

September 6, 2012

Ms. Margaret Gilligan
Associate Administrator for Aviation Safety
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

Dear Peggy,

The Performance Based Aviation Rulemaking Committee (PARC) is pleased to submit the enclosed report entitled, *Future Air Navigation System (FANS 1/A) Over Inmarsat Classic Aero (FOICA) Recommendations*. This report is based on an assessment of the Classic Aero communication services provided by Inmarsat's fourth generation (I-4) satellites and sub-network. The assessment concluded that these services support FANS 1/A controller-pilot data link communications (CPDLC) and automatic dependent surveillance – contract (ADS-C) required by reduced separations in oceanic and remote airspace.

The PARC Communications Working Group (CWG) has assessed other technologies, such as Iridium and high frequency data link (HFDL), for FANS1/A against the required communications performance (RCP) and required surveillance performance (RSP) specifications. These specifications are provided by the ICAO Global Operational Data Link Document (GOLD). The PARC CWG relies on the GOLD to ensure a globally consistent performance based approach to assessing the continued operational safety of communication and surveillance technologies that support air traffic services. As the FAA expands data link implementation in its domestic airspace, the experience gained in these activities will facilitate seamless operations worldwide.

The industry will benefit from the FAA's formal recognition of the *FOICA Recommendations Report*. This recognition will facilitate the global use of FOICA and any further demonstrations that may be required by other States. The report contains the conditions and results under which PARC CWG evaluated FOICA to determine compliance against the RCP 240 specification for CPDLC and RSP 180 specification for ADS-C. Also, the *FOICA Recommendations Report* will serve as the baseline for PARC CWG's project that has recently begun to evaluate Inmarsat SwiftBroadband Safety Services. The results contained in this report substantiate that FOICA is capable of meeting the RCP240 and RSP 180 specifications. ANSPs will ensure continued compliance through post-implementation monitoring in accordance with the GOLD.

The PARC therefore recommends the FAA to concur with the assessment that the FANS1/A over Inmarsat I-4 Classic Aero network had performed satisfactorily against GOLD RCP 240 and RSP 180 specifications. Additionally, the PARC recommends the FAA to advocate internationally, that aircraft using the I-4 satellites and sub-network are eligible for CPDLC/ADS-C applications, including those that require compliance to RCP 240 and RSP 180 specifications such as reduced separations in oceanic and remote airspace.

The PARC appreciates your continued support of its activities and invites you to discuss any aspects of these recommendations at your earliest convenience. The PARC respectfully requests the FAA to provide us with a formal response. We thank the members and constituents of PARC for their support in this activity.

Sincerely,

A handwritten signature in blue ink, appearing to read "Dave Nakamura".

Dave Nakamura
Chairman
Performance-based operations Aviation
Rulemaking Committee

Cc: T. Kraft
A. Oldach
M. Steinbicker
B. DeCleene
J. McCarthy



FANS 1/A over Inmarsat-4 Classic Aero (FOICA) Recommendations

23 August 2012

Prepared by:

Performance Based Operations
Aviation Rulemaking Committee

Communications Working Group
(PARC CWG)



Foreword

The Performance-Based Operations Aviation Rulemaking Committee (PARC) is an FAA-sponsored activity that operates according to the Administrator's authority under 49 USC 106(p)(5). The PARC comprises members from the FAA and the aviation community at large, provides recommendations to FAA's Senior Management for action and implementation. The PARC has been effective over the last decade in implementing performance based navigation. In 2005, the PARC established the Communications Working Group (CWG) to address a number of issues related to the implementation of aeronautical communication systems. These systems included, among others, the future air navigation system (FANS) 1/A, the aeronautical telecommunication network (ATN), and satellite voice communications.

The PARC CWG is committed to applying the performance-based concept, which aims to leverage existing capability and maximize benefits by:

- ❑ Enabling cost-effective alternatives, using different technologies and existing capabilities, that meet business needs in a more timely manner;
- ❑ Providing performance-based criteria to demonstrate aircraft equipment and capability without technological or implementation-specific constraints; and
- ❑ Enabling different levels of service in common airspace to a fleet of aircraft with varying capability and performance.

The PARC CWG develops recommendations that directly support matters that relate to the FAA's regulatory criteria and guidance material for implementation of voice and data communications within the U.S. National Airspace System (NAS). However, the PARC CWG recognizes that global harmonization is crucial to the success of any State or regional implementation initiative. As such, the PARC CWG prepares Coordination Drafts for broad review and solicits input on such matters of interest to the aviation community. If you would like more information on PARC CWG activities or would like to comment on this Report, please contact either Arnold Oldach (aoldach@rockwellcollins.com) or Tom Kraft (tom.kraft@faa.gov).

Table of contents

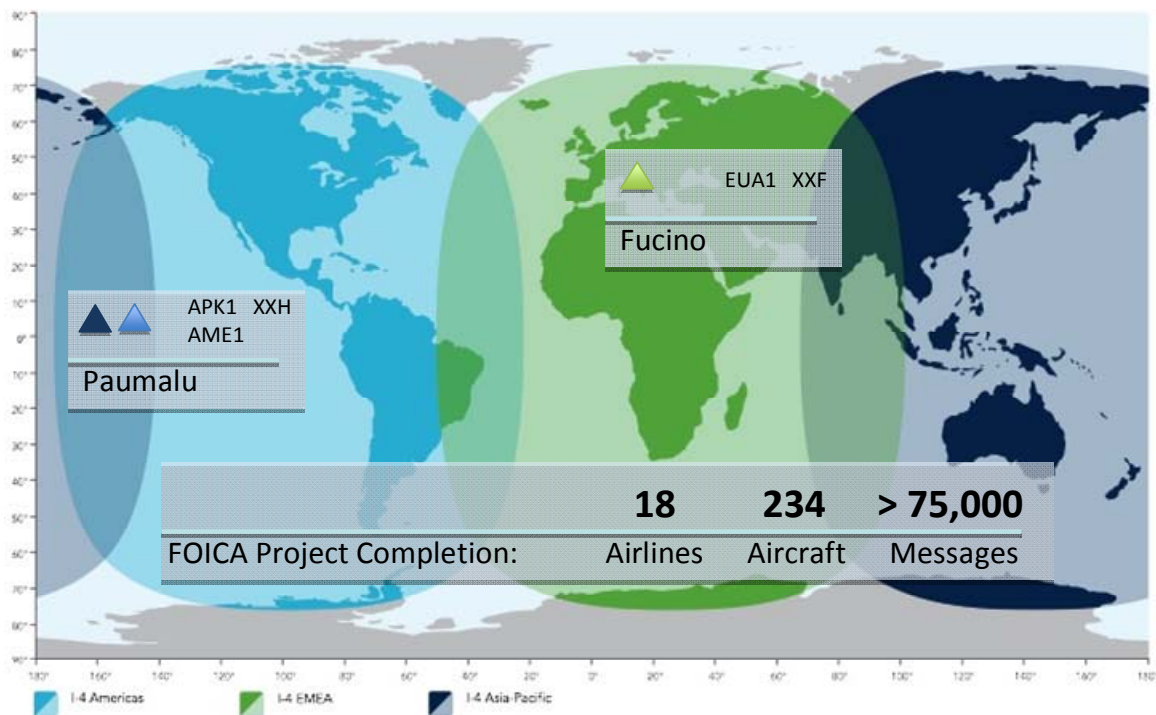
Contents	Page
Background	1
Purpose and Scope	2
Benefits – Operators	2
Goal and results of this project	3
Recommendations	3
Stakeholders	4
Project schedule	5
Description of project	5
Tasks	6
Satellite and Network Descriptions	6
Aircraft Configuration	9
Aircraft equipage	10
Regulatory – Performance Standards and Guidance Material	12
Evaluation Results	12
Lab and Aircraft Evaluations	12
RCP 240/RSP 180 Operational Evaluation Results	13
ADS-C Results Summary	13
ADS-C RSP 180 95% Non-Performing Dispositions	15
ADS-C RSP 180 99.9% Non-Performing Dispositions	18
CPDLC RCP 240 Summary	22

Executive Summary

Classic Aero Safety Services on the fourth generation (I-4) satellites and sub-networks were operational in September 2009 and were implemented in accordance with established International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) and RTCA Minimum Aviation System Performance Standards (MASPS). Bench tests and flight tests had all been satisfactorily completed, however, there was no clear avenue for validating performance in an encompassing manner and the number of eligible aircraft with Future Air Navigation System (FANS 1/A) Controller-Pilot Data Link Communications (CPDLC) and Automatic Dependent Surveillance – Contract (ADS-C) on I-4 remained insignificant until beginning of 2011. This changed with the release and adoption of ICAO Global Operational Data Link Document (GOLD), which included Required Communication Performance (RCP 240) and Required Surveillance Performance (RSP 180) performance specifications and the activity undertaken by the Performance based Aviation Rule Making Committee – Communications Working Group (PARC CWG).

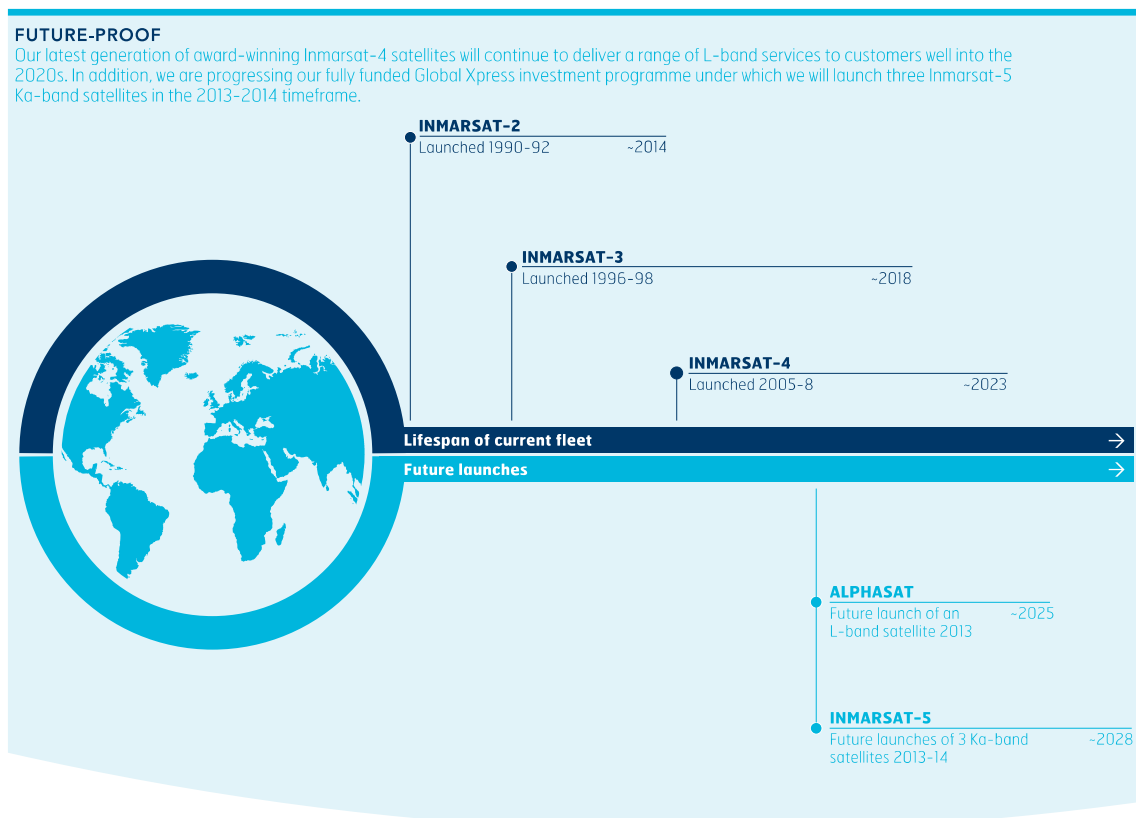
As such, there became a prominent avenue and opportunity to populate the I-4 sub-network with aircraft that had certified avionics to conduct compliance against the GOLD RCP 240 and RSP 180 specifications. It was also important to provide traceability that Inmarsat's Classic Aero functions in the I-4 satellite and sub-network could meet the criteria specified in GOLD when substantially loaded with FANS1/A CPDLC and ADS-C capable aircraft, performing only safety services, or in conjunction with non-safety SwiftBroadband cabin services.

The results of the project are contained in this report with over 75,000 messages traversing three new ground stations/ocean regions and six air navigation service provider (ANSP) regions, (21 airlines, 234 aircraft activated for use on I-4). The PARC CWG has reached the consensus that the performance according to GOLD RCP 240 and RSP 180, is satisfactory to progress into post-implementation and move forward with the recommendations.



Background

Inmarsat's third generation (I-3) satellite and partner ground network has been the main provider for satellite based aircraft communications addressing and reporting system (ACARS) and FANS1/A data link since the mid 1990's. The service from Inmarsat that facilitates this oceanic voice and data safety services is called "Classic Aero". During that decade and into the current, an increasing reliance on data link has been evidenced and the economics of satellite systems has become increasingly more viable.



Starting in the mid 2000's, Inmarsat had the opportunity to launch and operate an additional satellite constellation, known as I-4, with a completely separate sub-network to introduce broadband communications "SwiftBroadband" into the aviation sector. Along with this new SwiftBroadband service, existing Classic Aero protocols were migrated to the I-4 network to continue Inmarsat's commitment to safety services for the aeronautical community. The Classic Aero service over the I-4 was designed and implemented per existing safety services criteria and therefore is just a new implementation of protocols already in use. Similarly there are no operational software upgrades required to any of the thousands of already fielded Inmarsat SATCOM systems to use the I-4 Classic Aero sub-network.

Classic Aero protocols and functionality over the I-4 network was successfully tested in Summer of 2009 using existing ARINC 741 avionics and Airbus aircraft (A340/A380) prior to official safety services deployment and use by operators. Continued performance monitoring is however warranted to ensure the network functions as intended, as the population of aircraft increases on this new network.

Purpose and Scope

The Performance-based Operations Aviation Rulemaking Committee Communications Working Group (PARC CWG) evaluates technologies in a performance-based framework for their suitability in aeronautical applications, such as a long range communication system (LRCS). The PARC CWG is/will or has completed evaluating:

- a) Iridium SBD – Alternative to other AMS(R)S capability;
- b) Inmarsat – Classic Aero and SwiftBroadband (SBB) (next generation) using the new “I4” Inmarsat satellites;
- c) ARINC – HFDFL for some performance-based operations and backup to satellite data;
- d) Satellite voice communications (Iridium and Inmarsat) providing an additional communication tool for use by controllers and pilots; and
- e) Communications supporting the next generation air transportation system (NextGen).

The results of these evaluations are intended to substantiate advice and recommendations to the FAA on operations, policy, standards, guidance material, and implementation. Global harmonization is also crucial to the success of any State or regional implementation initiative. Therefore, PARC CWG remains cognizant of developments on related international standards, guidance material and implementation, and includes matters of global harmonization in its advice and recommendations to the FAA.

This report specifically addresses recommendations related to FOICA operations

Benefits – Operators

Documentation under an official FAA sponsored forum:

- a) As previously described, the PARC CWG is responsible for a multiple set of LRCS, thereby expanding the utility of FANS1/A data link capabilities to support the GOLD RCP 240 and RSP 180 specifications for reduced aircraft separation.
- b) Operators can reference the output of this activity to request operational approval for favorable routes and separations. Perhaps this will make it easier when applying to applicable aviation authorities within a particular FIR.

Dual Constellation (Separate and Independent):

- a) Where a commercial agreement exists between an operator and Inmarsat providers, an aircraft may have the ability to use both, potentially in a backup situation.
- b) The I-4 satellites should serve to increase data link capacity, utility and performance of the Classic Aero service overall.

Avionics:

- a) The larger gain of the satellite antennas assists in reducing the overall power consumption in the avionics.
- b) Over the past two decades, advancement in Inmarsat satellite terminal technology has more than halved the weight, reduced the size by two thirds and dramatically reduced the price and while increasing the functionality (to include broadband in the cabin). Nowhere has this been

more evident as in the single aisle aircraft market looking to adopt safety services with the capability of SwiftBroadband ARINC 781 antenna and avionics systems, specifically for the use on I-4 network.

Goal and results of this project

The goal of this project was to verify that the Inmarsat I-4 Classic Aero sub-network is an additional viable sub-network for aeronautical safety services. This report provides the results of the evaluation that met this goal. While the I-4 satellites and network were designed and built to existing RTCA DO-270 MASPS, the project confirmed the following:

- a) Validated Inmarsat's I-4 network against the GOLD RCP 240 and RSP 180 specifications for reduced separation standards.

Note.— Some examples of the different separation standards where FANS 1/A provides an acceptable data link capability for RCP 240 and RSP 180 operations are reduced separation to 50 NM longitudinal in RNP 10 or RNP 4 airspace, and 30 NM lateral / 30 NM longitudinal in RNP 4 airspace.

- b) Where flight routes allow, observed the utility of aircraft to revert to the existing I-3 network as another independent sub-network, should there be mitigating circumstances that would warrant this (over Greenland or if there is a temporary outage of the I-4 network). Reverting to the I-3 network will be entirely at the discretion of the operator to configure their aircraft to switch itself over. There will be no interaction from either of Inmarsat's I-3 or I-4 network to trigger and manage this capability.
- c) Demonstrated that the performance of the I-4 satellites and sub-network are viable for reduced separation applications in oceanic and remote airspace.

Inmarsat's I-3 network for Classic Aero was not subject to evaluation under this project as it is already in use in applications of RCP 240 and RSP 180 specifications, such as in reduced separations in oceanic and remote airspace. ANSPs are conducting post-implementation monitoring of the I-3 network performance and exchanging information through contributory groups of ICAO planning and implementation regional groups (PIRGs) and State/Regional Monitoring Agencies.

Recommendations

The PARC recommends the FAA concur with the assessment that the FANS1/A over Inmarsat I-4 Classic Aero network had performed satisfactorily against GOLD RCP 240/RSP 180 specifications.

Note 1.— FANS1/A over Classic Aero is considered "approved" based on appropriate aircraft installation approval, operational authorization as appropriate, by the State of the Operator or State of Registry, and approval of ANSP service provisions by the appropriate ATS authority.

Note 2.— Per RTCA DO-306/EUROCAE ED-122, the GOLD RCP 240 and RSP 180 specifications are intended for CPDLC and ADS-C required for 50 NM and 30 NM longitudinal and 30NM lateral separation minima. Per the North Atlantic (NAT) Performance Based Communication and Surveillance Implementation Plan, RCP 240 and RSP 180 are the candidate specifications for Reduced Longitudinal Separation of 5 minutes between ADS-C equipped aircraft (RLongSM) and Reduced Lateral Separation of 25 Nautical Miles (NM) (RLatSM) separation minima, pending further validation trials and safety assessment.

Further, the PARC recommends the FAA consider advocating internationally, that aircraft using the I-4 satellites and sub-network are eligible for CPDLC/ADS-C applications that require compliance to RCP 240 and RSP 180 specifications such as supporting reduced separations.

Stakeholders

The participants in this evaluation are provided in **Table 1**.

Organization	Point of contact	email
PARC CWG	Arnold Oldach	aoldach@rockwellcollins.com
	Tom Kraft	tom.kraft@faa.gov
Aircraft Operators		
Twenty-one (21) aircraft operators participated in this evaluation. A complete breakout of airframe model, avionics systems and number of operators are detailed in this report. The specific operators will be provided upon request, as appropriate.		
Aircraft Manufacturers		
Boeing	Glenn Torgerson	glenn.a.torgerson@boeing.com
Airbus	Matthieu Lys	matthieu.lys@airbus.com
	Jerome Condis	jerome.condis@airbus.com
Bombardier	Victor Georghian	victor.gheorghian@aero.bombardier.com
Air Navigation Service Providers		
UK NATS	Iain Davies	iain.davies@nats.co.uk
NAV Canada	Fred Cosgrove	cosgrof@navcanada.ca
Airways Corporation New Zealand	Paul Radford	paul.radford@airways.co.nz
FAA	Tom Kraft	tom.kraft@faa.gov
	Theresa Brewer	theresa.brewer@faa.gov
Satellite Service Provider		
Inmarsat	Steve Kong	steve.kong@aeroconnex.com
Communication Service Providers		
SITA	Abderrahmane Ledjar	abderrahmane.ledjar@sitaaero.com
ARINC	Bill Doyen	wdoyen@arinc.com
Operational Authorization and Aircraft Certification (FAA)		
FAA, Flight Standards, Flight Technologies and Procedures Division		
FAA, Flight Standards, Air Transportation Division		
FAA, Aircraft Certification, Avionics Systems Branch		

Table 1 – FOICA Participants

Project schedule

The FOICA project schedule is shown in **Figure 1**. The majority of the work involved inviting certain operators with an appropriate mix of aircraft satellite equipment and aircraft types and evaluating their FANS1/A CPDLC and ADS-C data. The PARC CWG reviewed the data at each meeting for any analyses and actions.

The FOICA project started off with about 50 aircraft and 11 operators and had grown to 234 aircraft and 21 operators. The PARC CWG were able to obtain a statistically sufficient sample of ADS-C and CPDLC data to substantiate the recommendations provided in this report.

Venue	Date	Objectives/Items
PARC CWG 21	2010 – Seattle (Summer)	<ul style="list-style-type: none">• Requested I-4 Evaluation
PARC CWG 22	2010 – Phoenix (Fall)	<ul style="list-style-type: none">• Reviewed Preliminary I-4 Data
PARC CWG 23	2011 – Seattle (Winter)	<ul style="list-style-type: none">• Reviewed FAA I-4 Data• Described up to 80 aircraft on I-4
PARC CWG 24	2011 – Phoenix (Summer)	<ul style="list-style-type: none">• Baseline Project Plan• Review I-4 Data• Review Actions & Issue Resolution
PARC CWG 25	2011 – Everett (Fall)	<ul style="list-style-type: none">• Review I-4 Data• Review Actions & Issue Resolution• Sponsor Airlines @ Meeting?• Review Report & Recommendations
PARC CWG 26	2012 – Phoenix (Winter)	<ul style="list-style-type: none">• Review I-4 Data• Review Actions & Issue Resolution• Review Report & Recommendations
PARC CWG 27	2012 – Williamsburg (Summer)	<ul style="list-style-type: none">• Final Performance Assessment• Submit Report & Recommendations• SBB Safety Project Agreement
PARC CWG 28	2012 – Livermore (Fall)	<ul style="list-style-type: none">• Start SBB Safety Services

Figure 1 – FOICA project schedule

Description of project

The main difference of this project when compared to traditional developmental projects (e.g., upcoming SBB Safety Project) is that participants, who have been selected for this evaluation, would just use previously certified aircraft equipment. In this project's instance, the operator would request or be invited to sign-up and register with an I-4 service provider while retaining or ensuring they continue to have access to the existing I-3 network. The I-4 system provides additional satellites and a sub-network alternative thereby improving availability of Classic Aero Services.

Tasks

The project consisted of the following tasks:

- a) Invited select operators that have a varied range of aircraft types, avionics manufacturers and system architectures or functionalities to join the I-4 network;
- b) Updated the GES selection list in the SATCOM ORT Table of the avionics;
- c) Updated commercial and registration details at the service providers;
- d) Monitored ADS-C and CPDLC messages at the ANSP's [FAA, NAVCanada, UKNATS, and AirwaysNZ];
- e) Reported and analyzed per GOLD; and
- f) Identified any problem areas where the data is not meeting the GOLD RCP 240 and RSP 180 specifications and worked to understand if any improvements were needed.

Satellite and Network Descriptions

Inmarsat's total Classic Aero service is facilitated by a total combination of "7+1" satellites as shown in **Figure 2**. The "+1" refers to the Japanese MTSAT satellite that covers the Indian and Pacific Ocean regions centered on Japan. While this satellite performs Classic Aero functions, it is operated and owned independent of Inmarsat. The other 7 satellites consist of 4xInmarsat-3 and 3xInmarsat-4 satellites.

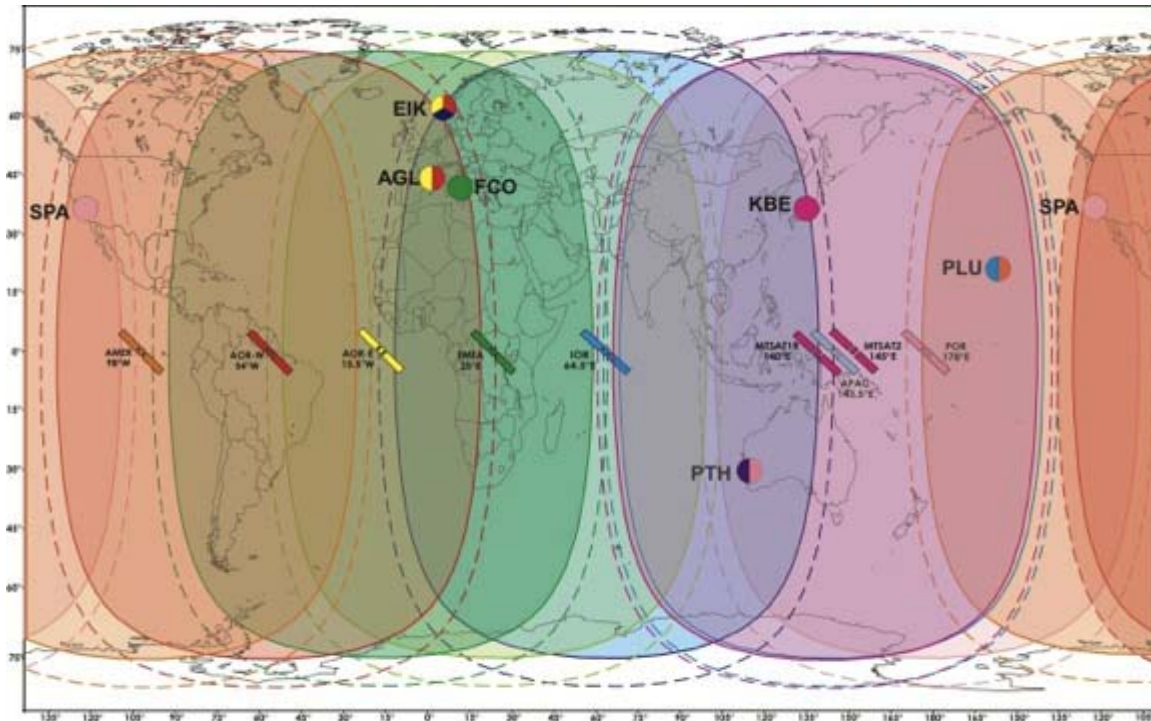


Figure 2 – Inmarsat 3 and 4 "7+1" Constellation

Partner Ground Earth Stations (GES) located at Perth (PTH-Australia), Aussaguel (AGL-France), Santa Paula (SPA-USA) and Eik (EIK-Norway) service Inmarsat-3 satellites. The Inmarsat-4 Satellite Access Stations (SAS) are self-owned and operated and are located at Paumalu (PLU-Hawaii) and Fucino (FCO-Italy).

Table 2 provides more information in relation to where the satellites are located and which services they provide.

Satellite	Coverage	Longitude	Launch Vehicle	Launch Date	Services
I-4 F1	APAC	143.5° E	Atlas V	11 MAR 2005	Classic Aero (H+) SwiftBroadband
I-4 F2	EMEA	25° E	Zenit-3SL	08-NOV-2005	Classic Aero (H+) SwiftBroadband
I-4 F3	AMER	98° W	Proton-M	18-AUG-2008	Classic Aero (H+) SwiftBroadband
I-3 F1	IOR	64.5° E	Atlas II	03 APR 1996	Classic Aero (H/H+/I) Swift64
I-3 F2	AOR-E	15.5° W	Proton-K	06 SEP 1996	Classic Aero (H/H+/I) Swift64
I-3 F3	POR	178° E	Atlas IIA	18 DEC 1996	Classic Aero (H/H+/I) Swift64
I-3 F4	AOR-W	54° W	Ariane 44L	03 JUN 1997	Classic Aero (H/H+/I) Swift64

Table 2 – Satellite Constellation(s) for Classic Aero

The network and telecommunications technology is founded on a traditional 3G version of GSM mobile telephone protocols, adapted with proprietary technology to augment the signal and propagation characteristics needed in a satellite based system. From this waveform set, SwiftBroadband IP services are provided up to a data rate of 432kbps. Classic Aero is a separate waveform set that is not IP based, and therefore is an entirely separate system located alongside SwiftBroadband equipment at the Paumalu (Hawaii) and Fucino (Italy) SAS.



The I-4 Classic Aero sub-network uses two SAS and two Point of Presences (POP). Inmarsat processes the ACARS messaging using the Access Control and Signalling Equipment (ACSE) and distributes this via the Data Communications Network (DCN). From there, Distribution Partners (DP) and Communications Service Providers (CSP) interface to this information via the Meet Me Points (MMP) at New York and Amsterdam. It is now the responsibility of the CSP's to present the ACARS messaging to the operators and the applicable ANSP's. Each CSP has multiple interconnections into each of Inmarsat's POPs for added redundancy. **Figure 3** and **Figure 4** illustrate the example for ARINC and SITA as CSPs for ACARS and FANS1/A data link messages.

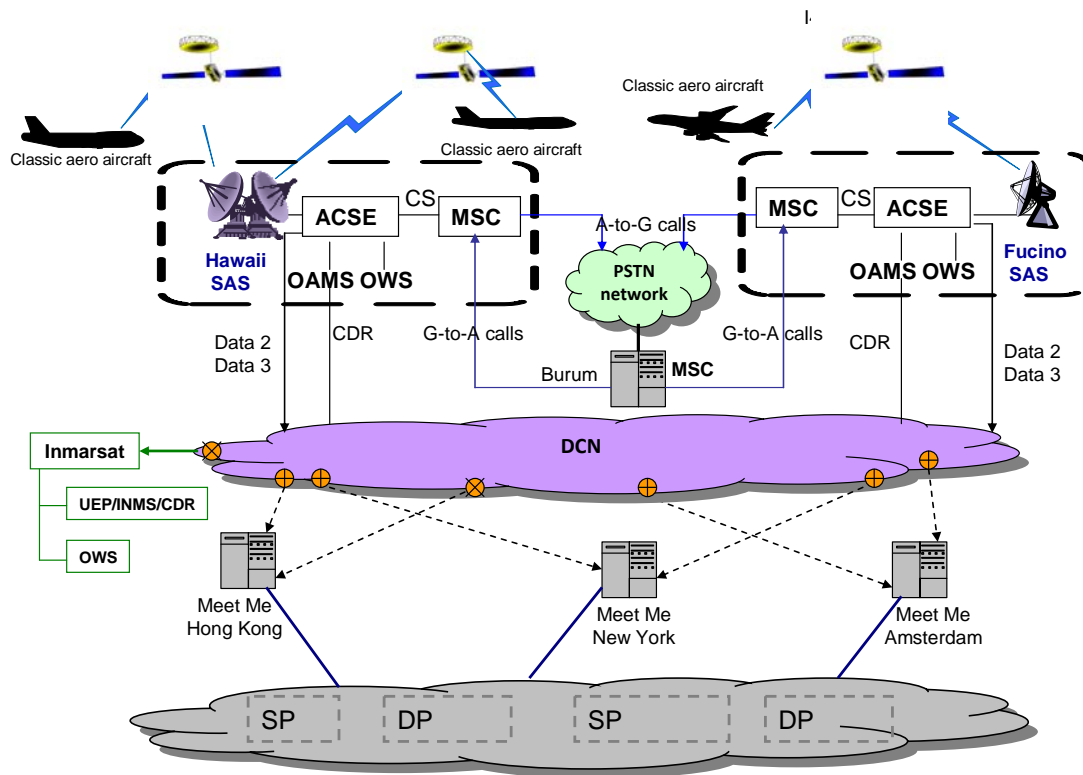


Figure 3 – Inmarsat-4 Satellite and Sub-Network Architecture

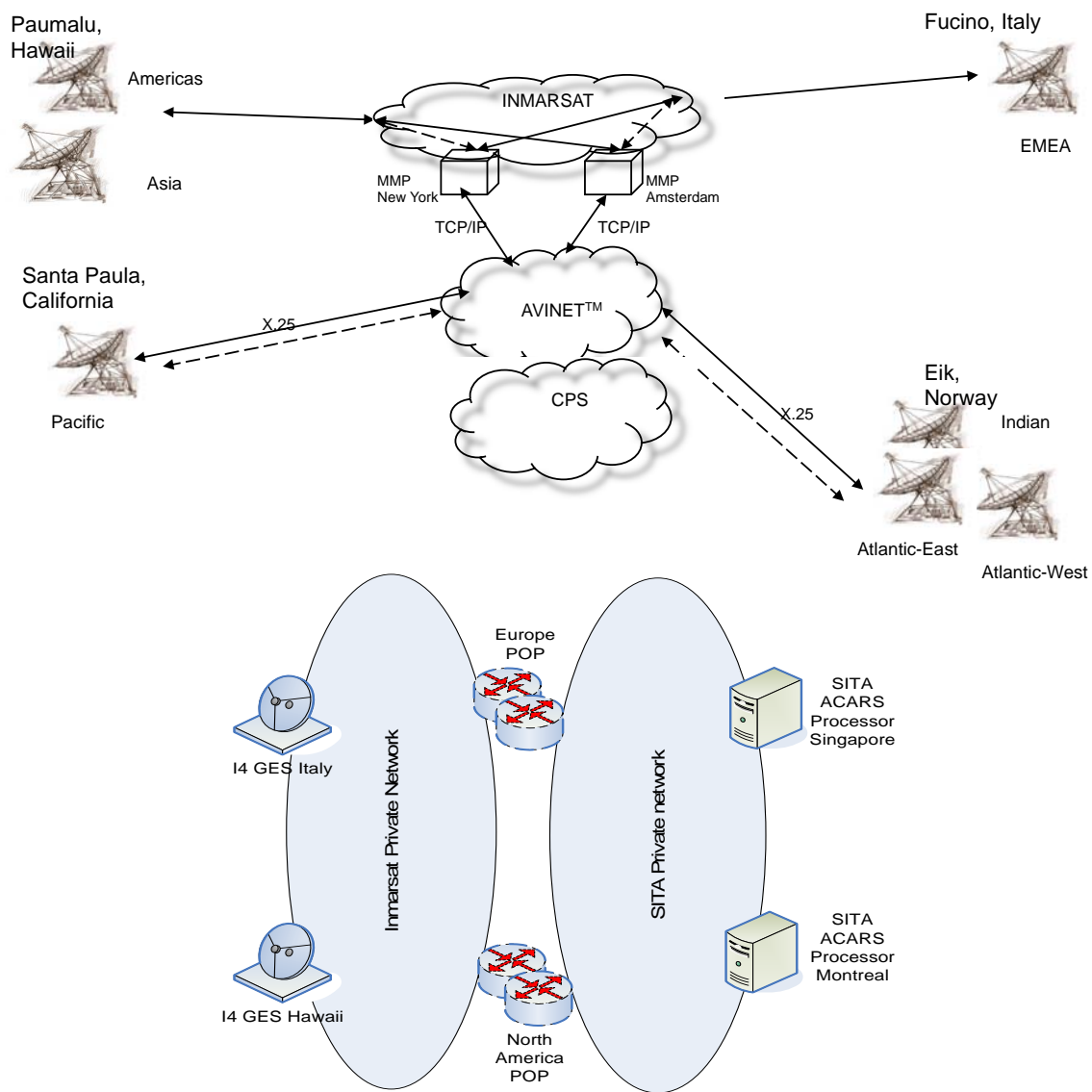


Figure 4 – ARINC (above) and SITA (below) Interconnections to SAS or GES

Aircraft Configuration

Operators and CSPs were encouraged to discuss appropriate candidates to participate in this evaluation. The total group of appropriate candidates consisted of a wide variety of aircraft makes, avionics vendors and routes through the North Atlantic and Pacific Ocean Regions. Suitable combinations of Inmarsat features and services comprised multiple channels of Classic Aero H+ and SwiftBroadband. **Table 3** provides a list of aircraft, avionics and services configurations that were evaluated in the project.

Operator	Aircraft Type	SDU	Com Services	Sub-Total	Total
Airline A	A330	Honeywell	Aero + SBB	2	2
Airline B	A380	Honeywell	Aero + SBB	2	2
Airline C	A330	Honeywell	Aero + SBB	8	11
	B777-F	Thales	Aero + SBB	1	
	B777	Honeywell	Aero only	2	
Airline D	B777-F	Thales	Aero + SBB	17	17
Airline E	A330	Honeywell	Aero + SBB	4	16
	A330	Honeywell	Aero only	7	
	A340	Honeywell	Aero only	2	
	A340	Rockwell	Aero only	1	
	MD11	Honeywell	Aero only	2	
Airline F	A330	Rockwell	Aero only	1	1
Airline G	A330	Honeywell	Aero only	18	80
	A340	Honeywell	Aero only	14	
	A340	Rockwell	Aero only	11	
	A380	Honeywell	Aero + SBB	8	
	B747-400	Rockwell	Aero only	29	
Airline H	A330	Honeywell	Aero + SBB	4	4
Airline I	A380	Honeywell	Aero + SBB	6	6
Airline J	A330	Honeywell	Aero + SBB	3	58
	A330	Honeywell	Aero only	22	
	A340	Honeywell	Aero only	4	
	B777	Honeywell	Aero only	25	
	B777-F	Thales	Aero only	2	
	B5EX	Rockwell	Aero + SBB	2	
Airline K	A330	Honeywell	Aero + SBB	5	8
	A330	Honeywell	Aero only	1	
	A330	Rockwell	Aero only	2	
Airline L	A330	Honeywell	Aero only	1	1
Airline M	A330	Honeywell	Aero + SBB	2	2
Airline N	A330	Honeywell	Aero + SBB	3	3
Airline O	B777-F	Thales	Aero + SBB	2	2
Airline P	B737-800	Thales	Aero + SBB	7	7
Airline Q	B777	Honeywell	Aero + SBB	2	2
Airline R	A340	Honeywell	Aero + SBB	2	9
	A380	Honeywell	Aero + SBB	5	
	B777	Rockwell	Aero + SBB	2	
Airline S	A330	Honeywell	Aero + SBB	1	1
Airline T	B777-F	Thales	Aero + SBB	1	1
Airline U	B747-8F	Rockwell	Aero + SBB	1	1
Total				234	234

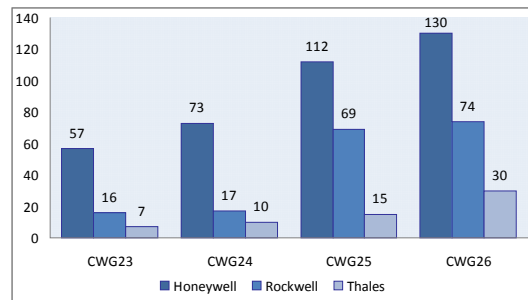
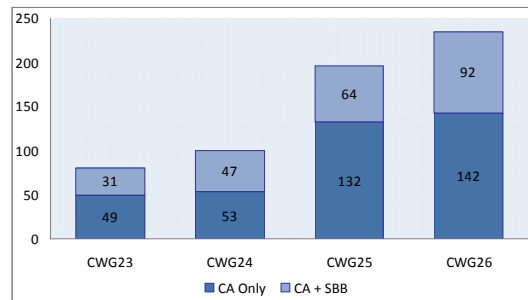
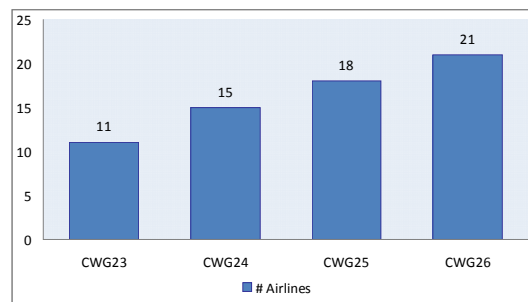


Table 3 – Aircraft, Avionics and Services Configurations

Aircraft equipage

All of the aircraft in **Table 3** are outfitted with FANS1/A, ACARS and various types of SATCOM systems. Honeywell systems generally correspond to ARINC 741 architecture; Rockwell Collins systems generally correspond to ARINC 761 and Thales systems all conform to ARINC 781. All three architectures can do either Classic Aero only or Classic Aero and SwiftBroadband. The main differences are that the larger systems can usually accommodate more channel combinations with larger amplifiers. For instance the ARINC 741 systems can do in excess of six Classic Aero voice calls, ACARS data, PC data and between two and four SwiftBroadband channels almost all simultaneously. The smaller systems, ARINC 761 and 781 perform less simultaneous functions but at least a minimum of two flight deck voice calls, ACARS data and two SwiftBroadband channels all simultaneously.

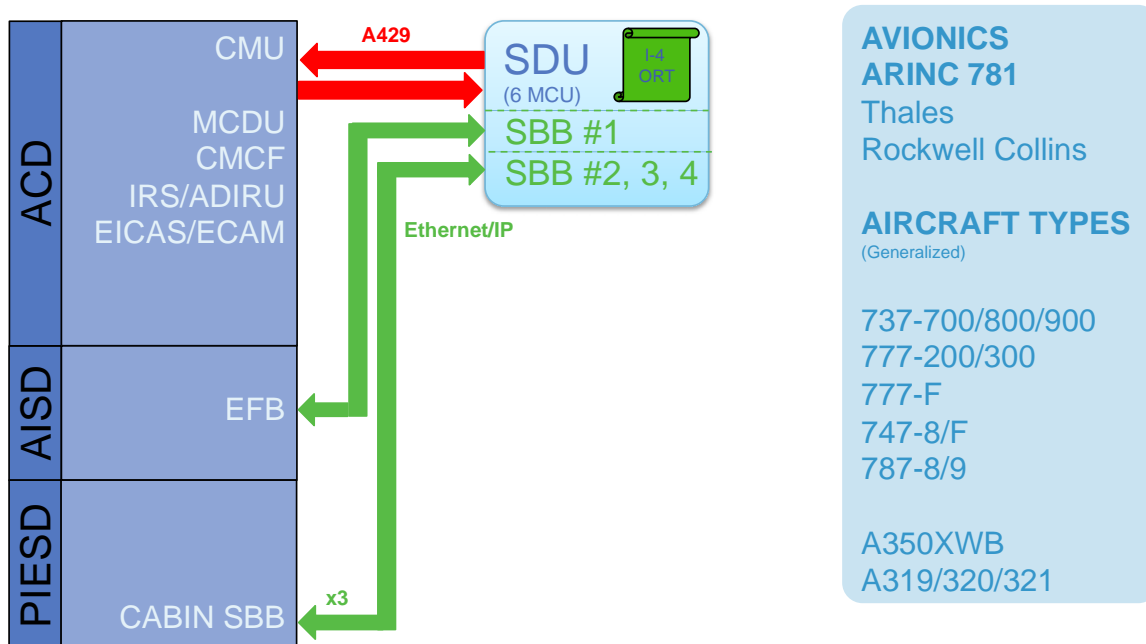


Figure 5 – Aircraft and Avionics Architecture for an ARINC 781 system (Example aircraft list)

Figure 5 illustrates how a typical aircraft installation is setup with Inmarsat systems having both Cockpit Safety Services and Cabin PICO Cell and Internet connections. In all SATCOM ARINC architectures, the required separation of cockpit and cabin functions are performed by separate channel cards and physical pin-out connections to various Security Domains within the aircraft. The three security domains are Aircraft Control Domain (ACD), Aircraft Information and Systems Domain (AISD) and Passenger Information and Entertainment Domain (PIESD). All ARINC conformed SATCOM architectures have separate connections, both at the physical and logical levels.

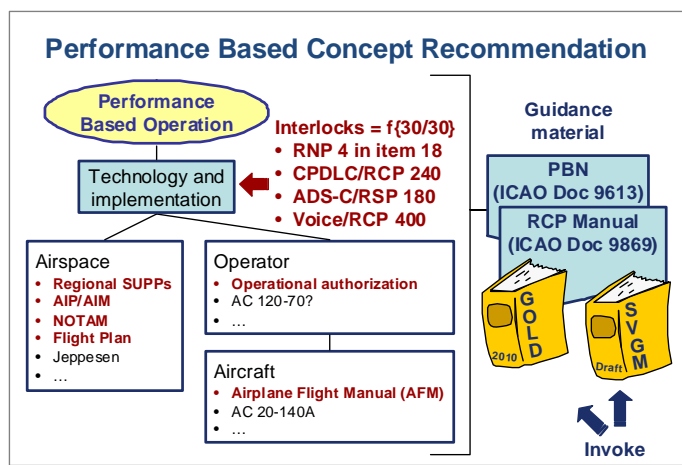
For the ACD, the physical connections are limited to the traditional ARINC 429 bus, are non-IP based and have no interconnections with any of the SBB channel cards. Correspondingly on the aircraft non-SATCOM end, the ACD is isolated from the other security domains. For the AISD and PIESD, these end user applications such as EFB and Cabin Internet are connected by separate channel cards and separate Ethernet connections via IP.

All SATCOM systems that perform both Classic Aero and SwiftBroadband are certified according to guidance as defined in various industry fora. ARINC 811 and RTCA SC216 are examples where each airframe manufacturer would address security aspects in their certification plans.

Regulatory – Performance Standards and Guidance Material

FANS1/A was originally introduced to provide improved communication and surveillance performance, such that aircraft can be reliably separated. Continued performance monitoring and a more comprehensive performance based framework are needed, as the FAA agreed in response to previous FANS 1/A over Iridium (FOI) and FANS 1/A over high frequency data link (FOH) recommendations. The FOICA project seeks to leverage and continue this concept (but doesn't need to repeat it as it is adequately covered in the previous projects). The below documents have been identified as components that would be required to be incorporated by the operator and partners that provide the data link service.

- ☐ ICAO GOLD
- ☐ ICAO 9925 AMS(R)S Manual
- ☐ AC20-140A Data Link – Aircraft
- ☐ AC20-150A Voice – Aircraft
- ☐ AC120-70B Data Link Operational Authorization
- ☐ Regional SUPPs
- ☐ AFM



However, since the Classic Aero service is currently being used for FANS1/A operations supporting reduced separations, then these documents are not expected to require any updates. The only real “new” aspects of the FOICA project are the satellites and ground based sub-network. This aspect is being validated by the results of the data being captured.

Evaluation Results

Lab and Aircraft Evaluations

All avionics manufacturers, Airbus and Boeing were coordinated with to test in the laboratory, existing and new SATCOM systems with the additional three I-4 satellites and two satellite access stations. Airbus performed flight tests and message validation in various airspace routes, regions and satellite coverage areas.

All of the lab and aircraft testing included comprehensive ACARS and FANS1/A messaging testing on the ground and in the air. There were no software or hardware changes to be certified, so there was no new certification activity as long as the existing offered SATCOM systems did not have SwiftBroadband capability in the aircraft. The primary observation was whether or not the messaging was successfully received and sent from both ends across the new satellites and networks.

All of these tests were completed in summer 2009 prior to Classic Aero over I-4 being activated in September 2009.

RCP 240/RSP 180 Operational Evaluation Results

Initial and early data collating were reviewed on a best effort case in CWG22, and 23, with data coming from AirwaysNZ, FAA, NAVCAN and UKNATS. Consistent data sets in accordance to GOLD and sufficient quantities of aircraft performing FANS1/A data link were achieved from CWG 24 and on. However there were not enough aircraft flying in the South Pacific (AirwaysNZ) enabled on the I-4 network to consistently evaluate performance, therefore only data from FAA, NAVCAN and UKNATS are provided. The results herein are provided as follows:

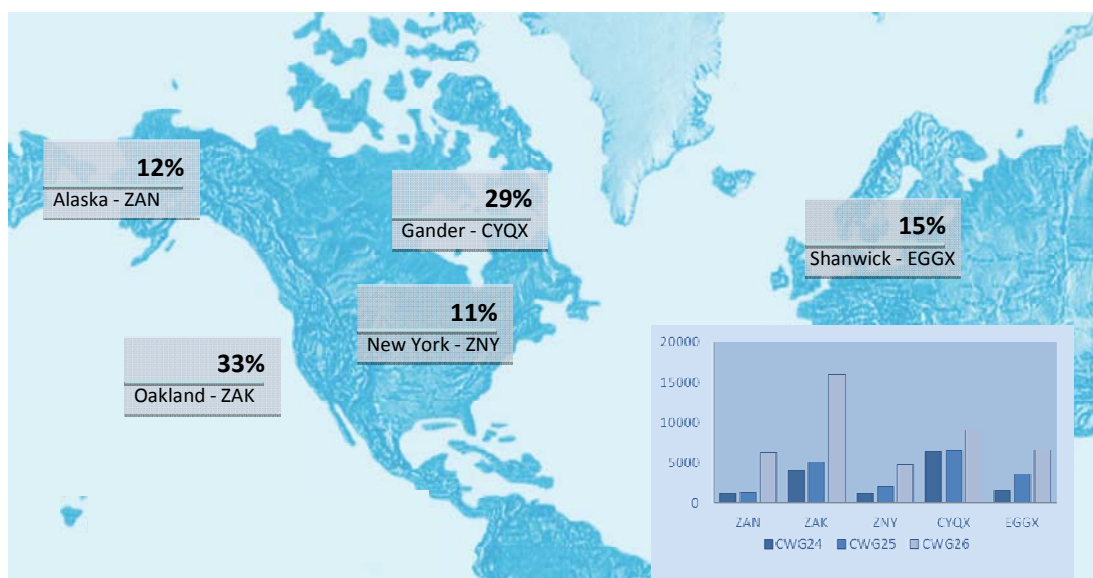
- a) ADS-C RSP Results Summary
- b) ADS-C RSP 180 95% Non-Performing Dispositions
- c) ADS-C RSP 180 99.9% Non-Performing Dispositions
- d) CPDLC RCP 240 Summary

ADS-C Results Summary

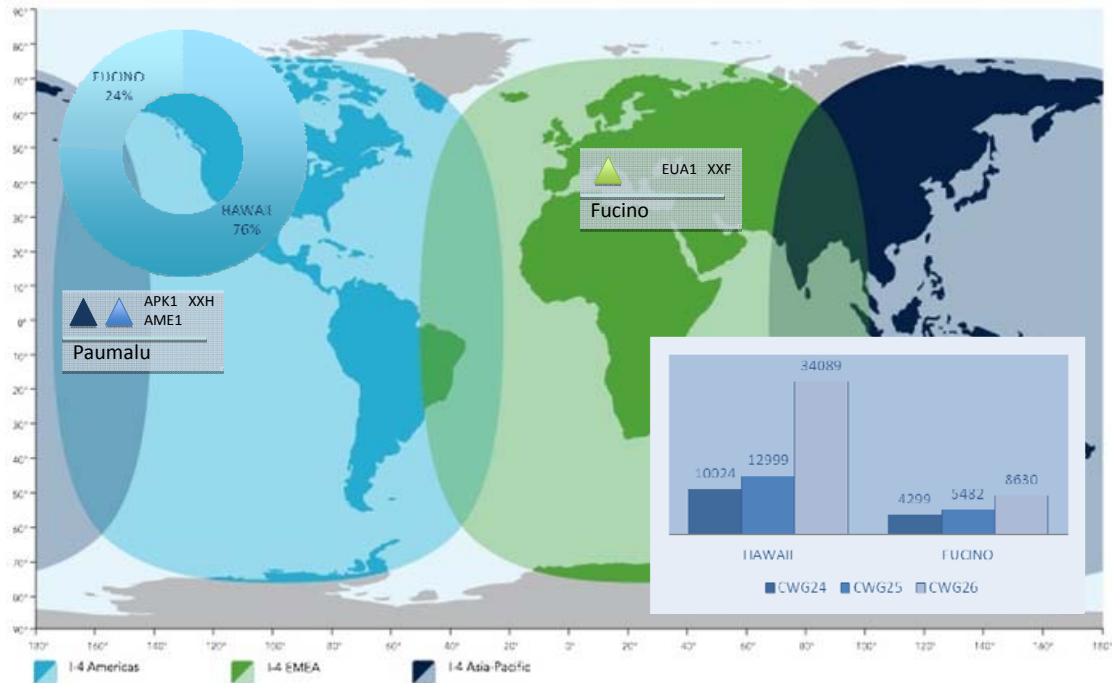
In total over the official CWG24/25/26 evaluation periods, over 75,000 ADS-C messages were logged and during this time, around 234 aircraft and 21 airlines were activated onto the I-4 network to contribute to the data sets. The number of airlines/aircraft on the I-4 network continues to grow as qualified end-users start a managed migration to this network, continuing a sizeable set of messages for post-implementation monitoring.

The ADS-C messages resulted in the following message proportions between the various FIRs totaling 12% for ZAN, 33% for ZAK, 11% for ZNY, 29% for CYQX and 15% for EGGX. The traffic via these ANSP regions resulted in Paumalu GES taking in 76% of traffic (2xsatellite regions) versus 24% for Fucino (1xsatellite region). The volume of traffic as spread between ARINC and SITA represented approximately one thirds to two thirds respectively.

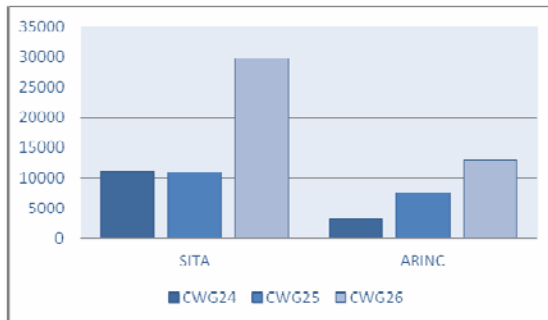
Total FOICA Project ADS-C Messages by FIR 2011 – CWG 24, 25, 26



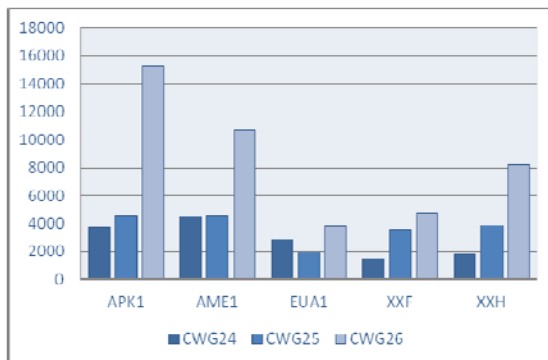
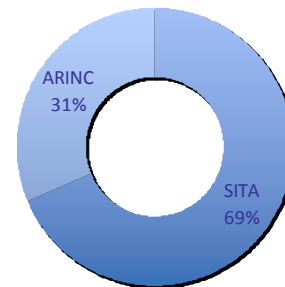
Total FOICA Project ADS-C Messages by I-4 GES 2011 – CWG 24, 25, 26



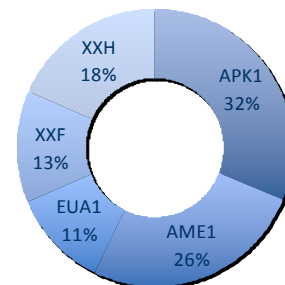
Total FOICA Project ADS-C Messages by CSP 2011 – CWG 24, 25, 26



Total ADS-C Messages by CSP



Total ADS-C Percentages by GES ID



ADS-C RSP 180 95% Non-Performing Dispositions

While ADS-C messages did not meet 100% of the time at RSP 180 (95% and 99.9%), there was only a need to further look into certain areas that may be of concern. These further investigations are noted in areas where the ADS-C results did not meet the RSP 180 at the 95% level and there were four of these instances:

- Investigation Item 1: ZAN – Anchorage Performance: B777-F Thales ARINC 781 Classic Aero and SBB
- Investigation Item 2: ZAN – AME1 Performance @ CWG26
- Investigation Item 3: ZAK/ZOA – B747-8 Performance @ CWG25
- Investigation Item 4: EGGX – Shanwick Performance with Airline G

FANS1/A ADS-C Message Performance to GOLD RSP180 @ 90 sec

FOICA PROJECT: FANS1/A OVER INMARSAT I-4 CLASSIC AERO

Supporting "Operational Safety" requirements in reduced airspace separations

	FAA									NAVCANADA				UKNATS			
	Pacific Ocean						Atlantic Ocean			Atlantic Ocean				Atlantic Ocean			
	ZAN - Anchorage FIR			ZAK - Oakland FIR			ZNY - New York FIR			CYQX - Gander FIR				EGGX - Shanwick FIR			
	APK1	AME1	XXH	APK1	AME1	XXH	AME1	EUA1	XXH	AME1	EUA1	XXF	XXH	AME1	EUA1	XXF	XXH
	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
CWG24	89.0	ND	ND	98.9	96.8	99.4	96.9	ND	99.5	97.4	97.6	99.2	98.5	96.4	98.0	98.4	96.9
CWG25	90.0	ND	ND	98.8	97.5	94.2	97.0	ND	98.6	96.2	96.4	98.2	98.0	94.8	96.8	98.8	98.2
CWG26	95.0	85.0	99.2	98.8	97.8	99.0	97.5	99.0	99.2	96.2	95.8	99.0	99.0	98.4	98.0	99.0	99.0

1 2 3 4

FAIL: <95%
PASS: >=95%
ND=No Data

CWG24 2011 - (FAA): February-April, (NAVCAN): February-May, (UKNATS): December-March

CWG25 2011 - (FAA): May-July, (NAVCAN): May-August, (UKNATS): April-July

CWG26 2011 - (FAA): July-December, (NAVCAN): September-December, (UKNATS): August-November

Conclusions

- While performance over the official evaluation period is not a perfect PASS score, PARC CWG committee has deemed above performance as satisfactory to progress into "Post-Implementation Monitoring".
- Sub-par performances are described in FOICA report

Investigation Item 1: ZAN – Anchorage Performance: B777-F Thales ARINC 781 Classic Aero and SBB

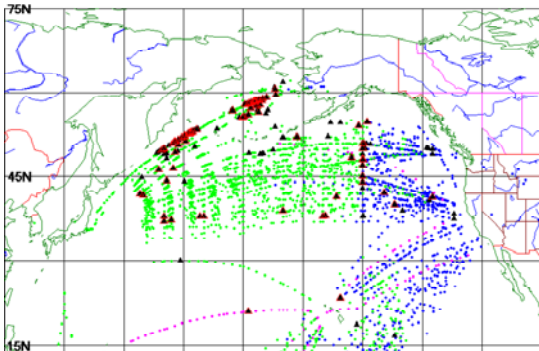
This configuration resulted in a cargo operator flying the latest B777-F with newly certified Classic Aero and SBB avionics. Apparent anomalies were observed consistently when flying routes near the Aleutian Islands and the Kamchatka Peninsula. The performance of ADS-C messages suffered significantly but those same aircraft when cross referenced to Oakland FIR performed adequately. Initially, the Thales avionics did not have the latest firmware upgrades, but after several review sessions, these appear to be incorporated. It is thought that there are VHF/SATCOM transitions within these regions, so the normal multi-mode communication latencies are suspected of contributing to the results. This seems to support the data at Oakland where the same aircraft do actually meet performance specifications. It was also noted that within this region, there could be effects due to the satellite edge of coverage effects, since the two satellites APAC and AMER do intersect within this general broad vicinity.

A CRA Problem Report has been raised and Inmarsat is looking into this aspect. This is intended to be further resolved at the regular Post-Implementation Monitoring Forum.

KZAN – Anchorage Performance

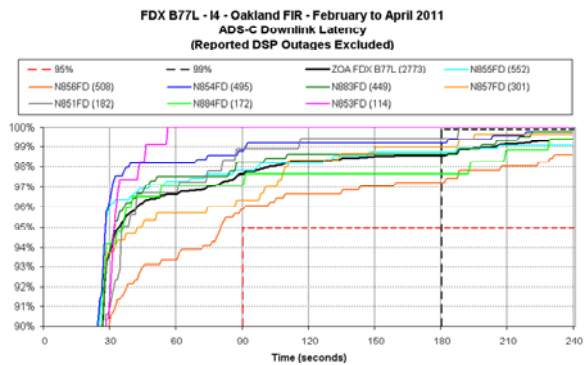
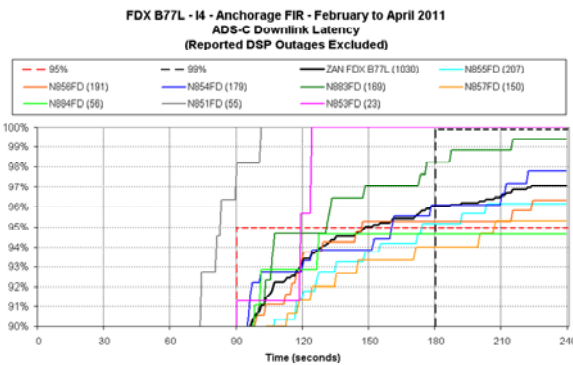
Investigation: Fedex 777-F with Thales Classic Aero + SBB

1



- Caused by this airline configuration for CWG 24 & 25
- Software logon issue provided
- 8 x Aircraft involved, problems along Aleutian Islands (ZAN), but passing in Oakland FIR
- Likely VHF/SATCOM multi-mode issue
- Improved in CWG26

Disposition: Continue to monitor in Post-Implementation CNSG based forum



Investigation Item 2: ZAN – AME1 Performance @ CWG26

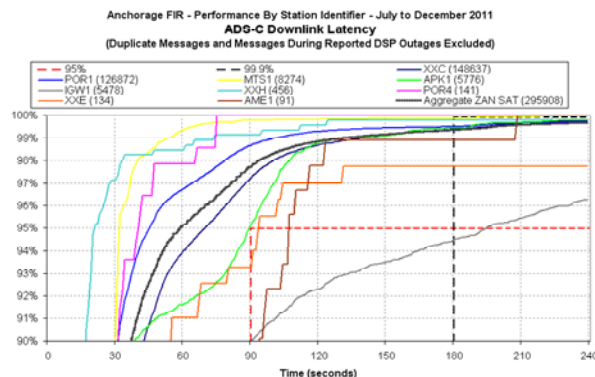
For CWG26 review at AME1 GES, there were only 91 data points logged and these did not meet the RSP 180 @95% criteria. Since the data set is new and of low volume it was decided to monitor this in Post Implementation Monitoring.

No further actions or PR's needed to be raised.

KZAN – Anchorage Performance

Investigation: CWG 26 AME1 Performance

2



- Only 91 Data points, no data from previous CWG 24 & 25
- Unknown Airline & Aircraft Configuration

Disposition: Continue to monitor in Post-Implementation CNSG based forum, unless FAA would like a more in-depth review

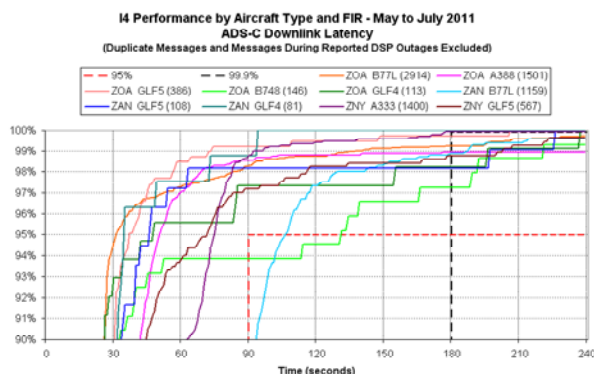
Investigation Item 3: ZAK/ZOA – B747-8 Performance @ CWG25

This particular item was attributed to a new Boeing 747-8 during test flight exercises in a pre-delivery configuration using the newest Rockwell Collins Classic Aero + SBB configuration. It was unknown as to what flight tests or maneuvers were being performed. It is thought to re-evaluate once in a post-delivery to airline configuration. **No Action Required.**

KZAK – Oakland Performance

Investigation: CWG 25 XXH Performance

3



- Boeing 747-8 Test Flight Aircraft
- Rockwell Collins Classic Aero + SBB configuration
- Aircraft not delivered at that stage?

Disposition: Re-evaluate once in post-delivery configuration

Investigation Item 4: EGGX – Shanwick Performance with Airline G

Airline G is a substantive airline operator having about 80 aircraft approved for use on the I-4 Classic Aero Network. While this airline will use the I-4, it is set to secondary preference and uses the I-3 Classic Aero Network as first preference. Therefore it is similar to having a first/second mode of communications system, whereby only when the I-3 network is experiencing problems, will these aircraft then log onto the I-4 network. For this evaluation, only 71 data points were registered on I-4 out of a possible 80 aircraft (in revenue airline service), so it suggests that those aircraft experienced intermittent I-3 issues and only performed minor data link volumes on the I-4 network before reverting back the I-3 network. The time for the switching between I-3 and I-4 networks seemed to add to the latency figures.

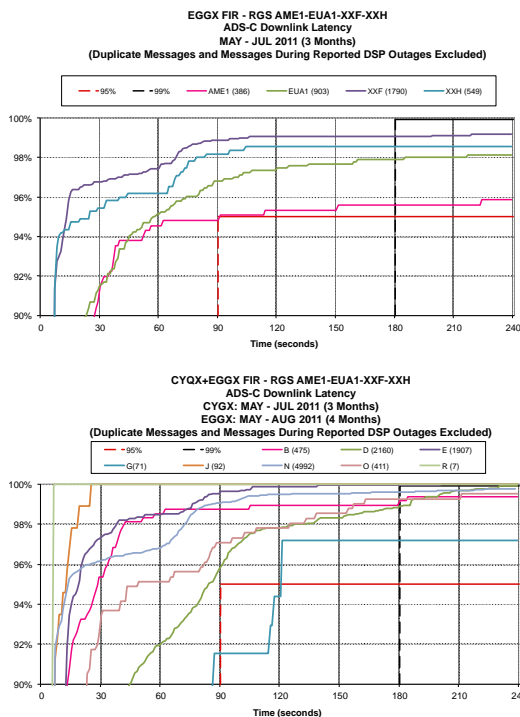
It is important to note that the I-3 and I-4 Classic Aero networks are independent of each other and do not auto-revert, or hand off automatically. So it is up to the aircraft's avionics to determine when to check for the first preference network availability/restoration or to stay on the network that is set to secondary preferences. RCP 240/RSP 180 evaluations should remain isolated to each of the networks independently and if an airline uses primarily the I-3 network, then the RCP 240/RSP 180 monitoring should be contained to that network. Should an airline use the I-4 network as primary, then the RCP 240/RSP 180 monitoring should focus on the I-4 performance accordingly.

Should there be a concern relating to Airline G's overall performance, then a review of data link performance should be conducted on Airline G's I-3 statistics instead.

EGGX – Shanwick Performance

Investigation: CWG 25 AME1 Performance

4



- Airline G Performance: 71 data points
- Mix of Aircraft/Avionics
- Primary Logon for these aircraft are set to I-3 stations, not I-4. Data shows that these aircraft are sending/receiving data intermittently on I-4, suggesting that they come in/out of I-3 logons. This can cause messages to exhibit longer logon and message delivery time, when switching between I-3 & I-4.
- The I-3 & I-4 sub-network systems do not have auto-reversion capability. The I-3 and I-4 systems should be measured independently and this behavior should be noted.

Disposition: Preliminary data suggests there may be something awry with the I-3 network, causing these aircraft to logon to I-4 for brief periods of time. Not expected to be an I-4 issue.

ADS-C RSP 180 99.9% Non-Performing Dispositions

The following series of charts are included to show that while the RSP 180 performance at 99.9% is not met all the time, there are quite a few other GES or I-3 related performances that exhibit similar upper limit constraints. It is not known if meeting 99.9% message latency is an absolute requirement, but coming close to meeting it is highly desired. In general if the performance meets at 99.0%, then perhaps it should be regarded as acceptable performance from an "Operational Efficiency" standpoint. This should further be explored at the ANSP level or discussed at other fora for consensus opinion.

FANS1/A ADS-C Message Performance to GOLD RSP180 @ 180 sec
FOICA PROJECT: FANS1/A OVER INMARSAT I-4 CLASSIC AERO
Supporting "Operational Safety" requirements in reduced airspace separations

	FAA									NAVCANADA				UKNATS			
	Pacific Ocean						Atlantic Ocean			Atlantic Ocean				Atlantic Ocean			
	ZAN - Anchorage FIR			ZAK - Oakland FIR			ZNY - New York FIR			CYQX - Gander FIR				EGGX - Shanwick FIR			
	APK1	AME1	XXH	APK1	AME1	XXH	AME1	EUA1	XXH	AME1	EUA1	XXF	XXH	AME1	EUA1	XXF	XXH
	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
CWG24	96.5	ND	ND	99.4	98.4	99.4	97.8	ND	99.8	99.3	98.2	99.8	99.5	98.2	99.0	99.0	96.9
CWG25	98.9	ND	ND	99.4	98.8	97.2	98.6	ND	99.9	98.6	97.4	99.0	99.0	95.6	97.8	99.0	98.5
CWG26	99.5	99.0	99.8	99.5	99.0	99.5	98.5	99.0	99.8	99.2	99.5	99.5	99.5	99.2	99.5	99.5	99.5

FAIL: <95% ACCEPTABLE: >=99% and <99.5% PASS: >=99.5% ND=No Data

CWG24 2011 - (FAA): February-April, (NAVCAN): February-May, (UKNATS): December-March

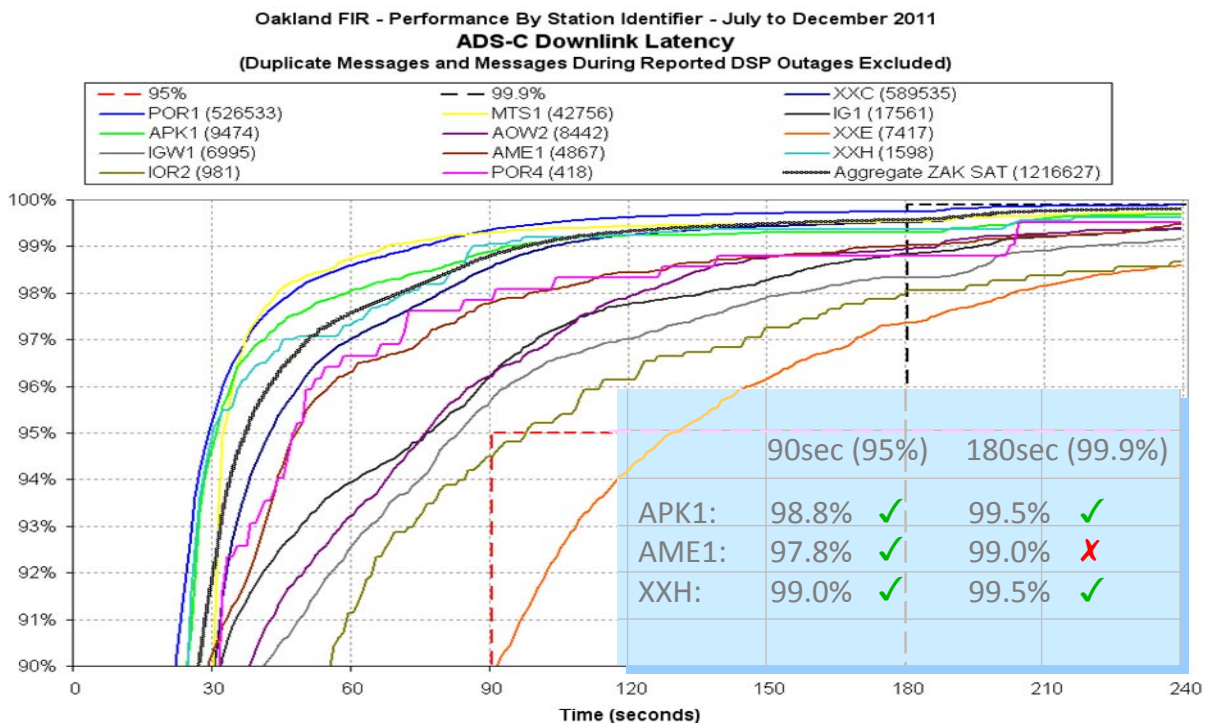
CWG25 2011 - (FAA): May-July, (NAVCAN): May-August, (UKNATS): April-July

CWG26 2011 - (FAA): July-December, (NAVCAN): September-December, (UKNATS): August-November

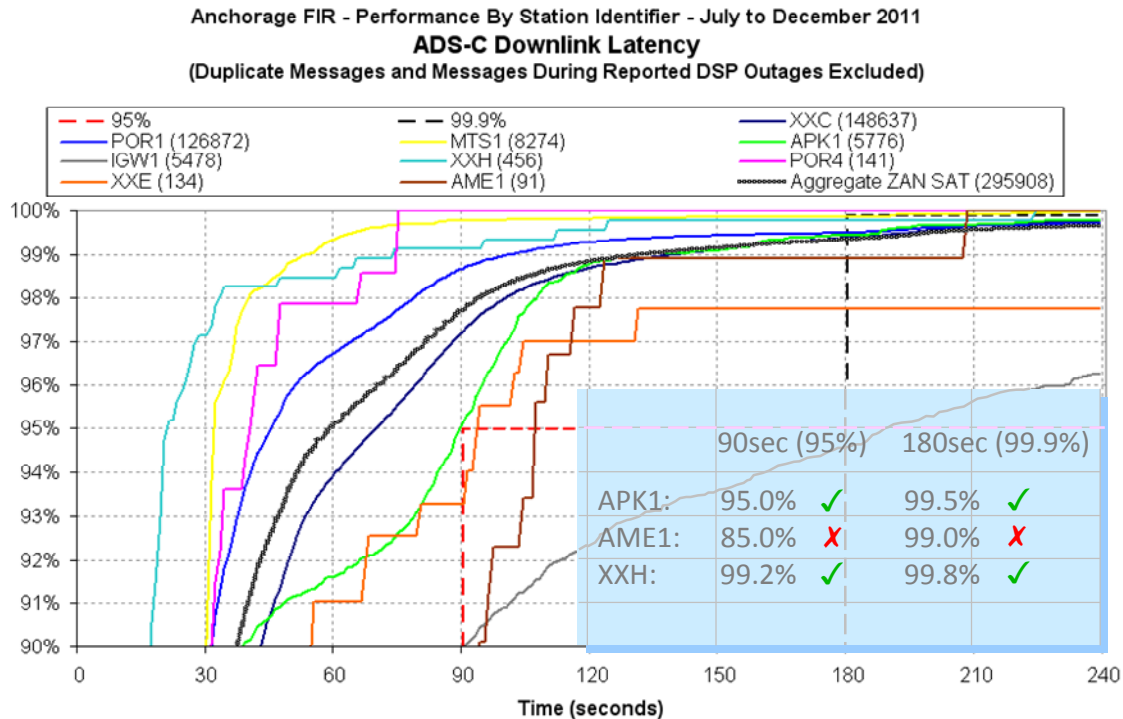
Conclusions

- 1) Industry expectations: "Cannot meet GOLD requirement of 99.9%?": This data shows that 99.5% to 99.9% "CAN BE MET". Perhaps a requirement for >99% could be considered in the future?
- 2) ACTION (For Air Navigation Service Providers): Should "Operational Efficiency" in densely populated FIRs be required, then consider >99% as an acceptable performance criteria?

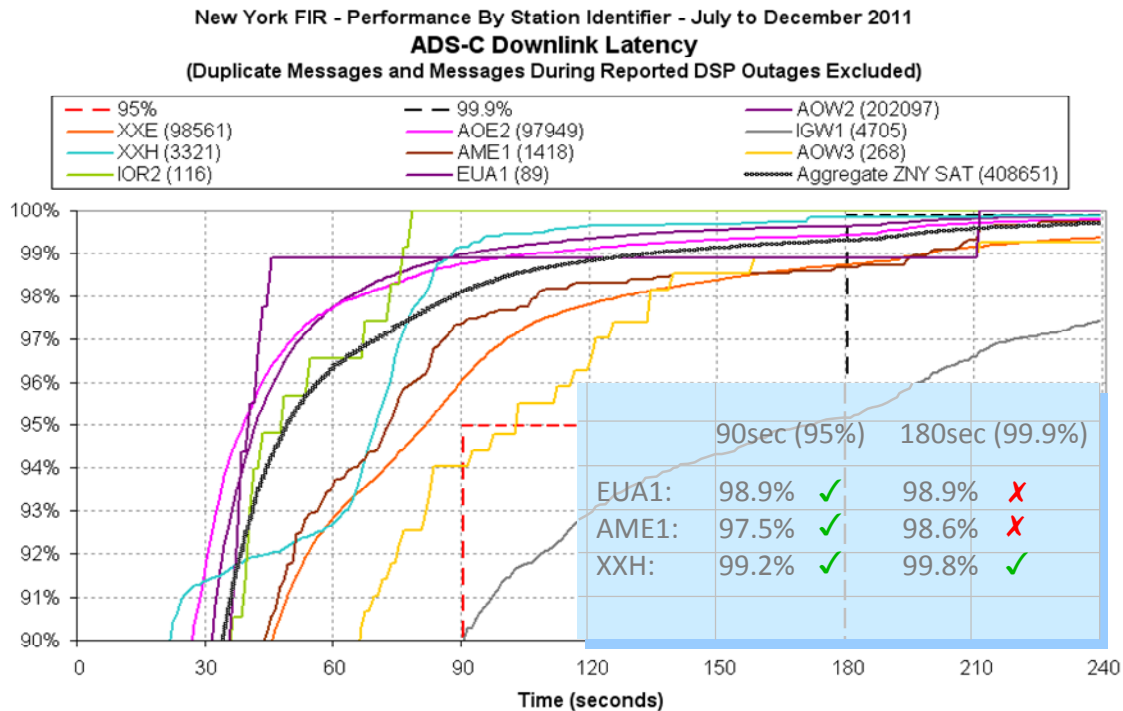
I-4 Performance: FAA – Oakland FIR



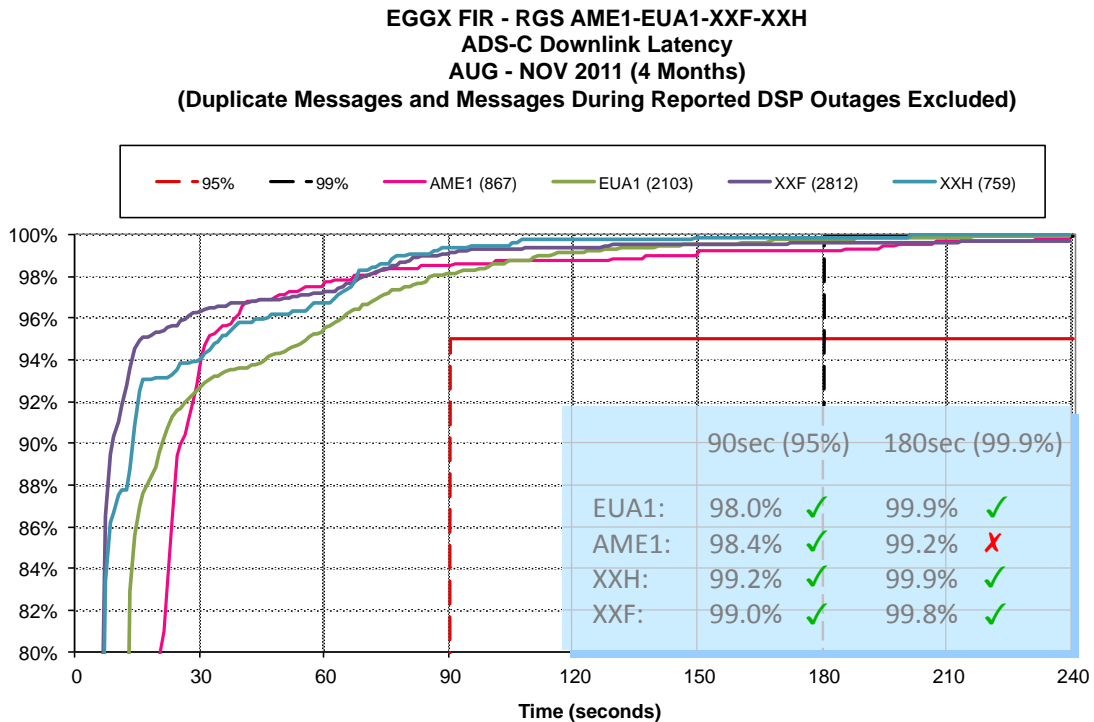
I-4 Performance: FAA – Anchorage FIR



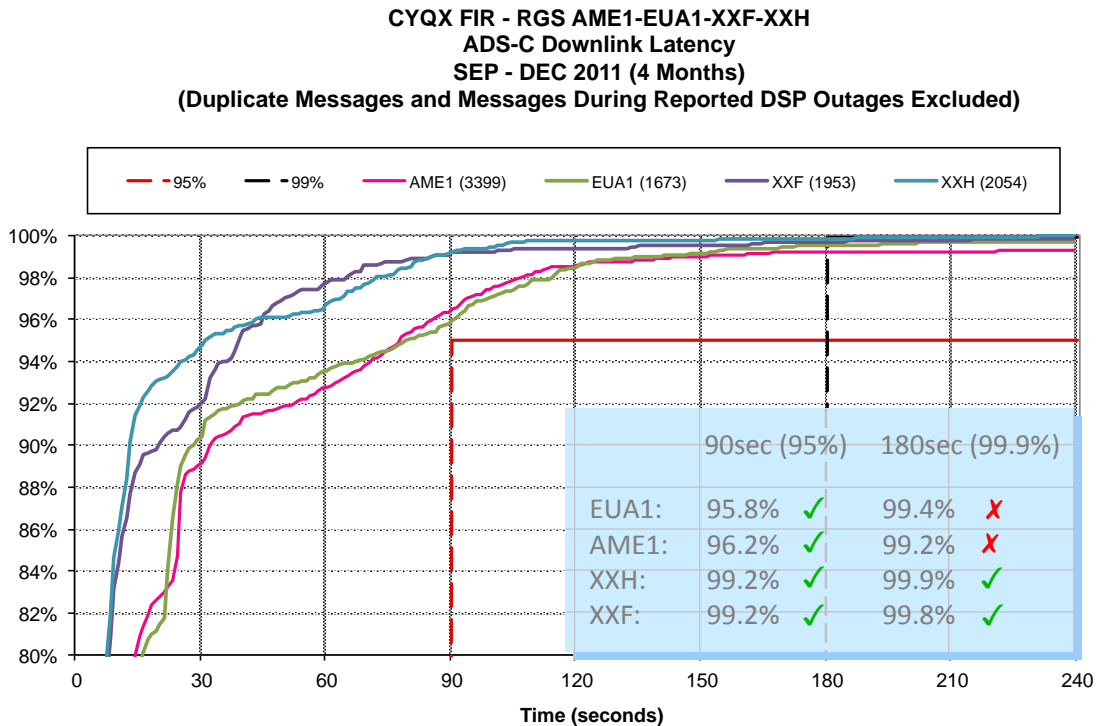
I-4 Performance: FAA – New York FIR



I-4 Performance: UKNATS – Shanwick FIR



I-4 Performance: NAVCANADA – Gander FIR



CPDLC RCP 240 Summary

The FAA, UKNATS, NAVCANADA provided data for detailed analysis of RCP 240 CPDLC performance at each of the CWG24/25/26 sessions and will be provided upon request, as appropriate. The message count is approximately a few thousand messages overall and throughout these periods, there were no apparent non-performance items, and will be further analyzed in post-implementation monitoring.