International Civil Aviation Organization

The Twenty-First Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/21)

Bangkok, Thailand, 14-17 June 2016

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

PARMO HORIZONTAL SAFETY \ REPORT

(Presented by the United States/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 2015. 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), 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 2015 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 there six 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 2015.

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 Anchorage and Oakland oceanic airspace during the period January 2015 to December 2015.

Anchorage and Oakland Oceanic Airspace – estimated annual flying hours = 984,696.30 hours *(note: estimated hours based on Dec 2015 traffic sample data)*			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 20 30NM Lateral Risk	*0.53 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
RASMAG 20 30NM Longitudinal Risk	*3.74 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
RASMAG 20 50NM Longitudinal Risk	*2.32 x 10^{-9}*	*5.0 x 10^{-9}*	*Below TLS*
30NM Lateral Risk	**0.51 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

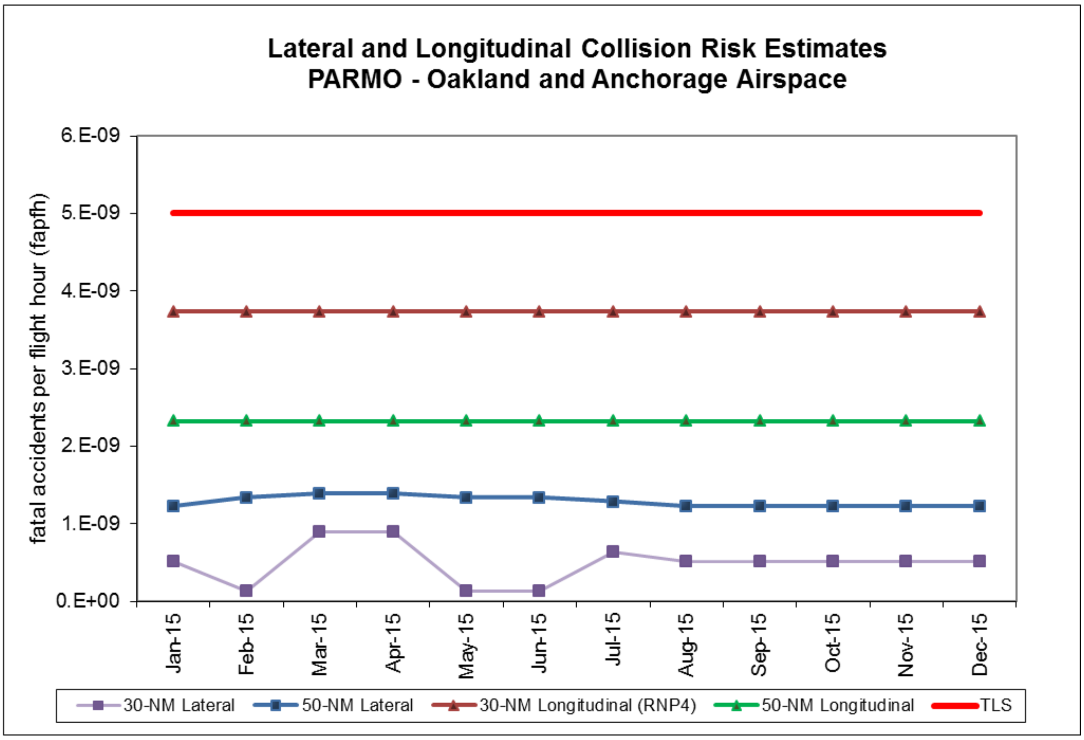


Figure 1: Anchorage and Oakland Oceanic Airspace Horizontal Risk Estimates

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;	3
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
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);	

DEVIATION CODE	CAUSE OF DEVIATION	NUMBER OF OCCURRENCES
E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility;	2
F	Navigation errors, including equipment failure of which notification was not received by ATC or notified too late for action;	
G	Turbulence or other weather related causes (other than approved);	
H	An aircraft without PBN approval;	
I	Others (Please specify)	

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

2.4 The FAA plans to implement the ADS-C Climb/Descend Procedure (CDP) during calendar year 2016. The PARMO has developed a monitoring process to evaluate safety-related metrics from the application of this procedure. The PARMO will bring initial results of this monitoring process to the next RASMAG meeting.

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.

…………………………….

Horizontal Safety Monitoring report for Anchorage and Oakland Flight Information Regions (FIRs) January to December 2015

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 2015. 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 2015 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. Traffic movement data are archived through the FAA's ATOP system. These data encompass position reports, filed flight plans, and communication messages between the pilots and air traffic controllers.

2.3.2. 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 2015 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 2015.

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 2015 in the Anchorage and Oakland oceanic FIRs. There were a total of six (6) 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-15	1
Feb-15	2
Mar-15	1
Apr-15	0
May-15	0
Jun-15	1
Jul-15	0
Aug-15	0
Sep-15	0
Oct-15	0
Nov-15	0
Dec-15	1
Total	**6**

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	Number of Occurrences
Operational Errors		
A	Flight crew deviate without ATC Clearance;	3
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
C	Flight crew waypoint insertion error, due to correct entry of incorrect position or incorrect entry of correct position;	0
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;	2
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;	0
Deviation due to Meteorological Conditions		
G	Turbulence or other weather related causes (other than approved);	0
Others		
H	An aircraft without PBN approval;	0
I	Other	0

2.5.3. Four of the reports listed in Table 2 are LLD events, two are LLE events.

2.5.4. Figure 1 shows the approximate locations of the six LLD and LLE reports received by the PARMO.

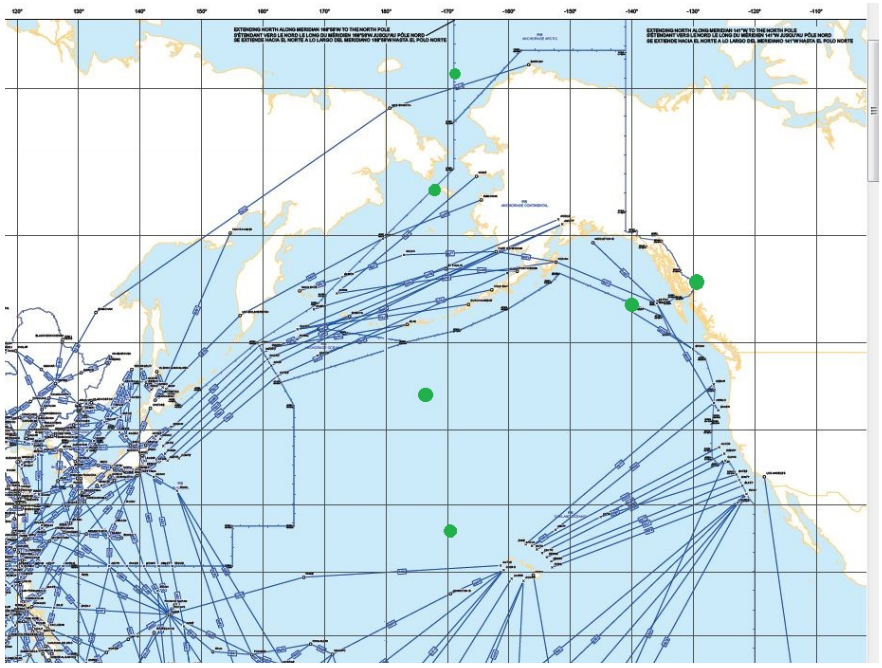


Figure 1. Approximate locations of the six (6) LLD and LLE event reports

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

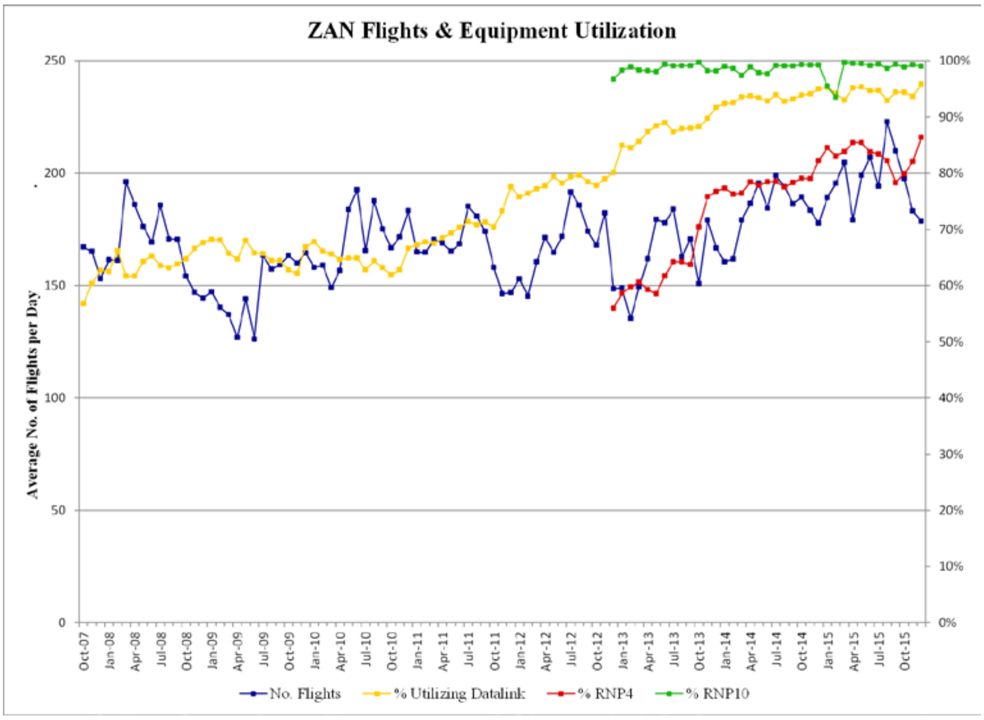


Figure 2. Number of data link flights and proportion of RNP observed in Anchorage oceanic airspace

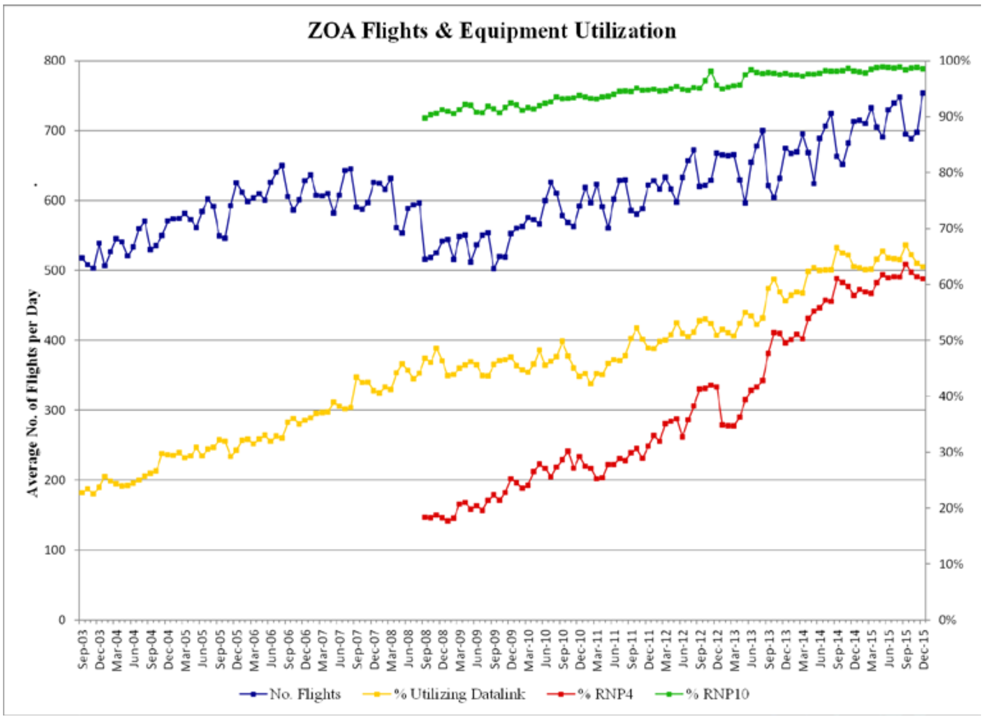


Figure 3. Number of data link flights and proportion of RNP observed in Oakland oceanic airspace

2.7. Observed Data Link Performance

2.7.1. Attachment B 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 through December 2015.

2.7.2. 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.

2.7.3. The data in Attachment B 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.

2.8. *Estimate of Horizontal Collision Risk for Pacific Airspace*

2.8.1. Estimation of lateral collision risk

2.8.2. 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:

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

2.8.3. Table 3 provides the lateral collision risk model parameter definitions and values used in the estimation of lateral risk.

Table 3. Parameter Values for the Lateral Collision Risk Estimates

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value

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
$\overline{\lvert\dot{z}\rvert}$	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
λ_y	Average aircraft wing-span	0.0333-NM	Weighted average
λ_z	Average aircraft height with undercarriage retracted.	0.0100-NM	Weighted average
$P_z(0)$	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.	1.485×10^{-8} for 30NM lateral separation / 3.378×10^{-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	0.0606	Average value estimated from December 2015 traffic sample
$E_y(opp)$	Opposite direction lateral occupancy	0.0112	Average value estimated from December 2015 traffic sample

2.8.4. 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.

2.9. *Estimation of longitudinal collision risk*

2.9.1. 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:

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

2.9.2. 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.

2.9.3. 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:

$$HOP(t\,|\,V_1V_2) = \frac{\pi\lambda_{xy}^2}{16\lambda^2} e^{-|D_x(t)|/\lambda}\left(\frac{|D_x(t)|}{\lambda} + 1\right) \qquad (3)$$

2.9.4. 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.

2.9.5. 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.

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

2.9.7. 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.

2.9.8. 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.

2.9.9. 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.

2.9.10. Table 4 provides the longitudinal collision risk parameters used in the safety assessment for the ongoing use of the 30NM and 50NM longitudinal separation minima.

Table 4. 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	Larger value of λ_y and λ_x
λ	Scale parameter for	5.82 knots	Reference 6

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
	speed error distribution		
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)

2.10. *Collision risk estimates*

2.10.1. Figure 4 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. The SASP is undertaking a re-evaluation of the risk model under observed navigation performance and the RNP type for GNSS aircraft. The SASP is also examining the speed error distribution used in the collision risk model. Recent data support the effect of application of tactical ATC procedures that limit the speed variation between closely spaced aircraft pairs.

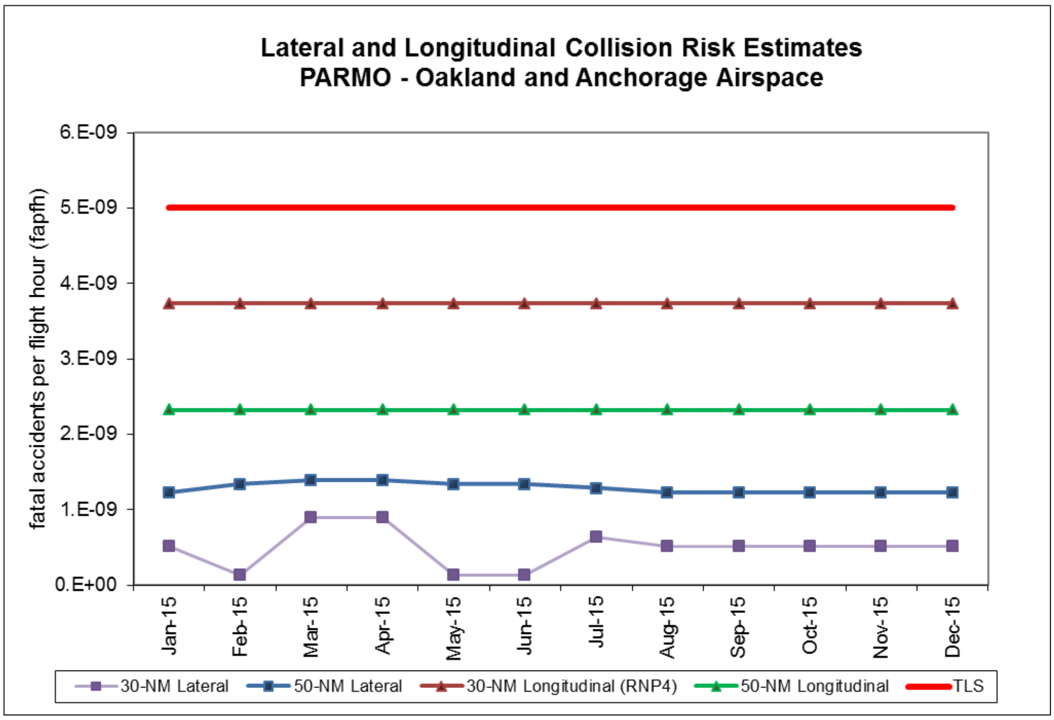


Figure 4. Horizontal Collision Risk Estimates for Anchorage and Oakland Oceanic Airspace

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

2.10.2. The data in Figure 4 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.

2.10.3. Table 5 provides a summary of the data. (see * note above) As noted earlier, one of the work items for the SASP MSG is to develop a process to monitor the speed performance associated with longitudinally separated aircraft pairs. Once developed, this process would be made available to all EMAs for inclusion in the monitoring activities for performance-based longitudinal separation minima. The results from the speed error monitoring and the pertinent data link communication monitoring could provide more meaningful measures for the safety oversight of performance-based longitudinal separation in the region.

Table 5. Horizontal Collision Risk Estimates for Pacific Airspace

Anchorage and Oakland Oceanic Airspace – estimated annual flying hours = 984,696.30 hours ***(note: estimated hours based on Dec 2015 traffic sample data)***			
Risk	**Risk Estimation**	**TLS**	**Remarks**
RASMAG 20 30NM Lateral Risk	*0.53×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 20 30NM Longitudinal Risk	*3.74×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
RASMAG 20 50NM Longitudinal Risk	*2.32×10^{-9}*	*5.0×10^{-9}*	*Below TLS*
30NM Lateral Risk	**0.51×10^{-9}**	5.0×10^{-9}	**Below TLS**
30NM Longitudinal Risk	**3.74×10^{-9}**	5.0×10^{-9}	**Below TLS**
50NM Longitudinal Risk	**2.32×10^{-9}**	5.0×10^{-9}	**Below TLS**

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.

RASMAG/21

WP/17 Attachment B

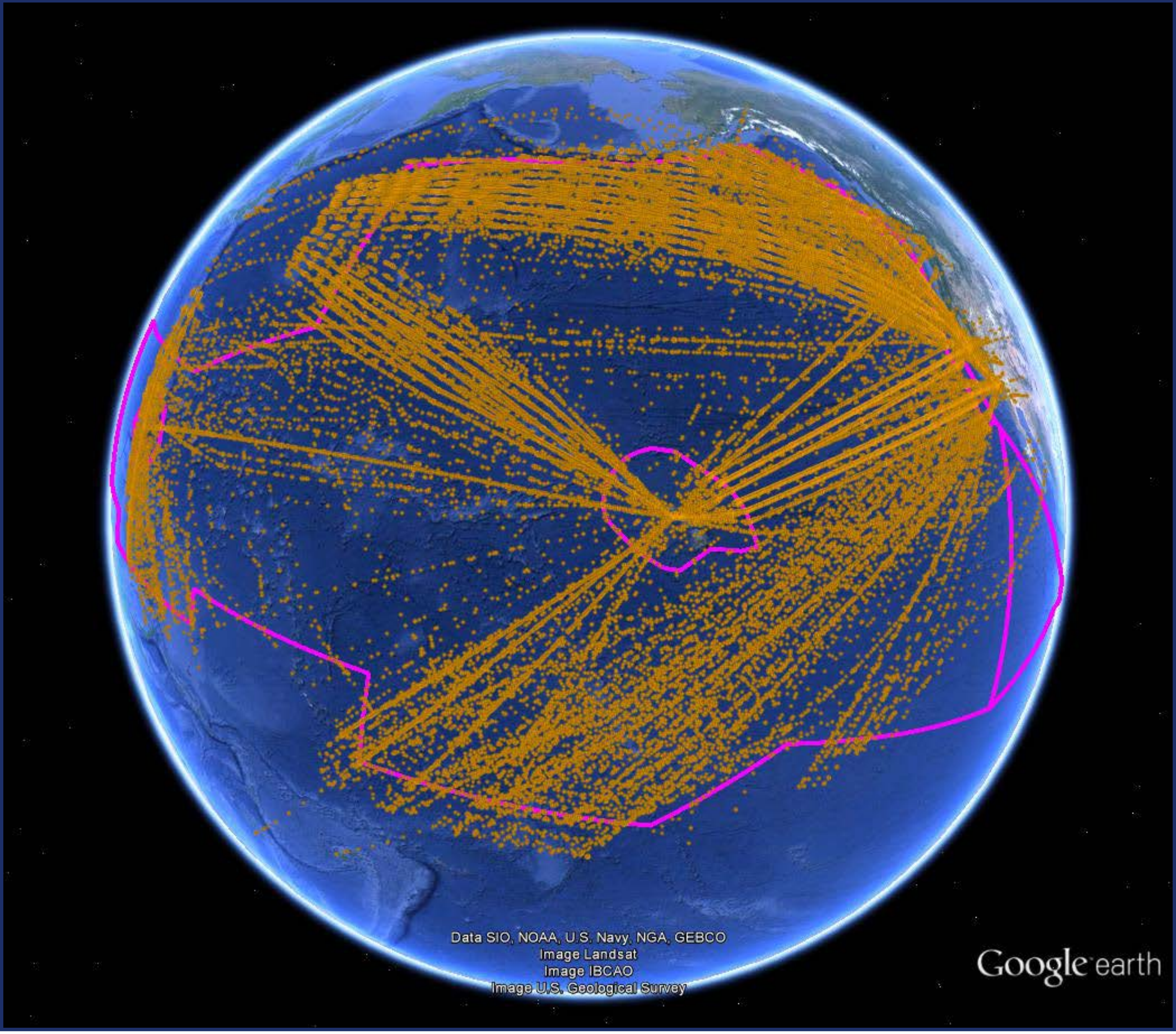
Prepared by:
Theresa Brewer-Dougherty
FAA Technical Center
Separation Standards Analysis Branch
theresa.brewer@faa.gov

Bangkok, Thailand
14-17 June 2016

Overview

- Overview of FANS Data Link Usage in US Oceanic FIRs
- Summary of Reported Outages and Measured Availability
- PBCS Performance Criteria
- Aggregate FANS Data Link Performance
- ASP for SATCOM Station Identifiers by FIR
- Aggregate FANS Data Link Performance by Operator

Oakland FIR KZAK



KZAK – FANS Data Link Usage

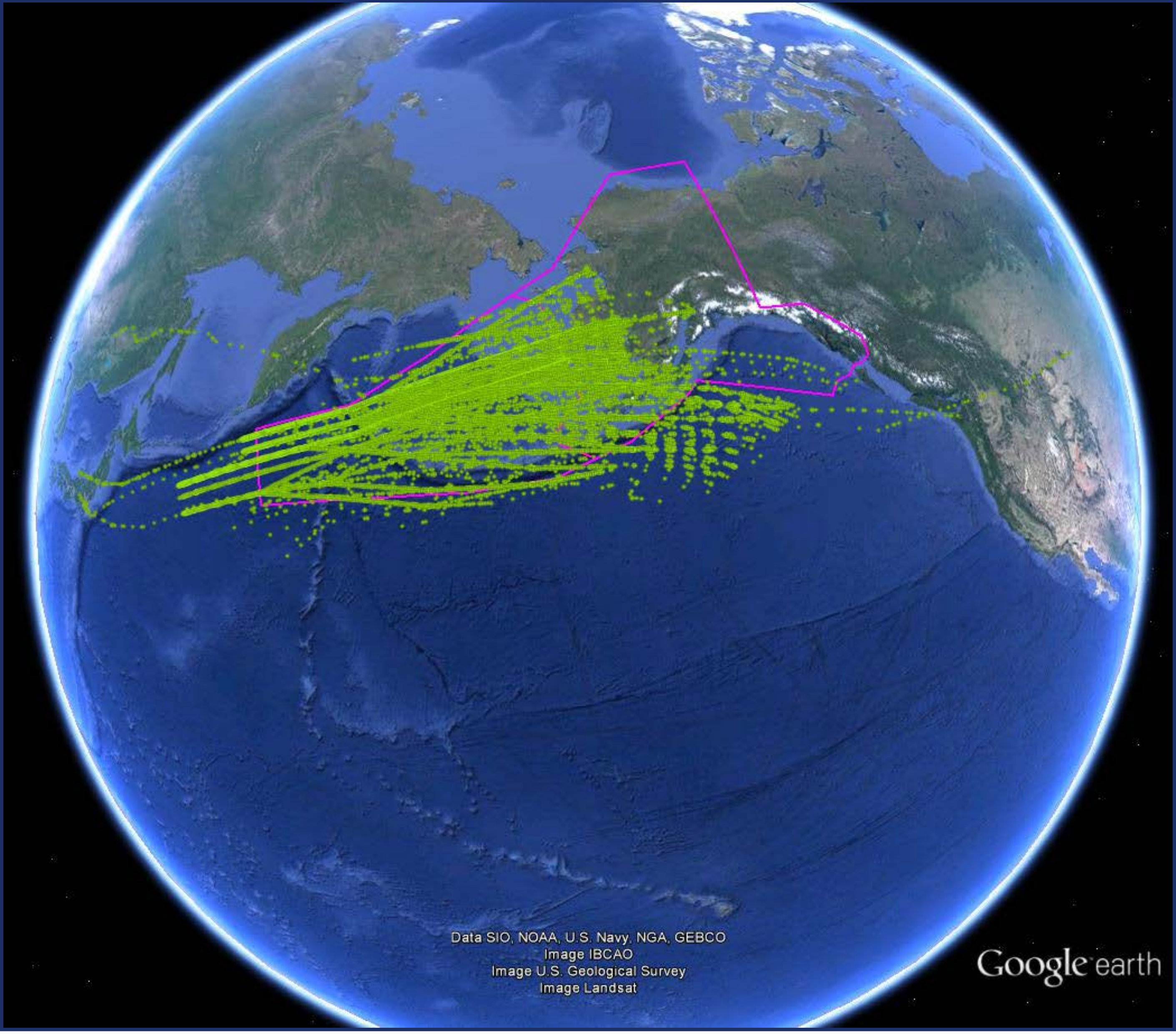
July – December 2015

Total flights	132,607
% flights using FANS data link	65%
% RNP4	71%

Average FANS data link flights per day	452
% using Iridium	6%
% using Inmarsat I-4	23%

Total FANS data link airframes	2,508
% using Iridium	10%
% using Inmarsat I-4	28%

Anchorage FIR
PAZA



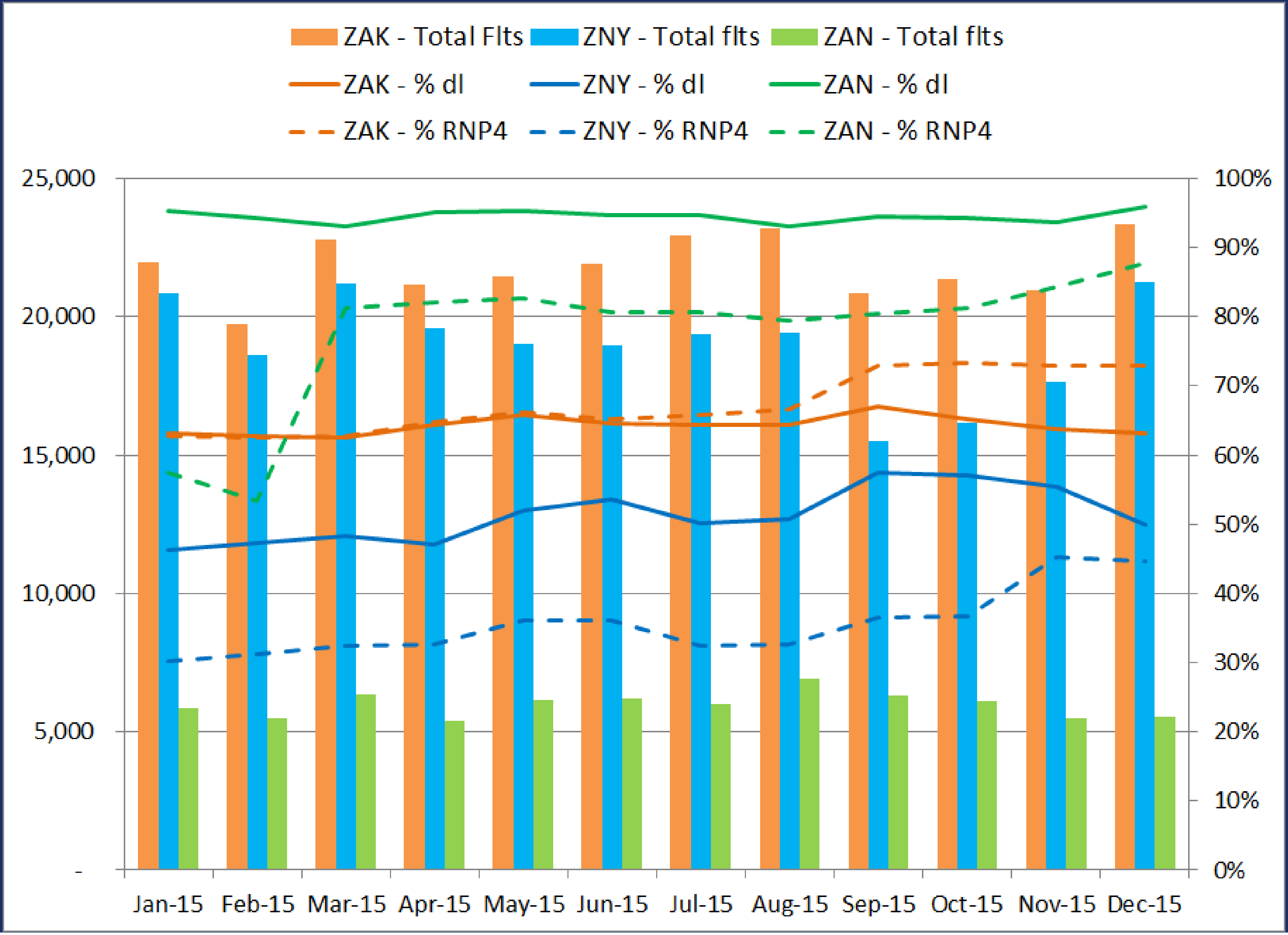
PAZA – FANS Data Link Usage

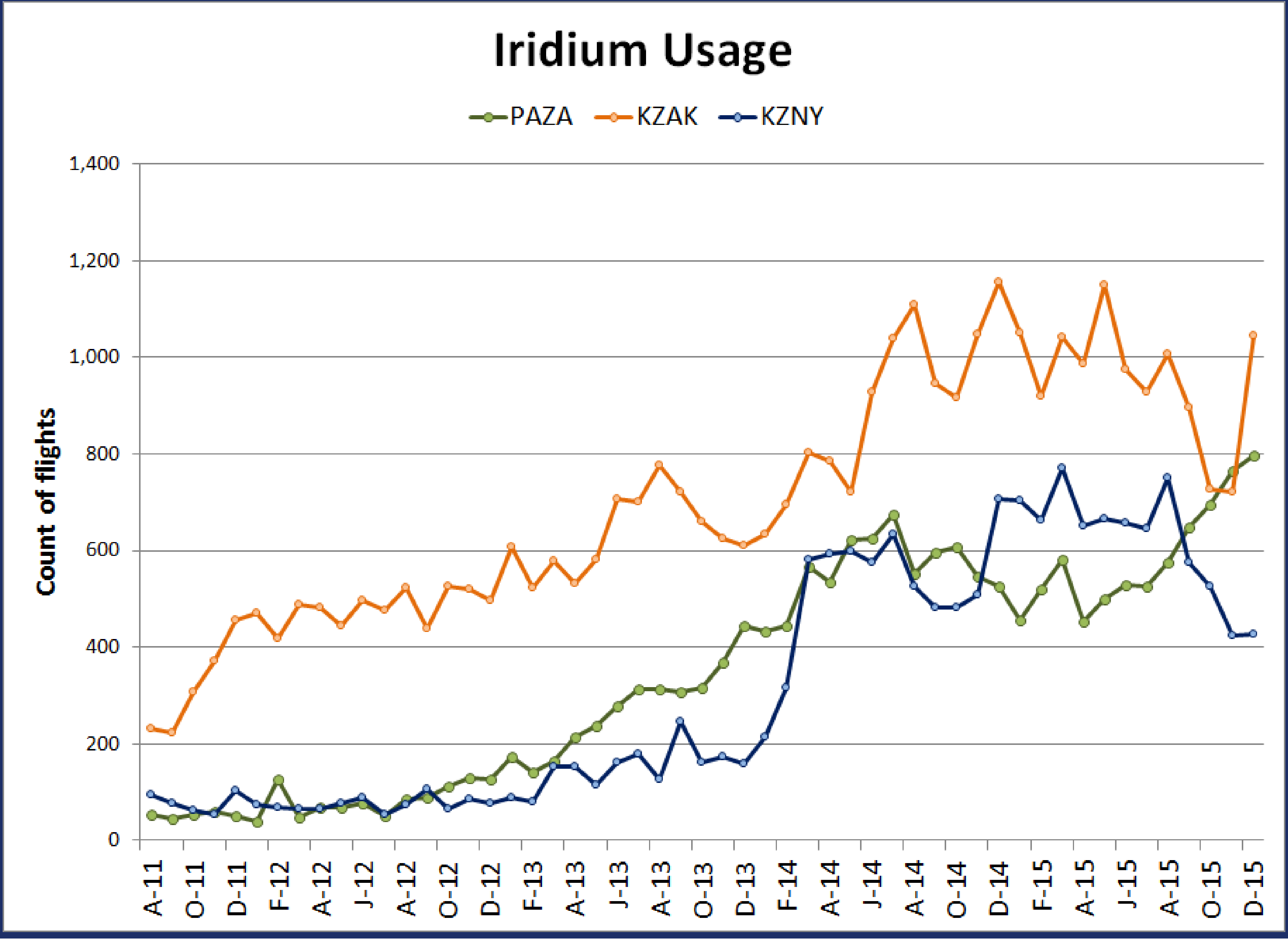
July – December 2015

Total flights	36,371
% flights using FANS data link	94%
% RNP4	82%

Average FANS data link flights per day	187
% using Iridium	9%
% using Inmarsat I-4	31%

Total FANS data link airframes	1,650
% using Iridium	10%
% using Inmarsat I-4	27%


ZAK - Total Flts
ZNY - Total flts
ZAN - Total flts
ZAK - % dl
ZNY - % dl
ZAN - % dl
ZAK - % RNP4
ZNY - % RNP4
ZAN - % RNP4
25,000
20,000
15,000
10,000
5,000
-
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15


Iridium Usage
PAZA
KZAK
KZNY
Count of flights
1,400
1,200
1,000
800
600
400
200
0
A-11
O-11
D-11
F-12
A-12
J-12
A-12
O-12
D-12
F-13
A-13
J-13
A-13
O-13
D-13
F-14
A-14
J-14
A-14
O-14
D-14
F-15
A-15
J-15
A-15
O-15
D-15

Outages Reported since July 2015 (1 of 2)

START DATE	START TIME (UTC)	DURATION (HH:MM:SS)	SERVICE IMPACTED	SATELLITE REGION IMPACTED	NOTIFICATION SOURCE	NOTES
5-Sep-15	01:53	02:00:00	ARINC I-3	POR, IOR	ARINC	Inmarsat Global Ltd has resolved I-3 Pacific Ocean Region for Classic Aero over 13 and the I-3 India Ocean Region for Classic Aero over 13 region
5-Sep-15	03:21	00:41:00	SITA Iridium	Global	SITA	Iridium customers may have experienced intermittent Short Burst Data service delay during the above timeframe
6-Sep-15	03:21	01:00:00	I-4	EMEA	ARINC	Degradation has been rectified - no cause was provided.
6-Sep-15	03:03	00:59:00	I-4	EMEA	SITA	There was a degradation over EUA1 Ocean region on I4 Ground Earth Station in Fucino due to Inmarsat network issue. Aircrafts switched to Atlantic and Indian Ocean region during this period.
20-Sep-15	12:52	04:12:00	I-3	POR	ARINC	Issue on the 3F3 satellite was resolved on the return direction
20-Sep-15	12:45	04:18:00	I-3	POR	SITA	Unscheduled loss of Classic Aero Services in Pacific Ocean Region (POR) has been resolved
25-Sep-15	16:31	02:03:00	ARINC Iridium	Global	ARINC	one of Iridium's terrestrial Internet Service Providers experienced an issue with routing traffic through their network backbone. As a result, users may have experienced failed data transmissions if their traffic utilized the failing route. Iridium was able to correct this issue by forcing all traffic to another ISP and have opened a ticket with the affected provider. Please note that as a result of the traffic rerouting, some users may have experienced additional delays lasting until at least 20:34 or longer as these changes fully propagated across the internet.
9-Jan-16	16:36	00:14:00	SITA	Global	SITA	A network interruption occured in our SIN Data center and the services were switched to our Montreal Center
21-Jan-16	21:37	00:55:00	Inmarsat I-4	EMEA	ARINC	Inmarsat network service degradation in I-4 EMEA for SwiftBroadband

Outages Reported since July 2015 (2 of 2)

START DATE	START TIME (UTC)	DURATION (HH:MM:SS)	SERVICE IMPACTED	SATELLITE REGION IMPACTED	NOTIFICATION SOURCE	NOTES
25-Sep-15	16:31	02:45:00	SITA Iridium	Global	SITA	Customers may experience issues with Iridium Datalink ACARS service
30-Sep-15	19:19	00:54:00	ARINC I-3	IOR	ARINC	
30-Sep-15	18:45	00:20:00	SITA I-3	IOR	SITA	
23-Oct-15	11:24	00:12:00	SITA I-4	EMEA	SITA	Inmarsat I-4 Ground Earth Station in Fucino experienced an unplanned interruption of service
26-Oct-15	02:20	00:21:00	Inmarsat SBB	APAC	ARINC	Inmarsat reports they performed an AGGW server switch in Hawaii. Issue resolved. (XXU).
27-Oct-15	14:32	00:39:00	Inmarsat I-4	EMEA	SITA	Fucino GES Inmarsat Voice and Data Services
27-Oct-15	14:56	00:15:00	Inmarsat I-4	EMEA	ARINC	No update on cause
30-Oct-15	01:05	00:50:00	Inmarsat I-3	POR	SITA	
30-Oct-15	01:56	00:07:00	Inmarsat I-3	POR	ARINC	Inmarsat experienced a network service degradation
19-Nov-15	04:30	00:05:00	MTSAT	MTSAT	SITA	SATELLITE Voice and Data Services via MTSAT were affected due to a maintenance issue at MTSAT
5-Dec-15	18:25	00:26:00	Inmarsat I-4	EMEA	ARINC	Inmarsat experienced a network service degradation
17-Dec-15	12:46	00:30:00	Inmarsat I-4	EMEA	ARINC	Inmarsat experienced a network service degradation
7-Jan-16	17:27	01:44:00	Inmarsat I-3	IOR	ARINC	Inmarsat for Classic Aero over I3 outage
9-Jan-16	16:36	00:14:00	SITA	Global	SITA	A network interruption occured in our SIN Data center and the services were switched to our Montreal Center
21-Jan-16	21:37	00:55:00	Inmarsat I-4	EMEA	ARINC	Inmarsat network service degradation in I-4 EMEA for SwiftBroadband

Measured Availability
Using Reported Outages from Jan to Dec 2015

PBCS criteria - max values						
Safety - 99.9%				48	520	99.90%
Reliability - 99.99%				4	52	99.99%
Satellite	**Region**	**DSP**	**Station ID**	**# unplanned outages > 10 min**	**Sum of unplanned outages > 10 min (min)**	**Estimated availability**
Inmarsat I-3	AOR-E	SITA	AOE2	2	70	99.99%
		ARINC	XXN	2	35	99.99%
	AOR-W	SITA	AOW2	2	92	99.98%
		ARINC	XXW	2	35	99.99%
	IOR	SITA	IOR2	2	131	99.98%
		ARINC	XXI	4	568	99.89%
	POR	SITA	POR1	4	343	99.93%
		ARINC	XXP	3	35	99.99%
Inmarsat I-4	EMEA	SITA	EUA1	1	145	99.97%
		ARINC	XXF	7	210	99.96%
	Americas	SITA	AME1	1	35	99.99%
		ARINC	XXH	1	35	99.99%
	Asia-Pac	SITA	APK1	1	35	99.99%
		ARINC	XXA	1	35	99.99%
Iridium	Global	SITA	IGW1	12	1,068	99.80%
		ARINC	IG1	6	593	99.89%

(green)	**Meets safety and reliability criteria**
(yellow)	**Meets safety criteria only**
(pink)	**Does not meet safety or reliability criteria**

PBCS Performance Criteria
Time/Continuity

Performance Measure	Percentage of Messages Required to Meet Criteria	ADS-C		CPDLC	
		RSP180 Criteria (sec)	RSP400 Criteria (sec)	RCP240 Criteria (sec)	RCP400 Criteria (sec)
ASP Actual Surveillance Performance	95%	**90**	**300**		
	99.9%	**180**	**400**		
ACTP Actual Communication Technical Performance	95%			**120**	**260**
	99.9%			**150**	**310**
ACP Actual Communication Performance	95%			**180**	**320**
	99.9%			**210**	**370**
PORT Pilot Operational Response Time	95%			**60**	**60**

July – December 2015

DATA LINK PERFORMANCE BY MEDIA TYPE

Performance by Media Type | Oakland

July – December 2015

84,272 flights

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	2,631,360	98.6%	99.4%	109,709	99.7%	99.7%	99.5%	99.7%	98.5%
SAT	2,330,955	98.7%	99.5%	106,944	99.7%	99.8%	99.5%	99.7%	98.5%
VHF	288,100	98.7%	99.2%	2,022	99.7%	99.7%	99.5%	99.8%	98.4%
HF	12,290	69.2%	82.4%	31	--	--	--	--	--
VHF-SAT				229	91.7%	94.8%	94.3%	96.5%	96.1%
SAT-VHF				192	100.0%	100.0%	99.0%	99.5%	96.4%
SAT-HF				165	90.3%	93.3%	95.2%	95.8%	97.6%
HF - SAT				121	99.2%	99.2%	94.2%	97.5%	86.8%
HF-VHF				4	--	--	--	--	--
VHF-HF				1	--	--	--	--	--

Performance by Media Type | Anchorage

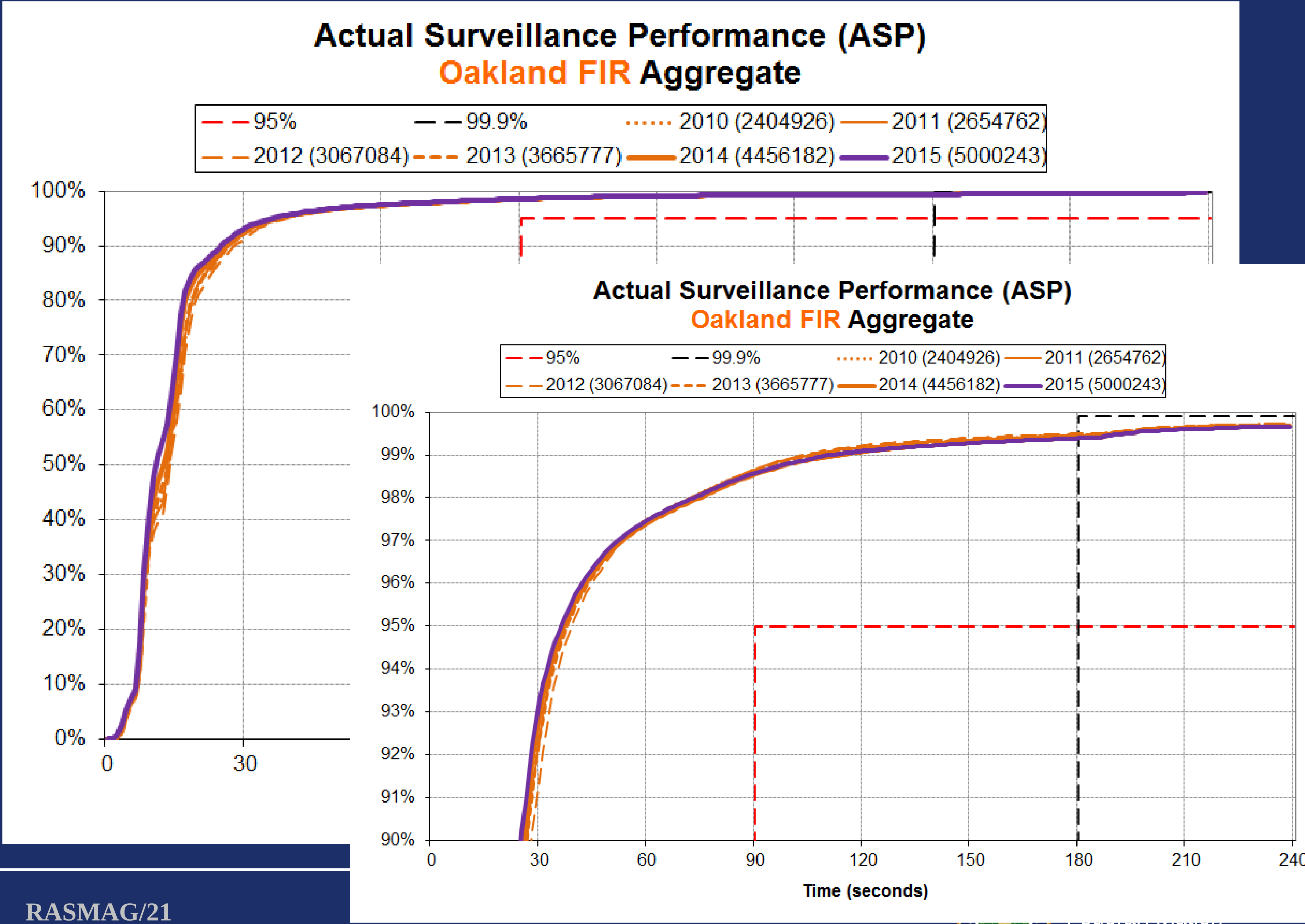
July – December 2015

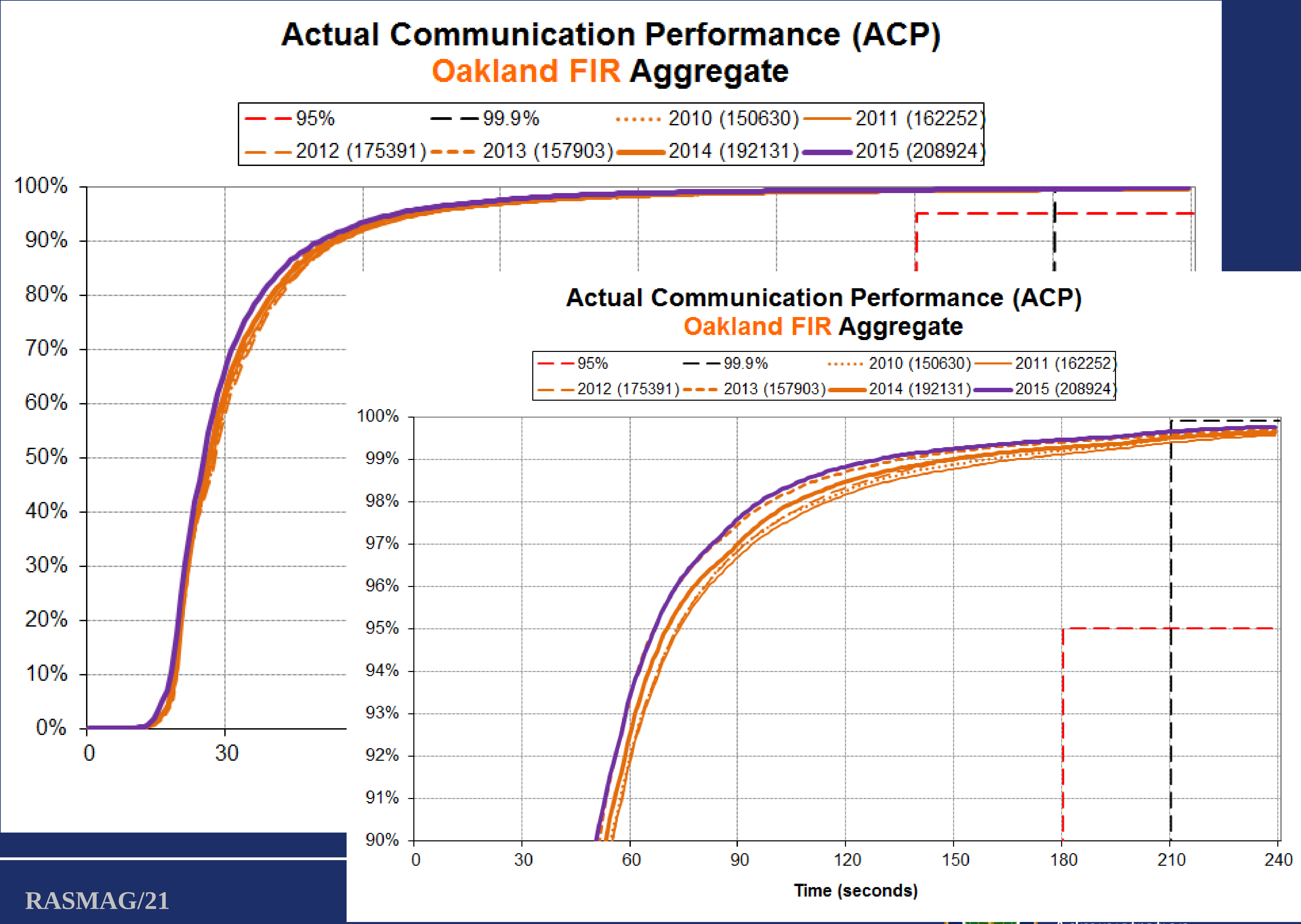
34,497 flights

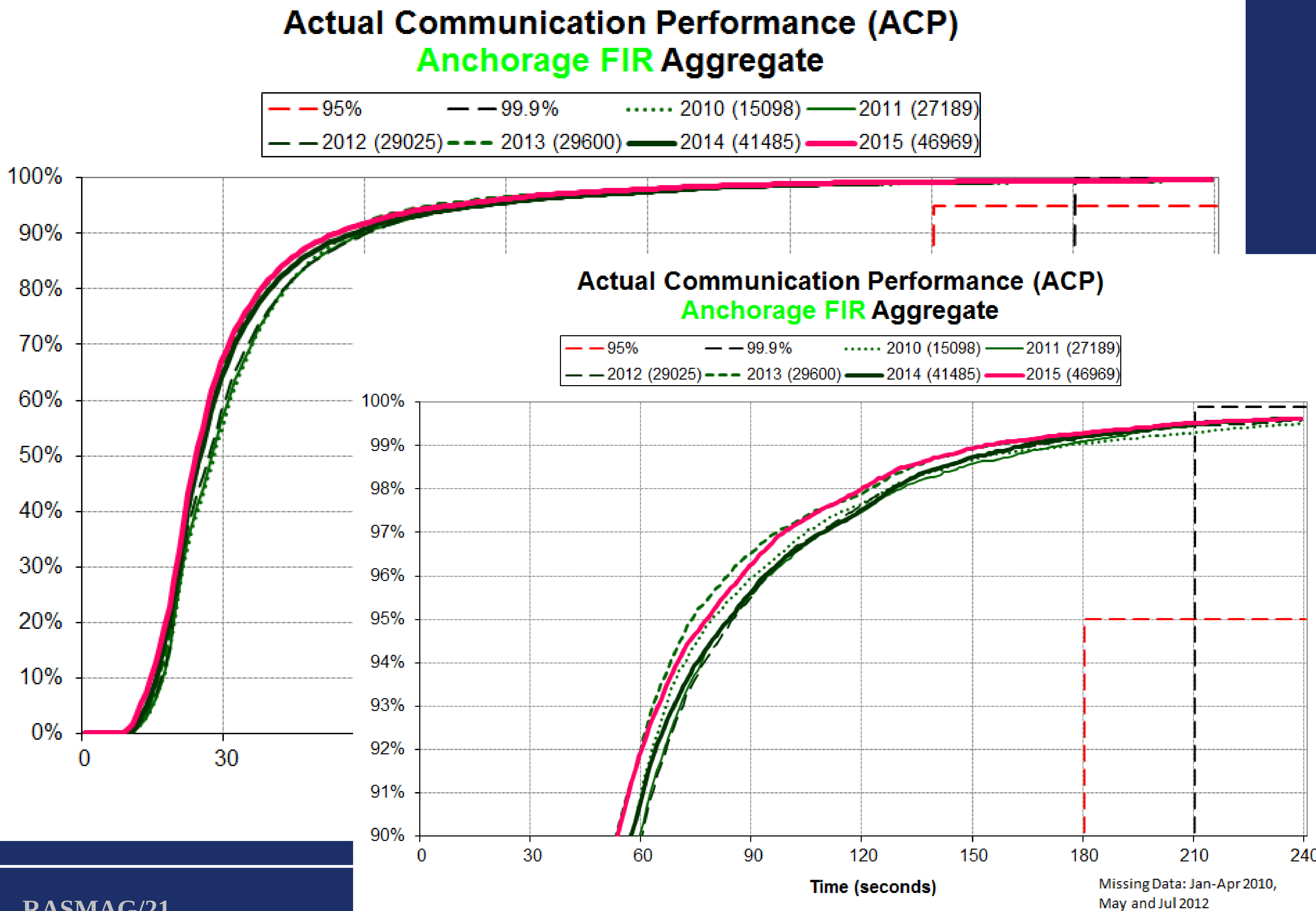
Media Type	ADS-C			CPDLC					
	Count of ADS-C Downlink Messages	ADS-C 95%	ADS-C 99.9%	Count of CPDLC Transactions	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
Performance Criteria		**RSP 180**			**RCP 240**				
Aggregate	1,226,721	97.9%	99.1%	23,817	99.5%	99.6%	99.3%	99.5%	97.9%
SAT	828,453	97.7%	99.2%	16,045	99.5%	99.6%	99.3%	99.6%	97.7%
VHF	390,810	99.0%	99.3%	7,268	99.7%	99.7%	99.6%	99.7%	98.6%
HF	7,418	63.4%	77.5%	8	--	--	--	--	--
SAT-VHF				261	99.6%	100.0%	98.1%	99.2%	90.4%
VHF-SAT				159	92.5%	96.9%	93.1%	94.3%	95.0%
SAT-HF				39	--	--	--	--	--
HF-SAT				27	--	--	--	--	--
VHF-HF				7	--	--	--	--	--
HF-VHF				3	--	--	--	--	--

2010 - 2015

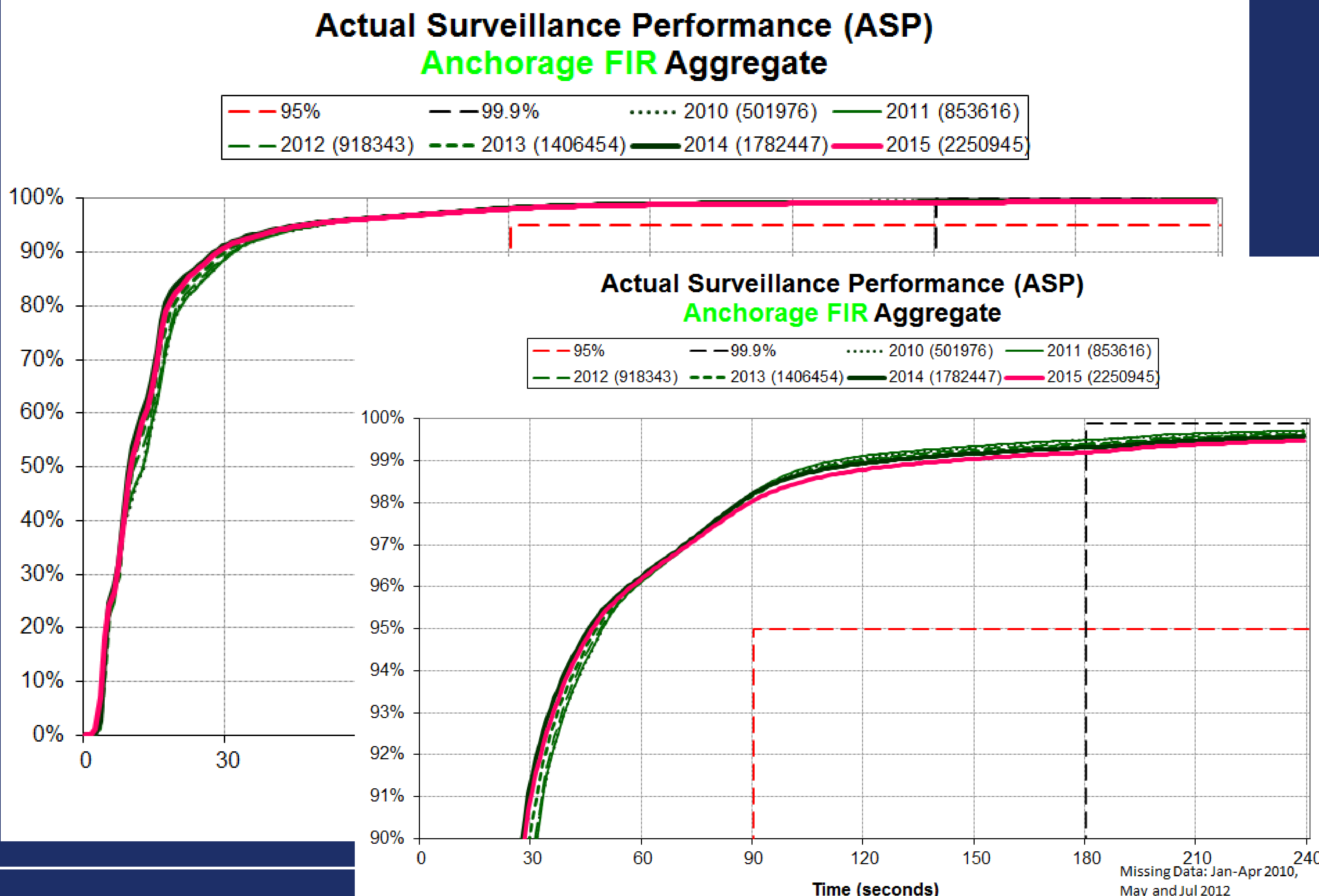
ANNUAL AGGREGATE FIR PERFORMANCE


Actual Surveillance Performance (ASP)
Oakland FIR Aggregate
95%
99.9%
2010 (2404926)
2011 (2654762)
2012 (3067084)
2013 (3665777)
2014 (4456182)
2015 (5000243)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
Actual Surveillance Performance (ASP)
Oakland FIR Aggregate
95%
99.9%
2010 (2404926)
2011 (2654762)
2012 (3067084)
2013 (3665777)
2014 (4456182)
2015 (5000243)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
150
180
210
240
Time (seconds)


Actual Communication Performance (ACP)
Oakland FIR Aggregate
95%
99.9%
2010 (150630)
2011 (162252)
2012 (175391)
2013 (157903)
2014 (192131)
2015 (208924)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
Actual Communication Performance (ACP)
Oakland FIR Aggregate
95%
99.9%
2010 (150630)
2011 (162252)
2012 (175391)
2013 (157903)
2014 (192131)
2015 (208924)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
150
180
210
240
Time (seconds)



Actual Communication Performance (ACP)
Anchorage FIR Aggregate
95%
99.9%
2010 (15098)
2011 (27189)
2012 (29025)
2013 (29600)
2014 (41485)
2015 (46969)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
Actual Communication Performance (ACP)
Anchorage FIR Aggregate
95%
99.9%
2010 (15098)
2011 (27189)
2012 (29025)
2013 (29600)
2014 (41485)
2015 (46969)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
150
180
210
240
Time (seconds)
Missing Data: Jan-Apr 2010, May and Jul 2012


Actual Surveillance Performance (ASP)
Anchorage FIR Aggregate
95%
99.9%
2010 (501976)
2011 (853616)
2012 (918343)
2013 (1406454)
2014 (1782447)
2015 (2250945)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
Actual Surveillance Performance (ASP)
Anchorage FIR Aggregate
95%
99.9%
2010 (501976)
2011 (853616)
2012 (918343)
2013 (1406454)
2014 (1782447)
2015 (2250945)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
150
180
210
240
Time (seconds)
Missing Data: Jan-Apr 2010, May and Jul 2012

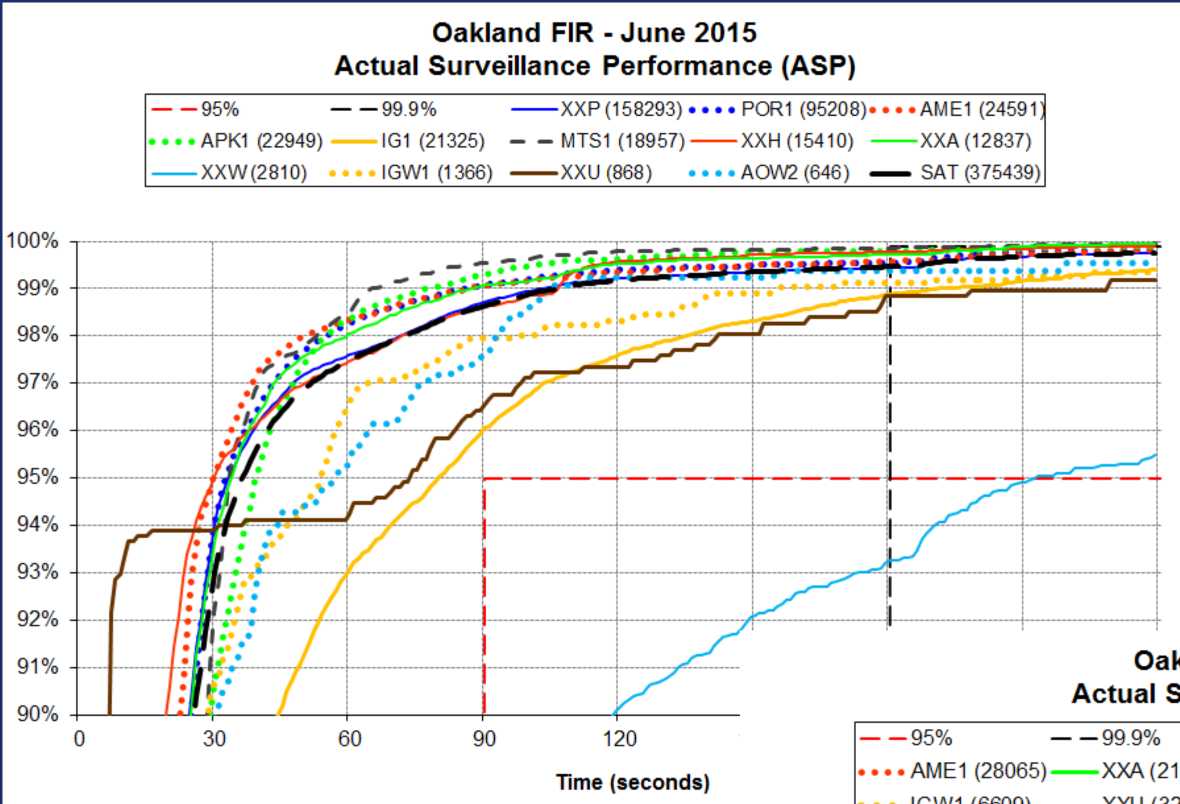
Overview

- Analysis period: June and December 2015
- Analysis by FIR: Oakland, Anchorage
- ASP → RSP180 criteria
- Station identifiers designate "path" taken by data link messages between aircraft and ATC
- "Paths" vary between the four constellations of satellites and between the two data link service providers

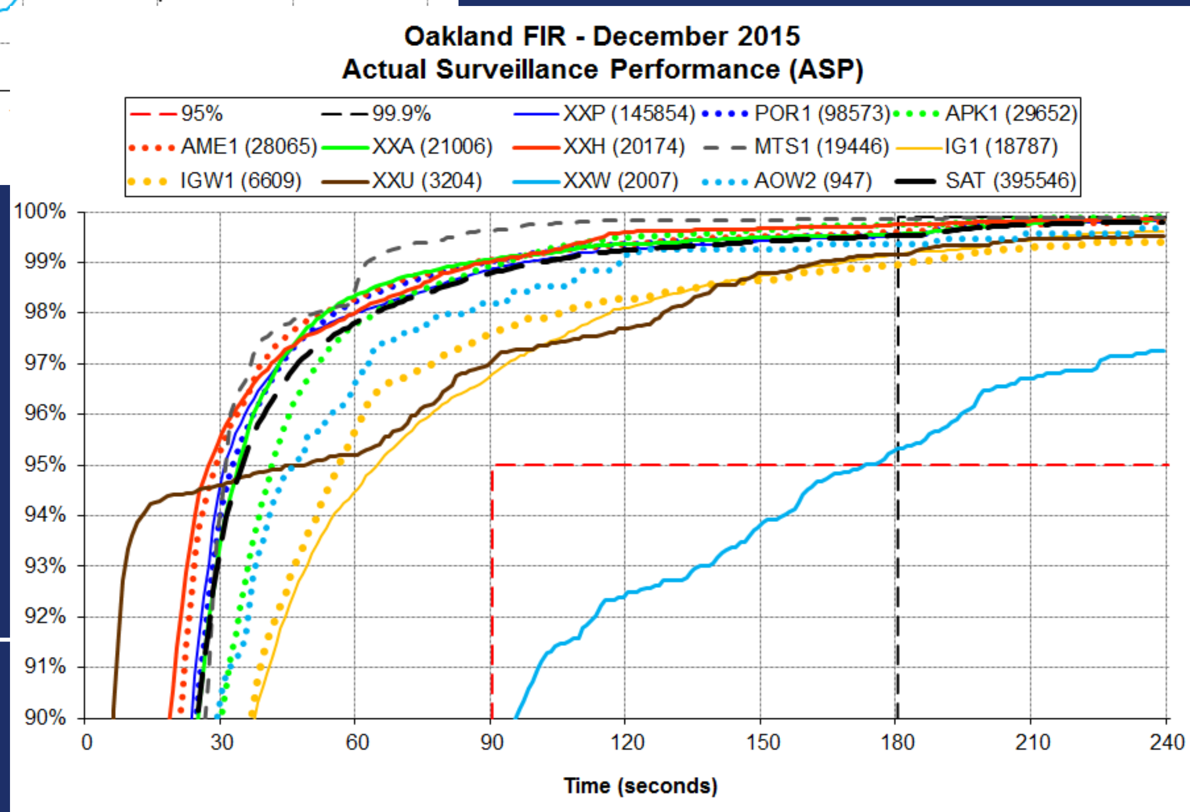
June and December 2015

ASP BY STATION IDENTIFIER

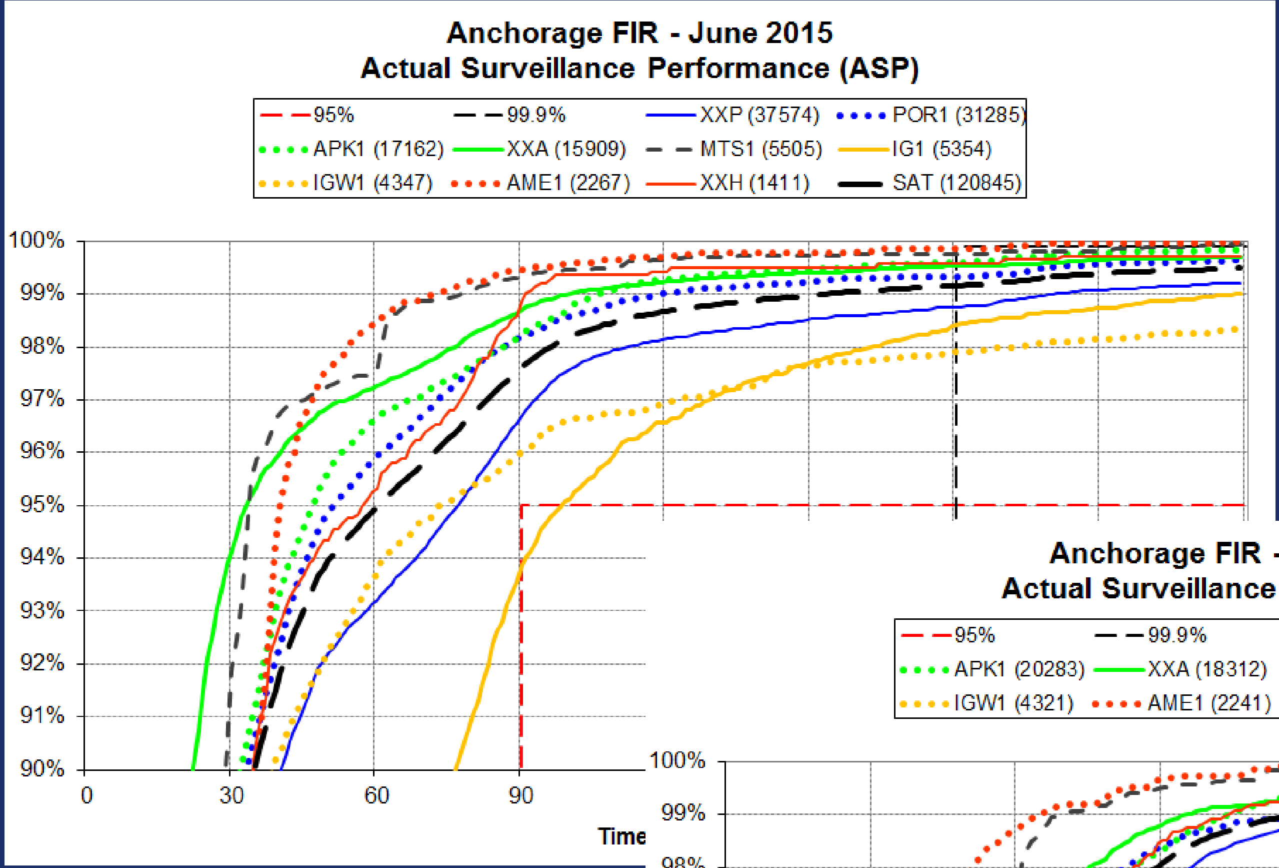
GES LOCATION(S)	SATELLITE/ REGION	SITA	ARINC
Burum, Netherlands	Inmarsat I-3 AOR-E	**AOE2**	**XXN**
	Inmarsat I-3 AOR-W	**AOW2**	**XXW**
Perth, Australia	Inmarsat I-3 IOR	**IOR2**	**XXI**
	Inmarsat I-3 POR	**POR1**	**XXP**
Fucino, Italy	Inmarsat I-4 EMEA	**EUA1**	**XXF**
	Inmarsat I-4 EMEA SBB	**EME9**	**XXB**
Paumalu, Hawaii, US	Inmarsat I-4 Americas	**AME1**	**XXH**
	Inmarsat I-4 Asia-Pacific	**APK1**	**XXA**
	Inmarsat I-4 Americas SBB	**AMR9**	**XXU**
	Inmarsat I-4 Asia-Pacific SBB	**PAC9**	**XXS**
Kobe and Hitachiota, Japan	MTSAT Japan	**MTS1**	**--**
Phoenix, Arizona, US	Iridium Global	**IGW1**	**IG1**

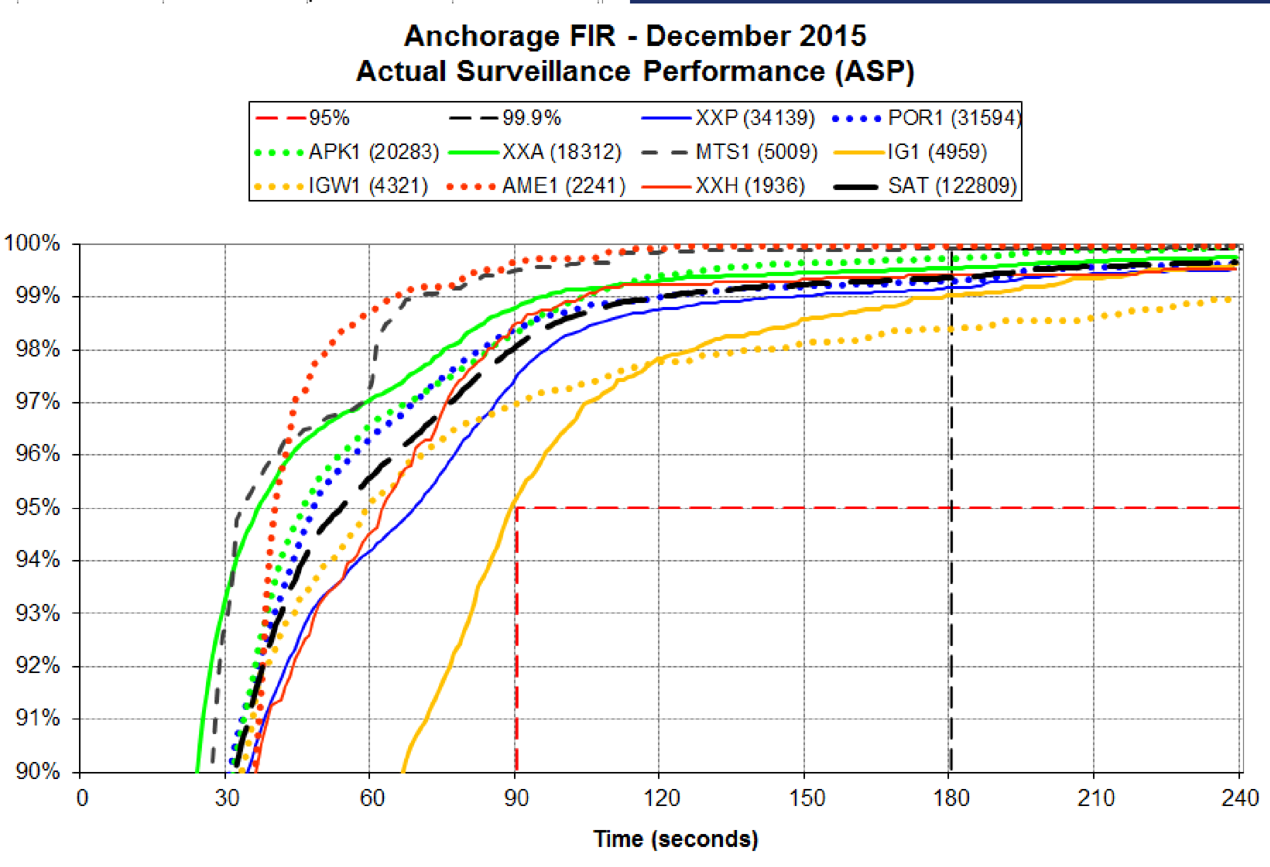


Oakland FIR - June 2015
Actual Surveillance Performance (ASP)
95%
99.9%
XXP (158293)
POR1 (95208)
AME1 (24591)
APK1 (22949)
IG1 (21325)
MTS1 (18957)
XXH (15410)
XXA (12837)
XXW (2810)
IGW1 (1366)
XXU (868)
AOW2 (646)
SAT (375439)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
Time (seconds)



Oakland FIR - December 2015
Actual Surveillance Performance (ASP)
95%
99.9%
XXP (145854)
POR1 (98573)
APK1 (29652)
AME1 (28065)
XXA (21006)
XXH (20174)
MTS1 (19446)
IG1 (18787)
IGW1 (6609)
XXU (3204)
XXW (2007)
AOW2 (947)
SAT (395546)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
150
180
210
240
Time (seconds)


Anchorage FIR - June 2015
Actual Surveillance Performance (ASP)
95%
99.9%
XXP (37574)
POR1 (31285)
APK1 (17162)
XXA (15909)
MTS1 (5505)
IG1 (5354)
IGW1 (4347)
AME1 (2267)
XXH (1411)
SAT (120845)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
Time


Anchorage FIR - December 2015
Actual Surveillance Performance (ASP)
95%
99.9%
XXP (34139)
POR1 (31594)
APK1 (20283)
XXA (18312)
MTS1 (5009)
IG1 (4959)
IGW1 (4321)
AME1 (2241)
XXH (1936)
SAT (122809)
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
0
30
60
90
120
150
180
210
240
Time (seconds)

July – December 2015

DATA LINK PERFORMANCE BY OPERATOR/AIRCRAFT TYPE

Summary of Performance by Operator/Aircraft Type

Oakland FIR

- 161 operator/aircraft type pairs with at least 100 ADS-C messages
- 99 operator/aircraft type pairs with at least 100 RCP transactions during this 6-month period

Criteria	RSP180 ASP	RCP240 ACTP	RCP240 ACP	RCP240 PORT
Meets 95%	155	99	99	90
Meets 99.9%	29	43	38	
Below 99.9% but above 99.0%	114	53	52	
Below 99.0%	18	3	9	
Total pairs	***161***	***99***		

Operator/Aircraft Types Not Meeting RSP180/RCP240

Oakland FIR

July – December 2015

Operator/ Aircraft Type	ADS-C				CPDLC						
	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%
P/B788	11,794	<0.1%	94.1%	94.7%	363	0.3%	99.5%	99.5%	99.5%	99.5%	99.5%
A/B752	7,701	<0.1%	94.0%	97.6%	235	0.2%	97.5%	97.9%	96.6%	97.5%	94.0%
MIL/DC10	3,321	<0.1%	91.4%	95.2%	86	0.1%	98.8%	100.0%	95.4%	96.5%	88.4%
IGA/CL35	1,256	<0.1%	93.6%	96.7%	17	<0.1%	100.0%	100.0%	100.0%	100.0%	88.2%
A/B753	260	<0.1%	92.3%	92.7%							
AQ/B752	116	<0.1%	93.1%	100.0%	6	<0.1%	100.0%	100.0%	100.0%	100.0%	100.0%

Summary of Performance by Operator/Aircraft Type

Anchorage FIR

- 114 operator/aircraft type pairs with at least 100 ADS-C messages
- 51 operator/aircraft type pairs with at least 100 RCP transactions during this 6-month period

Criteria	RSP180 ASP	RCP240 ACTP	RCP240 ACP	RCP240 PORT
Meets 95%	107	51	50	46
Meets 99.9%	26	26	19	
Below 99.9% but above 99.0%	65	19	26	
Below 99.0%	23	6	6	
Total pairs	***114***	***51***		

Operator/Aircraft Types Not Meeting RSP180/RCP240

Anchorage FIR

July – December 2015

Operator/ Aircraft Type	ADS-C				CPDLC						
	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%
P/B788	27,287	1.7%	94.4%	95.8%	431	1.8%	96.3%	96.5%	96.3%	97.0%	97.7%
Y/B763	21,440	1.3%	94.5%	97.1%	137	0.6%	97.8%	98.5%	95.6%	97.1%	94.2%
R/B788	11,269	0.7%	94.1%	95.5%	142	0.6%	95.8%	95.8%	93.7%	95.1%	95.8%
CY/B788	4,163	0.3%	92.2%	94.0%	63	0.3%	96.8%	96.8%	96.8%	96.8%	100.0%
DW/K35R	359	<0.1%	80.5%	81.6%	4	<0.1%	100.0%	100.0%	100.0%	100.0%	100.0%
MIL/C135	227	<0.1%	71.4%	74.9%	1	<0.1%	100.0%	100.0%	100.0%	100.0%	100.0%
S/B763	102	<0.1%	77.5%	79.4%							