance Criteria		**RSP 180**			**RCP 240**				
Aggregate	2,007,861	98.7%	99.5%	85,317	99.7%	99.8%	99.4%	99.6%	98.2%
SAT	1,769,677	98.7%	99.5%	83,383	99.7%	99.8%	99.4%	99.6%	98.2%
VHF	231,510	99.4%	99.8%	1,639	99.9%	99.9%	99.7%	99.8%	97.7%
Performance Criteria		**RSP 400**			**RCP 400**				
HF	6,665	92.9%	95.5%	47	--	--	--	--	--

A.5. Table A-2 provides the ACP, ACTP, PORT, and ADS-C surveillance latency performance, respectively, during the time period July 2013 through December 2013 for the Anchorage oceanic FIR. There were 27,681 flight operations in the Anchorage FIR during this time period. 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%
Performance Criteria		**RSP 180**			**RCP 240**				
Aggregate	759,030	98.2%	99.4%	16,170	99.5%	99.6%	99.2%	99.4%	97.7%
SAT	490,328	97.6%	99.3%	10,897	99.5%	99.6%	99.1%	99.4%	97.5%
VHF	263,342	99.7%	99.8%	5,058	99.9%	99.9%	99.7%	99.8%	98.4%
Performance Criteria		**RSP 400**			**RCP 400**				
HF	5,269	90.9%	94.1%	22	--	--	--	--	--

A.6. The data shown in Tables A-1 and A-2 is highlighted green to indicate the specific criterion has been met. The yellow highlighted cells indicate that the actual level is over 99 percent but not quite at the 99.9 percent level. Both tables show 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 show that the majority of the data link communication messages are sent via satellite data link in both the Oakland and Anchorage Oceanic FIRs.

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 are shaded in **green** indicate that the 95 percent target level was attained. Values that are shaded 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

Code	Count of ADS-C	% of Total ADS-C	ADS-C 95%	ADS-C 99.9%	Count of CPDLC	% of Total CPDLC	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
A	275,390	13.7%	98.2%	99.3%	13,049	15.3%	99.6%	99.6%	99.2%	99.4%	96.4%
NNN	206,257	10.3%	97.7%	99.5%	4,774	5.6%	99.6%	99.7%	99.1%	99.6%	97.2%
L	157,432	7.8%	98.8%	99.6%	7,995	9.4%	99.6%	99.7%	99.2%	99.4%	97.2%
G	137,588	6.9%	99.7%	99.9%	7,127	8.4%	99.9%	99.9%	99.9%	99.9%	99.6%
D	125,276	6.2%	99.0%	99.7%	4,069	4.8%	99.8%	99.8%	99.6%	99.7%	98.8%
B	107,887	5.4%	98.9%	99.4%	4,332	5.1%	99.6%	99.7%	99.4%	99.6%	98.6%

Code	Count of ADS-C	% of Total ADS-C	ADS-C 95%	ADS-C 99.9%	Count of CPDLC	% of Total CPDLC	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
R	91,343	4.5%	98.6%	99.5%	3,293	3.9%	99.6%	99.6%	99.3%	99.5%	97.8%
Q	89,040	4.4%	98.6%	99.7%	4,644	5.4%	99.8%	99.9%	99.8%	99.8%	98.9%
E	69,845	3.5%	99.1%	99.6%	2,934	3.4%	99.8%	99.8%	99.5%	99.7%	98.5%
J	67,121	3.3%	99.3%	99.7%	4,490	5.3%	99.8%	99.9%	99.7%	99.8%	99.4%
T	57,847	2.9%	99.3%	99.7%	2,798	3.3%	99.8%	99.8%	99.6%	99.7%	99.1%
H	56,244	2.8%	99.6%	99.8%	2,595	3.0%	99.9%	99.9%	99.7%	99.8%	99.3%
S	52,800	2.6%	98.1%	99.3%	1,553	1.8%	99.2%	99.4%	99.2%	99.4%	99.0%
F	51,980	2.6%	99.0%	99.6%	4,943	5.8%	99.8%	99.8%	99.7%	99.8%	99.6%
N	48,226	2.4%	98.9%	99.2%	928	1.1%	99.3%	99.4%	99.0%	99.7%	98.3%
O	47,461	2.4%	98.7%	99.6%	2,090	2.4%	99.9%	99.9%	99.8%	99.8%	99.4%
Y	38,020	1.9%	97.2%	98.4%	712	0.8%	98.7%	98.9%	98.2%	98.6%	97.8%
NNNN	35,573	1.8%	98.4%	99.5%	881	1.0%	100.0%	100.0%	99.9%	99.9%	98.8%
PPPP	32,687	1.6%	99.3%	99.8%	1,851	2.2%	99.8%	99.8%	99.6%	99.8%	99.4%
ZZZZ	28,107	1.4%	99.2%	99.5%	942	1.1%	100.0%	100.0%	98.2%	98.5%	93.8%
V	22,646	1.1%	99.7%	99.8%	962	1.1%	99.7%	99.7%	99.7%	99.9%	99.4%

A.8. The data in Table A-3 show 21 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. One operator does not meet the 95 percent criteria for PORT within 60 seconds.

A.9. The top 15 operators in terms of number of ADS-C reports in the Anchorage FIR are presented in Table A-4. The operator information is de-identified in the Table. Values that are shaded in **green** indicate that the 95 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

Code	Count of ADS-C	% of Total ADS-C	ADS-C 95%	ADS-C 99.9%	Count of CPDLC	% of Total CPDLC	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
D	83,950	11.1%	98.4%	99.6%	1,292	8.0%	99.6%	99.7%	99.2%	99.5%	98.0%
A	76,383	10.1%	98.5%	99.5%	1,602	9.9%	99.8%	99.8%	99.4%	99.6%	95.6%
Q	75,955	10.0%	97.8%	99.4%	1,555	9.6%	99.9%	99.9%	99.6%	99.6%	98.4%
Y	59,603	7.9%	95.8%	97.8%	631	3.9%	95.6%	96.4%	95.7%	96.7%	94.8%
L	58,356	7.7%	98.7%	99.7%	1,446	8.9%	99.5%	99.7%	98.4%	98.9%	95.2%
S	51,128	6.7%	96.3%	98.9%	867	5.4%	99.4%	99.5%	99.3%	99.7%	98.5%
H	42,356	5.6%	99.0%	99.6%	1,267	7.8%	99.9%	100.0%	99.8%	99.8%	97.9%
J	41,684	5.5%	99.1%	99.7%	1,383	8.6%	99.7%	99.8%	99.6%	99.8%	99.5%
G	39,402	5.2%	99.2%	99.7%	954	5.9%	100.0%	100.0%	100.0%	100.0%	99.4%
R	32,638	4.3%	98.6%	99.6%	533	3.3%	99.3%	99.3%	99.1%	99.6%	99.1%
F	32,114	4.2%	98.8%	99.7%	1,444	8.9%	99.8%	99.9%	99.7%	99.7%	99.3%
NNNN	26,193	3.5%	98.3%	99.4%	294	1.8%	100.0%	100.0%	99.7%	99.7%	97.6%
T	23,435	3.1%	99.1%	99.7%	568	3.5%	99.3%	99.7%	99.5%	99.7%	98.2%
RRR	19,199	2.5%	97.7%	99.3%	175	1.1%	100.0%	100.0%	100.0%	100.0%	92.6%

P	11,838	1.6%	98.5%	99.5%	352	2.2%	99.7%	99.7%	99.7%	99.7%	99.4%

A.10. The data in Table A-4 show all of the operators meet the 95 percent criterion for RSP180 ADS-C downlink latency and RCP240 ACTP and ACP. All but one of the operators meet the 95 percent criteria for PORT within 60 seconds.

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