September 17, 2010

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, *FANS 1/A over Iridium (FOI) and Performance-Based Concept Recommendations*.

This report supports widespread use of the future air navigation system (FANS 1/A) controller-pilot data link communications (CPDLC) and automatic dependent surveillance – contract (ADS-C). For more than a decade, CPDLC and ADS-C have demonstrated advances in safety with operational and environmental benefits through increases in airspace capacity, reduced separations, user preferred routes, dynamic airborne reroute procedure and trajectory operations, such as tailored arrivals, all resulting in greener operations.

Incentives continue to justify fleet equipage and expansion of data link services worldwide. However, the North Atlantic (NAT) Region is planning to mandate data link operations beginning in 2013, coincident with the European implementing rule for data link services. The data link operations in the NAT are intended to minimize the effects of operational errors and pilot deviations to meet target levels of safety, and eventually support reduced separations. The PARC has been looking at optimum solutions to meet immediate and near to mid term critical needs, while staying on the path to the Next Generation Air Transportation System (NextGen).

Significant operational and safety benefits will be lost unless actions are taken to sustain current communications and surveillance capabilities. Furthermore, NextGen operational improvements will depend on appropriate and operationally acceptable communications and surveillance capabilities together with performance based navigation (PBN). Implementing the recommendations provided in the attached report will promote expansion of data link services, provide incentives for fleet equipage and enable performance-based operations consistent with NextGen objectives.

FOI is a significantly lower cost solution than other aeronautical mobile satellite (route) service (AMS(R)S) alternatives. Iridium-based equipment is easier to retrofit on aircraft, draws less power, is lighter in weight, and provides global coverage, including the Polar Region. The global air transportation system will benefit from FOI as it provides a practical alternative for air navigation service providers (ANSPs) to expand data link service, and for commercial and business aviation markets to equip their fleets more quickly.

The PARC has found that Iridium is viable for CPDLC/RCP 240 and ADS-C/type 180 operations. Therefore, the PARC requests the FAA to expedite the steps necessary to remove restrictions on current FOI operations to realize immediate gains in operational and safety benefits.

In addition, the PARC requests the FAA to plan for and implement in the near and mid terms a performance-based framework for required communication performance (RCP) and surveillance performance specifications. A performance-based framework will enable ANSPs to apply different service levels to eligible operators and leverage "less capable" aircraft in the same airspace. More importantly, implementation of this framework will ensure continued operational safety of current performance-based operations, such as reduced separations in oceanic and remote airspace, and facilitate seamless operations worldwide as the FAA expands data link implementation in its domestic airspace. The performance-based framework is flexible to add performance specifications when they are needed for new applications, such as the use of satellite voice communications and to transition to NextGen.

Implementation of a performance-based framework can begin now. Based on ICAO Doc 9869, *Manual on Required Communication Performance (RCP)*, initial performance specifications are already provided in the ICAO *Global Operational Data Link Document (GOLD)*, First Edition, issued in June. The NAT Region, the Asia-Pacific Region, and the South Atlantic Sub-Region have formally accepted the GOLD, and have begun planning and implementation for its application.

The PARC appreciates your continued support of its activities and invites you to join us in a discussion of these recommendations at your convenience. Please call me if you have any questions or would like to set up a discussion. Lastly, I have to recognize Tom Kraft and the team for doing such a great job on this task.

Sincerely,

Chairman
Performance based operations Aviation
Rulemaking Committee

Cc: J. McGraw
L. Smith
B. DeCleene
J. McCarthy
T. Kraft
A. Oldach

Federal Aviation Administration

Final Draft

FANS 1/A over Iridium and Performance-Based Concept Recommendations

September 16, 2010

Prepared by:

Performance Based Operations Aviation Rulemaking Committee

Communications Working Group (PARC CWG)

Table of contents

List of Figures

List of Tables

FOREWORD

The Performance-based Operations Aviation Rulemaking Committee Communications Working Group (PARC CWG) initiated the future air navigation system (FANS 1/A) over Iridium (FOI) project in 2008 in the best interest of the aviation community to advance communication technology and leverage existing capabilities to meet operational needs. The project, completed in August 2010, substantiates recommendations provided in this report through laboratory evaluations, pre-FOI operations to evaluate performance of aeronautical operational control (AOC) communications, and FOI operations.

Each participant volunteered to participate in the FOI project, agreed to bear their own costs and provided information to support the evaluations. The PARC CWG appreciates the cooperation of operators, air navigation service providers (ANSPs), communication service providers (CSPs), satellite companies, avionics suppliers, aircraft manufacturers, regulators, and all those who were essential in bringing this project to completion.

The PARC CWG's reliance on central reporting agencies (CRAs), the North Atlantic (NAT) data link monitoring agency (DLMA), ANSPs and the FAA Technical Center optimized proper handling of the data and capitalized on the resources and expertise needed to conduct data analysis and coordinate on corrective actions.

The PARC CWG embraced the International Civil Aviation Organization (ICAO) Global Operational Data Link Document (GOLD) for the FOI project to provide:

a) Globally recognized success criteria, in accordance with required communications performance (RCP) and surveillance performance specifications, provided at Appendix B and Appendix C, respectively; and

b) Guidelines to monitor and analyze the data, in accordance with Appendix D.

The PARC looks forward to continue its work with the FAA and other stakeholders to ensure FOI operations continue to perform as intended in an acceptably safe manner.

September 16, 2010

Introduction

Since 2007, use of the Iridium satellite communication (SATCOM) voice and data services to support air transportation has grown dramatically. Initial installations have been geared more toward the business aviation market. However, new avionics are now available, and both ARINC and SITA, the two main communication service providers (CSPs) for aeronautical use, have added Iridium SATCOM services to their existing portfolio of satellite, very high frequency (VHF), and high frequency (HF) data link (HFDL) communication services supporting aircraft communications addressing and reporting system (ACARS). This capability is referred to as ACARS over Iridium (AOI). A number of air carrier and commercial operators are now equipped, and installations are rapidly continuing to support voice and data communications for aeronautical operational control (AOC).

In 2007, the International Civil Aviation Organization (ICAO) amended the standards and recommended practices (SARPs) in ICAO Annex 10 — *Aeronautical Telecommunications – Volume III — Communication Systems*, to revise aeronautical mobile satellite (route) service (AMS(R)S). In 2010, ICAO issued Doc 9925, *Manual on the AMS(R)S*, to provide the guidance material to allow the use of Iridium for communications supporting air traffic services (ATS). Air navigation service providers (ANSPs) are looking at Iridium as a viable solution to improve air traffic control (ATC) communications. Aircraft operators continue to pursue widespread use, including the use of Iridium short burst data service (SBD) for future air navigation system (FANS 1/A) operations worldwide. This capability is referred to as FANS 1/A over Iridium (FOI).

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 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 –HFDL 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 FOI operations and implementation of a performance-based framework for required communication performance (RCP) and surveillance performance specifications.

Benefits

FANS 1/A includes controller-pilot data link communications (CPDLC) and automatic dependent surveillance – contract (ADS-C), which enable:

a) Reduced separations based on the use of ADS-C, CPDLC and SATCOM to provide enhanced surveillance and communications over the high seas;

b) More efficient operations, by enabling trajectory optimization prior to departure and throughout the flight by use of user preferred routes (UPRs), dynamic airborne reroute procedures (DARP), trajectory operations such as the tailored arrival procedure at multiple airports, and climb/descent procedures (CDP);

c) Reduced CO_2 emissions minimizing environmental impact. The environmental benefits resulting from the use of FANS 1/A in oceanic airspace have been substantial and well documented through programs such as Asia and south Pacific initiative to reduce emissions (ASPIRE) and Atlantic interoperability initiative to reduce emissions (AIRE). Optimizing the route prior to departure provides environmental and economic benefit (i.e., carry gas to burn gas). Enabling comprehensive updates to the active flight plan when en route enables further optimization as new wind data become available during long-haul operations. The use of the tailored arrival procedure, which uses CPDLC to provide an optimized trajectory clearance just prior to exiting oceanic airspace, further minimizes environmental impact resulting in fuel-efficient operations. The tailored arrival procedure provides initial use of NextGen operations; and

d) Advances in safety through procedures supported by enhanced communications to issue route re-clearances using CPDLC. CPDLC enables the flight crew to automatically load route data into the aircraft flight plan, minimizing manual data entry errors. When operational errors and pilot deviations do occur, enhanced surveillance and communications reduces the exposure using ADS-C for automatic route conformance monitoring and provide indication to the controller only in non-conforming situations. CPDLC enables the controller to intervene more quickly to correct them.

FOI is a significantly lower cost solution than other AMS(R)S alternatives. Iridium-based equipment is easier to retrofit on aircraft, draws less power, is lighter in weight, and provides global coverage, including the Polar Region. The global air transportation system will benefit from FOI as it provides a practical alternative for ANSPs to expand data link service, and for commercial and business aviation markets to equip their fleets more quickly.

Recommendations

Significant operational and safety benefits will be lost unless actions are taken to sustain current communications and surveillance capabilities. Furthermore, NextGen operational improvements will depend on appropriate and operationally acceptable communications and surveillance capabilities together with performance based navigation (PBN). Implementing the recommendations provided herein should promote expansion of data link services, provide incentives for fleet equipage and enable performance-based operations consistent with NextGen objectives.

RECOMMENDATION 1. Expedite the steps necessary to remove restrictions on current FOI operations to realize immediate gains in efficiency and safety benefits.

Rationale. Iridium is viable for CPDLC/RCP 240 and ADS-C/type 180 operations. Iridium LLC has also committed to 81 new satellites scheduled to begin launches during the first quarter of 2015. The new constellation will be compatible with existing communication services and aircraft equipage, and offer new more efficient services.

a) ***Reduced separations***. Apply reduced ADS-C based separations between FOI aircraft and other aircraft. Aircraft have been certified with FOI capability and operators have received their authorization to use the FOI. The operators also have their required navigation performance (RNP 4) authorization for area navigation (RNAV). However, ANSPs have restricted the application of reduced ADS-C based separations between FOI aircraft and other aircraft.

b) ***Position reporting and identification***. Coordinate with Japanese Civil Aviation Bureau (JCAB) and the Civil Aviation Authority of the Fiji Islands on the possibility of removing additional position reporting and identification requirements for FOI aircraft. For FOI aircraft to participate in FANS 1/A operations, the following applies:

    1) Operators must complete coordination with JCAB at least 4 days prior to commencement of FOI operations;

    2) Upon entry into Fukuoka flight information region (FIR), the flight crew must send to the ATC facility, a CPDLC free text message indicating FOI; and

    3) In Fukuoka and Nadi FIRs, the flight crew must send CPDLC position reports at compulsory reporting points (HF/VHF position reports are not required).

RECOMMENDATION 2. In the near and mid terms, plan for and implement a performance-based framework for RCP and surveillance performance specifications.

Rationale. Implementation of a performance-based framework will enable ANSPs to apply different service levels to eligible operators and leverage "less capable" aircraft in the same airspace.

More importantly, implementation of a performance-based framework will ensure continued operational safety. Current operational ATC systems can potentially misapply air traffic services to an operator, aircraft type, or a single "broken" aircraft. This is most likely occurring today where reduced ADS-C based separations are applied, because the qualification criteria for communication and surveillance are not prescribed and there is no approval mechanism in place to ensure that the operational system complies with the criteria.

Since 1995, ANSPs had been evaluating actual FANS 1/A performance on the total fleet within an airspace. In 2007, the performance of the Inmarsat Classic Aero services began to degrade and, as a result, the FAA revised its plans from expanding reduced ADS-C based separations to limiting their application to targets of opportunity. The FAA and Airways New Zealand have since been conducting more extensive evaluations, in accordance with the ICAO *Global Operational Data Link Document (GOLD)*, and have observed that some operators and aircraft types are meeting RCP and surveillance performance

criteria and others are not. The performance is not always related to problems with the Inmarsat Classic Aero services. Nevertheless, the data indicates that the performance of current FANS 1/A operations remains at risk for a number of reasons that require increased scrutiny of the end-to-end operational system, including procedures, aircraft equipage, ATC automation, network, internetworking, ground earth stations (GESs), gateways and satellites.

During investigations of the FOI operations, PARC CWG identified a number of problems with some operators and some FANS 1/A aircraft using the Inmarsat Classic Aero services. CPDLC RCP and ADS-C safety performance monitoring and corrective action have effectively improved overall performance. However, not in all cases as there is no airspace requirement. Post-implementation monitoring detects non-compliances a period of time, e.g., 30-60 days, after a reduced separation could be misapplied. Implementation of a performance-based framework will provide a proactive means to ensure acceptable level of performance for communication and surveillance capability, and enable the FAA to resume its original plans to expand reduced ADS-C based separations. Additionally, as the FAA expands data link implementation in its domestic airspace, the performance-based framework will facilitate seamless operations worldwide and advance safety.

a) ***Timely implementation***. Begin implementing a performance-based framework now and in the near term. Based on ICAO Doc 9869, *Manual on Required Communication Performance (RCP)*, initial performance specifications are already provided in the ICAO *GOLD*, First Edition, issued in June. The NAT Region, the Asia-Pacific Region, and the South Atlantic Sub-Region have formally accepted the *GOLD*. The performance-based framework is flexible to add performance specifications in the near and mid terms to support other operational needs, such as the use of SATCOM voice as an approved LRCS, and transition to NextGen.

b) ***Planning considerations***. As soon as possible, amend the FAA's Flight Plan, NextGen Implementation Plan (NGIP), the AVS Work Plan for NextGen and other FAA planning documents, as necessary, to plan for implementing a performance-based framework for communications and surveillance. The plans should include the tasks necessary to:

    1) Coordinate with ICAO and Regional ATS coordinating groups, the global implementation of performance-based communications and surveillance.

    2) Identify the intended performance-based operations, applicable airspace and effective implementation dates for applying performance specifications to communication and surveillance capability.

    3) Identify the regulatory instruments that will need to be amended, e.g., aeronautical information publication (AIP), or equivalent, aeronautical charts, flight plan criteria, operational specifications, flight manual, and associated guidance material, e.g., advisory circulars and orders.

    4) Identify changes needed to FAA ATC procedures and/or automation for operations and for CPDLC RCP and ADS-C safety performance monitoring at the ATC facility and establish a timeline for implementation.

c) ***Global coordination***. Globally coordinate with ICAO and regional ATS coordinating groups to specify and prescribe airspace and service provision requirements and to recognize and use guidance material to qualify operators and aircraft capability for seamless operations, performance and interoperability. As a minimum, changes are needed to:

1) *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, ICAO Doc 4444) using performance specifications to provide global communication, navigation and surveillance (CNS) criteria for the performance-based operation, and the criteria for flight plan formats to identify aircraft equipment and capability.

2) *Regional Supplementary Procedures* (Regional SUPPs, ICAO Doc 7030,) to provide the applicable airspace where and when a State or Region implements a performance-based operation, and to include any supplemental requirements for the operator, the aircraft equipage, flight planning, and the air traffic service provision.

d) ***Specify criteria for the intended performance-based operation***. Revise ICAO Doc 4444 and other documents, as necessary, to specify the communication and surveillance capability and performance criteria based on the ICAO Doc 9869, *Manual on RCP* and the *GOLD*, together with the performance-based navigation criteria provided by ICAO Doc 9613, *Performance-based Navigation (PBN) Manual*.

1) Apply CPDLC/RCP 240 and ADS-C/type 180 specifications together with the RNAV/RNP 4 specification to 5-minute longitudinal separation, 25 nautical miles (NM) lateral separation on ½ degree spacing in the organized track system (OTS) planned in the NAT. These specifications already provide criteria for 30 NM lateral separation, 30 NM and 50 NM longitudinal separation.

2) Apply performance specifications where beneficial, such as to introduce a different technology, new implementation, or to apply a lower service level to "less capable" aircraft. CPDLC/RCP 400 and ADS-C/type 400 or SATCOM voice/RCP 400 may be used for 50 NM lateral, 10-minutes longitudinal separation, in reduced vertical separation minimum (RVSM) or greater separations. HF voice and RNAV/RNP 10 specifications provide minimum criteria for such separations.

3) Identify any new performance-based operations in domestic or oceanic airspace supported by data link that would need new performance-based specifications per ICAO Doc 9869, *Manual on RCP*. Coordinate new or amended RCP or surveillance specifications in appropriate industry forum, e.g., RTCA SC-214/EUROCAE WG-78, and ICAO forum, e.g., Operational Data Link Panel (OPLINKP). Establish new RCP and surveillance specifications only where beneficial and internationally agreed, and amend existing RCP and surveillance specifications within the performance-based framework consistent with current ICAO standards and guidance.

e) ***Prescribe criteria for the applicable airspace***. Similar to PBN, amend ICAO Doc 7030, *Regional SUPPs*, and AIPs to prescribe specifications that provide the criteria for performance-based communications and surveillance capability applicable to performance-based operations in the defined airspace. Amendments should include:

1) Reference to performance specifications to associate the specifications for the data link applications with the performance-based operation and to convey aircraft communication and surveillance capability in the flight plan for the ATC flight data processing system.

2) Aircraft and operator approvals by the State of the Operator or State of Registry.

f) ***Aeronautical charts***. Update aeronautical charts to indicate the data link services that are provided in any particular control area (CTA)/FIR, logon address, and other relevant charting information, such as SATCOM voice telephone numbers.

g) ***Flight plan***. Develop standards and guidance material on use 2012 flight plan provisions for designating appropriate RCP specifications for communications, such as CPDLC, and performance-based specifications for surveillance, including ADS-C and automatic dependent surveillance – broadcast (ADS-B). Prior to 2012, consider changes to flight plan filing requirements to add new designators for performance specifications in Item 18 that would coincide with ATC procedures and/or automation changes.

h) ***Operational Specifications***. Revise templates for the FAA A056, *Data Link Operational Specifications*, and *Letter of Authorization (LOA)* to provision for varying capability. Revise advisory circular (AC) 120-70B, *Operational Authorization Process for Use of Data Link Communication System*, and Order 8900.1, *Flight Standards Information Management System (FSIMS)*, to provide qualification criteria. In international forums, advocate a requirement for operational authorizations for non-U.S. operators issued by the State of the Operator or State of Registry.

i) ***ATC procedures and automation changes***. Develop and implement changes to ATC facility automation and/or procedures to apply appropriate level of service to eligible aircraft based on flight plan designators that identify the aircraft capability and operator's authorization for use.

j) ***CPDLC RCP and ADS-C safety performance monitoring***. Continue to monitor CPDLC and ADS-C performance in accordance with the *GOLD*. Develop procedures to notify appropriate parties, e.g., Principal Operations Inspectors (POIs) and operators, of non-conforming operations and to implement corrective action.

Figure 1 provides an overview of an implemented performance-based framework for communications and surveillance. The standards, such as the Regional SUPPs, AIPs and NOTAMs invoke the guidance material, such as the *PBN Manual* and the *GOLD*. The technology and implementation enable the ATC facility to provide the appropriate level of service to eligible operators. Operators are eligible as indicated in operational specifications and based on their filed flight plan.

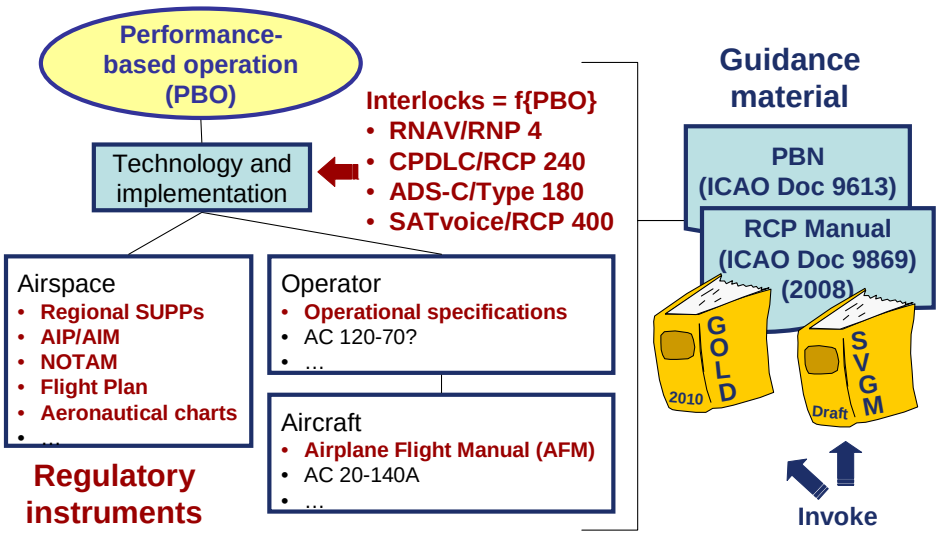

Figure 1. Relationship of standards, guidance material, technology and implementation

FOI project

The PARC CWG initiated the FOI project in March 2008 and completed it in August 2010 to substantiate recommendations provided in this report. This section provides a brief overview of the project.

Participants

All stakeholders in the FOI end-to-end system, i.e., operators, aircraft manufacturers, avionics suppliers, CSPs, Iridium, and ANSPs participated in the project to track system configuration, analyze data and correct problems. The following participated in the FOI operational evaluations:

a) Two operators, Continental Micronesia (CMI) and Cargolux (CLX), participated in the FOI operational evaluations. Delta, UPS, Hawaiian, Qantas, United, and Department of Defense/U.S. Air Force (DoD/USAF) supported the project.

b) The South Pacific ANSPs, the JCAB, and North Atlantic ANSPs provided data link services in 14 CTAs/FIRs and supported data collection as much as possible.

c) CSPs, ARINC and SITA, and the satellite company, Iridium LLC

d) The aircraft manufacturer, Boeing, and avionics suppliers, Avionica, International Communications Group (ICG), GE Aviation, Honeywell, and Rockwell Collins, provided support in data analysis and corrective action.

e) FAA Flight Standards, Aircraft Certification, and the Air Traffic Organization headquarters supported the project in their respective areas of responsibility.

Operations

Continental Micronesia (CMI), based in Guam, operates 11 Boeing 737-800 and 737-700 aircraft in extended over water operations outside of VHF coverage (see **Figure 2**). CMI trained over 100 pilots and received their operational authorization for FANS 1/A operations on November 20, 2009. Nine aircraft began FOI operations on December 12, 2009. The remaining 2 aircraft are scheduled to be FOI capable in September 2010. During the operational evaluations, CMI operated in the following CTAs/FIRs:

CTA/FIR (Logon)	CTA/FIR (Logon)
Oakland (KZAK)	Nadi (NFFF)
Fukuoka (RJJJ)	Honiara (AGGG) above FL 245
Brisbane (YBBB)	Nauru (ANAU) above FL 245.

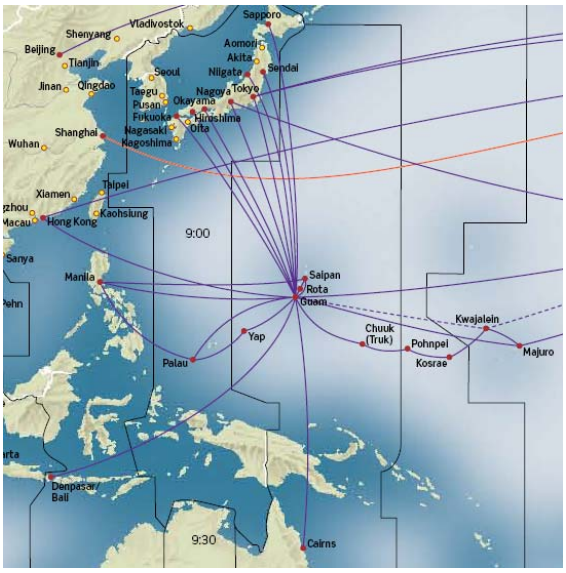

Figure 2. Continental Micronesia routes

Cargolux (CLX), in Luxemburg, operates 13 Boeing 747-400 aircraft in over 55 countries and services over 60 flight destinations (See **Figure 3**.) CLX trained over 400 pilots and received their operational authorization for FANS 1/A operations on September 7, 2009. All CLX aircraft began FOI operations on March 25, 2010. During the operational evaluation, CLX operated in the following CTAs/FIRs:

CTA/FIR (Logon)	CTA/FIR (Logon)	CTA/FIR (Logon)
Anchorage (PAZN)	Edmonton (CZEG)	Reykjavik (BIRD)
Atlantico (SBAO)	Fukuoka (RJJJ)	Shanwick (EGGX)
Canaries (GCCC)	Gander (CZQX)	Yangoon (VYYF)
Dakar (GOOO)	New York (KZWY)	

Figure 3. Cargolux routes

ANSPs provided data link service to FOI aircraft in the CTAs/FIRs provided in **Table 1**.

Table 1. Participating ANSPs and FIRs

Air Navigation Service Providers (ANSPs)		
ANSP – Pacific	**Participating CTA/FIR**	**Logon Address**
Airservices (Australia)	Brisbane	YBBB
Airservices (Australia)	Honiara	YBBB
Airservices (Australia)	Melbourne	YMMM
Airways Corporation New Zealand	Auckland	NZZO
FAA, Air Traffic Organization (ATO)	Anchorage	PAZN
FAA, Air Traffic Organization (ATO)	Oakland	KZAK
Fiji	Nadi	NFFF
French DGAC (Polynesia)	Tahiti	NTTT
JCAB (Japan)	Fukuoka	RJJJ
ANSP – Atlantic	**Participating FIRs**	
FAA, Air Traffic Organization (ATO)	New York	KZWY
Isavia Iceland	Reykjavik	BIRD
NAV Canada	Gander	CZQX

Air Navigation Service Providers (ANSPs)		
NAV Portugal	Santa Maria	LPPO
UK NATS	Shanwick	EGGX

The operator's authorization from the State of the Operator or State of Registry did not include any special requirements or restrictions regarding the use of Iridium in FANS 1/A operations. The ANSPs did not specify any special requirements or restrictions in service provisions and/or Regional SUPPs, AIP, or equivalent.

End-to-end configuration

The end-to-end Iridium satellite system overview is shown in **Figure 4**.

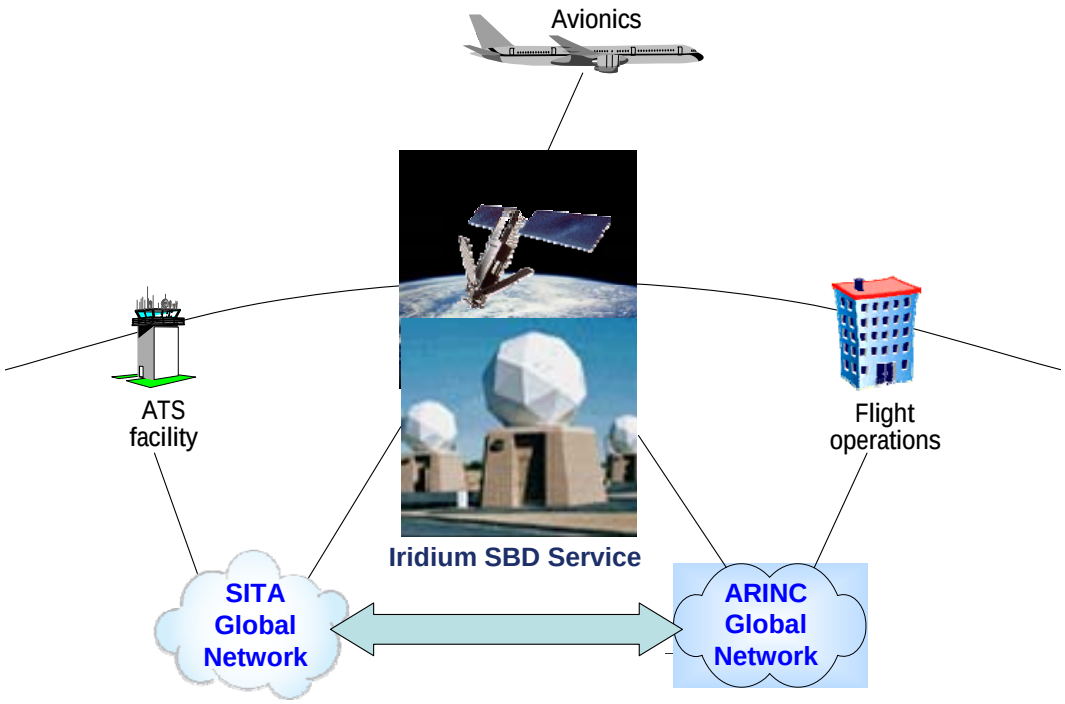

Figure 4. End-to-end Iridium satellite system overview

The ATC facilities were not modified for FOI operations.

The federated architecture typical for Airbus and Boeing aircraft equipment related to data link capability is shown in **Figure 5**. The FOI project evaluated the Avionica SatLINK and ICG ICS-220A satellite data units (SDUs) on Boeing aircraft in various configurations as shown in **Table 2**.

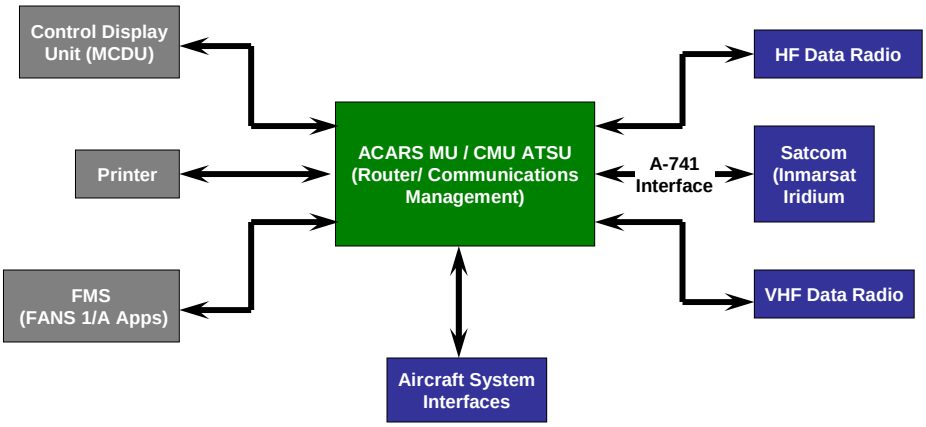

Figure 5. Typical federated aircraft architecture

Table 2. Aircraft/network configurations

Component Description	Component Configuration	Component Configuration
Operator	Continental Micronesia (CMI)	Cargolux (CLX)
Number of aircraft and type	Seven B737-800 and 2 B737-900	Thirteen B747-400
Iridium Satellite manufacturer and model:	Avionica SatLINK	ICG ICS-220A
Channels	1 channel (SBD-ACARS) 1 channel voice	1 channel (SBD-ACARS) 2 channel voice
Compliance standard	ARINC 741 SATCOM compliant interface	ARINC 741/761 SATCOM compliant interface
	ARINC 739 multi-function control display unit (MCDU) Interface	ARINC 739 MCDU Interface
	ARINC 724 management unit (MU) / ARINC 758 communications management unit (CMU) Interface	ARINC 724 MU / ARINC 758 CMU Interface
	ARINC 429 high speed (HS) or low speed (LS) Data - Bus Standard.	ARINC 429 HS or LS Data - Bus Standard.
ACARS type	Rockwell Collins CMU 900-101 (CMU)	Rockwell Collins DLM 900 (MU)
Flight management computer (FMC) manufacturer (with FANS 1 software)	GE Aviation	Honeywell
Service Provider	SITA	SITA

Evaluation results

The section provides a summary the FOI project evaluation results. Detailed results contain sensitive information and are provided as **Attachment A**, which is available only to FAA and FOI stakeholders.

Lab evaluations

Boeing conducted laboratory tests to show full end-to-end functionality and interoperability for the FANS 1/A ADS-C and CPDLC applications. The tests included multiple bench tests during both ARINC's and SITA's initial AOI operations. Aircraft equipment interoperability tests (AEIT) were conducted using both Avionica and ICG equipment with Collins and Honeywell CMUs. Successful live network tests were conducted with Oakland and Auckland centers and with a simulated center. The system supported an ADS-C periodic reporting interval of 2-minutes.

The laboratory tests demonstrated interoperability and functionality. Performance evaluations were conducted by monitoring and analyzing actual in-flight operations from participating operators.

ACARS over Iridium Evaluations

Evaluations were conducted on AOI message traffic volume, uplink message failure rate, and message block latency.

Prior to the start of FOI operations, ARINC and SITA provided data on AOI operations. Initial installations began in the middle of 2008 and by January 2009, four different operators were ready with 13 AOI aircraft. ARINC and SITA began early analysis of the Iridium subnetwork performance, and PARC CWG was able to determine over a longer period of time the stability and uniformity of that performance. By July 2010, 11 different operators and over 102 aircraft were participating in data collection supporting the FOI project. The PARC CWG evaluated data from August 2008 to July 2010.

The AOI evaluations concluded the following:

a) ***Aircraft/operator performance variations***. There are performance variations on message delivery for different aircraft installations. These variations are attributable to different satellite data units, FMSs, MCDUs, CMUs and MUs, aircraft system architecture, routing policies, and configuration options, and can significantly affect both AOI and FOI performance.

b) ***Ring alert***. SITA identified an issue on ring alert processing by the SBD server. Iridium developed a resolution to improve transit delay. The solution was incorporated into SBD release 5.2 update, which was implemented on April 28, 2010. Data collected following the SBD release 5.2 update through July, 2010 indicated the issued had been resolved, but did not have a material effect on message latency.

c) ***Signal loss/no acknowledgement***. Downlink delivery time statistics show some long delays on messages caused by either signal loss (NO COMM event triggers Media Advisory) or when the CMU retransmits a downlink message because it did not receive the Acknowledgement from the ACARS network. These system behaviors ultimately cause delay on AOI and FOI message traffic.

d) ***Stability and uniformity of performance***. Overall, the data showed the Iridium subnetwork performance in terms of message delivery failure rate and latency stabilized over a two-year period, given the changes made over the period of evaluation to improve the system.

e) ***Block message performance***. SITA measured block and message performance on 87,255 AOI messages, with an average length of 428. Message performance is not provided in this report although it is available upon request. The PARC CWG concluded that, on average, AOC messages were relatively large in size and did not represent typical CPDLC and ADS-C message size. While measurements are different, PARC concluded the performance was consistent with RCP 240/ADS-180 latency criteria.

FANS 1/A over Iridium Evaluations

Evaluations were conducted on ADS-C report delivery and CPDLC transaction latencies, in accordance with the *GOLD*. The evaluations considered latency on ADS-C reports, actual communication technical performance (ACTP), actual communication performance (ACP), and pilot operational response time (PORT) covering mainly the period May to July 2010 in Oakland and Auckland FIRs for CMI and CLX. For comparison, the evaluation also included some operators with Boeing 747 FANS 1/A and Boeing 737 FANS 1/A using Inmarsat.

Ideally, each ANSP was to provide FOI latency data in accordance with Appendix D of the *GOLD*. However, the *GOLD* had just been issued and plans are still underway to automate data collection in this manner. Therefore, the ANSPs provided FOI data in different forms that were used to draw a conclusion on the Iridium performance taking into account operational judgment. Only the FAA and Airways New Zealand provided FOI data in accordance with the *GOLD*.

Preliminary FOI evaluations began in July 2009 with CMI, and in November with CLX. By the end of the project in July 2010, the PARC CWG evaluated FOI data from 9 CMI and 13 CLX aircraft. During the evaluation period, the PARC CWG tracked changes in the end-to-end configuration to correlate with any notable changes in actual performance. Also, since FANS 1/A operations were new to CMI and CLX, crew training and FANS 1/A operations may have affected performance. These aspects of the evaluation did not relate directly to the viability of the Iridium technology. Generally, the latency, continuity and availability data indicated that the Iridium technology was viable for CPDLC/RCP 240 and ADS-C/type 180 operations.

Note.— The integrity of FANS 1/A operations is provided by the end system and, therefore, is not based on the type of media used. Integrity of the FOI installation on the aircraft was satisfied by the certification process for the FANS 1/A installation.

The FOI evaluations concluded the following:

a) ***Configuration changes***. Changes in Avionica SatLINK unit may have significantly improved actual performance, while changes in Iridium SBD 5.2 update did not show any significant improvement or degradation in actual performance, given the criteria provided by the RCP 240 and surveillance type 180 specifications.

b) ***ADS-C report delivery/CPDLC transaction latency***. Some operations and implementations can affect latency. As a result, while CPDLC ACTP for both CLX and CMI met latency criteria at 95%, ADS-C report delivery for CMI did not meet latency criteria at 95%. To date, the entire population of aircraft in an airspace, whether Inmarsat or Iridium, is not meeting the latency criteria at the 99.9%. However, some operators with Inmarsat have shown to meet the 99.9% latency criteria for their fleet.

c) ***Bimodal distribution***. The Iridium SBD and Inmarsat Classic Aero services both exhibit a bimodal distribution, which seems to be affecting message latency. One CSP indicated that 'multi-mode' distributions are related to communication protocols between the GES/gateway and the satellite. While there are many theories as to why this behavior is exhibited by both satellite operators, additional research is necessary to determine whether or not the effects on message latency is significant.

d) ***FANS 1/A operations***. Other considerations generally applicable to FANS 1/A, but not related specifically to Iridium subnetwork, can affect latency on ADS-C report delivery and CPDLC transactions. For example, rapid transmission of a sequence of messages at logon, routing policies in the CMU, multi-media architectures, such as in VHF, SATCOM and HFDL capable aircraft, transition logic and treatment of NO COMM status can all affect latency measurements for ADS-C report delivery and CPDLC transactions on the Iridium subnetwork.

e) ***CMU operations***. Some operators have CMUs that use a feature known as "Next on Busy." With this feature on HFDL-capable aircraft, if the satellite communications is busy, for example, sending a large multi-block AOC message, the system will transmit the ADS-C report using HFDL. In Fukuoka FIR, ADS-C reports or CPDLC messages received by the ATC facility over HFDL will be rejected.

f) ***ACP and PORT***. ACP, which includes the PORT was considered out of scope in evaluating the viability of the Iridium subnetwork; however, it was observed that there is a wide range of performance on ACP owing to PORT. ADS-C based separations assume the flight crew will respond to an intervention within one minute. Most operators are taking more than one minute at 95% to respond to CPDLC clearances requiring a WILCO/UNABLE response. We suspect that flight crews are using the flight deck printer in cases where PORT was significantly longer.

Service outages and availability

Evaluations were conducted on service outages and availability, in accordance with the *GOLD*. The evaluations considered service outages and availability for FANS 1/A operations using both Inmarsat and Iridium for the period January 2008 to July 2010. Since FANS 1/A operates over ACARS, service outages and availability affect both AOI and FOI operations.

A service outage is included in determining availability if it results in no service by more than 10 minutes to a significant portion of aircraft in any FIR. Depending on the failure, i.e., satellite, GES, gateway, network, internetwork, etc., the outage can affect global services, more than one FIR, or a significant portion of aircraft within an FIR. The availability of FANS 1/A services is calculated on a FIR basis taking into account operational impact. However, the PARC CWG was unable to obtain sufficient information to determine operational impact for the recorded outages. As a consequence, recorded outages were included, when in doubt. On the other hand, there is some evidence that suggests an outage may have occurred, but was not recorded and hence was not included. The recording of outages, their operational impact, affected service area, and other relevant information needed to determine availability is expected to improve as ANSPs apply *GOLD* guidelines.

FOI evaluations concluded the following:

a) ***Availability criteria***. In late 2007, the ANSPs established outage criteria associated with a 99.9% availability requirement for safety and 99.99% availability requirement for efficiency (RCP 240 refers), and began to record outages.

b) ***FANS 1/A – Inmarsat outages and availability***. In July 2010, the availability over the previous 12 months in the Pacific and Atlantic Ocean Regions was 99.98% and 99.96%, respectively.

c) ***FANS 1/A outages and availability***. As more operators use Iridium for their FANS 1/A operations, ATC facilities will provide FANS 1/A services to a mixed fleet, i.e., some using Iridium and some using Inmarsat. FANS 1/A (and ACARS) operations using Iridium, in combination with Inmarsat can provide higher availability, particularly if solutions can be found to resolve interference issues enabling operators to install both Inmarsat and Iridium on their aircraft for use on the same flight. Additionally, since installations of satellite communication systems typically include both voice and data communications, use of the dissimilar technologies could provide a venue for regressing HF voice communications. As use of polar routes continues to expand, Iridium will support both voice and data communication services, augmenting HF voice to meet communication and surveillance requirements for more efficient and safe operations.

d) ***FANS 1/A – Iridium outages and availability***. The availability (when considering only outages owing to technical difficulties) over the last 12 months of FANS 1/A services using Iridium globally was 99.94% in July 2010. However, when including the outages owing to inclement weather, availability over the last 12 months was at 99.73% in July 2010.

e) ***Rain fade***. The Iridium SBD service is susceptible to outages caused by inclement weather typically in July-September timeframe surrounding the gateway located in Tempe, Arizona. The inclement weather affects the Iridium SBD feeder link signal strength, referred to as rain fade. 2008 was among the worst monsoon seasons recorded by the National Weather Service. With the deployment of Iridium NEXT, Iridium is looking at instituting a dynamic switchover capability that would enable Iridium to proactively respond to service degradation, due to inclement weather, to reduce any potential negative impacts.

f) ***Notification of service degradation***. Notification of outages to ATC facilities and operators is an important part of operations. When timely notification of an outage is received, the ATC facility can safely transition airspace to separations that are not dependent on ADS-C and CPDLC. For RCP 240/type 180 operations, the criteria for notifying ATC facilities and operators of an outage is within 5 minutes from when the outage begins. Currently, this criteria is not met, regardless of type of media used for FANS 1/A operations. Additionally, the aviation community needs to agree on the definition of a service outage versus a service degradation, taking into account all media types, to determine the time a degradation becomes an outage from a user perspective, i.e., the data is "aged" and is of little to no value. A standardized process is needed to ensure that when outages occur timely notifications are issued, appropriate personnel receive the notifications and take action, as necessary.

Acronyms

Acronym	Description
AC	Advisory circular
ACARS	Aircraft communications addressing and reporting system
ACP	Actual communication performance
ACTP	Actual communication technical performance
ADS-B	Automatic dependent surveillance – broadcast
ADS-C	Automatic dependent surveillance – contract
AEIT	Aircraft equipment interoperability test
AIP	Aeronautical information publication
AIRE	Atlantic interoperability initiative to reduce emissions
AMS(R)S	Aeronautical mobile satellite (route) service
ANSP	Air navigation service provider
AOC	ACARS over Iridium
AOI	ACARS over Iridium
ASPIRE	Asia and south Pacific initiative to reduce emissions
ATC	Air traffic control
ATS	Air traffic services
CDP	Climb/descent procedure
CMU	Communications management unit
CO_2	Carbon dioxide
CPDLC	Controller-pilot data link communications
CRA	Central reporting agency
CSP	Communication service provider
CTA	Control area
DARP	Dynamic airborne reroute procedure
DLMA	Data link monitoring agency
DoD/USAF	Department of Defense/United States Air Force
FAA	Federal Aviation Administration
FANS 1/A	Future air navigation system 1/A
FIR	Flight information region
FMC	Flight management computer
FMS	Flight management system
FOI	FANS 1/A over Iridium
FSIMS	Flight Standards Information Management System
GES	Ground earth station
GOLD	Global Operational Data Link Document

Acronym	Description
HF	High frequency
HFDL	HF data link
HS	High speed
ICAO	International Civil Aviation Organization
JCAB	Japanese Civil Aviation Bureau
LOA	Letter of authorization
LRCS	Long range communication system
LS	Low speed
MCDU	Multi-function control display unit
MU	Management unit
NAT	North Atlantic
NextGen	Next generation air transportation system
NGIP	NextGen Implementation Plan
NM	Nautical mile
OTS	Organized track system
PANS-ATM	Procedures for Air Navigation Services — Air Traffic Management (ICAO Doc 4444)
PARC CWG	Performance based operations Aviation Rulemaking Committee Communications Working Group
PBN	Performance-based navigation
PBO	Performance-based operation
POI	Principal Operations Inspector
PORT	Pilot operational response time
RCP	Required communication performance
Regional SUPPs	Regional Supplementary Procedures (ICAO Doc 7030)
RNAV	Area navigation
RNP	Required navigation performance
RVSM	Reduced vertical separation minimum
SARPs	Standards and recommended practices
SATvoice	Satellite voice communications
SBB	SwiftBroadband
SBD	Short burst data
SDU	Satellite data unit
SVGM	Satellite voice guidance material
UPR	User preferred route
VHF	Very high frequency