Informal South Pacific Air Traffic Services Coordinating Group

FANS-1/A Datalink Communications Environment

Version 1.0 March 7, 2008

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1 Executive Summary

This document has been prepared by the ISPACG Data Link Working Group to provide a description to operational users of FANS-1/A datalink on the system elements that enable FANS-1/A.

The main purpose of this document is to provide operational users (pilots, air traffic controllers, and operational management) with a single source description of the current FANS-1/A environment.

This will provide the operational users with a better understanding of the system including current constraints and performance limitations.

2 Document Management

This document is owned and managed by the ISPACG Datalink Working Group.

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2.1 Amendment Record

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1.0	March 7,2008	Original version	N/A

3 Introduction

There are many elements comprising the end-to-end Future Air Navigation System (FANS-1/A) datalink communications environment. The purpose of this document is to provide a high level functional description of all of the end-to-end system elements, protocols, and redundancies, as well as identify the following:

- Standards and other documents applicable to FANS-1/A datalink communications.
- Performance constraints.
- Performance improvement options and considerations.
- Planned system element upgrades and/or significant changes and associated status.
- Datalink communication protocol differences, if any, among Air Traffic Service Providers, communications service providers, aircraft, and avionics manufacturers.
- FANS-1/A-Aeronautical Telecommunication Network (ATN) Convergence

Section 4 provides the standards and other documents applicable to FANS-1/A datalink communications.

Section 5 provides a high level functional description of all of the end-to-end system elements, protocols, and redundancies, as well as identify the performance constraints and improvement options and considerations.

Appendix A provides planned system element upgrades and/or significant changes and associated status.

Appendix B provides information on datalink communication protocol differences, if any, among Air Traffic Service Providers, communications service providers, aircraft, and avionics manufacturers.

Appendix C provides FANS-1/A-ATN convergence background and status.

4 Applicable Documents

4.1 Aircraft Communications Addressing and Reporting System Protocol Standards and Satellite Standards:

AEEC Developed *ARINC Specification 618: Air/Ground Character-Oriented Protocol Specification*.

AEEC Developed *ARINC Specification 619: ACARS protocols for Avionic End Systems*.

AEEC Developed *ARINC Specification 620: Data Link Ground System Standard and Interface Specification*.

AEEC Developed *ARINC Specification 622: ATS Data Link Applications over ACARS Air-Ground Network*.

AEEC Developed *ARINC Characteristic 741P1-9: Aviation Satellite Communication System – Part 1 – Aircraft Installation Provisions.*

AEEC Developed *ARINC Characteristic 741P2-6: Aviation Satellite Communication System – Part 2 – System Design and Equipment Functional Description.*

RTCA DO-215A, Guidance on Aeronautical Mobile Satellite Service (AMSS) End-to-End System Performance.

4.2 FANS-1/A References

FANS-1/A Operations Manual, Version 5.0, August 30, 2007.

Guidance Material for ATS Data Link Services in North Atlantic Airspace. (Updated version of the NAT Guidance Material is available on the NAT PCO website www.nat-pco.org.

RTCA DO-258A/EUROCAE ED-100A, Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications (FANS-1/A Interop Standard), April 7, 2005 (RTCA), April 2005 (Eurocae).

RTCA DO-306/EUROCAE ED-122, Safety and Performance Standard for Air Traffic Datalink Services in Oceanic and Remote Airspace (Oceanic SPR Standard), October 11, 2007 (RTCA), October 2007 (Eurocae)

RTCA/DO-212, Minimum Operational Performance Standards for Airborne Automatic Dependent Surveillance (ADS) Equipment, October 26, 1992.

RTCA/DO-219, Minimum Operational Performance Standards for ATC Two-Way Data Link Communications, August 27, 1993.

*AEEC Developed ARINC Characteristic 745-2: Automatic Dependent Surveillan*ce, June 1993.

4.3 ATN FANS References

To Be Developed

5 FANS-1/A Datalink Communications Environment

The end-to-end FANS-1/A Datalink Communications Environment includes the Air Traffic Service Provider (ATSP) FANS-1/A ground end-system, communication service provider (CSP) ground-ground and air-ground networks, internetworking between CSP's, aircraft, and ACARS and FANS-1/A avionics. The FANS-1/A applications operate over the ACARS networks. The following paragraphs provide a high level functional description of all of the end-to-end system elements, protocols, and redundancies.

5.1 ACARS Networks

A high level illustration of FANS ACARS datalink service provider networks is shown below in Figure 1. The networks each have a datalink processor with connectivity to the following: their own VHF ground stations, the Ground Earth Station (GES) they use, connectivity to their respective ATSP and Airline customer end systems, and internetworking function.

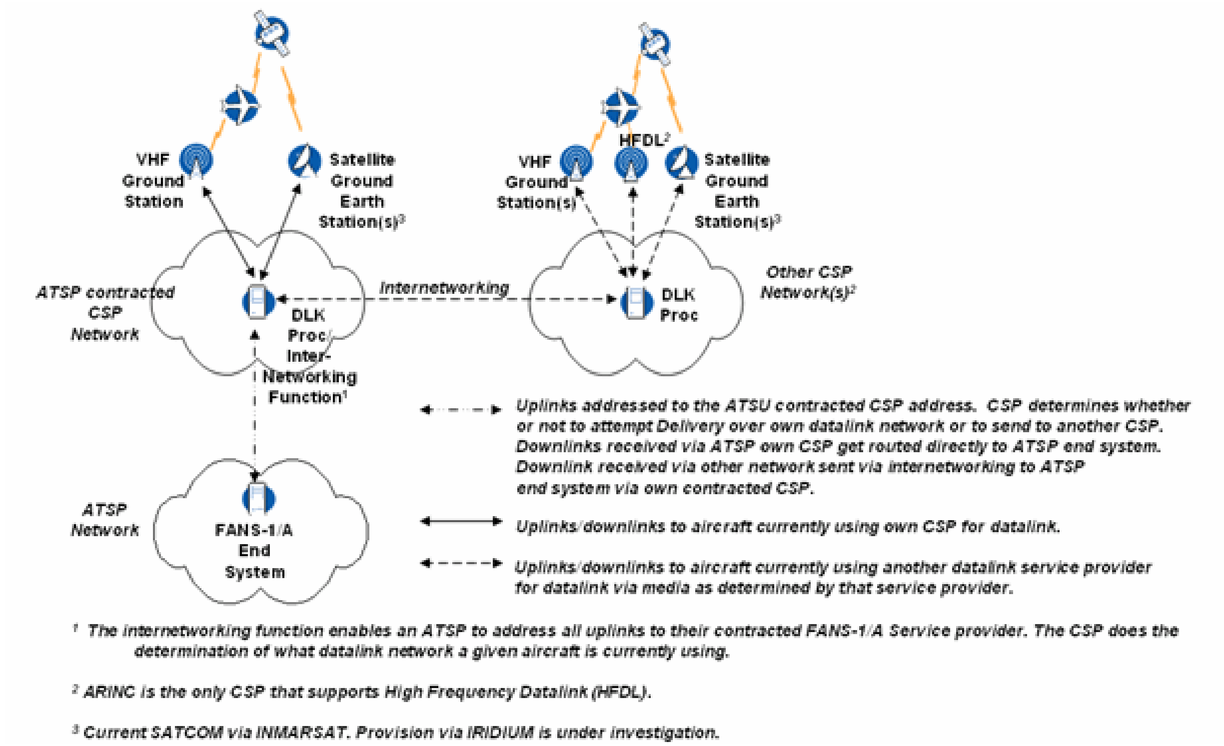


Figure 1. FANS-1/A Service

An ATSP is connected to the network of the CSP to whom they have contracted with for FANS-1/A service. A CSP FANS-1/A service enables a FANS-1/A ATSP access to the datalink networks supporting FANS-1/A through providing the required connectivity to a FANS-1/A ATSP and providing an internetworking function with other CSP's.

The internetworking function enables an ATSP to address all of their uplinks to a single CSP address such that the ATSP does not need to keep track of what specific CSP network an aircraft is currently using. The connected CSP then determines whether or not to attempt delivery over its own datalink network or to send via the internetworking link to another CSP network for delivery. ATS Internetworking allows airlines to have their choice of CSP and participate in ATS datalink services regardless of what CSP a given ATSP is connected. Airlines have different preferences with what CSP they use and sometimes they may also have different CSP preferences based on datalink media and region. All properly formatted FANS 1/A messages from ATS Facilities Notification (AFN), Controller-Pilot Datalink Communications (CPDLC), and Automatic Dependent Surveillance (ADS) are supported by CSP's supporting FANS-1/A. Downlinks received by another CSP are sent via the internetworking link to the CSP network to the ATS Provider FANS end system. The ACARS air-ground networks include VHF ACARS, VDL Mode 2/ACARS over Aviation VHF Link Control (AVLC) (VDL Mode 2/AOA), SATCOM, and, High Frequency Datalink (HFDL).

The following paragraphs further describe the air-ground networks, message routing, and internetworking.

5.2 Datalink Media

5.2.1 Very High Frequency (VHF) ACARS

The initial VHF ACARS media is also referred to as Plain Old ACARS (POA) and operates at a data rate of 2400 bits per sec (bps). The next generation VHF media is VDL Mode 2/ACARS over Aviation VHF Link Control (VDL Mode 2/AOA), which operates at a data rate of 31.5 kbps, and is available at various locations around the world.

The VHF ACARS network service providers include SITA, AVICOM Japan, DECEA Brazil, ARINC, ADCC China, and AeroThai.

Figures 2 and 3 show the SITA AIRCOM VHF ACARS and VDL Mode 2 coverage.

Figures 4, 5, and 6 show the ARINC GLOBALink® VHF ACARS and VDL Mode 2 coverage.

5.2.2 High Frequency Datalink

High Frequency Data Link, or HFDL, is part of ARINC's GLOBALink end-to-end communication system The HFDL system is a segment of the Aircraft Communications Addressing and Reporting System (ACARS) used to exchange Airline Operational Control (AOC) and Air Traffic Control (ATS) messages between aircraft end systems and corresponding ground-based stations. GLOBALink/HF provides HF-based, air-to-ground digital communications with aircraft using ARINC 635 protocol.

The HFDL system uses the principles of geographic diversity (the use of multiple ground stations in different geographic regions) and frequency diversity (the ability to use different frequencies based on propagation conditions) to optimize HF propagation. HF propagation is dependent on a region of the earth's atmosphere called the ionosphere, which extends approximately 30-375 miles above the earth's surface. HFDL is currently the only truly global aeronautical data link capability, and the only data link for flight routes over the North Pole. Inmarsat satellite SATCOM coverage becomes marginal around 80 degrees north and south latitude.

Figure 7 shows geographical locations of the HFDL ground stations (HGS) around the globe.

Each HGS operates on 2-3 channels and is equipped with a family of HF frequencies ranging from 2-30 MHz. Adaptive Frequency Management techniques are employed to obtain weekly Active Frequency Tables (AFT). These tables are derived from a combination of real-time ionospheric monitoring, solar and geomagnetic observational data and HF propagation models. Each week, an updated AFT is uploaded to each HGS from the ARINC Operations Center (AOC) in Annapolis, Maryland, USA. The AFT instructs the ground station on which frequencies to operate over the course of each 24-hour period.

Each HGS provides primary data link coverage for a radius of 3,000 nautical miles. Overlapping primary coverage areas enhanced by the natural ability of HF radio signals to support extra long-range communications beyond the primary coverage areas through multi-hop propagation, provide high availability HFDL communications worldwide. Strength of the HFDL system is that the aircraft need not communicate with the closest HGS for message delivery. The HFDR will select the HGS with a frequency with strong signal to noise characteristics with which to communicate.

ARINC is currently the only service provider who offers an HFDL service.

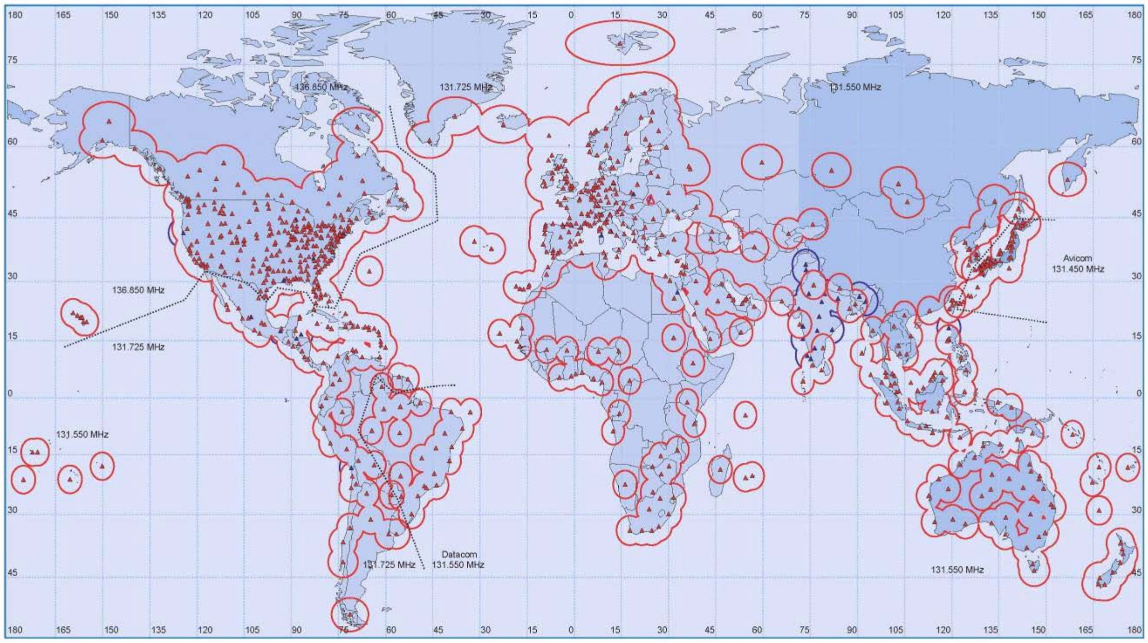


Figure 2. Worldwide SITA VHF AIRCOM ACARS Coverage

Figure 3. Worldwide SITA VDL Mode 2 Coverage

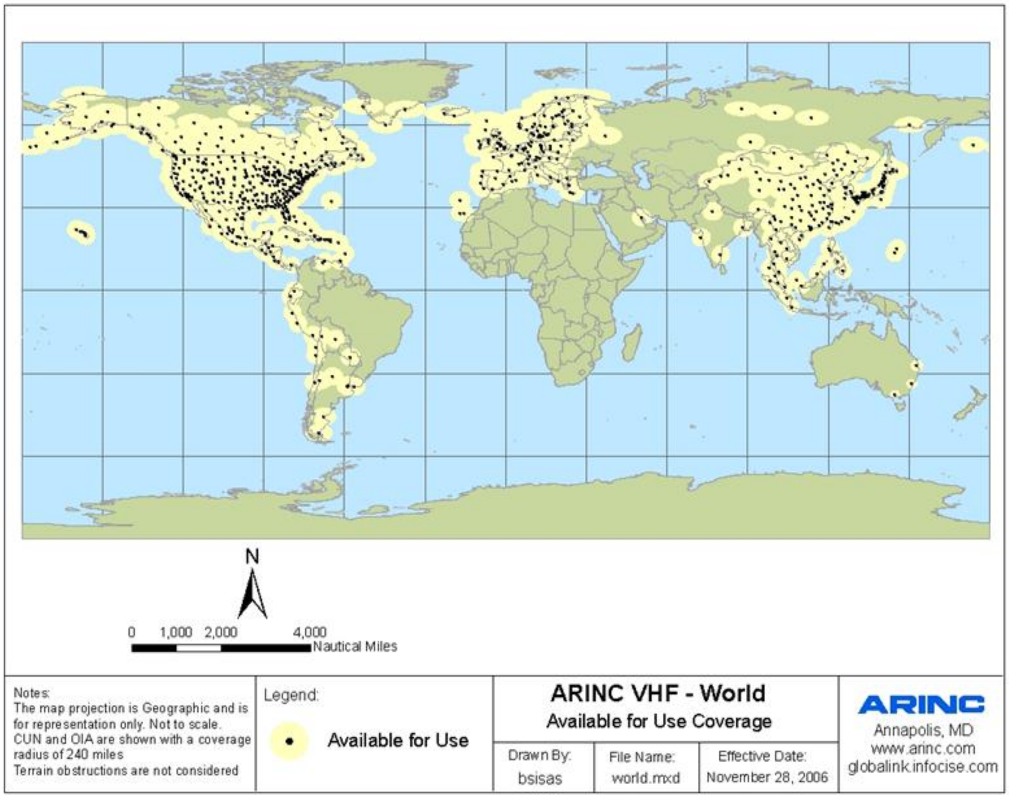


Figure 4, ARINC GLOBALink World Wide VHF Coverage

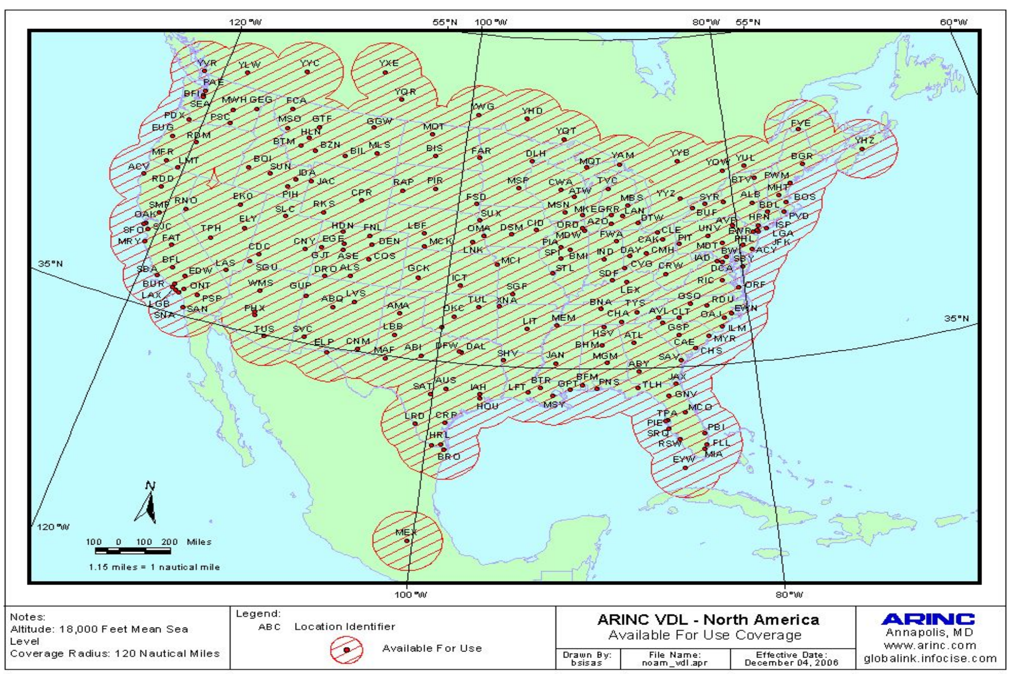


Figure 5, ARINC GLOBALink North American VDL Mode 2 Coverage

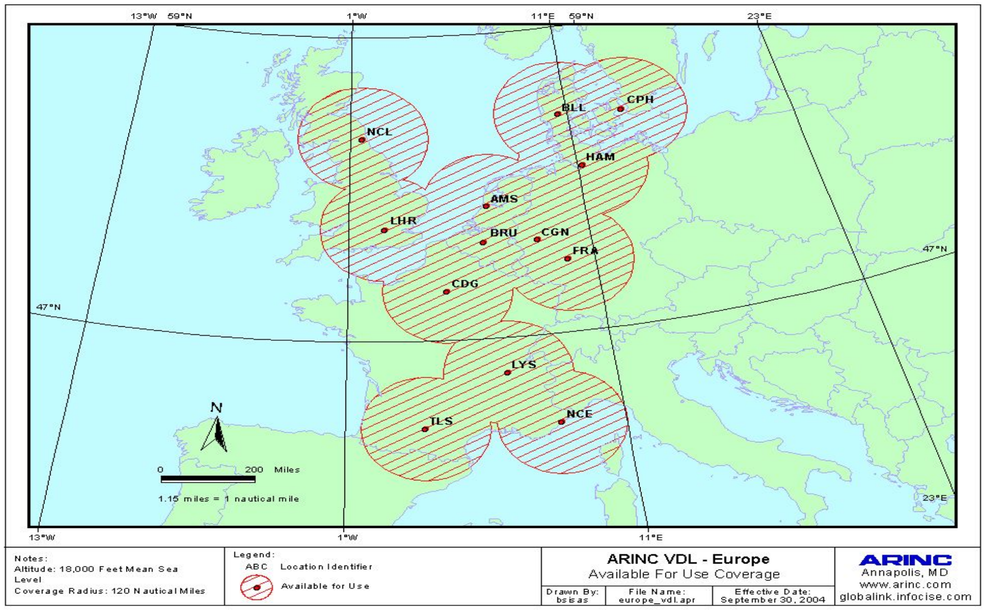


Figure 6, ARINC GLOBALink VDL Mode 2

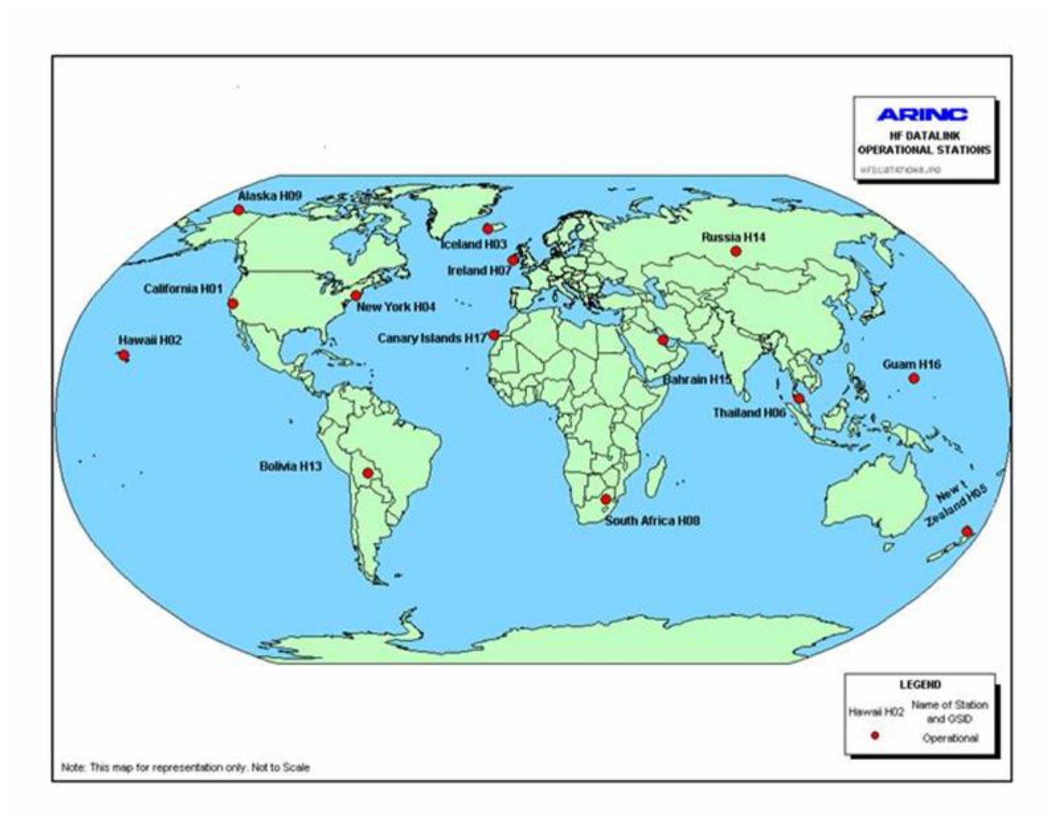


Figure 7, ARINC GLOBALink HFDL Operational Ground Stations

5.2.3 Satellite Datalink, also Referred to as SATCOM

Satellite Datalink Services depend on the following elements:

- Inmarsat I3 Satellites Supporting Aeronautical Mobile Satellite Service (AMSS):
  - Atlantic Ocean Region-East (AOR-E)
  - Atlantic Ocean Region-West (AOR-W)
  - Indian Ocean Region-(IOR)
  - Pacific Ocean Region-(POR)
- Ground Earth Stations (GES) to:
  - Provide links via the Inmarsat Satellites
  - Interface with the SITA Terrestrial Network
- Aeronautical Earth Stations (AES) to:
  - Provide the aircraft interface to the Inmarsat satellites

Note: The satellite service which is used to support ACARS and FANS is generally called the Inmarsat "classic" aeronautical service. There are a number of services used to provide the "classic" aero service. These services vary in capability, coverage, equipment size, and cost. The main services currently in use for FANS-1/A are:

- *Aero H. Multi-channel voice, 10.5kbps fax and data, delivered via a high-gain antenna within the satellites' global beams.*
- *Aero H+. Multi-channel voice, 10.5kbps fax and data, delivered via a high-gain antenna within the spot beams of the Inmarsat-3 satellites and the full footprint of the Inmarsat-4 Atlantic Ocean Region (AOR) satellite, at a lower cost per connection.*
- *Aero I. Multi-channel voice, 4.8kbps circuit-mode data and fax, delivered via an intermediate-gain antenna. Also supports low-speed packet data. Available in the spot beams of the Inmarsat-3 satellites and the full footprint of the Inmarsat-4 AOR satellite*

Figure 8 shows the Inmarsat I3 satellites as well as the GESs supporting the Inmarsat AMSS service.

Note: The Yamaguchi and Goonhilly GES are no longer available for data (ACARS) service, and it is planned to decommission Southbury in 2008.

Appendix A provides details of any Satellite upgrades implemented or planned to be implemented.

5.2.3.1 GES

Each GES has a GES operator. The SITA Satellite AIRCOM Service uses the Aussaguel GES operated by Vizada and the Perth GES operated by Stratos/Xantic. The ARINC Satellite Service uses the Eik, Southbury, and Santa Paula GESs operated by Telenor. All GESs were manufactured by NERA.

An ATSP connected to SITA can communicate with aircraft using the ARINC Satellite service GESs via SITA-ARINC ATS internetworking. An ATSP connected to ARINC can communicate with aircraft using the SITA Satellite AIRCOM Service via ARINC-SITA ATS internetworking.

Appendix A provides details of any GES upgrades implemented or planned to be implemented.

5.2.3.2 Aeronautical Earth Station

The SATCOM aircraft avionics that interface with the Inmarsat satellites are called aeronautical earth stations (AESs.) A Satellite Data Unit (SDU) and Radio Frequency Unit (RFU) comprise the AES. To establish a SATCOM session, the AES must logon to a GES. The AES determines what GES to logon to based on the owner requirements table (ORT) which can be setup based upon airline commercial preferences based on their CSP preference and other commercial considerations. In addition, it is

possible for the flight crew to override the automatic GES selection through manual selection. The logon provides information about the AES to the GES, such, as channel data rates supported.

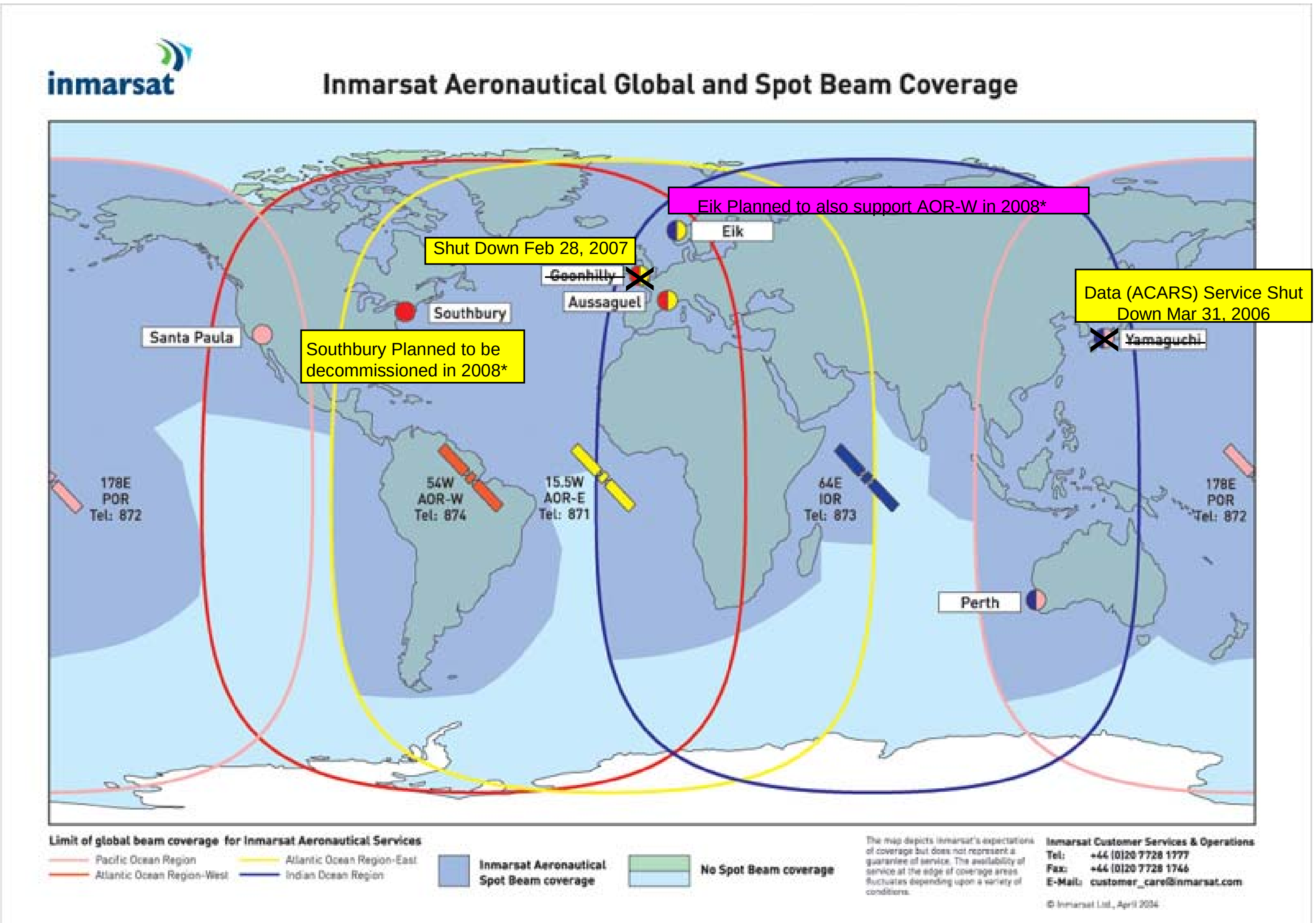


Figure 8 Inmarsat Aeronautical Global and Spot Beam Coverage

5.2.3.3 SATCOM Data Channel Types and Traffic Types

The SATCOM data channels carry the following traffic types:

- Data service traffic
- Packet-mode (data) and circuit-mode (voice) signalling traffic
- Satellite system management traffic

All data, signalling, and management messages are formatted into uniform signal units (SU).

5.2.3.4 Data Service Traffic

The data channels carry “Data-2” and “Data-3” types of data message traffic. “Data-2” is used for the FANS datalink messages sent via SATCOM ACARS.

The “Data-2” and “Data-3” traffic use the following channel scheme:

- P-Channel-Channel: All ACARS Uplinks go via the P-Channel
- R-Channel-Channel: Downlink Request for T-Channel (See Note)
- T-Channel: User Data downlinks sent via T-Channel after R-Channel Request (See NOTE)

Note: User data/messages less than 33 bytes go via the R-channel. Data messages greater than 33 bytes go via the T-Channel after successfully being assigned access through the R-channel request.

In the AMSS system, the P-channels are TDM with no possibility of collisions whereas R-channels are Slotted ALOHA-based which is subject to collisions. However, in the downlink case, all aircraft need to share the same channels so there will inevitably be message collisions that will increase with the traffic on the channel. In addition, the downlink traffic goes through a multi-step process when a message is greater than 33 bytes. The aircraft must first send the GES a request on the R-channel for a time slot on the T-channel before sending a downlink message. Upon receipt, the GES sends a T-channel time slot assignment to the aircraft via a P-channel. The aircraft then sends the downlink data message via the assigned T-channel time slot. The exception to this multi-step process is in the case where the downlink data message is less than 33 bytes. In this case, the downlink data message is sent via the R-channel in one step. The average FANS message is greater than 33 bytes.

5.2.3.5 Date and Voice Signaling Traffic

In addition to the actual data messages themselves, the data channels carry the following signalling data:

- Acknowledgment Traffic: each data message sent in one direction is acknowledged in the other direction.
- Reservation Traffic: if a downlink data message is greater than 33 octets, it is necessary to send a T-channel reservation request over the R-channel and the corresponding T-channel assignment is sent over the P-channel.
- Voice Channel Request Traffic: to make an air-to-ground call, an AES sends a voice channel request over the R-channel and the corresponding voice channel assignment is sent over the P-channel.
- CN86 Traffic: when a voice channel is released, the GES sends a confirmation SU over the P-channel.

5.2.3.6 System Management Traffic

The data channels carry the following data related to the management of Inmarsat system:

- Logon management data: this includes traffic generated by the system logon procedure, which includes in particular logon and logon/logoff acknowledgment SUs sent over the R-channel, logon confirm and logon/logoff acknowledgment SUs sent over the P-channel.
- System Broadcast data: a GES broadcasts both the partial and the complete (only a Psid sends the complete system table) of the system table and the spot beam map (this data is sent continuously over the Psid channel.)

5.2.3.7 Data Channel Data Rates and Loading

There a low speed (600 bps and 1200 bps) and high speed (10500 bps) data rates defined for the P, R, and T channels.

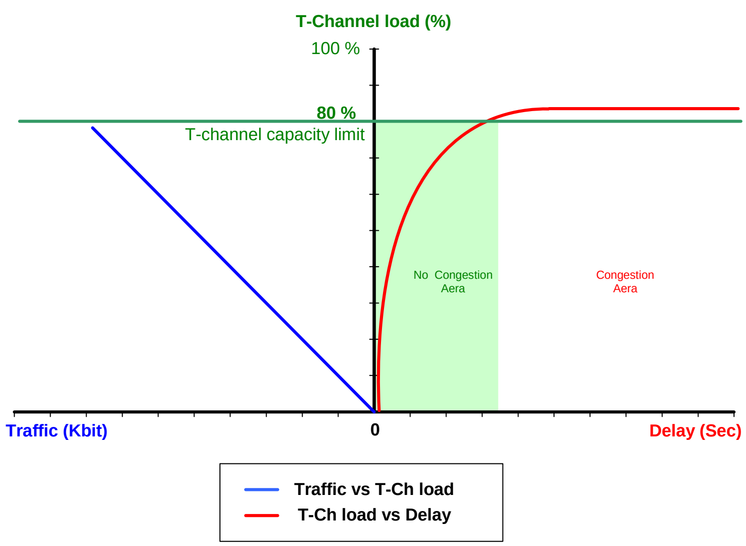
The AES R-channel and T-channel downlink data rates are determined by both the AES R-channel and T-channel capability and the GES's R- and T-channel allocation. The T-channel data rate used is determined by the GES channel assignment uplinked to the AES in response to an R-channel downlink

T-channel request for messages greater than 33 octets. The GES will attempt to use the highest data rate channel available for P-channel uplinks and R and T-channel assignment.

Some AESs are capable of low speed SATCOM only. Other AESs are capable of both high speed and low speed. However, not all aircraft that are capable of high speed operation have enabled the use of high speed SATCOM and, instead operate in low speed only. There are two reasons why an airline may choose not to enable the high speed capability. The first reason is that there were issues associated with the use of high speed SATCOM when it was first introduced, such, that, while these issues have since been corrected, a given airline may not yet have confidence in it. The second reason is that use of high speed data channels requires additional power over that required for low speed channels. The result of this is that fewer SATCOM voice channels are available when operating high speed data channel units at the edge of coverage in high latitudes.

The INMARSAT sponsored SATCOM Improvement Team is recommending to those airlines that are using low speed SATCOM channels to change to the high speed channels. Low or High speed channel use is selectable by individual airlines in the aircrafts Operational Requirements Table (ORT). This is complicated by the fact that some Satellite Data Units (SDU) on the aircraft will always use the high speed channel regardless of the setting in the aircraft ORT.

Data channel loading is the percentage of effective channel capacity used to transmit user data and signalling traffic. Figure 9 illustrates the T-channel loading effects on delay.



- **Channel load increases as traffic increases**
- **Congestion appears if the instantaneous load on a channel exceeds its capacity**
- **Congestion causes delay:**
  - **Data must be queued up for transmission**

Figure 9. Delay Versus T-Channel Load

5.2.3.8 Capacity Planning

The GES capacity is not infinite so users need to plan the addition of new applications to identify if required performance can be achieved. There is ongoing work on how to best achieve accurate capacity planning.

Global capacity planning by all stakeholders is necessary to draw up a plan for maintaining the availability of the classic aeronautical service at an acceptable level of performance through 2018.

The capacity planning approach to date has generally been a top down approach of setting targets for the percentage of data link messages to be delivered within given target times. This approach could only work so long as there was no capacity issue on the AMSS Inmarsat network. The top down targets may remain but the current problems show that the ISPACG and other FANS implementation groups around the world also need to start using a bottom up approach to predict the performance that will be provided for additional traffic.

The solution would be to feed any planned additional traffic into a model of how the Inmarsat/ICAO Aeronautical Mobile Satellite Service (AMSS) protocol works with its P, R, and T channels for the actual traffic on the existing channels assigned by Inmarsat and the data rates supported by the aircraft using the service. The planned additional traffic from AOC, APC and ATS traffic from all airlines and all ATS provider regional groups needs to be fed into a central model because they all share the same satellites and GES. This can be compared with the actual capacity.

Accurate ATS traffic forecasts are needed to have more accurate traffic forecasting to input into capacity plan models. An Excel based traffic forecast form was trialled but it soon became apparent that it was impractical to get such details from ATSP’s. Currently under investigation is a recommendation that each datalink service provider determine historical FANS growth and that Boeing in their role as CRA, identify any given ANSP FANS plans and airline equipage plans that Boeing views will result in a more than typical FANS traffic growth. The Boeing CRA will quantify such non-typical growth per ANSP and airline. More than typical growth is defined as growth that is greater than what would be predicted based on using historical data only. Datalink service providers can then take this information to refine their traffic forecast information.

5.3 ATS Internetworking, Routing and Media Selection, and ATS/AOC Prioritization

CSP's supporting FANS services support ATS internetworking. As previously described above, the internetworking enables 1) an airline to have their choice of CSP network/media to use when communicating with a given ATSP FANS end system, regardless of what CSP network it is connected to, and 2) enables a FANS ATSP to send uplinks to a single address without needing to know what CSP network a given aircraft is currently using. Downlinks received by the CSP that is not connected to the ATSP are sent to the ATSP via internetworking with the CSP connected to the ATSP. Uplinks from a FANS ATSP are sent to the internetworking function of the CSP to which the ATSP is connected. The internetworking function then determines whether the connected CSP should attempt delivery of the uplink or whether to route the uplink to the CSP that is not connected to the ATSP.

In the aircraft, the avionics determine the ATS downlink media selection and ATS/AOC prioritization levels supported.

The following paragraphs describe the SITA, ARINC, Boeing, and Airbus routing and media selection, and level of ATS/AOC prioritization provided.

5.3.1 SITA Internetworking Function, Routing, and Use of Media Advisories, and Prioritization

SITA determines whether or not to attempt delivery of uplinks originating from FANS ATSP's connected to SITA over the SITA datalink network or to route to a non-SITA datalink network based on media advisory information. Preference is given first to VHF, then SATCOM, then, HFDL (ARINC is the only HFDL service provider.) To further describe, preference is first given to the network whose media advisory information indicated that VHF datalink was established. If no VHF established media advisory information was obtained, preference is then given to the network whose media advisory information indicated that SATCOM datalink was established. In the absence of both VHF and SATCOM established media advisory information, but, media advisory indication of HFDL establishment, SITA will base its FANS routing decision on static information (the default SATCOM CSP). If the uplink is not successfully delivered via the default SATCOM CSP, then the uplink will be sent to ARINC to attempt delivery.

SITA supports the case in which the avionics interrupt a multi block AOC downlink to send an ATS downlink. There are no other levels of AOC/ATS prioritization supported.

5.3.2 ARINC Internetworking Function, Routing, and Use of Media Advisories, and Prioritization

ARINC's GLOBALink® Service includes three Back-End Processors (BEPs) located in Annapolis, USA; Beijing, China; and Bangkok, Thailand. The Annapolis BEP controls SATCOM and HFDL networks as well as AOA and VHF ACARS networks in Americas, Europe, Middle East and Africa. Beijing and Bangkok BEPs manage VHF ACARS networks in Asia.

Internetworking functionality implemented at ARINC is applicable to all ARINC networks described above as well as the SITA network. ARINC determines routing algorithms for uplinks originated by FANS ATSPs connected to ARINC networks based on media advisory information. If media advisory information is available, then preference is given first to VHF, then SATCOM, and then HFDL. If media advisory information is not available then uplink routing decision is made based on last successful delivery. If no messages have been delivered to/from aircraft within last twelve minutes then ARINC makes FANS uplink routing decision based on static information, which can be configurable by customer's request.

ARINC supports the case in which the avionics interrupt a multiblock AOC downlink to send an ATS downlink. In addition, ARINC can preempt uplink messages for a higher priority message as discussed in Section 3.4, Message Sequencing, of ARINC 618. ARINC only does this if the uplink in process and the higher priority uplink have different message labels (so the avionics can tell that these are two different messages). If the labels are the same, ARINC puts the higher priority message next in queue for transmission to the aircraft.

5.3.3 Boeing ATS downlink Media Selection and ATS/AOC Prioritization and Differences, if any, Among Airframe Type

Media selection for all Boeing aircraft is typically prioritized as follows (highest to lowest): VDL2, VHF, SATCOM, HF. Media selection and control of media priority will be left to each airline operator to define based on the requirements of the regions in which they operate their aircraft.

B737, B747, B757, and B767:

On the B737, B747, B757, and B767, the FANS-1 datalink applications reside in the Flight Management Computer (FMC) and the ACARS Management Unit (ACARS MU) or Communications Management Unit (CMU) manages transmission of messages to and from the airplane. Downlink message prioritization occurs at both the FMC and the ACARS MU/CMU.

The FMC prioritizes downlink message in the following order of priority (highest to lowest):

- ATC Datalink Messages
- ADS Messages
- AFN Messages
- AOC Messages

If multiple messages are queued in the FMC, higher priority messages will be inserted ahead of lower priority messages.

The ACARS MU/CMU is typically connected to multiple peripheral devices. ACARS MUs/CMUs which are approved for FANS-1/A communications are capable of receiving a downlink from the FMC while a message from another peripheral is being transmitted.

The ACARS MU/CMU transmits messages from the FMC prior to those created from direct interface with the ACARS MU/CMU, and other peripherals.

B777:

On the B777, the AFN and CPDLC functions reside in the Flight Deck Communication Function (FDCF) and the ADS function resides in the Flight Management Computing Function (FMCF). The Data Communications Management Function (DCMF) manages transmission of messages to and from the airplane. Downlink message prioritization occurs at the FDCF, FMCF and DCMF.

The FDCF prioritizes downlink message in the following order of priority (highest to lowest):

- ATC Datalink Messages
- AFN Messages
- AOC Messages

The FMCF prioritizes downlink message in the following order of priority (highest to lowest):

- ADS Messages
- AOC Messages

If multiple messages are queued in the FDCF and FMCF, higher priority messages will be inserted ahead of lower priority messages.

DCMF will prioritize messages received from FDCF and FMC in the following order of priority (highest to lowest):

- ATC Datalink Messages
- ADS Messages
- AFN Messages
- AOC Messages

The DCMF is typically connected to multiple functions and peripheral devices. The DCMF is capable of receiving a downlink from the FDCF and FMCF while a message from another peripheral is being transmitted.

The DCMF transmits messages from the FDCF and FMCF prior to those from other peripherals.

5.3.4 Airbus ATS downlink Media Selection and ATS/AOC Prioritization and Differences, if any, Among Airframe Type

4.3.4.1 Media selection in stable communication conditions

Downlinks

The Airbus avionics routing policy for down linked ATC messages via different media is factory set, and is in line with that implemented by Datalink Service providers:

- In FANS A Avionics the priority is VDL Mode A, then SATCOM

- In FANS A+ Avionics the priority is VDL Mode2, then VDL Mode A, then SATCOM, then HFDL.

FANS A avionics exist on A330/A340 aircraft and FANS A+ on A330/A340, A320 Family and A380.

When a media connection is established but is busy transmitting a higher priority message (AFN, ADS or CPDLC) the next lower priority media per the list above is used immediately. This is called the next-on-busy mechanism.

AOC messages routing policy is customizable and has no impact on ATC messages routing.

Uplinks

Uplinks are acknowledged over the media on which they are received, and the MAS are reported using this media. The media used for the uplink has no impact on the media used for any associated downlink. Downlink routing is only determined by the routing policy described above.

4.3.4.2 VHF coverage limit, VHF/SATCOM/HFDL transition:

If VHF link is considered available

The avionics makes up to 6 transmission attempts over VHF at 12s intervals for ATC (AFN, ADS & CPDLC) messages. If unsuccessful on VHF the avionics will attempt delivery via SATCOM (if logged on) after 72 seconds.

If VHF link is NOT available

The message is immediately transmitted over SATCOM if logged on.

If transmission over SATCOM is unsuccessful (despite being logged on) after 3 attempts at 3 minute intervals, the SATCOM is put into sleep mode for 10 minutes. At the expiry of the 10 minute sleep mode another transmission will be attempted over SATCOM if still logged on. If still unsuccessful and HFDL if installed then HFDL is used by FANS A+.

This processing will apply to ADS messages whose lifetime in the downlink queue is unlimited with FANS A, and limited to 30 minutes with FANS A+, after which they are flushed from the queue. CPDLC messages have a downlink queue lifetime of 2 minutes with FANS A and 3min 30 seconds with FANS A+.

<u>If VHF is not available and SATCOM is not logged on</u>

Messages are transmitted over HFDL with FANS A+, else they are purged at timer expiry according to the lifetime described above.

5.4 FANS-1/A Ground End Systems and Message Assurance

All FANS-1/A Ground End systems should include the ARINC 620 Message Assurance (MA) Text Element Identifier (TEI) with request delivery indication only (e.g. MA 123A, where the MA is the TEI, the 123 is the serial number of the uplink, and A designates request delivery indication only. Uplinks sent with message assurance will get an indication of whether or not the uplink was successful or not. Successful uplinks will be those in which the CSP that successfully delivered the uplink to the aircraft receive a technical acknowledgment from the aircraft. Upon receipt of the technical acknowledgment, the CSP that delivered the uplink sends a ground/ground message to the originator that uses the MAS standard message identifier and the MA TEI indicating Success (e.g. MA 123S, where MA is the TEI, 123 the serial number of the corresponding uplink, and S indicating success.) The indication for an uplink that was not successfully delivered is an “F” (e.g. MA 123F.) The ground/ground message “DT” line of the message will indicate the CSP and ground station over which the technical acknowledgment of the message was received for the message along with the time the technical acknowledgment was accepted, or, in the case of a multi block message, the final block.

5.5 “DT” Line

The DT line is included in both the MAS messages just described and the ground-ground message representation of an air-ground downlink message. In the downlink case, the DT line provides the CSP and ground station that received the message, or, in the case of a multi-block message, the first block of the air-ground downlink message, as well as the time of receipt and message sequence number. The CSP codes can be found in ARINC 620. A CSP may have a separate code for each media they support.

Appendix A - Planned System Element Upgrades and/or Significant Changes and Associated Status

A.1 GES Upgrades

A.1.1 SITA

SITA provides Satellite AIRCOM service based on the Inmarsat Classic Aeronautical service via a Ground Earth Station (GES) at Aussaguel (operated by Vizada) and a GES at Perth (operated by Stratos/Xantic) which were deployed in 1990. SITA has been in the process of implementing upgrades to both GESs to remove obsolete components. The first upgrade undertaken in late 2005 to replace the obsolete data switch called EBPACK has been completed. The second upgrade to replace the radio communications channel units was completed in two steps. The first step was for the channel units supporting data services which has now been completed at both the Aussaguel and Perth GESs. The second step was for the channel units supporting voice services which has now been completed at both the Aussaguel and Perth GESs.. The following is the GES Upgrade timeline and status:

2004:	SITA worked with the GES manufacturer Nera to define TAD Upgrade/EBPACK replacement.
2005 Feb:	Inmarsat contracted with Nera to develop a new generation of channel units.
2005 Aug:	France Telecom contracted with Nera for the channel units needed in Aussaguel.
2005 Oct:	Aussaguel GES TAD Upgrade/EBPACK Replacement completed.
2005 Nov:	Perth GES TAD Upgrade/EBPACK Replacement completed.
2006 Jun 29:	Aussaguel Data Channel Unit Upgrade completed.
2006 Aug:	Old channel units freed up as a result of the Aussaguel Upgrade installation at Perth completed. This resultedresulted in increased capacity and providedprovided additional spares until completion of Perth upgrade.
2006 Oct 5:	Perth GES Data Channel Unit Upgrade completed.
2006 Dec 14:	Perth GES TAD release to correct issues identified after data channel unit upgrade.2007
Mar 28:	Aussaguel Voice Channel Unit Upgrade completed.
2007 Apr 18:	Perth Voice Channel Unit Upgrade completed.

A brief description of the two upgrades follows.

A.1.1.2 Upgrade 1: Datalink Service Upgrade (Now completed at both the Aussaguel and Perth GESs)

In 2004, SITA contracted with the GES manufacturer (Nera) to develop a TAD (GES main computer) upgrade to improve its reliability and enable the replacement of the EBPACK (GES dataswitch/interface to terrestrial network). The TAD Upgrade included additional computer memory that enables an increase in the maximum number of Virtual Circuits from 1024 to 4096. Including the cost of installing the upgrade in the GES the total investment was in the order of $1 million. SITA replaced the EBPACK with a modern switch already used in SITA centers that provides high reliability and a better interface to SITA network management systems.

A.1.1.3 Upgrade 2: Inmarsat Classic Aero Channel Unit Replacement

In late 2004, Inmarsat organized a series of meetings with participants in classic aeronautical service provision to agree an approach to avoiding GES component obsolescence that could result in forcing the service to be shut down. It was agreed that the radio channel units were the most critical GES

component facing obsolescence and that to ensure fair competition all GES would need to be equipped with new generation channel units to keep providing the service. SITA agreed at that time with France Telecom and Xantic to contribute to the funding of the installation of the new channel units in their GES. In February 2005, Inmarsat contracted (for USD3.8 Million) with Nera to develop a new generation of channel units. SITA contributedcontributed funding of approximately USD4 million in total to the installation of the new channel units in the Aussaguel and Perth GESs.

The channel unit upgrade is necessary for the following reasons:

- Ground station equipment supplier Nera can no longer manufacture the legacy channel units due to component obsolescence meaning that GES capacity cannot be increased causing service performance to degrade as traffic increases.
- Inmarsat also needed the stations to have new units to make effective use of the new 4th generation satellites (I4's) and capitalizes on the global beam frequency spectrum
- Inmarsat is requiring all ground stations to comply with the relevant GES change notice standard by March 31, 2007

A.1.2 ARINC

2006 September Telenor contracts with Nera SatCom to upgrade the Eik and Santa Paula GESs to address parts obsolescence, increase capacity, and comply with the relevant Inmarsat change notice.

2007 February Contract with Telenor Satellite Services for the upgrade of Telenor's aeronautical satellite Ground Earth Stations at Eik, Norway and Santa Paula, California in the United States. The contract is worth approximately $6.5 million USD. Implement an upgrade to ACARS network to accommodate the additional capacity afforded by the GES upgrades.

2007 November Complete Eik and Santa Paula GES upgrade for both voice and data

A.2 Satellite Upgrades

A.2.1 INMARSAT

By mid 2008 GES closures will have significantly reduced the redundancy available to the classic AERO service. By mid 2008 SITA and ARINC will be operating through only 4 GES in total.

The existing I3 generation satellites have a service life expected through 2016-2019 and INMARSAT have advised the industry that they will be providing Classic AERO service on the new I4 generation of satellites which have a service life through 2023. INMARSAT will be moving the I4 satellites to provide classic AERO backup to the I3 satellites. This service is expected to be available in mid-2009 and the I4 satellites will communicate through INMARSAT owned Satellite Access Stations (SAS) which are in addition to the existing I3 GES. INMARSAT have advise that they will be providing Classic AERO service using Aero H/H+ and are investigating the demand for the Aero I service.

Figure 10 illustrates the coverage with the I4 satellites illustrated in their new positions. Only the existing SITA and ARINC GES which are used for the I3 satellites are illustrated.

Additional upgrades to the service as recommended by the FANS SATCOM improvement team will also be implemented. These include:

- Improved monitoring at system level
- Improved data gathering
- Ability to handover spectrum between GES (partial)

- Other improvements to AES and GES scheduled by November 2009 which include:
    - o Changes to the log on process to enable faster recovery after a GES failure.
    - o Explicit marking of the T-Ch superframe.
    - o Provision of terminal manufacturer and software load in log on signal unit.
    - o Increase loss of P channel timer to reduce relog on by AES

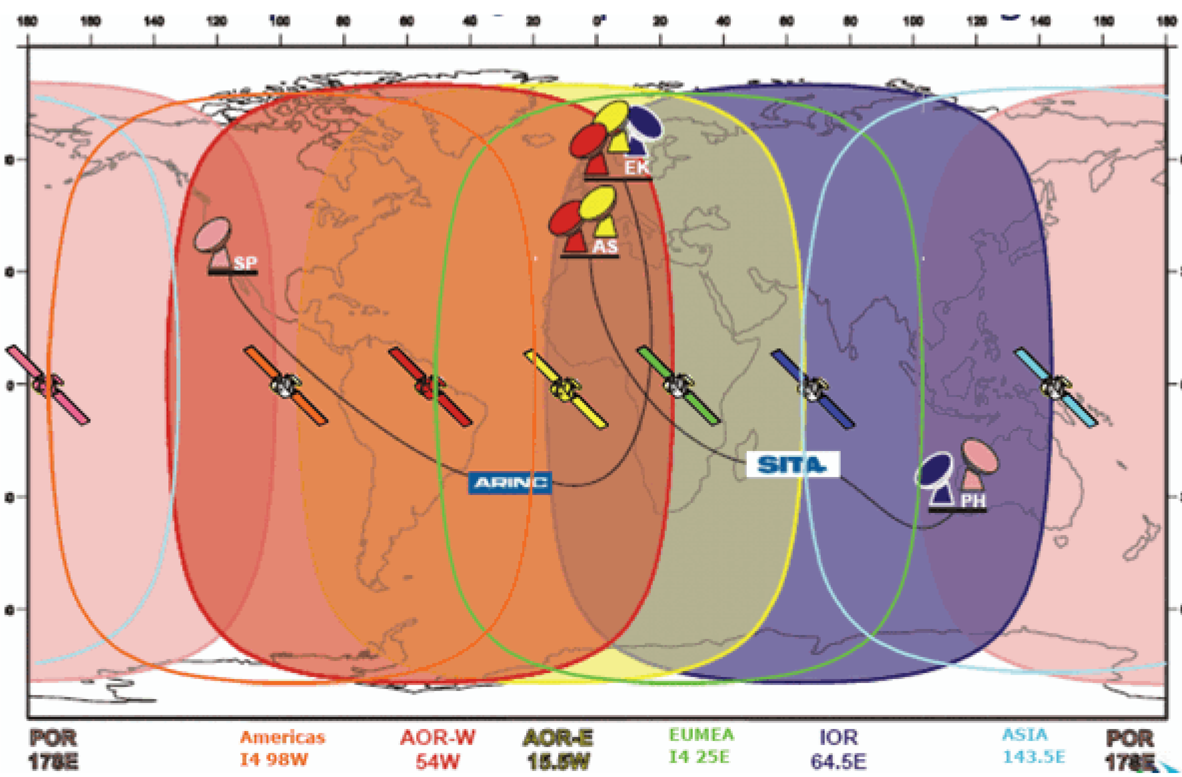


Figure 10: Classic AERO service mid 2009 with I4 and I3

A.3 Aircraft Upgrades

Nil

Appendix B – Interoperability differences not contained in DO-258A/ED-100A FANS-1/A Interoperability Standard

<u>To Be Developed</u>

Appendix C - FANS-1/A-ATN Convergence Background and Status

To Be Developed