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22 January 2013

AERONAUTICAL COMMUNICATIONS PANEL
Twentieth Meeting of Working Group M
Montreal, Canada
23 January 2013

Agenda Item 7: Updates of AMS(R)S SARPs documents and associated technical manuals.

RTCA SC-222 Final Review and Comment Version of Generic MASPS for AMS(R)S Services in Procedural Airspace including SwiftBroadband-specific Material

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Working Paper

SUMMARY

As discussed in a WP-04 from this meeting, SC-222 is currently in the final stages of approval for a generic Minimum Aviation System Performance Standard tightly linked to requirements in the ICAO GOLD and SVGM documents. This working paper presents working paper SC-222/WP-095, the generic MASPS document, and SC-222/WP-096, the SBB specific material. These documents are currently completing RTCA's Final Review and Comment process. Approval for publication is anticipated at the March meeting of RTCA's Program Management Committee.

WG-M members are invited to consider how this document may inform future WG-M deliberations.

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MINIMUM AVIATION SYSTEM PERFORMANCE STANDARD FOR AMS(R)S DATA AND VOICE COMMUNICATIONS SUPPORTING REQUIRED COMMUNICATIONS PERFORMANCE (RCP) AND REQUIRED SURVEILLANCE PERFORMANCE (RSP) IN PROCEDURAL AIRSPACE

Committee Working Paper SC-222/WP-095

Prepared by SC-222

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Foreword

This report was prepared by Special Committee 222 (SC-222) and approved by the RTCA Program Management Committee (PMC) on mm, dd, yy.

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- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunications Union and other appropriate international organizations can be based.

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1 INTRODUCTION

1.1 Objective and Scope

This document contains Minimum Aviation System Performance Standards (MASPS) for Aeronautic Mobile Satellite (Route) Services (AMS(R)S) that provide safety communications to aircraft in procedural airspace. The performance defined in this document is intended to provide (1) data communication services that comply to either the RCP240 or RCP400 standards of Required Communications Performance (RCP) for two-way, bidirectional, controller-to-pilot data communications and to the RSP180 or RSP400 standards of Required Surveillance Performance (RSP) for one-way aircraft-to-Air Traffic Service Provider surveillance-related information, and (2) voice communication services that comply with RCP400/V for two-way, bidirectional voice communications between pilots and controllers. Requirements for data communication services are referenced to and refined from the ICAO Global Operational Data Link Document (GOLD), and requirements for voice services are referenced to and refined from the ICAO Satellite Voice Guidance Material (SVGM) document. In keeping with the intent of the GOLD and the SVGM, this document provides requirements at the Communication Service Provider (CSP) level. In addition, other requirements are refined from the ICAO AMS(R)S SARPs.

Note: This document recognizes that data link communications meeting the RSP standard are traditionally associated with the surveillance community. However, at the CSP level, there is no fundamental distinction between traditional two-way communications and the one-way surveillance applications. Therefore, both RCP240 and RSP180 are treated as data communications services.

This document anticipates that more than one CSP may provide RCP-compliant services in procedural airspace, and that the same CSP may also provide a different suite of services using a different satellite subnetwork for air-ground communications. Therefore, in addition to the technical requirements at the CSP level that apply to any and all of the CSPs, regardless of subnetwork, this document also provides instructions for the preparation of system-specific material related to CSP-level requirements and performance using an individual specific satellite service provider. Such system-specific information will become part of a system-specific attachment to this document.

Compliance with the standards in the main body and the related system-specific material of this document is recommended as one means of assuring that an air-to-ground/ground-to-air communications service based on a particular satellite service will perform its intended function(s) satisfactorily under conditions normally encountered in routine aeronautical operations for the designated operational environment(s). Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

The specific requirements for the Aircraft Earth Station (AES) element that supports a particular satellite subnetwork used in such an AMS(R)S system will be found in the appropriate Normative Appendices to DO-262 *Minimum Operational Performance standards (MOPS) for Avionics Supporting Next Generation Satellite Systems (NGSS)*. The latest revision of that document should be consulted for the technical requirements related to the design and performance of AES equipment used in the system described in this document.

1.2 Document Overview

This document is organized as follows.

The main body of the document follows the RTCA guidelines for MASPS preparation. After this initial introductory section, Section 2 contains the system requirements at the CSP level. Most of these requirements are presented in tabular form to simplify the cross-reference matrices required in the system-specific material. Section 3 is retained to maintain compliance with the MASPS drafting guidelines. Section 3 content is minimal, however, because partitioning below the CSP level, if any, will be on a system-specific basis, and will be covered in the system-specific material. The RCP concept is applied at the CSP level. Section 4 contains suggested verification methods for the CSP level requirements defined in Section 2.

This document adds a Section 5 to the standard MASPS outline. Section 5 contains guidance for the preparation of system-specific attachments to this document.

System-specific material as defined in Section 5 will be provided as attachments to this document. Each system-specific attachment will describe the system that provides AMS(R)S, and will contain information detailing system compliance with the requirements in the main body of this document and verification plans. Each system-specific attachment is expected to function as a stand-alone MASPS for that system.[1] Each system-specific attachment may include its own appendices, as necessary for the description and declaration of the system performance. Suggested appendices are identified in Section 5.

1.3 AMS(R)S System Overview

The boundary of the AMS(R)S system described in this document is shown in Figure 1-1. On the ground side, the AMS(R)S system receives inputs from and provides outputs to the Air Traffic Service Provider (ATSP). On the air side, the AMS(R)S system receives baseband inputs from and provides baseband outputs to the User Avionics, which typically consists of Communication Management Units (CMUs) and the Audio Management System (AMS). Networking within the aircraft and networking within the ATSP ground network is not included in the AMS(R)S system. CSP networking from the ATSP interface to the appropriate satellite service provider interface, satellite service provider networking, satellite ground facilities, satellites, and satellite system avionics[2] are included within the AMS(R)S system.

The AMS(R)S *system* should support CPDLC and ADS data communications and voice communications, as well as such additional data services as may be declared, specified, and verified in the system-specific material. This requirement is at the CSP level: there is no intent that every aircraft be equipped to support every service. Aircraft equipage standards will be determined by national certifying authorities.

This document recognizes that the AMS(R)S system denoted in Figure 1-1 is itself a "system of systems". Therefore, the AMS(R)S system will necessarily be partitioned into lower level networks and systems. A notional view of such partitioning is shown in Figure 1-2. The CSP is partitioned in to the Communications Network Provider (CNP) and the Satellite Service Provider (SSP). The actual partitioning underlying any specific CSP performance will be dependent on the specifics of the CNP, SSP, and technology used for the satellite constellation and network. Such details are intended for disclosure in the system-specific material described in Section 5, below.

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[1] Without such a system-level description, including a description of the various services provided, there will be no basis for establishing the technical requirements on the Aeronautical Earth Station (AES) described in the equivalent system-specific material in DO-262A or successor documents.

[2] Usual practice within the community refers to the satcom-specific avionics, including antennas, as the Aeronautical Earth Station or AES.

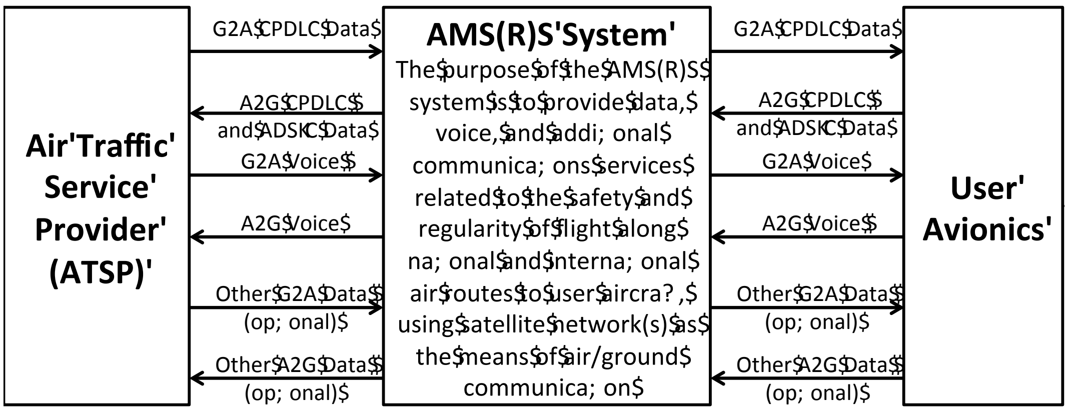

Figure 1-1: AMS(R)S System Boundary Diagram

One element of Figure 1-2 that will not vary from between CSPs is the CSP Network Boundary. This boundary indicated by the dashed line box extending from points A-B and G-H in Figure 1-2, defines the limits of the various availability specifications referenced to the GOLD and SVGM documents. Thus, the discussion of Section 1.6 and specific requirements of Section 2.3 are *CSP Network* level requirements. The availability of the AES and user avionics are a matter for aircraft design and equipage and *are not* included in the overall network availability requirements.

Other specific requirements of Section 2.3 apply to message latency. In this case the measurable boundary is that of the solid line box from A-C and F-H in Figure 1-2. With these boundaries, the contribution of the AES *is* included in the overall latency measurements.

These boundaries for availability and latency are slightly different than the partitioning chosen in GOLD and SVGM documents. The difference is intentional: it serves to provide measurable boundaries for the various elements of RCP.

In actual practice, various combinations of ATSP, CNPs and aircraft are possible. Figure 1-3 illustrates four typical cases of such interworking through CNPs identified only as “CNP1” and “CNP2”.[3] Aircraft A, Aircraft B, and Aircraft C represent the cases where the relevant ATSP has contracted with CNP1 to provide AMS(R)S communications to aircraft in procedural airspace under its jurisdiction. In the first case (Aircraft A) the operator of User Aircraft A contracts with CNP1 as its sole CSP. Thus the only communications path between the aircraft to the ATSP is through CNP1. In this case, no internetworking is required. The second case (Aircraft B) illustrates the situation where CNP2 is designated an emergency backup for air-to-ground communication with Aircraft B. When this emergency backup (dashed path B-2) is activated aircraft-to-ground and ground-to-aircraft paths pass through CNP2, but CNP-to-ATSP communication services are provided by CNP1. Therefore interworking between CNP2 and CNP1 is required. Paths C-1 and C-2 illustrate the cases where the operator of User Aircraft C has a primary contract with CNP2 and a backup path with CNP1. In this case, Path C-1 requires internetworking between CNP2 and CNP1. Finally, the operator of Aircraft D contracts with CNP2 as its sole provider and CNP2 also has a connection with the relevant ATSP. This fourth case requires that the ATSP have service contracts with both CNP1 and CNP2. This is an unusual situation. The intent of this specification is that the availability and latency numbers apply to all cases, and, therefore, include the effects of *both* CNPs and any interworking hardware and software that may be required to service Aircraft B and Aircraft C.

1.4 Data Services

This document provides overall standards for data communications between the aircraft and the ATSP that comply with some combination of RCP240, RCP400, RSP180 or RSP400.[4]

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[3] In terms of this figure, CNP1 and CNP2 should be interpreted as logical designations. That is, there is no intent to identify either CNP1 or CNP2 with a particular network provider in all circumstance.

[4] Clearly, the communications with Aircraft A and Aircraft D should have lower latency, while the communications with Aircraft B and Aircraft C should have higher availability due to the presence of redundant paths.

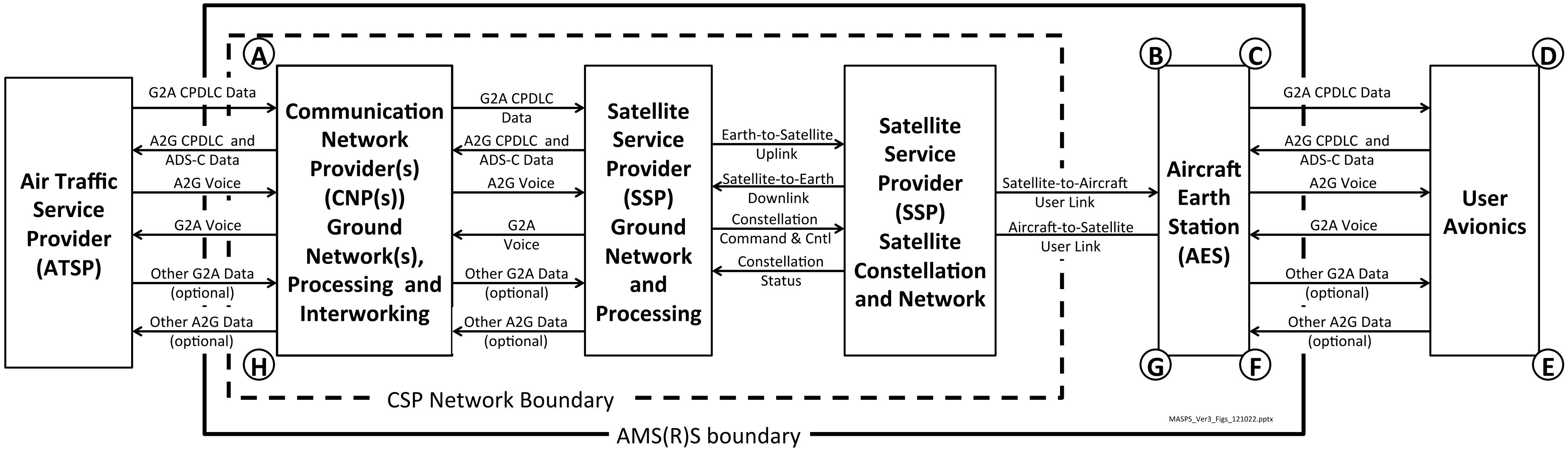

Figure 1-2: Notional AMS(R)S Partitioning

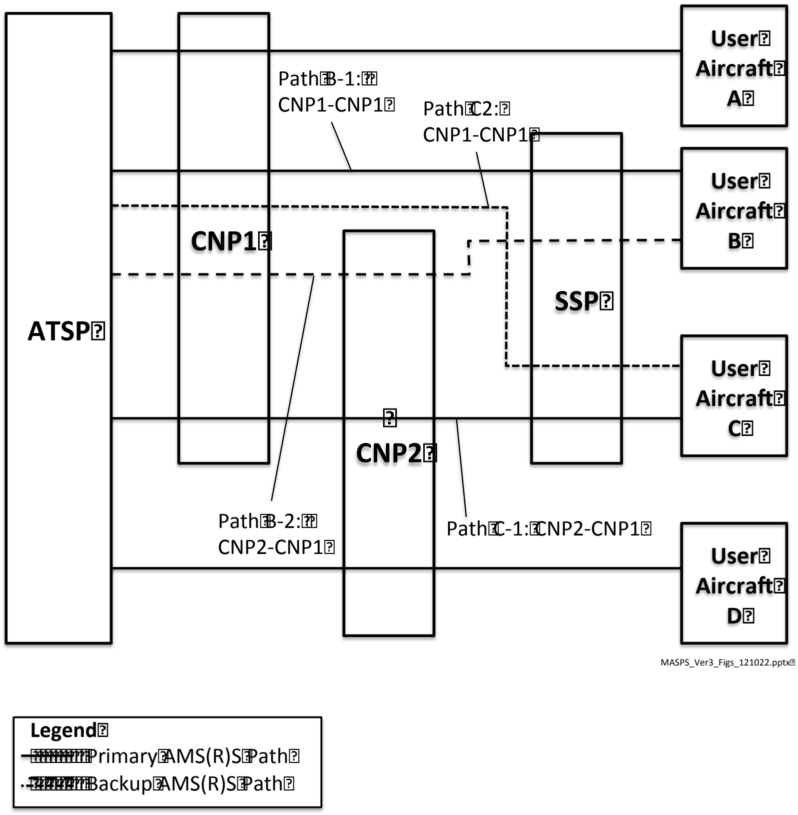

Figure 1-3: Illustration of CNP Internetworking

1.4.1 Required Communications Performance

The concept of Required Communication Performance (RCP) is defined in the ICAO *Global Operational Data Link Document (GOLD)*, Appendix B. As developed in GOLD, *required communication performance* consists of a collective set of performance measures established to ensure that the overall communications transaction is suitable for certain operational goals. For example, these operational goals may be "achieve 30 nautical mile lateral and 30 nautical mile along-track separation in procedural airspace." The GOLD maps these operational goals to CSP-level requirements.

Because it is operationally focused, the GOLD establishes the RCP values at the overall service level. The GOLD graphically displays this requirement and its allocation to various sub-elements by means of a message sequence chart, as shown in Figure 1-4. This level is labeled "RCPxxx", where "xxx" is replaced by a three digit code specifying the overall duration of the (two-way) operational communications transaction (see Figure 1-4). For the purpose of the current document, the relevant performance is RCP240 or RCP400 for data service.

GOLD then performs a first-level partitioning/allocation process of the overall RCP into four sub-elements: the Air Traffic Service Provider (ATSP), i.e., the FAA or NATS; the Communications Service Provider; the Aircraft system, e.g., the AES, CMU, flight management system, displays, etc.; and the aircraft operator, i.e., the pilot or co-pilot. The specifics of these allocations are shown graphically in Figure 1-4. The GOLD, which was prepared by ATSP experts, has a much higher-level view of the communications transaction than does the subnetwork-based DO-270. The "Block Diagram View" of Figure 1-4 provides a block diagram that reconciles the scope of the GOLD with the scope of earlier DO-270/DO-262 documents. As shown in the "MASPS Allocation/Requirement View" of Figure 1-4, this current document melds the two approaches together, by establishing measurable elements of RCP which may be consistently combined to establish compliance with the overall RCP level.

In terms of the labeled points in Figure 1-4, the two-way CSP requirements correspond to the aggregate transit delay of Point A through Point C, *plus* Point F through Point H. The user avionics delays (Point C to Point D, and Point E to Point F) are accommodated by means of a standard allocation, as discussed in Section 3 of this document. To facilitate direct measurement of transit delays, this partitioning modifies the GOLD partition by including the AES' transit delay as part of the CSP allocation.

This document establishes CSP-level requirements by combining delay and continuity together as joint requirements[5].

1.4.2 Required Surveillance Performance

The concept of Required Surveillance Performance (RSP) is defined in Appendix C of the ICAO GOLD document. As developed in GOLD, *required surveillance performance* consists of a collective set of performance measures established to ensure that the overall communications transaction is suitable for certain surveillance-related operational goals. For example, these operational goals may be: "achieve 30 nautical mile lateral and 30 nautical mile along-track separation in procedural airspace." The GOLD maps these operational goals to CSP-level requirements.

Unlike RCP, RSP is defined in terms of a one-way transaction from the aircraft to the controller. In terms of Figure 1-4, the CSP portion transaction time of this corresponds to Point F through Point H, with an allocation for the avionics Point E to Point F. As discussed in RCP above, the partitioned boundary for the CSP has been modified to include the AES so as to create measurable requirements.

For the purpose of the current document, the relevant performance is RSP180 or RSP400 for data service supporting surveillance applications.

1.5 Voice Services

The ICAO SVGM document extends the concept of RCP to voice services in a similar manner to GOLD. For voice performance, the relevant performance levels are RCP400/V and RSP400/V, which correspond to two-way, end-to-end voice communications transactions that are completed in 400 seconds or less. The 400 seconds includes the time of the conversation between the ground party and the pilot. RCP400/V corresponds to a ground initiated call while RSP400/V corresponds to an air initiated call.

As discussed in RCP above, the partitioned boundary for the CSP has been modified to include the AES so as to create measurable requirements.

This document requires that, at the CSP level, the AMSR(R)S system provide RCP400/V and RSP400/V. This is not meant to imply that all individual aircraft be equipped to perform voice operations over the AMS(R)S network.

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[5] See, for example, requirement D10, *et seq*., below. The *value* of the delay is associated with a *probability*, i.e., a probability of achieving that delay.

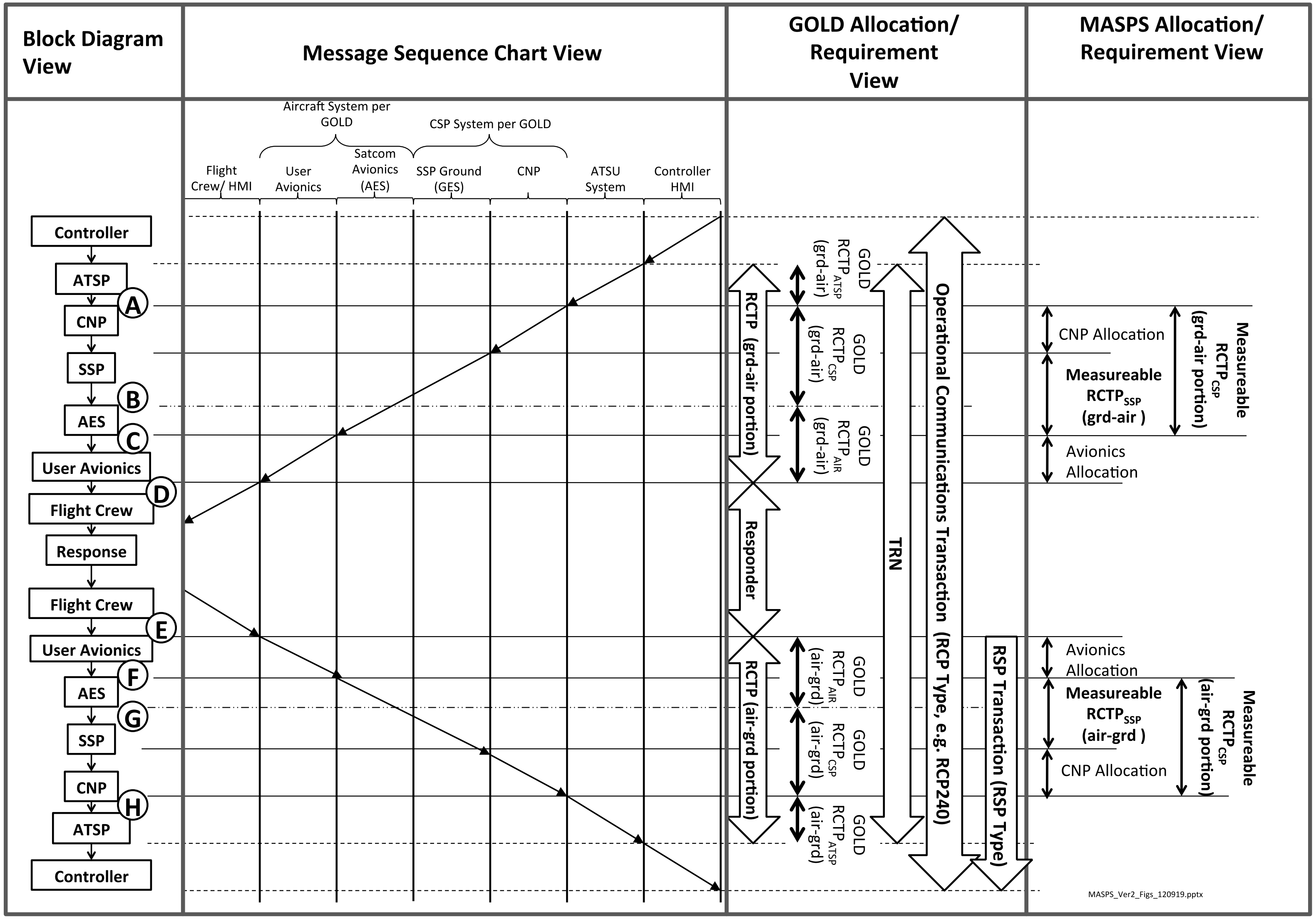

Figure 1-4: Four Views of Required Communication Performance and Required Surveillance Performance Requirements and Allocations for Data Services

1.6 Network Availability and Unplanned Outages

The GOLD establishes two different measures of network availability: availability for efficiency, and availability for safety. As with other GOLD requirements, these are based on both the ATS management of the airspace and the necessity to maintain safe separation of aircraft. The following paragraphs provide examples of the efficiency and safety requirements.

In oceanic airspace with a relatively high density of aircraft (e.g. > 300 aircraft in the North Atlantic Track), the underlying requirement on system availability is the controller load necessary to re-task all of the aircraft in a particular region in the event of a communication system failure that affects a large number of aircraft. This is a serious matter, as the act of re-tasking imposes safety considerations beyond those associated merely with communications of safety-related information to individual aircraft. Therefore, the desire is that the system availability be high enough to render this region-wide re-tasking a rare event. This is the basis of the "availability for efficiency" or “operational efficiency” requirement on availability.

On the other hand, in less-densely populated oceanic airspace (e.g. <100 aircraft in the South Pacific) the primary concern is not the re-tasking effort but the actual safety communication with the individual aircraft. Therefore, the desire is that the system availability be high enough to render loss of safety-related communications by themselves a rare event, but it is acceptable to have the probability of such loss be greater than the probability of the re-tasking in densely populated airspace. This is the basis of the "availability for safety" or “operational safety” requirement on availability.

In either case, we interpret the availability requirement to be at the CSP’s network boundary shown in Figure 1-2, which is equivalent to a signal-in-space availability. That is, determination of an outage should be based on the assumption that an addressed aircraft has a working AES. AES availability should be treated separately and independently. These assumptions are the basis for the outage-related definitions in the following Section.

1.7 Definition of Terms

This section provides explicit definitions for terms used in this document based around their definition and use in GOLD, SVGM, the ICAO SARPs, and ITU documents.

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Term	**Definition**	**Reference or Source**
ADS-C	Automatic Dependent Surveillance is a method of surveillance that relies on (is dependent on) downlink reports from an aircraft's avionics that occur automatically whenever specific events occur, or specific time intervals are reached. ADS does not require an independent surveillance source, such as a radar antenna, to operate. The *–C* in ADS-C indicates *Contract* meaning that the ground sets the parameters and rate of the reports.	
AES	Aircraft Earth Station. A mobile earth station in the aeronautical mobile-satellite service located on board an aircraft. An AES consists of all equipment required to receive, demodulate, decode, process and forward signals received from the satellite and to accept, process, format, encode, modulate and transmit messages from the aircraft end systems.	ICAO Annex 10 Part I, Chapter 1, expanded for clarity.
AIR TRAFFIC SERVICE PROVIDER (ATSP)	The entity providing Air Traffic Control and Management services for the relevant airspace. In most cases, the ATSP is a government organization, such as FAA.	
ATS SURVEILLANCE SERVICE	A term used to indicate a service provided directly by means of an *ATS surveillance system.*	ICAO Doc. 4444
ATS SURVEILLANCE SYSTEM	A generic term meaning variously, ADS-B, PSR, SSR or any comparable ground-based system that enables the identification of aircraft. *Note: A comparable ground-based system is one that has been demonstrated, by comparative assessment or other methodology, to have a level of safety and performance equal to or better than monopulse SSR.*	ICAO Doc. 4444
CALL SETUP TIME	The time from when the address information required for setting up a call is received by the *CSP* or the *AES* to when the ringing tone or answer signal is provided to the called party. When computing statistics of call set up times, the following conditions are excluded: calls not set up owing to network congestion, aircraft busy conditions, faulty aircraft equipment, aircraft not in level flight, aircraft outside the coverage area, and aircraft not logged on.	SVGM

Term	Definition	Reference or Source
COMMUNICATIONS NETWORK PROVIDER (CNP)	For the purpose of this document, the Communications Network Provider consists of the element or elements of the *Communications Service Provider (CSP)* that provide terrestrial network, aggregation, context switching, etc., necessary to interface the *Air Traffic Service Provider (ATSP*) with the *Satellite Service Provider (SSP)*. For example, requirements on the terrestrial network and infrastructure associated with a given Communication Service Provider are considered to be CNP requirements, even when the same corporate entity serves as the overall system-level CSP *and* the subsystem CNP.	
COMMUNICATIONS SERVICE PROVIDER (CSP)	The CSP entity provides the communications pathway between the *ATSP* and the user avionics. For communications applications, this pathway is bi-directional, but surveillance applications only use the pathway in the air-to-ground direction. The CSP is defined to consist of the *Communications Network Provider* and the *Satellite Service Provider*. The CSP may also provide Air Traffic Control-related communications using other air-to-ground networks (e.g. VDL). Such communications are *not* covered in this document. For clarification between the CSP and CNP, see the explanation associated with CNP.	
COVERAGE VOLUME	The portion of the Earth's surface over which AMS(R)S can be provided by the *SSP* element of the overall *CSP*. See Section 2.2.2	
CPDLC	Controller Pilot Data Link Communications is a means of communication between controller and pilot, using data link for Air Traffic Control communications ensuring the safety and regularity of flight along national and international air routes.	GOLD
DROPPED CALL RATE	The probability that a call that has been successfully set-up is dropped during a voice transaction of 120 seconds. (The value of 120 seconds is selected based on a typical duration of a safety-service voice call between pilot and ATS. The value is established only for the purpose of computing the dropped call rate)	SVGM clarified
GRADE OF SERVICE (GOS)	Grade of service is the probability of a call in a circuit group being blocked or delayed for more than a specified interval. This is always with reference to the busy hour when the traffic intensity is the greatest. Grade of service may be viewed independently from the perspective of incoming versus outgoing calls, and is not necessarily equal in each direction or between different source-destination pairs.	ITU FED-STD-1037C

Term	Definition	Reference or Source
NETWORK AVAILABILITY	$1 - \frac{\sum \text{Operationally significant unplanned outage durations}}{\text{Elapsed time}}$ The specific computation used to determine network availability may vary from *CSP* to *CSP*, as defined in the system-specific material.	Clarification of GOLD.
ONE-WAY TRANSIT DELAY	The time for a data message to pass from Point A to Point C or from Point F to Point H shown in Figure 1-4.	Clarification of GOLD to provide measurable end points.
OPERATIONAL EFFICIENCY	An operational requirement based on the controller workload necessary to reorganize the relevant *procedural airspace* in the event of an *operationally significant unplanned outage* of AMS(R)S. See 1.6	Clarification of GOLD
OPERATIONAL SAFETY	An operational requirement based on maintaining the safety of the relevant *procedural airspace* in the event of an *operationally significant unplanned outage* of AMS(R)S. See 1.6	Clarification of GOLD
OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES	An *unplanned outage* whose duration exceeds the *outage duration limit.*	Clarification of GOLD
OUTAGE	A loss of service to a multiplicity of aircraft within a specific airspace.	
OUTAGE DURATION	The time interval from the start of the *outage* (loss of service) to the restoration of service (end of outage).	GOLD
OUTAGE DURATION LIMIT	The maximum acceptable duration of an unplanned outage before there is operational impact. In this document, the value is 10 minutes for RCP240 and RSP180 data services, 20 minutes for RCP400 and RSP400 data services, and 20 minutes for voice services	GOLD
PROCEDURAL AIRSPACE	An airspace where information derived from an *ATS surveillance system* is not required for the provision of air traffic control service.	GOLD
RCP240	See 2.3	GOLD
RCP400	See 2.3	GOLD
RCP400/V	See 2.3	SVGM
RSP180	See 2.3	GOLD
RSP400	See 2.3	GOLD
RSP400/V	See 2.3	SVGM
SATELLITE SERVICE PROVIDER (SSP)	For the purpose of this document, the Satellite Service Provider is the entity providing bi-directional data and voice communications between user aircraft in the relevant airspace and the terrestrial network of the *Communications Network Provider (CNP).* The SSP provides the satellites, the ground traffic gateways, ground interconnect and associated monitoring and control.	

Term	Definition	Reference or Source
TRANSIT DELAY	In packet data systems, the elapsed time between a request to transmit an assembled data packet and an indication at the receiving end that the corresponding packet has been received and is ready to be used or forwarded.	ICAO Annex 10, Vol 3, Part I, Chapter 3.1
TWO-WAY TRANSIT DELAY	For the purpose of this document and associated system-specific material, this is the time for a *CPDLC* message to pass from Point A to Point C, plus the time for the response to pass from Point F to Point H as shown in Figure 1-4. For air-initiated communications, the process is reversed, but the measurement points remain the same.	
UNPLANNED OUTAGE	An outage that was not declared in advance to affected users by the *CSP*.	
VOICE LATENCY	The elapsed time commencing at the instant that speech is presented to the AES and concluding at the instant that the speech enters the interconnecting network external to the Communications Service Provider and *vice versa*. This delay includes vocoder processing time, physical layer delay, RF propagation delay and any other delays within the CSP network.	

1.8 Reference Documents

The following list of documents form references for the various requirements within this document. System-specific material may contain additional references. In the case of conflict between the referenced documents and this document, the requirements of this document should take precedence.

Reference	**Title**
Annex 10	"Annex 10 to the Convention on International Civil Aviation, Aeronautical Communications, Volume III Communication Systems, (Part I Digital Data Communication Systems)," International Civil Aviation Organization (ICAO), Montreal, July, 2007
DO-262A	"Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (NGSS)," RTCA, Inc., Washington, DC, DO-262A, Dec. 16, 2008
DO-270, Including Change 1	“Minimum Aviation System Performance Standards (MASPS) for the Aeronautical Mobile-Satellite (R) Service (AMS(R)S) as Used in Aeronautical Data Links”, RTCA, Inc., Washington, DC, DO-270, Dec. 1, 2001; Change 1 issued April 14, 2009.
GOLD	"Global Operational Data Link Document (GOLD)," International Civil Aviation Organization (ICAO), Montreal, 14 June, 2010

SVGM	"Satellite Voice Guidance Material (SVGM)," International Civil Aviation Organization (ICAO), Montreal, First Edition, 23 July 2012.
ICAO Doc. 4444	"Procedures for Air Navigation Services — Air Traffic Management", 15th Edition, effective 22 November 2007, including amendments 1-3, through 15 November 2012
ANSI/ASA S3.2-2009	"Method for Measuring the Intelligibility of Speech over Communication Systems, ANSI, American National Standards Institute/Acoustical Society of America, 2009"

2 COMMUNICATION SERVICE PROVIDER REQUIREMENTS

Note: To facilitate the pro-forma compliance matrices required for the system-specific attachments to this generic system-level requirement document, the system-level performance requirements in Section 2.3 are presented in tabular form.

2.1 General Requirements

The AMS(R)S system **SHALL** meet all pertinent airworthiness, human factors and operational requirements including alerts, controls and frequency management considerations.

Requirements relating to carriage of AMS(R)S equipment on aircraft and implementation of ground infrastructure supporting AMS(R)S **SHALL** be in accordance with national requirements, regional agreements or international agreements, including the level of system capability, as appropriate for Air Traffic Service operations and Aeronautical Operational Control. This document anticipates that different AES requirements may apply to AMS(R)S offered through different satellite subnetworks.

2.2 Standard Operating Conditions

2.2.1 Traffic Environment

When measured at the CSP interfaces (Points A and H of Figure 1-4), the standard operating conditions for data, and voice communications **SHALL** be as established by relevant national or regional ATSP. For the purpose of this document, such operating conditions should include the maximum number of aircraft in the operational airspace, the average data rates to and from an operational aircraft using the AMS(R)S service, the average call demand (Erlang) loading for cockpit voice services, and the maximum burst data rate required for an individual aircraft.

For the purposes of delay measurement, the standard data message **SHALL** consist of one block of 220 octets of user input data of controller or pilot-defined information, along with associated checksums and protocol headers defined by the satellite network and other intermediate systems within the SSP and CNP subsystems.

The AMS(R)S system **SHALL** meet its requirements under the defined traffic environment.

Note: The intent of the standard data message definition is to establish a test condition for system delay. There is no requirement to partition longer transactions into 220 byte segments.

2.2.2 Procedural Airspace

The AMS(R)S system **SHALL** meet its requirements for aircraft in normal flight configurations while operating in procedural airspace. GOLD defines *procedural airspace* as an airspace where information derived from an ATS surveillance system is not required for the provision of air traffic control service. The ATS surveillance system and ATS surveillance service are defined in Section 1.7.

Note: The procedural airspace relevant to the specific satellite subnetwork included in the overall CNP network will be in the intersection of all procedural airspace with the geographical coverage volume of the relevant satellite system. There is no requirement on the minimum or maximum coverage volume to be provided by the satellite system, but it is expected that any such volume will be a substantial fraction of the Earth's surface.

2.2.3 Radio Frequency Spectrum

When providing AMS(R)S communications, the satellite subnetwork of an AMS(R)S system **SHALL** operate only in frequency bands which are appropriately allocated to AMS(R)S and protected by the ITU Radio Regulations.

2.2.4 Radio Frequency Environment

The AMS(R)S system **SHALL** exhibit Radio Frequency (RF) compatibility with communications, navigation, and surveillance systems approved for aeronautical use when those systems are 1) operating in accordance with applicable national and international regulations, and 2) operated on aircraft conforming to current and foreseen future operational conditions appropriate for procedural airspace. In addition, the AMS(R)S system **SHALL** meet its performance requirements in the presences of relevant terrestrial communications systems operating in the same or closely proximate bands.

Note: RF compatibility includes unintentional RF emissions, in band susceptibility and out of band susceptibility.

The detailed RF performance requirements are included in the AES MOPS (DO-262) and are not covered in this document.

2.3 Standard Services

The performance parameters for data services in GOLD for the CSP are captured in four similar tables within different sections of GOLD Appendix B and C. Table 2-1 combines these performance parameters from various sections of GOLD in a single table. These parameters are the basis for the CSP-level requirements presented in Section 2.3.

Table 2-1: Relation of Key CSP Network Parameters to ATSP Management of Procedural Airspace

	Units						
RCP/RSP type		RCP240 efficiency	RCP240 safety	RCP400 safety	RSP180 efficiency	RSP180 safety	RSP400 safety
GOLD ref		B.2.1.2	B.2.1.2	B.3.1.2	C.2.1.2	C.2.1.2	C.3.1.2
95% TT	s	100	100	240	84	84	270
99.9% ET	s	120	120	280	170	170	340
Availability		0.9999	0.999	0.999	0.9999	0.999	0.999
Outage Duration Limit	min	10	10	20	10	10	20
Maximum number unplanned outages		4	48	24	4	48	24
Maximum accumulated unplanned outage time	min/yr	52	520	520	52	520	520
Unplanned outage notification delay	min	5	5	10	5	5	10

The technical requirements necessary to implement these key network parameters are given in tabular form in Sections 2.3.1, 2.3.2, and 2.4

Note: Within the requirements tables, requirements are indicated by the word SHALL. Additional bold terms, such as TWO-WAY TRANSIT DELAY, are defined in Section 1.7

2.3.1 Data Services

ID	Title	Requirement	Reference / Source
D10	RCP240 CPDLC TT	The **SYSTEM,** if used for RCP240 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 100s or better for 95% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.2.1.2
D20	RCP240 CPDLC ET	The **SYSTEM,** if used for RCP240 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 120s or better for 99.9% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.2.1.2
D30	RSP180 ADS TT	The **SYSTEM,** if used for RCP240 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 84s or better for 95% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.2.1.2
D40	RSP180 ADS ET	The **SYSTEM,** if used for RCP240 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 170s or better for 99.9% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.2.1.2
D50	RCP400 CPDLC TT	The **SYSTEM,** if used for RCP400 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 240s or better for 95% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.3.1.2
D60	RCP400 CPDLC ET	The **SYSTEM,** if used for RCP400 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 280s or better for 99.9% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.3.1.2
D70	RSP400 ADS TT	The **SYSTEM,** if used for RSP400 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 270s or better for 95% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.3.1.2
D80	RSP400 ADS ET	The **SYSTEM,** if used for RSP400 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 340s or better for 99.9% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.3.1.2

ID	Title	Requirement	Reference / Source
D90	ADS and CPDLC Availability Safety	The **SYSTEM**, if used for Operational Safety, **SHALL** provide a **NETWORK AVAILABILITY** of 0.999 or better as measured in a 12-month period.	GOLD B.2.1.2 GOLD B.3.1.2 GOLD C.2.1.2 GOLD C.3.1.2
D100	ADS and CPDLC Availability Efficiency	The **SYSTEM**, if used for Operational Efficiency, **SHALL** provide a **NETWORK AVAILABILITY** of 0.9999 or better as measured in a 12-month period.	GOLD B.2.1.2 GOLD C.2.1.2
D110	RCP240 and RSP180 Number of Unplanned Outages Safety	The **SYSTEM**, if used for RCP240 or RSP180 applications for Operational Safety, **SHALL** have no more than 48 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	GOLD B.2.1.2 GOLD C.2.1.2
D120	RCP400 and RSP400 Number of Unplanned Outages	The **SYSTEM**, if used for RCP400 or RSP400 applications, **SHALL** have no more than 24 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	GOLD B.3.1.2 GOLD C.3.1.2
D130	RCP240 and RSP180 Number of Unplanned Outages Efficiency	The **SYSTEM**, if used for Operational Efficiency, **SHALL** have no more than 4 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	GOLD B.2.1.2 GOLD C.2.1.2
D140	RCP240 and RSP180 Unplanned Notification Time	The **SYSTEM,** if used for RCP240 or RSP180 applications, **SHALL** provide notification to **ATSP**s within 5 minutes of an **UNPLANNED OUTAGE**.	GOLD B.2.1.2 GOLD C.2.1.2
D150	RCP400 and RSP400 Unplanned Notification Time	The **SYSTEM,** if used for RCP400 or RSP400 applications, **SHALL** provide notification to **ATSP**s within 10 minutes of an **UNPLANNED OUTAGE**.	GOLD B.3.1.2 GOLD C.3.1.2
D160	ADS and CPDLC Data Addressing	The **SYSTEM SHALL** use the ICAO 24-bit aircraft address as the addressing mechanism for ACARS data.	ICAO SARPS 12.7.1
D170	ADS & CPDLC Data Test Points	The **SYSTEM SHALL** include suitable test points to allow measurement of **TRANSIT DELAY**.	
D180	ADS & CPDLC Data Analysis	The **SYSTEM SHALL** include analysis capability for verification and post implementation monitoring to demonstrate compliance with requirements D10 to D80.	GOLD Appendix D

2.3.2 Voice Services

ID	Title	Requirement	Reference / Source
V10	Voice G/A Call Set Up 95%	The **SYSTEM SHALL** provide a ground to air **CALL SET UP TIME** of 25s or better for 95% of call set up attempts as measured in a 1-month period.	SVGM
V20	Voice G/A Call Set Up 99%	The **SYSTEM SHALL** provide a ground to air **CALL SET UP TIME** of 30s or better for 99% of call set up attempts as measured in a 1-month period.	SVGM
V30	Voice A/G Call Set Up 95%	The **SYSTEM SHALL** provide an air to ground **CALL SET UP TIME** of 10s or better for 95% of call set up attempts as measured in a 1-month period.	SVGM
V40	Voice A/G Call Set Up 99%	The **SYSTEM SHALL** provide an air to ground **CALL SET UP TIME** of 15s or better for 99% of call set up attempts as measured in a 1-month period.	SVGM
V50	Voice Dropped Call Rate	The **SYSTEM SHALL** provide a **DROPPED CALL RATE** of 0.01 or better as measured in a 1-month period.	SVGM
V60	Voice Grade of Service	The **SYSTEM SHALL** provide a **GRADE OF SERVICE (GOS)** of 0.01 or better as measured during the busy hour of any month.	SVGM ICAO SARPS
V70	Voice Quality	The **SYSTEM SHALL** provide a mean intelligibility DRT (Diagnostic Rhyme Test) score of at least 85 when measured in accordance with ANSI/ASA S32-2009 in a jet transport aircraft noise environment.	
V80	Voice Latency	The 1-way **VOICE LATENCY** of the System **SHALL** be 0.485 seconds or better in both the air to ground and ground to air direction.	ICAO SARPS
V90	Voice Availability	The **SYSTEM SHALL** provide a **NETWORK AVAILABILITY** of 0.999 or better as measured in a 12-month period.	SVGM
V100	Voice Number Unplanned Outages	The **SYSTEM SHALL** have no more than 24 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	SVGM
V110	Voice Unplanned Notification Time	The **SYSTEM SHALL** provide notification to **ATSP**s within 10 minutes of an **UNPLANNED OUTAGE**.	SVGM
V120	Voice Addressing	The **SYSTEM SHALL** use the ICAO 24-bit aircraft address as the addressing mechanism for voice.	ICAO SARPS 12.7.1
V130	Voice Security	The **SYSTEM SHALL** provide security mechanisms to ensure that only authorized entities can call the aircraft cockpit.	
V140	Voice CLI and Priority Indication	The **SYSTEM SHOULD** provide caller line ID and priority indication for ground to air calls.	SVGM

ID	Title	Requirement	Reference / Source
V150	Voice Priority Levels	The **SYSTEM SHALL** provide voice channels with three (3) additional levels of priority (i.e. a total of 4 including APC (Aeronautical Passenger Communications)) in both air-to-ground and ground-to-air directions, aligned with the relevant ICAO standards, namely AOC/AAC (Airline Operational Control/Airline Administrative Control), ATS (Air Traffic Services) and EMG (Emergency), that are all prioritized above cabin voice calling (APC).	SVGM

2.4 Optional Enhanced or Future Services

ID	Title	Requirement	Reference / Source
E10	Enhanced or Future Services	Enhanced or future data and/or voice services **SHALL** meet the requirements established in the system specific material	System-specific material

3 SUBSYSTEM REQUIREMENTS

At the highest level, the CSP system is decomposed into the Communication Network Provider (CNP) and the Satellite Service Provider (SSP). The allocation of the RCP-based requirements at the CSP level contained in Section 2 to lower level systems and subsystems is expected to be a function of the specific satellite network. Significant differences may be expected between networks. For example, a network of satellites in geosynchronous orbit will certainly have different data transit delay and voice latency qualities than a network of satellites in low Earth orbit. Therefore, any partitioning of system-level requirements to subsystems or lower is properly part of the system-specific material prepared in accordance with Section 5 of this document.

3.1 Performance Allocation Methodology

This document continues the practice instituted in GOLD and SVGM of allocating transaction times (or their RSP and voice equivalents) on the basis of an additive combination of the performance of elements of the CSP network.

The additive combination is used for the purpose of establishing the requirement. This is an extremely conservative methodology, meaning that systems designed to meet such requirements are very likely to achieve significantly better performance than the aggregate value. Compliance with the requirement may be demonstrated using standard statistical methods.

4 SUBSYSTEM VERIFICATION

4.1 Verification Techniques

Performance verification may take the following forms

BT Bench tests of representative elements of the AMS(R)S. This verification method is especially appropriate for tests of the AES and related subsystems. Special instrumentation is permitted for such tests. Test results may be aggregated and combined by analysis for the purpose of establishing system requirements

FT Flight tests using representative aircraft with typical installations. Special instrumentation is permitted for such tests. Test results may be aggregated and combined by analysis for the purpose of establishing system requirements

NT Controlled trials of ground network elements of the AMS(R)S system. Special instrumentation is permitted for such tests. Test results may be aggregated and combined by analysis for the purpose of establishing system requirements

OT Operational trials of numerous representative aircraft during normal operations with normal operational processes throughout the AMSR(S) system. Special instrumentation is not permitted for such tests. Test results may be aggregated and combined by analysis for the purpose of establishing system requirements

A Analysis, including computer simulations, may be used to verify system performance for extreme conditions that may not be practical to measure directly by any of the test methods.

I Inspection may be used to verify system performance in those cases where the requirement concerns documentation or human-machine interfaces.

4.2 Verification of Specific System Requirements

Prior to operational approval as an AMS(R)S provider, the CSP **SHALL** verify system performance against the requirements of Section 2. Verification **SHALL** be restricted to the categories indicated in Section 4.1 unless alternate means of providing equivalent data have been approved in advance. Candidate means for compliance with this requirement may be found in Appendix D to the ICAO GOLD and SVGM documents.

4.3 Verification of Allocated Requirements

Prior to operational approval as an AMS(R)S provider, the CSP **SHALL** verify compliance with such allocated subsystem requirements as may be identified in the system-specific material, and such enhanced or future requirements identified in the system-specific material. Verification **SHALL** be restricted to the categories indicated in Section 4.1 unless alternate means of providing equivalent data have been approved in advance.

4.4 Post Implementation Monitoring of System Operations

The CSP **SHALL** provide medium-term to long-term monitoring of the AMS(R)S performance against the performance requirements of Section 2, and such subsystem requirements as may be identified in the system-specific material, and such enhanced or future requirements identified in the system-specific material. Suggested means for compliance with this requirement may be found in Appendix D to the ICAO GOLD and SVGM documents.

Note: This requirement is <u>*not*</u> *intended to impose real-time monitoring of system performance. Instead, the expectation is that such performance data will be collected over time periods on the order of months and will be regularly analyzed to verify compliance or to provide guidance regarding corrective action, if necessary.*

5 FORMAT AND CONTENT OF SYSTEM SPECIFIC MATERIAL

The generic nature of this overall document anticipates creation of system-specific material providing additional system design, performance, and partitioning requirements based on incorporation of differing satellite subnetworks into the CSP system. Inclusion of such system-specific material in RTCA documents is already part of DO-262A and DO-270.

In the current document, the *technical* requirements have been established in tabular form in Section 2. The instructions for the *format and content* of the system-specific material are contained in the following subsections.

5.1 Format

The system-specific material **SHALL** comply with the standard RTCA templates for publication in all matters of page layout, font size, header and footer content, front matter, etc.

The system-specific material **SHALL** comply with the content and outline described in Section 5.2, below. For the purpose of compliance, the third-level subparagraph heading (e.g., 5.2.1 Introduction) **SHALL** be considered a first-level paragraph heading. That is, 5.2.1, 5.2.2, 5.2.2.1, etc., shall become 1, 2, 2.1, etc. in the system-specific material.

5.2 Content

The following subparagraphs provide the title of the paragraphs for the system-specific material, along with a description of the content.

5.2.1 Section 1 - Introduction

The Introduction **SHALL** contain an introduction and overview of the system-specific material. This section **SHALL** identify the overall CSP system under discussion, including the specific satellite network and satellite services described in the system-specific material.

5.2.2 Section 2 - Compliance

5.2.2.1 Section 2.1 Compliance Summary

This section **SHALL** declare which RCP, RSP, and RCP/V levels and operational service levels (i.e., operational safety or operational efficiency, Table 2-1) the system described in the system-specific material is designed to provide.

This section **SHALL** also declare the coverage volume of the system.

This section **SHALL** also declare any additional communication services offered for AMS(R)S use.

These declarations will serve as a summary of the compliance details indicated in the next section.

5.2.2.2 Section 2.2 – Compliance Details

This section **SHALL** contain a series of tables that declare compliance with the CSP-level system requirements contained in Section 2 above and declare such additional performance as may be desired. The start of a sample *pro-forma* table for the requirements of Section 2.3.1 is shown in Table 5-1. For each requirement in the Section 2 Compliance table, the system-specific material shall indicate one of the following four levels of compliance:

C Complies with the requirement

E Exceeds the requirement, that is, offers significantly *better* performance than the minimum required in Section 2. In cases where system-specific material indicates **E**, the more stringent performance parameter **SHALL** be clearly declared, and **SHALL** become the requirement for the system under discussion. For the purpose of the system-specific declarations, an **E** level **SHALL** be declared when the offered performance is more than 20% better than the requirement in Section 2. For example, a system that claims a TWO WAY TRANSIT DELAY of 65 seconds would be 35% better than the requirement D10, and should declare an **E** level of compliance. Systems are not *required* to declare any **E** levels. In this example, the system-specific material could claim a **C** level, but then would not be able to take advantage of the 65 second transit delay in any associated analysis.

M Marginally does not comply with the requirement. In cases where system-specific material indicates **M**, the less stringent performance parameter **SHALL** be clearly declared, and **SHALL** become the requirement for the system under discussion. For the purpose of the system-specific declarations, "marginal non-compliance" means a capability that is no more than 20% worse than the performance requirement of Section 2. For example, a system that claims a TWO WAY TRANSIT DELAY of 115 seconds would be 15% worse than requirement D10, but might still be acceptable for certain applications. In this case, the system-specific material should indicate an **M** level of compliance.

NC Does not comply with the stated Section 2 requirement. Systems that cannot meet the 20% threshold of an **M** requirement must declare **NC.** For example, a system that could provide a TWO WAY TRANSIT DELAY of 125 seconds would miss the requirement of D10 by 25%, and therefore would have to declare an **NC** with respect to that requirement.

Table 5-1: *Pro-Forma* Compliance and Declaration Table

ID from Sect. 2	Requirement Title from Section 2	System-Specific Declared Value	Compliance Level	Verification Plan Reference
D10	RCP240 CPDLC TT			
D20	RCP240 CPDLC ET			
D30	RSP180 ADS TT			
D40	RSP180 ADS ET			
Etc.	Etc.			

In completing Table 5-1, the requirement identification (Reqt. ID) and the Requirement Title from Section 2 **SHALL** be retained. The system-specific declared value shall be the level of performance achieved by the system under description, and shall become a requirement for that system. The Compliance level will be in accordance with the instructions given above. The table **SHALL** contain a reference to the section(s) of system-specific verification plan(s) that discuss(es) verification of this requirement.

In each case of an indication of C, M, or NC, this section of the system-specific material **SHALL** contain a brief explanation and rationale of the indicated performance. This is intended to be a summary only; additional explanation will be required later in the system-specific material.

In addition to the *pro-forma* table summarizing compliance with the requirements of Section 2, above, this section **SHALL** contain additional *pro-forma* tables indicating equivalent performance requirements for additional communication services offered by the system under consideration. The format for these tables is indicated in Table 5-2.

Table 5-2: *Pro-Forma* Declaration Table for System-Specific AMS(R)S Services

ID	Service Requirement Title	System-Specific Requirement Text	Verification Plan Reference

In completing Table 5-2, a unique requirement identification (ID) and Requirement Title from Section 2 **SHALL** be assigned/declared. The system-specific service requirement **SHALL** be clearly and unambiguously stated. The statement of Section 2 requirements may be used as a model for appropriate statement of requirements. The system-specific declared value **SHALL** be the level of performance achieved by the system under description, and **SHALL** become a requirement for that system. The table **SHALL** contain a reference to the section(s) of system-specific verification plan(s) that discuss(es) verification of this requirement.

Note: Preparers of system-specific material are not required to offer additional safety services, but when such services are offered the requirements need be declared as described above. In case where additional safety service are not offered, the system-specific material should simply state that no additional services are specified. In that case, Table 5-2 may be deleted from the system-specific material.

5.2.3 Section 3 - System Design and Description

This section **SHALL** contain a description of the system design sufficient to 1) permit review of the design for its ability to provide AMS(R)S, and 2) to inform potential users of how the system will achieve the parameter values declared in response to Section 5.2.2 and Table 5-1. At a minimum this content shall include the following:

- a description of the satellites, orbit(s), constellation, and spot beam pattern/usage
- geographic coverage area or areas; a map or series of maps may be appropriate for conveying this information

- a summary of the operational environment, including such features as the number of aircraft, minimum aircraft spacing, radio frequency interference environment seen by individual aircraft within the environment, etc.
- a summary of the CNP-level network
- a description of the underlying SSP communication ground network
- a summary of the satellite-aircraft-satellite air interface
- a summary of the capacity of the CNP and SSP networks in terms of the number and mix of aircraft in a specific procedural airspace[6] that could be served with the mandatory services and the approximate average throughput to and from the aircraft under such conditions
- a summary of the CNP and SSP network support for priority, precedence, and preemption of aeronautical services.

In addition, this section of the system-specific material **SHALL** contain an allocation to at least the CNP and SSP level of any parameter declared as **E** or **M,** and a rationale concerning the appropriate nature of such an allocation.

This section **SHALL** also contain a description of how ATSP and aircraft operators can effectively use the system for AMS(R)S in spite of any parameters declared as **NC** in response to Section 5.2.2 and Table 5-1.

Parameters that are declared to the **C** level may be partitioned if desired, but such partitioning is not required.

As part of any required or optional partitioning to lower levels of the system design, the system-specific material **SHALL** include a clear statement of how the performance of lower-level systems is combined to achieve the overall system performance, and a rationale for such combination.

The system-specific material in this section may be organized in order and outline in the matter most appropriate to the preparer of the material, provided that the content requirements are satisfied.

5.2.4 Section 4 - Verification Plans

5.2.4.1 Section 4.1 - Pre-approval Verification Plan

This plan **SHALL** describe how the system performance declared in response to Section 5.2.2 and Table 5-1, will be verified prior to approval by appropriate regulatory bodies. A description of system design features that facilitate the collection and reporting of performance data **SHALL** be included with this plan.

Representative data may be contained within this section, if desired.

5.2.4.2 Section 4.2 – Post Implementation Monitoring Plan

This plan **SHALL** describe how the system performance declared in response to Section 5.2.2 and Table 5-1 will be monitored during on-going operation of the system as an AMS(R)S provider. A description of system design features that facilitate the collection and timely reporting of performance data during system operation **SHALL** be included with this plan. To the extent that such features have already been described in the previous section, they may be referenced.

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[6] It is strongly recommended that the North Atlantic airspace be taken as the representative airspace.

5.2.5 Appendices - Associated Appendices

The system-specific material may contain appendices that expand on topics discussed in response to these instructions. Examples of possible appendix content might include a detailed model of the radio-frequency environment, an aircraft- and data-level traffic model substantiating the system description, detailed rationale regarding the partition to or combining of subsystem requirements, etc. Appendices are permitted, but not required

APPENDIX A - MEMBERSHIP

APPENDIX B - GLOSSARY OF ACRONYMS

{Editor's Note: Not updated for Version 2.2]

ACRONYM	DEFINITION	FIRST USE, OR, ADDITIONAL INFORMATION
A	Analysis	4.1
AAC	Airline Administrative Control	2.3.2
A2G	Air to Ground	Figure 1-1, Figure 1-2
ACARS	Aircraft Communications and Reporting System	2.3.1
ADS	Automatic Dependent Surveillance	1.7
ADS-B	Automatic Dependent Surveillance Broadcast	1.7
ADS-C	Automatic Dependent Surveillance (Contract)	1.7
AES	Aircraft Earth Station	1.7
AMS	Audio Management System	1.3
AMS(R)S	Aeronautical Mobile Satellite (Route) Service	1.7
ANSI	American National Standards Institute	1.8
APC	Aeronautical Passenger Communications	2.3.2
AOC	Airline Operational Control	2.3.2
ASA	American Standards Association	1.8
ATS	Air Traffic Service(s)	1.7
ATSP	Air Traffic Service Provider	1.7
BT	Bench Test	4.1
C	Complies (with requirement)	5.2.2
CLI	Caller Line Identification	2.3.2
CMU	Communications Management Unit	1.3
CNP	Communications Network Provider	1.71.7
CPDLC	Controller-Pilot Data Link Communications	1.7
CSP	Communications Service Provider	1.7
DRT	Dynamic Rhyme Test	2.3.2
E	Exceeds (requirement)	5.2.2
EMG	Emergency	2.3.2
ET	Expiration Time	2.3.1
FAA	(US) Federal Aviation Administration	1.4
FT	Flight Test	4.1
G2A	Ground-to-Air	Figure 1-1
GOLD	Global Operational Data Link Document	1.1
GOS	Grade of Service	1.7
I	Inspection	4.1
ICAO	International Civil Aviation Organization	1.1
ID	Identification	2.3.1
ITU	International Telecommunications Union	1.7
M	Marginal (compliance with requirement)	5.2.2
MASPS	Minimum Aviation System Performance Standard	1.1
MOPS	Minimum Operational Performance Standard	1.1
NATS	(UK) National Air Traffic Services	**Error! Reference source not found.**
NC	Non-Compliant (with requirement)	5.2.2
NGSS	Next Generation Satellite System	1.1
NT	(Ground) Network Test	4.1
OT	Operational Test	4.1

PMC	(RTCA) Program Management Committee	Foreword
PSR	Primary Surveillance Radar	1.7
RCP	Required Communication Performance	1.7
RCTP	Require Communications Technical Performance	**Error! Reference source not found.**
RF	Radio Frequency	2.2.3
RSP	Required Surveillance Performance	1.7
SARPs	(ICAO) Standards and Recommended Practices	1.1
SSP	Satellite Service Provider	1.7
SSR	Secondary Surveillance Radar	1.7
SVGM	Satellite Voice Guidance Material	1.3
TRN	(AMS(R)S) Transaction	1.4
TT	Transaction Time	2.3.1
VHF	Very High Frequency	2.2.2

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ATTACHMENT 1

MINIMUM AVIATION SYSTEM PERFORMANCE STANDARD FOR AMS(R)S DATA AND VOICE COMMUNICATIONS SUPPORTING REQUIRED COMMUNICATIONS PERFORMANCE (RCP) AND REQUIRED SURVEILLANCE PERFORMANCE (RSP) IN PROCEDURAL AIRSPACE

INMARSAT SWIFTBROADBAND

Prepared by SC-222

Version draft 4, SC-222/WP-096, November 28, 2012 – update post SC222 plenary 27 November

RTCA Paper No. 232-12/SC222-023

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Copies of this document may be obtained from

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Comment [asb1]: Ask RTCA if this and page iii needed, and general format of an attachment.

Foreword

This report was prepared by Special Committee 222 (SC-222) and approved by the RTCA Program Management Committee (PMC) on mm, dd, yy.

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;

- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunications Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

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APPENDICES

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1 INTRODUCTION

1.1 Objective & Scope

This attachment contains system specific material for support of AMS(R)S using the Inmarsat SwiftBroadband (SBB) system. The Inmarsat SBB system also provides non safety services although the focus of this attachment is AMS(R)S (i.e. safety services). This attachment complies in format to Section 5 of the main body of this document.

1.2 Document Overview

Section 1 is an introduction and overview of the system specific material and of the Inmarsat SBB system.

Section 2 is a compliance matrix to the requirements of the main body of this document.

Section 3 presents the system design and description.

Section 4 is the verification plan.

Appendix A contains a glossary of acronyms.

Appendix B contains an Interference Model for Emissions Associated with Ancillary Terrestrial Component (ATCt) Ground Stations.

1.3 SwiftBroadband System Overview

The Inmarsat SBB system provides data and voice communication services that will enable widespread implementation of the 30-30nm separation standards for oceanic operations along international air routes. Data communication (using ACARS)[1] complies with the RCP240 and RSP180 requirements in GOLD, while voice communications complies with the RSP400/V requirements in SVGM.

SBB is composed of four segments:

- Airborne (or user) segment known as an Aircraft Earth Station (AES).
- The satellites.
- The Inmarsat ground infrastructure.
- The Communication Network Provider’s (CNP’s) ground infrastructure.

The SBB data and voice communication services described in this document are delivered between the AES avionics interface and the CNPs’ ATSP/airline interfaces as shown in Figure 1-1 of the main body of this document.

SBB is delivered over the Inmarsat-4 (3 satellites launched between 2005 and 2008) and Alphasat (expected to be launched in 2013) satellites using user links in the L band and feeder links in C band. The satellites are geosynchronous with inclination typically less than 3 degrees, and provide worldwide coverage with the exception of polar regions. Key aspects of the I4 satellites are a single 9m aperture antenna and a transparent, bent-pipe, digital signal processor (DSP) that performs the channelization and beamforming functions. Each satellite provides a global beam, 19 regional beams and typically 192 narrow spot beams.

SBB provides the following services[2]:

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[1] ICAO standards for the detailed required communications performance of IP links and services do not exist. Hence this attachment presents, in Section 3, Inmarsat’s internal performance requirements for the SBB prioritized IP service.

[2] Non safety services are described in Section 3.1.5.

- ACARS data.
- Voice.
- Prioritized IP. Both standard and streaming are offered.

Four classes of AES are defined:

- Class 4 which uses an Enhanced Low Gain Antenna (ELGA).
- Class 7 which uses an Intermediate High Gain Antenna (IGA).
- Class 6 which uses an High Gain Antenna (HGA).
- Class 6 with Classic Aero reversion capability which uses an High Gain Antenna (HGA).

Inmarsat owns and operates the satellite ground infrastructure and delivers traffic at Meet Me Points (MMPs) to CNPs such as ARINC and SITA. The CNPs provide key elements of the end to end ACARS and Voice service and deliver traffic to ATSPs and airlines.

SBB is based on UMTS 3G technology and delivers standard 3G voice and IP data services. In addition, gateway functions are included that utilize the 3G bearer services to provide the ACARS service and the VoIP component of the voice service.

SBB shares the same satellite and ground infrastructure that is used to deliver similar services to other market segments (enterprise (also known as land portable), land mobile and maritime). The enterprise service is known as BGAN (Broadband Global Area Network) and this term is often used to describe the totality of the system across all market segments. The maritime service is known as FleetBroadband.

AESs that incorporate Classic Aero reversion capability are designed for tight interoperability with the Classic Aero service operating on the I3 and I4 satellites, and these AESs may seamlessly switch between the three networks.

1.4 Definition of Terms

Please see Section 1.7 of the main body of this document.

1.5 Reference Documents

Please see Section 1.8 of the main body of this document.

2 COMPLIANCE

2.1 Compliance Summary

For those AESs without Classic Aero reversion capability, SBB is designed to meet at service introduction:

- Data services: RCP240, RCP400, RSP180, and RSP400[3] for operational safety.
- Voice services: RCP400/V, RSP400/V for operational safety.
- Prioritized IP services: as described in Section 2.2.3.3.

After a period of time in Post-Implementation Monitoring, for those AES without Classic Aero reversion capability, SBB is designed to meet additionally:

- Data services: RCP240, and RSP180 for operational efficiency.

For those AESs with Classic Aero reversion capability, the combined Classic and SBB service is designed to meet at service introduction all the above services.

The above services are met over the coverage area shown in Figure 2-1 for AESs that are in straight and level flight. This area represents a 5º elevation angle to the satellites.

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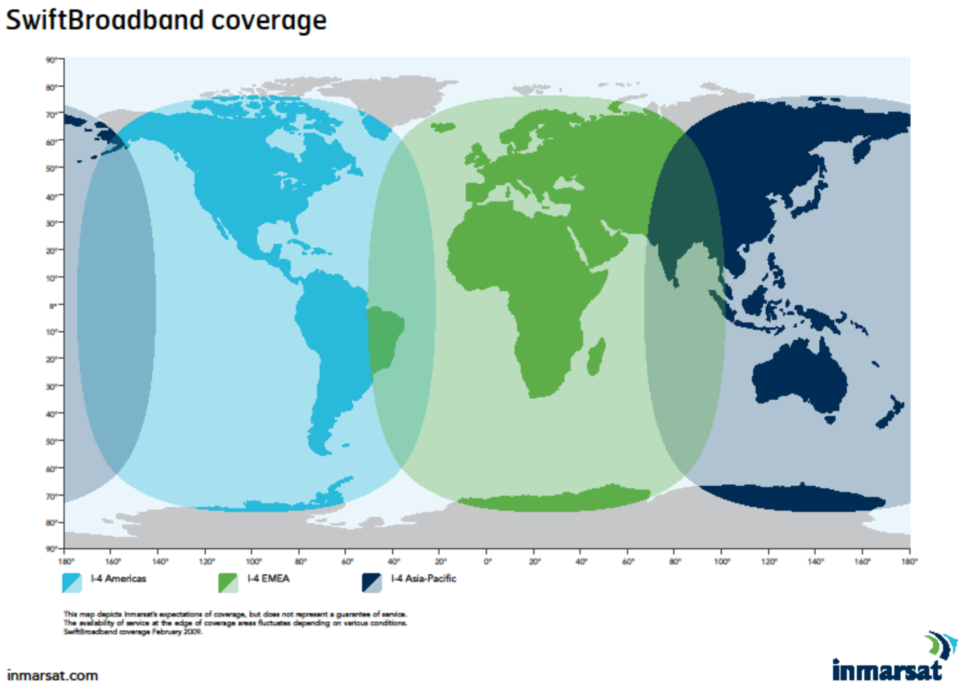
[3] The driving requirements for SBB are RCP240 and RSP180. Since RCP400 and RSP400 are a ‘subset’ of RCP240 and RSP180 respectively, then SBB also meets these requirements.



This map depicts Inmarsat's expectations of coverage, but does not represent a guarantee of service.
The availability of service at the edge of coverage areas fluctuates depending on various conditions.
SwiftBroadband coverage February 2009.

Figure 2-1: SBB Coverage

2.2 Compliance Details

2.2.1 General Requirements

Compliant

2.2.2 Standard Operating Conditions

2.2.2.1 Traffic Environment

Compliant subject to ATSPs providing the traffic environment.

2.2.2.2 Procedural Airspace

Compliant

2.2.2.3 Radio Frequency Spectrum

Compliant

2.2.2.4 Radio Frequency Environment

Complaint

2.2.3 Standard Services

The tables in this section declare the compliance to the requirements in Section 2 of the main body of the document using the codes shown in Section 5 of the main body of the document. Performance is met throughout the coverage area shown in Figure 2-1.

2.2.3.1 Data Services

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
D10	RCP240 CPDLC TT	The **SYSTEM**, if used for RCP240 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 100s or better for 95% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.2.1.2	100s/95%	C	4.2
D20	RCP240 CPDLC ET	The **SYSTEM**, if used for RCP240 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 120s or better for 99.9% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.2.1.2	120s/99.9%	C	4.2
D30	RSP180 ADS TT	The **SYSTEM**, if used for RSP180 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 84s or better for 95% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.2.1.2	84s/95%	C	4.2
D40	RSP180 ADS ET	The **SYSTEM**, if used for RSP180 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 170s or better for 99.9% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.2.1.2	170s/99.9%	C	4.2
D50	RCP400 CPDLC TT	The **SYSTEM**, if used for RCP400 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 240s or better for 95% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.3.1.2	100s/95%	C	4.2

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
D60	RCP400 CPDLC ET	The **SYSTEM**, if used for RCP400 applications, **SHALL** provide a **TWO-WAY TRANSIT DELAY** of 280s or better for 99.9% of all CPDLC messages transmitted by the ATSP as measured in a 1-month period.	GOLD B.3.1.2	120s/99.9%	C	4.2
D70	RSP400 ADS TT	The **SYSTEM**, if used for RSP400 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 270s or better for 95% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.3.1.2	84s/95%	C	4.2
D80	RSP400 ADS ET	The **SYSTEM**, if used for RSP400 applications, **SHALL** provide a **ONE-WAY TRANSIT DELAY** of 340s or better for 99.9% of all ADS-C messages transmitted by the aircraft as measured in a 1-month period.	GOLD C.3.1.2	170s/99.9%	C	4.2
D90	ADS & CPDLC Availability Safety	The **SYSTEM**, if used for Operational Safety, **SHALL** provide a **NETWORK AVAILABILITY**[4] of 0.999 or better as measured in a 12-month period.	GOLD B.2.1.2 GOLD B.3.1.2 GOLD C.2.1.2 GOLD C.3.1.2	0.999	C	4.2

---

[4] See Section 4.2.9 for the computational method for availability where there is an outage over part of the network.

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
D100	ADS & CPDLC Availability Efficiency	The **SYSTEM**, if used for Operational Efficiency, **SHALL** provide a **NETWORK AVAILABILITY** of 0.9999 or better as measured in a 12-month period.	GOLD B.2.1.2 GOLD C.2.1.2	0.9999 for AES with Classic backup 0.9999 for AES without Classic backup after a period of time in Post-Implementation Monitoring 0.999 for AES without Classic backup at initial service introduction	C C NC	4.2
D110	RCP240 & RSP180 Number Unplanned Outages Safety	The **SYSTEM**, if used for RCP240 or RSP180 applications for Operational Safety, **SHALL** have no more than 48 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	GOLD B.2.1.2 GOLD C.2.1.2	48	C	4.2
D120	RCP400 & RSP400 Number Unplanned Outages	The **SYSTEM**, if used for RCP400 or RSP400 applications, **SHALL** have no more than 24 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	GOLD B.3.1.2 GOLD C.3.1.2	24	C	4.2

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
D130	RCP240 & RSP180 Number Unplanned Outages Efficiency	The **SYSTEM**, if used for Operational Efficiency, **SHALL** have no more than 4 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.[5]	GOLD B.2.1.2 GOLD C.2.1.2	4 for AES with Classic backup	C	4.2
				4 for AES without Classic backup after a period of time in Post-Implementation Monitoring	C	
				48 for AES without Classic backup at initial service introduction	NC	
D140	RCP240 & RSP180 Unplanned Notification Time	The **SYSTEM,** if used for RCP240 or RSP180 applications, **SHALL** provide notification to **ATSP**s within 5 minutes of an **UNPLANNED OUTAGE**.	GOLD B.2.1.2 GOLD C.2.1.2	5mins	C	4.2
D150	RCP400 & RSP400 Unplanned Notification Time	The **SYSTEM,** if used for RCP400 or RSP400 applications, **SHALL** provide notification to **ATSP**s within 10 minutes of an **UNPLANNED OUTAGE**.	GOLD B.3.1.2 GOLD C.3.1.2	5mins	C	4.2

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[5] There is no requirement to monitor outages of individual aircraft. Outages shall be monitored at the network level.

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
D160	ADS & CPDLC Data Addressing	The **SYSTEM SHALL** use the ICAO 24-bit aircraft address as the addressing mechanism for ACARS data.	ICAO SARPS 12.7.1		C	4.2
D170	ADS & CPDLC Data Test Points	The **SYSTEM SHALL** include suitable test points to allow measurement of **TRANSIT DELAY**.			C	4.2
D180	ADS & CPDLC Data Analysis	The **SYSTEM SHALL** include analysis capability for verification and post implementation monitoring to demonstrate compliance with requirements D10 to D80.	GOLD Appendix D		C	4.2

2.2.3.2 Voice Services

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
V10	Voice G/A Call Set Up 95%	The **SYSTEM SHALL** provide a ground to air **CALL SET UP TIME** of 25s or better for 95% of call set up attempts as measured in a 1-month period.	SVGM	25s/95%	C	4.2
V20	Voice G/A Call Set Up 99%	The **SYSTEM SHALL** provide a ground to air **CALL SET UP TIME** of 30s or better for 99% of call set up attempts as measured in a 1-month period.	SVGM	30s/99%	C	4.2

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
V30	Voice A/G Call Set Up 95%	The **SYSTEM SHALL** provide an air to ground **CALL SET UP TIME** of 10s or better for 95% of call set up attempts as measured in a 1-month period.	SVGM	10s/95%	C	4.2
V40	Voice A/G Call Set Up 99%	The **SYSTEM SHALL** provide an air to ground **CALL SET UP TIME** of 15s or better for 99% of call set up attempts as measured in a 1-month period.	SVGM	15s/99%	C	4.2
V50	Voice Dropped Call Rate	The **SYSTEM SHALL** provide a **DROPPED CALL RATE** of 0.01 or better as measured in a 1-month period.	SVGM	0.01	C	4.2
V60	Voice Grade of Service	The **SYSTEM SHALL** provide a **GRADE OF SERVICE (GOS)** of 0.01 or better as measured during the busy hour of any month.	SVGM ICAO SARPS	0.01	C	4.2
V70	Voice Quality	The **SYSTEM SHALL** provide a mean intelligibility DRT (Diagnostic Rhyme Test) score of at least 85 when measured in accordance with ANSI/ASA S32-2009 in a jet transport aircraft noise environment.		85	C	4.2
V80	Voice Latency	The 1-way **VOICE LATENCY** of the System **SHALL** be 0.485 seconds or better in both the air to ground and ground to air direction.	ICAO SARPS.	0.585 sec 1st call 0.750 sec 2nd call	NC[6]	4.2
V90	Voice Availability	The **SYSTEM SHALL** provide a **NETWORK AVAILABILITY** of 0.999 or better as measured in a 12-month period.	SVGM	0.999	C	4.2

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[6] Although the system is non compliant to the ICAO SARPS requirement, it is believed the system is fit for purpose. The original justification for the SARPS requirement is not known, although it is suspected to be either based on VHF or what was achieved by the Classic Aero 9.6kbps codec. It is further noted that Classic Aero has been measured as achieving 0.59 sec for the 4.8kbps codec. The ICAO SARPS requirement is for the 'subnetwork' while this specification includes the ground network, although the latter is not expected to add a significant delay.

ID	Title	Requirement	Reference / Source	System-Specific Declared Value	Compliance Level	Verification Plan Reference
V100	Voice Number Unplanned Outages	The **SYSTEM SHALL** have no more than 24 **OPERATIONALLY SIGNIFICANT UNPLANNED OUTAGES** in a 12-month period.	SVGM	24	C	4.2
V110	Voice Unplanned Notification Time	The **SYSTEM SHALL** provide notification to **ATSP**s within 10 minutes of an **UNPLANNED OUTAGE**.	SVGM	10mins	C	4.2
V120	Voice Addressing	The **SYSTEM SHALL** use the ICAO 24-bit aircraft address as the addressing mechanism for voice.	ICAO SARPS 12.7.1		C	4.2
V130	Voice Security	The **SYSTEM SHALL** provide security mechanisms to ensure that only authorized entities can call the aircraft cockpit.			C	4.2
V140	Voice CLI and Priority Indication	The **SYSTEM SHOULD** provide caller line ID and priority indication for ground to air calls.	SVGM		C	4.2
V150	Voice Priority Levels	The **SYSTEM SHALL** provide voice channels with three (3) additional levels of priority (i.e. a total of 4 including APC (Aeronautical Passenger Communications)) in both air-to-ground and ground-to-air directions, aligned with the relevant ICAO standards, namely AOC/AAC (Airline Operational Control/Airline Administrative Control), ATS (Air Traffic Services) and EMG (Emergency), that are all prioritized above cabin voice calling (APC).	SVGM		C	4.2

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2.2.3.3 Enhanced Services

Performance is met throughout the coverage area shown in Figure 2-1.

These requirements are not derived from the communication performance needed for current or planned operational applications. Instead they reflect the capability that Inmarsat is offering.

ID	**Title**	**Requirement**	**Reference / Source**
E10	Simultaneous services standard IP	Requirements E30-E80 SHALL be met while the AES simultaneously supports ACARS and two channels of voice.	
E20	Simultaneous services streaming IP	Requirements E90-E110 **SHALL** be met while the AES simultaneously supports ACARS and two channels of voice.	
E30	Priority IP TT Class 4	The **SYSTEM SHALL** provide a **ONE-WAY TRANSIT DELAY** of 10s plus $^{1}/_{9}$s[7] per kbit above 10kbits, or better, for 95% of all Priority IP standard messages to or from the aircraft for Class 4 (ELGA) AES as measured in a 1-month period.	
E40	Priority IP Standard ET Class 4	The **SYSTEM SHALL** provide a **ONE-WAY TRANSIT DELAY** of 15s plus $^{1}/_{7}$s per kbit above 10kbits, or better, for 99.9% of all Priority IP standard messages to or from the aircraft for Class 4 AES (ELGA) as measured in a 1-month period.	
E50	Priority IP Standard TT Class 7	The **SYSTEM SHALL** provide a **ONE-WAY TRANSIT DELAY** of 10s plus $^{1}/_{90}$s per kbit above 10kbits, or better, for 95% of all Priority IP standard messages to or from the aircraft for Class 7 AES (IGA) as measured in a 1-month period.	

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[7] Fractions are used to make the requirement more understandable. The data rate, after the first 10kbits, is 9kbits/s, but the requirement is worded in terms of delay since that is the performance parameter of interest.

ID	**Title**	**Requirement**	**Reference / Source**
E60	Priority IP Standard ET Class 7	The **SYSTEM SHALL** provide a **ONE-WAY TRANSIT DELAY** of 15s plus $^1/_{70}$s per kbit above 10kbits, or better, for 99.9% of all Priority IP standard messages to or from the aircraft for Class 7 AES (IGA) as measured in a 1-month period.	
E70	Priority IP Standard TT Class 6	The **SYSTEM SHALL** provide a **ONE-WAY TRANSIT DELAY** of 10s plus $^1/_{135}$s per kbit above 10kbits, or better, for 95% of all Priority IP standard messages to or from the aircraft for Class 6 AES (HGA) as measured in a 1-month period.	
E80	Priority IP Standard ET Class 6	The **SYSTEM SHALL** provide a **ONE-WAY TRANSIT DELAY** of 15s plus $^1/_{110}$s per kbit above 10kbits, or better, for 99.9% of all Priority IP standard messages to or from the aircraft for Class 6 AES (HGA) as measured in a 1-month period.	
E90	Priority IP Steaming rate Class 4	The **SYSTEM SHALL** provide streaming rates[8] of 12 kbits/sec to the aircraft and 8 kbits/sec from the aircraft for Class 4 AES (ELGA).	
E100	Priority IP Steaming rate Class 7	The **SYSTEM SHALL** provide streaming rates of 160kbits/sec to the aircraft and 96kbits/sec from the aircraft for Class 7 AES (IGA).	
E110	Priority IP Steaming rate Class 6	The **SYSTEM SHALL** provide streaming rates of 192kbits/sec to the aircraft and 112kbits/sec from the aircraft for Class 6 AES (HGA).	
E120	Priority IP Streaming Delay	Streaming services for all classes **SHALL** have a round trip delay of 1000ms or less as measured in a 1-month period.	

---

[8] Available PDP context rates start at 4kbits/sec, and then double (e.g. 4, 8, 16, 32....). The rates shown here assume the AES requests multiple PDP contexts (e.g. 12=8+4, 92=64+32, 112=64+32+16, 160=132+32, 192=128+64) - the AES may request a lower rate.

ID	Title	Requirement	Reference / Source
E130	Priority IP Streaming Jitter	Streaming services for all classes **SHALL** have a jitter of 40ms or less as measured in a 1-month period.	
E140	Priority IP Streaming Packet Loss	Streaming services for all classes **SHALL** have a packet loss rate of 0.001 or less as measured in a 1-month period.	
E150	Priority IP Streaming Call Connect Ratio	Streaming services for all classes **SHALL** have a call connect ratio of 0.99 or higher as measured in a 1-month period.	
E160	Priority IP Streaming Dropped Call Rate	Streaming services for all classes **SHALL** have a dropped call rate of 0.01 or less as measured in a 1-month period.	
E170	Priority IP Streaming Call Connect Time	Streaming services for all classes **SHALL** have a call connect time of 3s or better for 99% of call set up attempts as measured in a 1-month period.	
E180	Priority IP Availability	The **SYSTEM SHALL** achieve a **NETWORK AVAILABILITY** of 0.999 or better as measured in a 12-month period.	

3 SYSTEM DESIGN AND DESCRIPTION

3.1 Telecommunication Services

3.1.1 Introduction

The primary aim of the system is to provide a highly available, high priority ACARS link for the reliable and safe transfer of ATS messages that meets RCP240 and RSP180 performance requirements. Voice services to the cockpit are also provided to the same level as currently provisioned via Classic Aero. In addition a Prioritized IP service is offered supporting new ATS/AOC applications.

The SBB data and voice communication services are delivered between the AES' avionic interface, and the CSPs' ATSP/airline interfaces i.e. between points C/F and A/H in Figure 1-2 of the main body of this document.

All of the SBB services utilize appropriate priority and pre-emption mechanisms to ensure guaranteed access in congestion situations.

The SBB service consists of:

- ACARS data service.
- Voice service.
- Prioritized IP Service.

These are described in the following subsections.

3.1.2 ACARS data service

The ACARS data service is a high availability data service with priority and pre-emption supporting ATS and AOC ACARS applications at RCP240 and RSP180 performance levels. The ground side interface to the ATSP/airlines is ARINC 618 over ARINC 620. The airside interface to the CMU is ARINC 620 over Williamsburg over ARINC 429. Both the air and ground side interfaces are the same as for Classic Aero and hence the use of Classic Aero or SBB for ACARS is transparent to pilots and ground users. The service handles one ACARS block at a time to an aircraft due to the ARINC 620 limitation of being a 'stop and wait' protocol.

3.1.3 Voice service

The voice service provides two channels of prioritized voice to the cockpit. In addition, the following security provisions are provided: ciphering on the air interface to provide confidentiality, and use of PINs on ground to air calls to restrict access to calling the cockpit from non-authorized callers. The ground side interface is via the PSTN whilst the airside interface is typically analog 4 wire voice and ARINC 429 control. Both the air and ground side interfaces are the same as for Classic Aero, including addressing using the ICAO 24-bit aircraft address, and hence the use of Classic Aero or SBB for voice is transparent to pilots and ground users.

3.1.4 Prioritized IP Service

The Prioritized IP Data service supports IP based applications that require a timely and prioritized service compared to the non safety SBB IP service. Examples of this might be:

- New ATS applications.
- New AOC applications.
- Meteorological applications.

- Engine data.
- Flight data downloaded after a critical event.

Both fixed rate (streaming) and variable bit rate (standard) IPv4 services are provided.

The standard IP service class is a variable bit rate IP service. It is also known as background class. Capacity is allocated dynamically by the network on the basis of the user's demand, the user's current link quality and the competing demands of other users sharing the same L-Band frequency in the same spot-beam. The background class connection provides reliable in-order delivery over the satellite, i.e. any data lost due to random errors on the radio link is automatically retransmitted and re-ordered by the SBB infrastructure before being presented to the user.

The streaming class IP service is a fixed bit rate IP service. The user sets the bit rate at the start of the connection and this rate is fixed for the duration of that connection. This class is designed for real-time applications that benefit from low delay variations but can tolerate a somewhat higher packet error rate.

3.1.5 Non Safety Services

In addition non safety services are provided by the network. The totality of the SBB services offered by the network is shown in Figure 3-1.

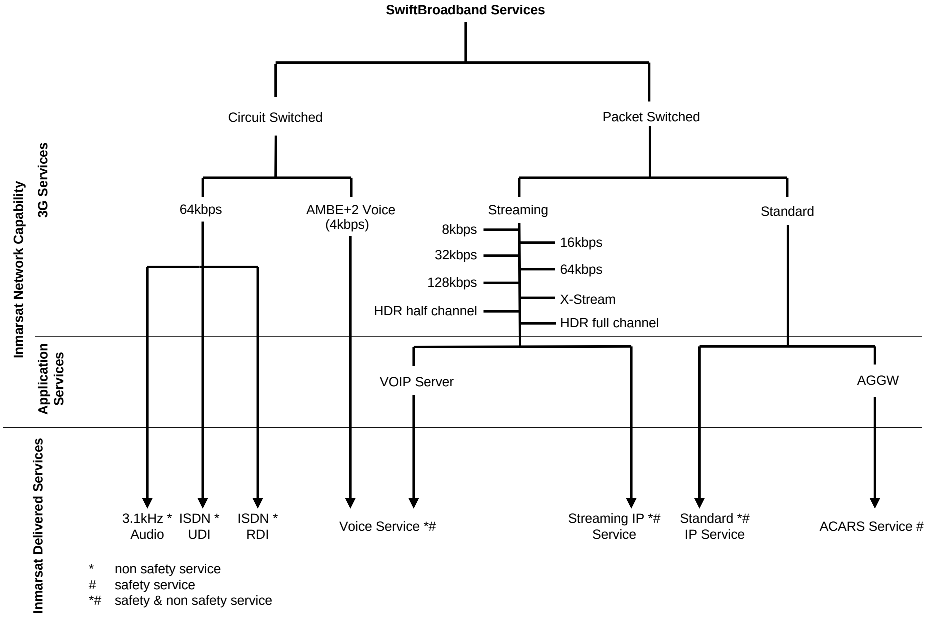

Figure 3-1: SBB Services (Including Non Safety Services)

Note: An AES may not provide all the services shown.

3.2 Physical System Architecture

SBB is composed of four segments as shown in Figure 3-2:

- Airborne (or user) segment known as an Aircraft Earth Station (AES).
- The satellites.
- The Inmarsat ground infrastructure.
- The Communication Network Providers' (CNPs) ground infrastructure.

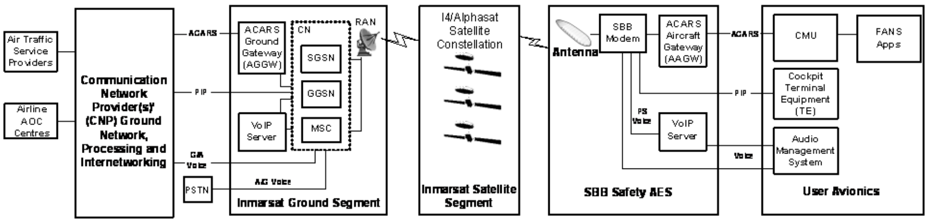

Figure 3-2: SBB Architecture

Note: Non safety services are not shown.

3.2.1 Airborne segment

The airborne segment is known as the Aircraft Earth Station (AES) and consists of all the functionality to translate the RF signal in space to the baseband voice and data interfaces into the aircraft.

There are four classes of AES which are described in Section 1.3.

The key logical components of the AES are:

- Antenna.
- Diplexer.
- High Power RF Amplifier.
- Up/ down converters.
- Modems.
- ACARS gateway.
- VoIP gateway.
- Data interfaces.
- Voice interfaces.

A more detailed description of the AES can be found in the RTCA DO-262B MOPS. ARINC Characteristic 781 avionics is a typical implementation of the AES which consists, for the large form factor variant, of an antenna, a Diplexer/Low Noise Amplifier (DLNA), a Satellite Data Unit (SDU), an SDU Configuration Module (SCM), and an optional Flange Mount High Power Amplifier (FMHPA). A small form factor variant is also defined in ARINC Characteristic 781 which consists of small antenna, a small Satellite Data Unit (SDU), an SDU Configuration Module (SCM), and an optional High Power Amplifier/Low Noise Amplifier/Diplexer (HLD).

The ACARS gateway function is responsible for:

- Encapsulating ACARS messages into a PDP context.

- For an AES that also supports Classic Aero, choosing which Inmarsat sub-network (Classic Aero or SBB) to use.

The VoIP gateway function is responsible for:

- Providing the VoIP function to support a 2nd voice channel when required.

Security requirements and suggested security architectures can be found in ARINC Characteristic 781 attachment 8, which shows methods of segregation of different security domains that are sharing a common SBB 'channel card'.

Two examples of SBB AES, based on ARINC Characteristic 781 architectures, are shown below.

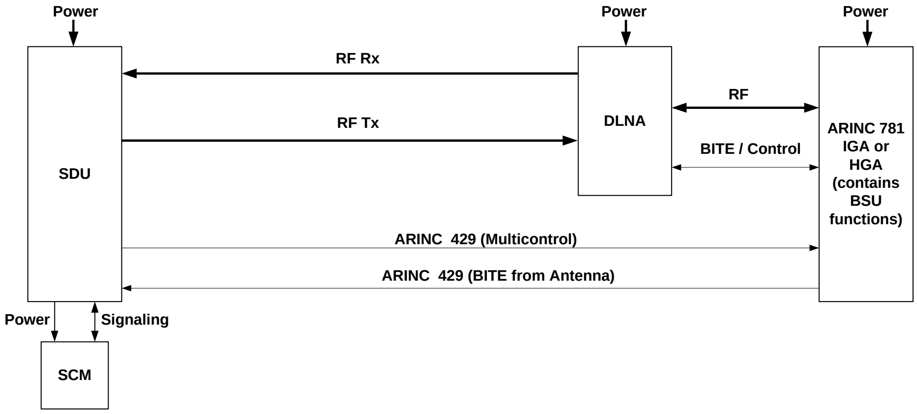

Figure 3-3: AES (ARINC 781 Large Form Factor Architecture without FMHPA)

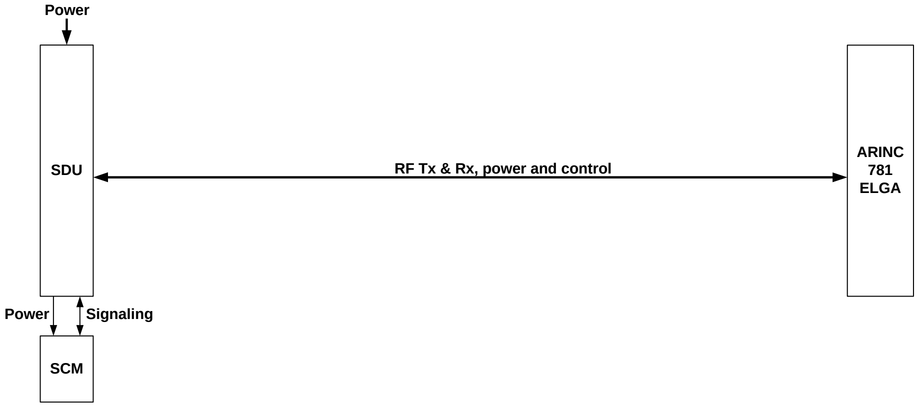

Figure 3-4: AES (ARINC 781 Compact System, Configuration 3)

3.2.2 Space Segment

The space segment consists of the I4 satellites and Alphasat in geostationary orbit as shown below:

Satellite	Coverage at 1 Jan 2013	Longitude at 1 Jan 2013[9]	Launch vehicle	Launch date
Inmarsat-4 F1	Asia-Pacific	143.5° east	Atlas V	11 Mar 2005
Inmarsat-4 F2	Europe, Middle-East, Africa	25° east	Sea Launch Zenit-3SL	8 Nov 2005
Inmarsat-4 F3	Americas	98° west	Proton-M/Briz-M	18 Aug 2008
Alphasat	Not launched	Not launched	Ariane	Expected 2013

Table 3-1: Inmarsat Satellites

3.2.2.1 I4 Satellites

The I4 satellites are based on Astrium’s Eurostar 3000 platform.

In order to minimize fuel consumption and reduce launch mass, the I4 satellites were launched into a 3° inclined orbit, such that inclination naturally reduces over time to 0°, when it starts to increase again. The orbit inclination is controlled to within 3° by using the spacecraft plasma propulsion subsystem for North/South station keeping, whilst chemical thrusters are used for East/West station keeping. The dry mass of the spacecraft is estimated at around 3400kg, with a separation mass in the region of 6000kg, depending on the launch vehicle. An artist’s impression of the I4 spacecraft in orbit is shown in Figure 3-5.

The I4 satellites were designed and procured to allow Inmarsat to introduce the BGAN family of services including SBB. The I4 satellites can also support existing Inmarsat services, with the exception of Inmarsat A services.

Figure 3-5: The Inmarsat 4 Spacecraft

3.2.2.1.1 Payload Architecture

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[9] Alphasat is planned to operate at 25° east. I4 satellite locations post Alphasat launch are not yet known.

A key feature of the Inmarsat 4 satellite is the single 9 m aperture unfurlable reflector, which, combined with the 120 element feed array, forms the L band antenna, used for both transmit and receive. The 9 m reflector is stowed during the launch and transfer orbit phases of the mission, and is deployed once the satellite is in geo-synchronous orbit. The use of a single reflector ensures that a high level of coverage congruency is provided between all transmit and receive beams. Two separate horns serve as the C band antennas, and separate phased arrays are used for the two SBAS navigational downlinks at the GNSS L1 and L5 frequencies.

The heart of the payload is a transparent, bent-pipe, digital signal processor (DSP) that performs the channelization and beamforming functions. The DSP provides very fine granularity in the allocation of bandwidth to the various beams, with 100 kHz channels[10], and also enables the generation of a variety of different types of beams, with the required pointing. The DSP also provides the capability to steer the antenna beams to accommodate the motion of the spacecraft when operating in inclined orbit. The channels can be combined to produce wider bandwidth channels, allowing Inmarsat to better match the power and bandwidth resources to the user requirements. The DSP also allows Inmarsat to tailor the satellite coverage and refine the beam sets, so as to better meet the traffic and service demands, and allows additional flexibility in dealing with any failed SSPA or LNA. The satellite channels are dynamically allocated to the various beams, allowing Inmarsat to cope with variable traffic patterns.

Figure 3-6 presents a simplified block diagram for the I4 payload. On the forward C-to-L link, the signals received from the SAS are received by the C band antenna, filtered and passed to the C band receiver. The amplified signal is filtered and down converted by the C band down converter and, after going through the required analogue-to-digital (A/D) converters, is fed to the DSP. The DSP is responsible for breaking the signals into the appropriate 200 kHz channels, and for applying the correct beam forming coefficients to each channel. The channelized and beamformed signals, after being converted to analog signals by digital-to-analog (D/A) converters, are then fed to the L band post-processor, which employs SAW technology to filter and convert the signals to L band, before feeding them to the Multi Port Amplifier (MPA). The MPA comprises Input Networks (INet), the solid-state power amplifiers (SSPAs) and the Output Networks (ONets) that amplify the signal, and feed it to the appropriate feed elements. The purpose of the MPA is to ensure a more even loading of the various SSPAs. The SSPAs are configured in groups of 5x4, providing the required redundancy.

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[10] In operation, channelization is normally set to 200kHz.

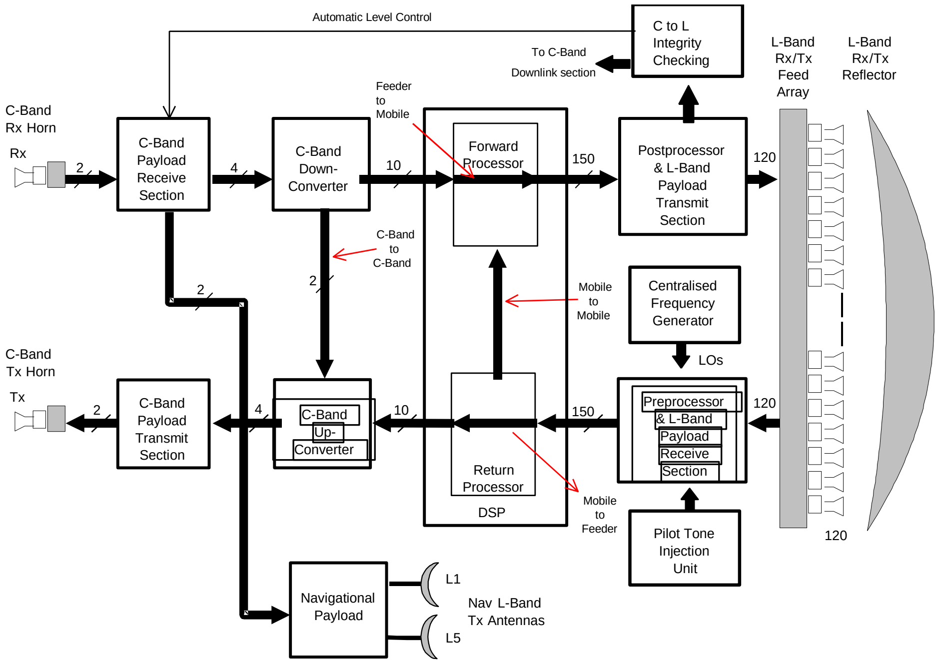


Figure 3-6: I4 Payload Block Diagram

The process on the return L-to-C link is symmetrical to that observed on the forward C-to-L link. Here, the signals received by the L band antenna are amplified by the low noise amplifiers (LNA) and fed to the L band pre-processor, which performs the required filtering and down-conversion of the signals to base-band, before passing them to A/D converters that feed the DSP. The DSP performs the required channelizing and beamforming functions, and passes the signals to the required D/A converters, which then feed the C band up-converter. High power SSPAs are used on the C band output section to provide the required amount of power to the C band antenna.

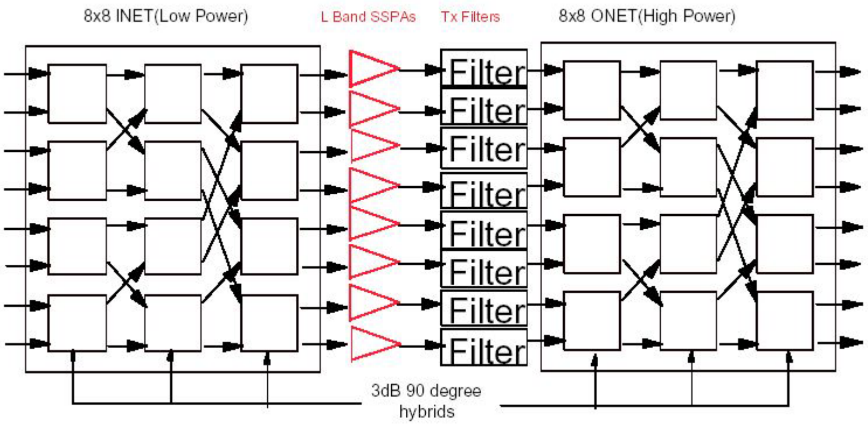


Figure 3-7: I4 MPA Configuration (Redundancy Not Shown)

In order to ensure that the drive level to the SSPAs is kept within the specified range, and the linearity performance is maintained, a power control loop samples the current driven by the L band SSPAs on the forward link, and controls the gain at the C band receivers, whilst on the return link automatic level control circuits are used on the C band SSPAs. The payload incorporates integrity checking units on both the forward and return links which check the continuity of each mobile element path. For the forward link, a C-band test carrier is fed to each L-band mobile element path, tapped off at the ONET output, and routed to the C band Link Integrity Checker (CLIC). The CLIC senses the signal at each of the 120 element paths, and feeds it to the C-band splitter, the output of which is linked to the C-band downlink for transmission back to the SAS. This allows the SAS to check the continuity of each transmit path with the minimum of on board hardware. On the return link a similar process is used, but the approach taken mimics that used on Inmarsat 3 satellites, whereby a test tone is generated by the payload itself and transmitted to the SAS at C-band.

In addition to the main Communications Payload, the I4 satellites also carry a Navigation Payload which is designed to support Satellite Based Augmentation System (SBAS) operations. The payload transmits satellite navigation signals at the GPS L1 and L5 frequencies which allows the real-time relay from on-ground monitoring networks of integrity and accuracy augmentation data for orbiting Global Navigation Satellite Systems (GNSS) such as GPS and GLONASS.

3.2.2.1.2 Frequency Plan And Channelization

Like all previous generations of Inmarsat satellites, the I4 spacecraft use L band for communication between the user terminals (UT) and the satellite, and C band for the feeder link between satellite and the Satellite Access Stations (SAS). Table 3-2 presents the Inmarsat 4 frequency bands.

	User Link	**Feeder Link**
	(MHz)	(MHz)
Uplink	1626.5 – 1660.5	6425.0 – 6575.0
Downlink	1525.0 – 1559.0	3550.0 – 3700.0

Table 3-2: I4 Frequency Bands

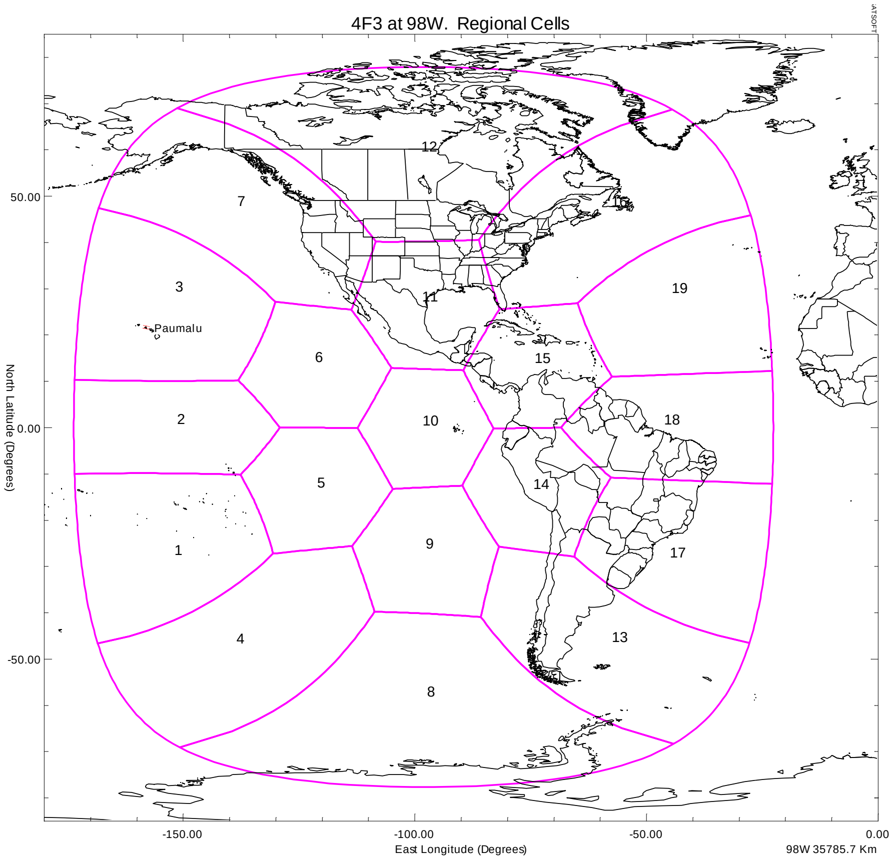
The I4 satellite, through the DSP, provides up to 630 x 200 kHz bi-directional channels for use in the C-to-L and L-to-C transponders. The DSP also allows for L-to-L links, enabling direct UT-to-UT calls. In addition, the I4 satellites also include a separate direct SAS-to-SAS link, providing 5 MHz of bandwidth, for direct C-to-C communications.

3.2.2.1.3 Satellite Beams

On the feeder link the Inmarsat 4 satellites provide two global beams, one being RHCP and the other being LHCP. The beams cover all the points within the satellite field of view with elevation greater than 5 degrees.

The user link, using RHCP, provides a global beam, regional spot beams and narrow spot beams. The global and regional spot beams are used to support some of the older Inmarsat services, and also support call set-up procedures for the BGAN services. The narrow spot beams are used by the new BGAN services. A 3-color frequency re-use scheme is used for the regional beams, whilst a 4-color scheme is used on the more densely packed narrow spots.

Figure 2-1 shows the coverage areas of the three I4 satellites. Figure 3-8 and Figure 3-9 show examples of regional beams and narrow spot beams respectively. Inmarsat has the ability to reconfigure spot beams based on changing requirements.



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628 **Figure 3-8: Example I4 Regional Beams**

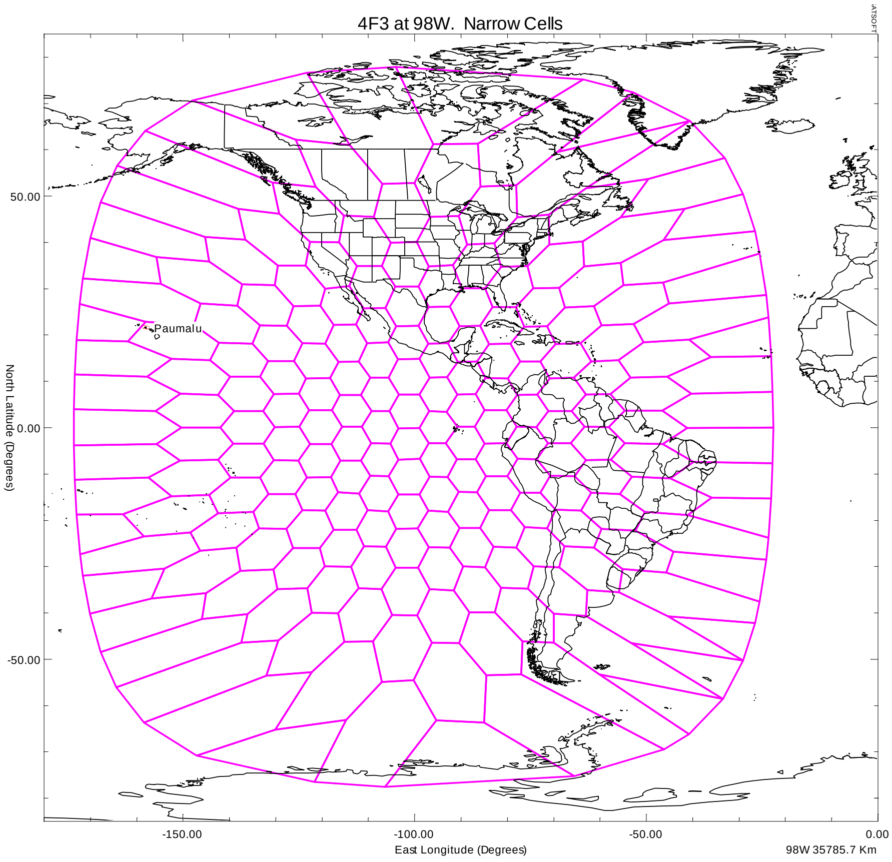

Figure 3-9: Example I4 Narrow Spot Beams

3.2.2.2 Alphasat Satellite

The Alphasat satellite is broadly similar to the I4 satellites, relying on a large L band reflector and on a digital signal processor, which provides beam forming and channelization functions. The following are key differences:

1. The reflector aperture has been increased from 9m to 11m, providing higher EIRP and sensitivity.
2. The digital signal processor is a second generation unit, able to support a larger number of beams and channels.
3. Alphasat not only covers the whole traditional L band MSS allocation at 1525 – 1559 MHz/1626.5 – 1660. 5 MHz, but also supports the extended L band MSS allocations at 1518 – 1525 MHz/1668 – 1675 MHz.

3.2.3 Inmarsat Ground segment

3.2.3.1 General

The Inmarsat ground segment consists of both traffic carrying and non traffic carrying components. Inmarsat owns and operates the ground infrastructure. This description concentrates on the traffic carrying components and provides a high level description and then further detail on relevant aspects.

The key traffic carrying components are housed in the Satellite Access Stations (SASs). Network Control, Satellite Control and Business Support are managed from Inmarsat HQ. The Data Communications Network (DCN) connects, using IP, the various physical sites and includes the IP and ACARS Meet Me Points (MMPs) where this traffic is handed over to the Communication Network Providers. Inmarsat offers MMPs for IP and ACARS in Amsterdam, and New York. The Voice MMPs are New York and London.

The non traffic carrying components are principally the Business Support System (BSS) and Network Operations Centre (NOC), which are both located at Inmarsat HQ. The BSS handles activation (also known as provisioning) and billing. The NOC is responsible for control and liaison across the network and with Communication Network Providers.

In addition, satellite control uses Telemetry Tracking and Control (TT&C) stations, and the Payload Control System (PCS). The Satellite Control Centre is located at Inmarsat HQ.

Traffic is landed at the SAS sites. There are three SASs for SBB located at Burum, (Netherlands), Fucino (Italy), and Paumulu (Hawaii). Burum and Fucino provide service to the Europe Middle East and Africa (EMEA) satellite, whilst Hawaii provides service to the Americas (AMER) and Asia Pacific (APAC) satellites.

The functions are essentially separated into Radio Access Network (RAN), Core Network (CN), and Gateways. The Radio Access Network is responsible for all aspects of the satellite access network, including management of the satellite resources and access to the satellite radio interface. The Core Network functions essentially comprise service management and switching functions, and are largely independent of the access network technology. The CN has the same functionality and interfaces as UMTS 3G CN, and is procured as COTS. The Gateways utilize 3G bearer services to deliver ACARS and the VoIP component of the voice service.

3.2.3.2 Radio Access Network

The Radio Access Network (RAN) entities are typically replicated per satellite.

The RAN systems can be broadly separated into the satellite specific and network specific functions as follows:

Satellite-specific entities include:

- Tracking, Telemetry and Control (TT&C).
- Payload Control System (PCS).
- Global Resource Manager (GRM).
- Frequency Planning Subsystem (FPS).
- Radio Frequency Subsystem (RFS).

The SBB network-specific Radio Access Network functions are represented by the Radio Network Subsystem (RNS) which comprises:

- Radio Network Controller (RNC).

- Channel Unit Subsystem (CUS).

Each network which accesses the satellite will also provide an independent equivalent set of functions to the SBB Network-specific Radio Network Subsystem, which may use different naming conventions.

3.2.3.2.1 Satellite Specific Functions

The Tracking, Telemetry and Control (TT&C) functions are responsible for monitoring the satellite bus and all aspects of health of the satellite, and provide security mechanisms and modems that allow the satellite payload to be configured by the Payload Control System.

The Payload Control System (PCS) is specifically responsible for managing the satellite payload. This includes configuring the beam forming networks and transponder frequency and gain settings to create spot beams and to illuminate these beams with 200kHz sub-bands.

The Global Resource Manager (GRM) is responsible for arbitrating requests for sub-bands in each beam from various Radio Network Subsystems. The GRM is able to perform dynamic optimization of the macro-level resources to minimize interference into each sub-band. The GRM works within constraints set by the frequency plan, maintains a view of the resource utilization in each beam by each RNS and has the capability to instruct an RNS to release sub-bands if required.

The Frequency Planning Subsystem (FPS) is responsible for establishing the time-of-day based frequency plan which defines the degrees of freedom under which the GRM is able to operate. Certain frequencies will be allocated on a static basis to each RNS, whereas others will either be able to be manoeuvred within different beams or between different RNS entities on a demand assigned basis.

The Radio Frequency Subsystem (RFS) provides the RF uplink and downlink capability for both TT&C functions and RNS subsystems, and include all antenna control mechanisms, High Power Amplifiers, Low Noise Amplifiers, RF Level Control and up-conversion and down-conversion and IF distribution infrastructure. It is possible that RFS subsystems may be deployed on different sites for redundancy purposes, and the TT&C functions and RNS functions may be operated via independent RFS subsystems.

3.2.3.2.2 Radio Network Subsystem

The RNS implements the SBB 3G Network Specific Functions that can be broadly split into the Channel Unit Subsystem (CUS) and Radio Network Controller (RNC) functions.

The Channel Unit Subsystem provides banks of transmit and receive modems configured on independent Transmit (Tx) and Receive (Rx) Channel Cards (six modems per card). The modems within each Channel Card are capable of handling a single 200 kHz sub-band. These Channel Cards are deployed in banks which access the various IF distribution feeds from the RFS. Each bank of Channel Cards is deployed in a 1-for-n redundancy on a shelf basis.

The Radio Network Controller comprises a number of internal entities, including the following:

- Host Controller (hot standby 1:1 redundancy).
- Core Network Gateway (hot standby 1:1 redundancy).
- Main Control Processor (1:n redundancy).

The Host Controller performs a number of functions, including:

- Interfacing to the GRM to obtain satellite resources for operation.
- Configuring Channel Unit Subsystem with sub-bands.
- Broadcasting system information.
- Controlling initial mobile terminal access (registration) to the Radio Access Network.
- Maintaining state information for the mobile terminals registered with the RAN.

The Core Network Gateway is responsible for:

- Interfacing to the PS and CS domains of the Core Network for provision of services to mobile terminals.

The Main Control Processors are responsible for the signalling and user-plane towards the mobile terminals, and are responsible for the following primary functions:

- Performing security functions such as ciphering of signalling and user-plane connections.
- Controlling mobile terminal handover between satellite spot beams as required.
- Performing admission control for service provision within the constraints of available capacity.
- Performing link adaptation to compensate for variations in the link quality to individual mobile terminals.
- Performing scheduling of satellite resources on a real-time basis to allocate services to functions.

3.2.3.3 Core Network

The main components of the Core Network are shown below.

Note: These are standard 3G COTS so those interested can find further details on the web.

Serving MSC	Serving Mobile Switching Centre. The switching network at which the core network interfaces to that part of the access network in which the mobile terminal is located. The Serving MSC interacts with a database called the Visitor Location Register (VLR) containing information regarding the mobile stations it is currently serving.
Gateway MSC	Gateway Mobile Switching Centre. The switching node which connects a UMTS core network with an external circuit-switched network such as ISDN or PSTN.
SGSN	Serving GPRS Support Node. The packet router at which the core network interfaces to the part of the access network in which the mobile terminal is located.
GGSN	Gateway GPRS Support Node. Another packet router connecting the UMTS core network with an external packet-switched network, such as the Internet or IP leased lines.

HLR	Home Location Register. The Home Location Register (HLR) is the main database of permanent subscriber information for a mobile network. The HLR contains pertinent user information, including address, account status, and preferences.

3.2.3.4 ACARS Ground Gateway

The ACARS Ground gateway utilizes the 3G background IP bearer service to encapsulate ACARS messages. It interfaces to the GGSN and CNPs. It is further described in Section 3.3.3.

3.2.3.5 VOIP Gateway

The second voice channel is provided by using Voice over IP technology over the air interface. A standard COTS gateway is used in the ground infrastructure. Signalling is sent over a 3G standard IP PDP primary context established at power on of the AES, while the voice frames are sent over a 3G streaming IP PDP secondary context which is set up during call establishment. Both the standard and streaming context use the same priority mechanisms as used for the prioritized IP service. The VoIP gateway is also used to implement number translation. It is further described in Section 3.3.4.

3.2.4 CNP infrastructure

The Communications Network Provider (CNP), see Figure 3-2, provides the ground infrastructure component for voice, ACARS and IP services to the ATSPs and airlines. The CNP normally contracts with the airlines and ATSPs for the service – i.e. the business model is Inmarsat sell satellite air time at a wholesale level to the CNPs who in turn sell the service at a retail level to ATSPs and airlines. The CNP provides the end user ground connectivity and interacts with ground hosts via standard communication interfaces. ARINC and SITA are CNPs.

For ACARS traffic, the CNP provides ground network connectivity, ACARS processing and internetworking. The CNP establishes and maintains the connectivity to the AGGW for each ocean region. This connectivity provides the means to communicate with aircraft logged onto SBB. CNPs not only provide the end users a path to communicate with an aircraft, they also provide the management, formatting and routing of the ACARS traffic. The aircraft communicate with the CNP Processor for transmission and reception of ACARS messages using protocols specified in AEEC specifications 618 and 620. The CNP Processor performs the ACARS protocol handling functions, including the formatting, routing, and internetworking functions. In some cases, the CNP Processor executes the message re-assembly function to reconstruct multi-block ACARS messages. The routing function uses the destination addresses derived from the ACARS messages for data transfer to the ground. The internetworking function is used to exchange ACARS messages between CNPs in the case where the ground host and the aircraft use a different CNP, as described in Section 1.3 of the main body of this document.

The CNP infrastructure for voice allows authorized ground users to establish secure voice calls with aircraft. The infrastructure allows the ground user to communicate with the aircraft at different call priorities, as defined in Section 3.3.4.

For Prioritized IP service, the CNP provides the required ground connectivity, management, and routing of the traffic to and from the aircraft.

3.3 Logical System Architecture

3.3.1 Introduction

Figure 3-10 shows the SBB logical architecture. The air interface, known as IAI-2 (Inmarsat Air Interface 2), is bespoke and is designed to maximize the performance and capacity of the satellite. Above the air interface are standard 3G protocols and these deliver 3G bearer services as well as administrative access functions. 3G bearer services are both packet switched (PS) and circuit switched (CS), and conform to the 3G specifications. Gateways are used to provide additional services and in particular an ACARS gateway and a Voice over IP Gateway provide the ACARS service and a ‘second voice channel’.

The CNP ACARS infrastructure provides the mobility management function and selects between different ACARS services (VHF, satellite, etc). The CNP IP infrastructure provides connectivity from the Inmarsat meet me points and the ATSP and airline systems. The CNP voice infrastructure’s main function is to provide selection of different satellite regions and services, and provide security.

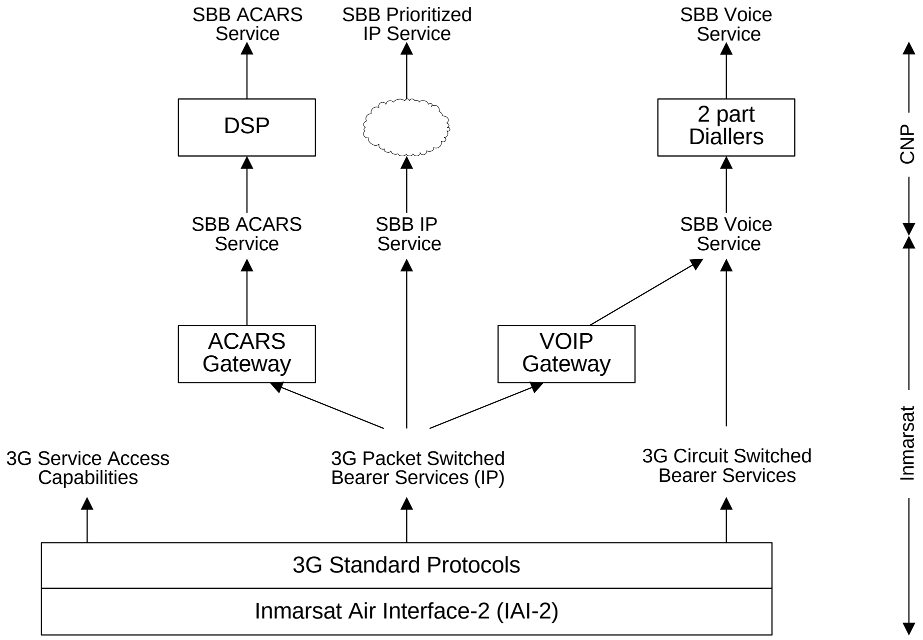

Figure 3-10: SBB Logical Architecture

3.3.2 3G transport

The two lower layers in Figure 3-10 provide a 3G transport function.

The service access capabilities include authentication, authorization and security. Standard 3G security mechanisms are employed including ciphering of the air interface.

Both circuit switched and packet switched bearer services are supported.

Circuit switched voice uses a bespoke AMBE+2 codec operating at 4 kbits/s.

Packet switched services are provided over IP, and both streaming and background are provided.

Circuit switched priority is implemented based on standard 3G Enhanced Multi Level Precedence and Pre-emption (eMLPP) mechanisms and bespoke modifications to the air interface.

Packet switched priority is implemented using standard 3G Allocation/Retention Priority (ARP) mechanisms and bespoke modifications to the air interface.

PS and CS priority mechanisms within the 3G transport ensure that the required RCP/RSP data and voice performance is delivered in congestion situations where the congestion could be from another lower priority user on the same aircraft, a SBB non safety user or a BGAN or FleetBroadband user.

3.3.3 ACARS

3.3.3.1 Introduction

This service is primarily an IP packetization of ACARS messaging whereby ARINC 618/620 messages and protocols are maintained outside both the ground and aircraft gateways.

ACARS over SBB uses a prioritized Standard IP connection. One of the main roles of the gateways is to set up the PDP contexts required to send these IP packets. These PDP contexts are set up with a Priority or Assured Access level above that of other BGAN users. The service handles one ACARS block at a time to an aircraft due to the ARINC 620 limitation of being ‘stop and wait’ protocol.

The gateway function (the ACARS Aircraft Gateway (AAGW)) on the aircraft (incorporated within the AES) and another on the ground (the ACARS Ground Gateway (AGGW)) encapsulate ACARS messages and select the appropriate satellite link. The SBB 3G components in the AES, RAN and CN provide a transport mechanism with priority / pre-emption capability but otherwise are no different to the SBB non safety IP service.

The interface to the CMU re-uses Williamsburg over ARINC 429, allowing integration on the aircraft for the ACARS service without changes to the CMU or Aircraft End System. This interface is unchanged from that currently defined in the ARINC 741 and ARINC 781 Characteristics for AESs. The intention is that the SBB ACARS service may easily be implemented by AES conforming to these standards.

The interface from the Inmarsat infrastructure to the CNPs is a small extension of the interface used for the Classic aero service operating over the Inmarsat-3 and Inmarsat-4 satellites.

3.3.3.2 SBB ACARS service architecture overview

Figure 3-11 is an overview of the ACARS data service architecture.

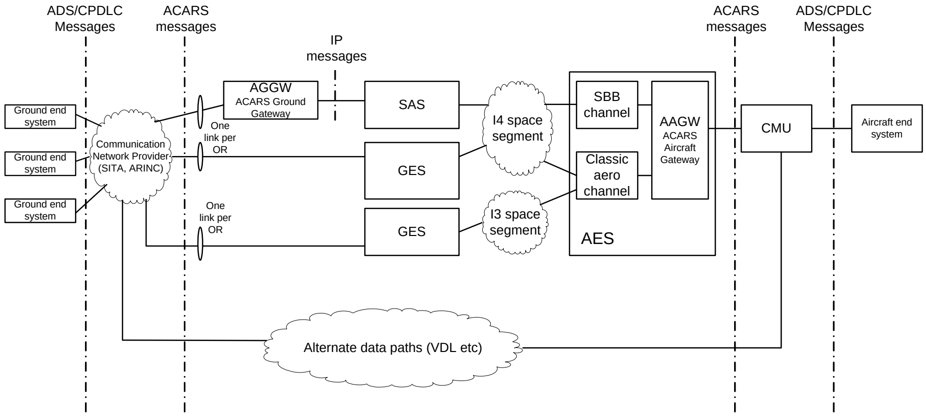

Figure 3-11: ACARS Data Service End-To-End Architecture

The main components of the ACARS Service architecture are:

AAGW	ACARS Aircraft Gateway. A functional block within the AES that is responsible for encapsulating ACARS messages in a wrapper to allow them to be sent via SBB, and, for those AES supporting Classic Aero reversion, choosing which Inmarsat sub-network (Classic aero or SBB) to use. The aircraft gateway does not provide a guaranteed delivery of messages to (or from) the ground gateway. Rather, it is responsible for ensuring a communications link with the ground, where permitted by the AES resources and network availability. The ultimate responsibility for ensuring message delivery is at the ACARS messaging layer.
ADS	Automatic Dependent Surveillance. Automatic Dependent Surveillance is a method of surveillance that relies on (is dependent on) downlink reports from an aircraft's avionics that occur automatically whenever specific events occur, or specific time intervals are reached. The required communication performance (RCP) for ADS is RSP180.
AGGW	ACARS Ground gateway. This function is located on the ground and provides a connection point to the SBB 3G network. The AGGW also maintains a record of the log-on status of each aircraft, and monitors the performance of the SBB ACARS data service with respect to the requirements of RCP240/RSP180.
AES	Aircraft Earth Station. The equipment located on the aircraft that provides a communication link via satellite. The AES includes modems for the Inmarsat SBB network and optionally for the Classic Aero network.
CMU	Communication Management Unit. The equipment located on the aircraft responsible for routing communications between aircraft and ground. The CMU manages communication across multiple sub-networks:

- VHF radio (Terrestrial)
- HF radio (Terrestrial)
- Inmarsat (satellite)
- Iridium (satellite)

CPDLC	Controller Pilot Data Link Communications. CPDLC is used for air traffic control. The required communication performance (RCP) for CPDLC is RCP240.
GES	Ground Earth Station. The entity on the ground that connects terrestrial telephony and data networks to Inmarsat's Classic Aero network.
SAS	Satellite Access Station. The entity on ground that connects terrestrial telephony and data networks to Inmarsat's SBB network.

Figure 3-12 shows the peer-peer communications within the system. The SBB ACARS service differs from the Classic Aero service in having two additional layers supporting communications: a gateway-gateway communications layer, and a UDP/IP layer.

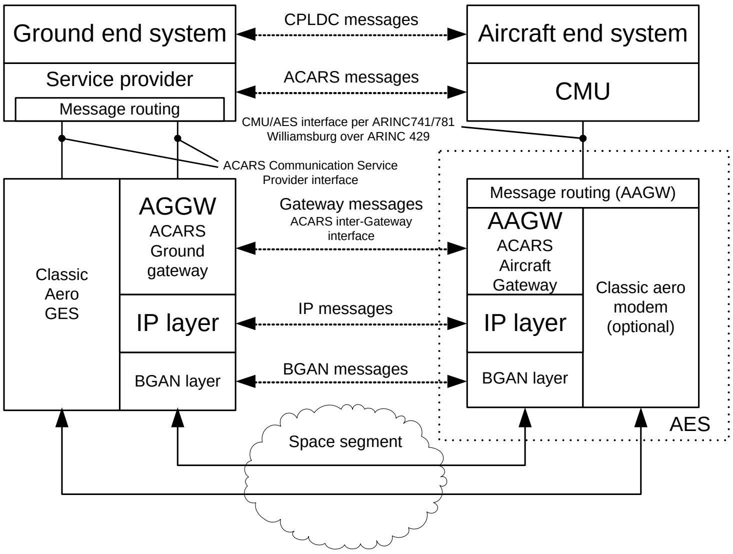

Figure 3-12: Data Service Protocol Stack Architecture

3.3.3.3 SBB ACARS data service AES operation

The sequence of operations for an aircraft to use the SBB ACARS service is shown in the state and message sequence diagrams below. The initial operations (camping on, registering with the RAN, attaching to the SGSN, authenticating and setting up a PDP context) are standard SBB / 3G operations. The subsequent operations (logging in for

SBB ACARS service, sending and receiving ACARS messages and performing link tests (keep alives)) have been developed specifically for the SBB ACARS service.

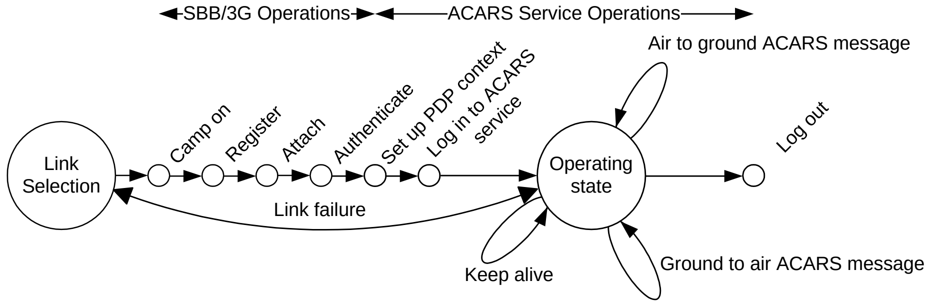

Figure 3-13: State Diagram for AES ACARS Function

3.3.3.4 ACARS Message Sequence & Timing Diagrams

Figure 3-14 is a message sequence chart which shows an air to ground ADS message being sent.

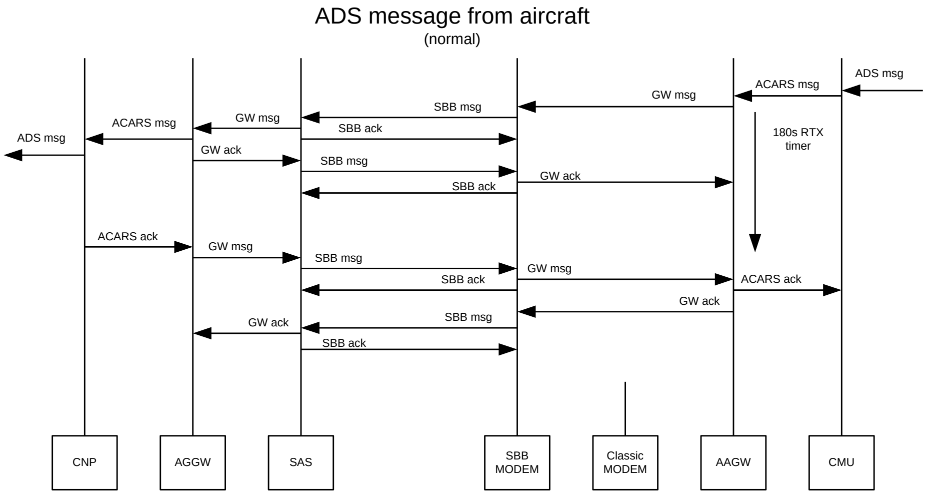

Figure 3-14: Normal ADS Message delivery from Aircraft

An aircraft message is sent from the aircraft CMU to the AES in the same way as for Classic Aero. The message is received by the AAGW function in the AES. A link to the ground using the SBB network has previously been established (via a log-on transaction). The AAGW encapsulates the ACARS message into a format suitable for intra-gateway transmission and timestamps the message. The message is then sent to the ground gateway function over the SBB network. The message is received by the AGGW and forwarded to the communications network provider (CNP). The time of dispatch to the CNP is compared with the time of arrival at the AAGW to allow the message latency to be calculated. The AGGW sends an acknowledgement of receipt to the AAGW.

The CNP sends an ACARS message acknowledgement upon receipt of the message. This message is timestamped on receipt by the AGGW, encapsulated in a wrapper and sent to the aircraft. The message is received by the AAGW, the wrapper is removed and it is sent to the CMU. The AAGW then sends an acknowledgement of message delivery, with timestamp, to the AGGW. The AGGW calculates and stores the latency in message delivery. The AGGW sends an acknowledgement of message delivery, together with the measured latency, to the CNP.

If the AAGW does not receive a message acknowledgement, it re-tries sending the message once.

Figure 3-15 shows a ground to air CPDLC message.

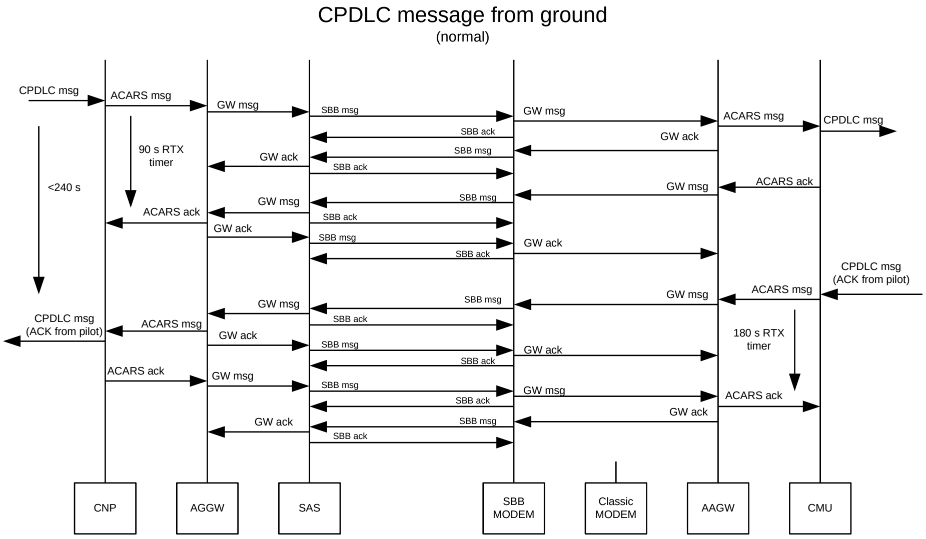

Figure 3-15: Normal CPDLC Message (Controller to Pilot to Controller)

The process is similar to the ADS message transaction. However there is a second transaction (at the ACARS level) which is the pilot acknowledging receipt of the controller’s message.

3.3.3.5 SBB ACARS Data Service Ground Network

Figure 3-16 shows the BGAN packet switched architecture with the addition of the ACARS Ground Gateways and associated networking.

There are two AGGW sites – one in Paumalu (Hawaii) and one in Burum (Netherlands) and each of these sites accommodates a redundant AGGW architecture (initially dual redundant but the design accommodates the addition of further redundant servers in a “server cluster” configuration with each server known as a “node”). In normal operation, both AGGW sites are operational and handle ACARS traffic that lands locally at that SAS site, i.e. Paumalu handles traffic from the Americas (AMER) and Asia-Pacific (APAC) satellite regions, while Burum handles traffic from the European, Middle East and Africa (EMEA) satellite region. The two AGGW sites continuously synchronize AES log-on information between each other. In the event of an AGGW site switch (due to maintenance or a failure), all traffic can be routed to the remote AGGW site in order to provide a backup service. Hence each AGGW site can serve multiple GGSN/satellites. Switchover between sites is carried out under manual control. Within a site, the component nodes of an AGGW typically operate in a load share mode but will fail over automatically to the non failed node(s). The nodes of an AGGW present the same IP address to the aircraft since there is a GGSN Load Balancer network element between the GGSN and the AGGW. The IP address provided to the AES to access an AGGW server is actually a Virtual IP Address (VIP) of the local GGSN Load Balancer. This GGSN Load Balancer is also responsible for routing traffic to the remote AGGW site in the event of a site switch.

The BGAN SAS located at Burum supports the EMEA satellite with the BGAN SAS located at Fucino acting as a backup. When the Fucino SAS acts as prime it normally connects to the Burum GGSN, although it can connect to its own GGSN. RNCs at a site connect to one SGSN, with one RNC per satellite.

The ACARS gateways communicate with the ARINC and SITA data centers via the existing BGAN “Meet-Me-Points” at New York (NY) and Amsterdam using an evolution of the Classic/I4 Data 2 interface. Dedicated connections are provided from each ACARS Gateway on a per satellite region basis, supported by that ACARS Gateway, and each of these connections has link redundancy as shown in Figure 3-16. ARINC and SITA networks have redundant connections into the MMPs at NY and Amsterdam.

The selection of which CNP to use will be based (as in Classic/I4) on a table held within the AGGW associating each activated (provisioned) AES with a service provider. AESs are added to the table during the provisioning process. An aircraft operator may select either a single CNP or both a preferred and backup CNP.

The IP address allocated to the aircraft is dynamically allocated from the 10.0.0.0/8 address range.

The AGGW contains the following key functions:

- Exchanges messages with the CNPs.
- Exchanges messages with the aircraft.
- Manages TCP/IP connections to the CNPs.
- Synchronizes with twin and other site.
- Authorizes AES.
- Interfaces to activation system.
- Logs message transactions and accumulates Quality of Service (QoS) statistics.
- Creates, logs, displays, and makes available CDRs to CNPs.
- Graphical User Interface (GUI).

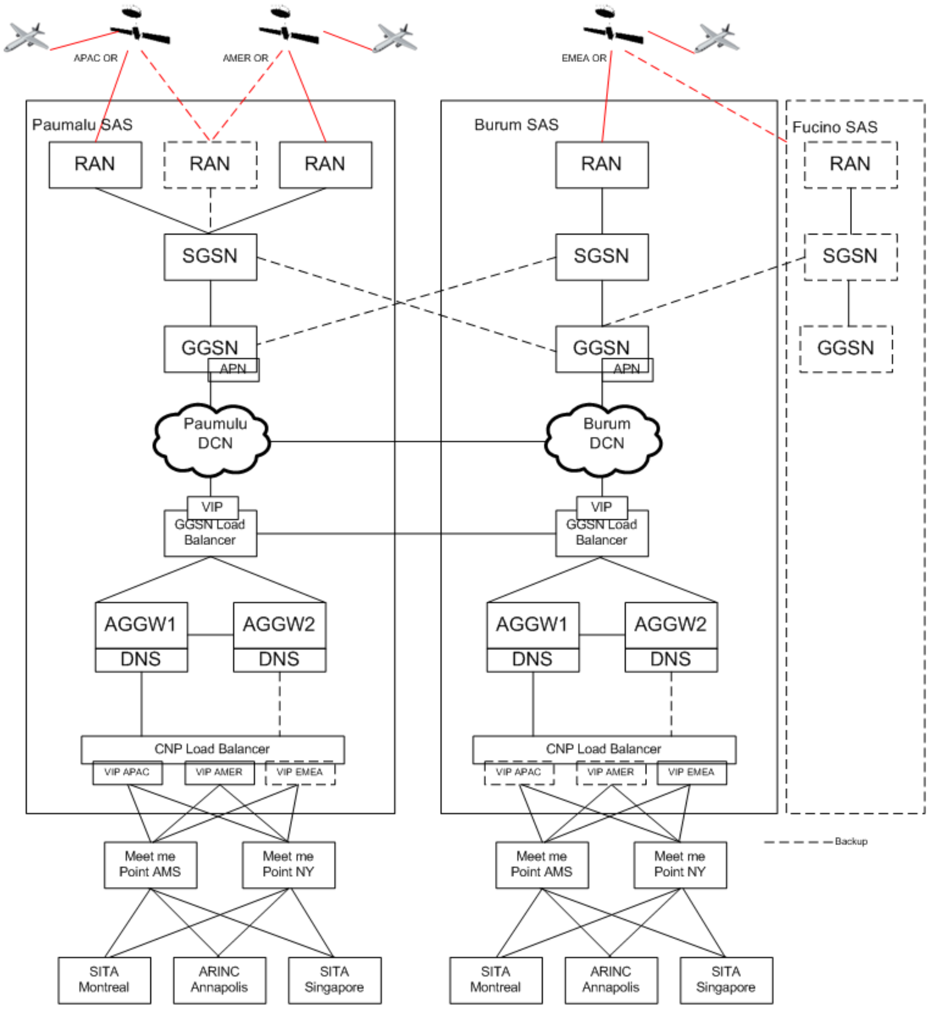

Figure 3-16: ACARS Ground Infrastructure Networking Topology

3.3.3.6 Link Management Including Failover

The AES selects which satellite to use, as well as performing on-going monitoring of its availability and performance. The AES uses a number of different criteria to determine link failure and hence switch to an alternate link. For those AES supporting Classic Aero reversion capability, the AES also selects which service (SBB or Classic Aero) to use.

3.3.3.7 QOS monitoring

The ACARS SBB service includes provision for quality of service monitoring. This ensures the key performance parameters of RCP240/RSP180 are being satisfied. The key parameters are:

- Message latency which is described in Section 4.1.1.
- Availability of message delivery. This applies to delivery of ACARS messages..

Key performance data is accumulated within the Inmarsat ground infrastructure.

The following provisions are implemented in the air interface between the AAGW and AGGW:

- Inclusion of message sequence numbers within the gateway wrapper for ACARS messages.
- Inclusion of a timestamp in the gateway wrapper for air to ground gateway messages. The message is time-stamped with the time of arrival from the CMU.
- Addition of an acknowledgement for ground to air ACARS messages. The acknowledgement is time-stamped with the time of delivery to the CMU and the sequence number of the ground to air message being acknowledged.

The AES synchronizes an internal clock with the SBB network using the time synchronization message from the SBB network (Attribute Value Pair (AVP) UTC date and time) when the AES acquires the global beam.

3.3.4 Voice

3.3.4.1 Introduction

Key characteristics of the voice service are:

- The end to end interfaces and functionality remain the same as Classic Aero. End to end means the interface from the AES to the aircraft, and from the CNPs to their ATSP and airline customers. Hence it is transparent to an end user (e.g. pilot or ground user) whether Classic Aero or SBB is used, and indeed the end user may not be aware which system is being used.
- Two voice channels are provided. One voice channel is provided through the SBB 3G Circuit Switched bearer service. The second channel is provided using VoIP technology running on the SBB 3G Packet Switched bearer service.

The above drive the system design.

The additional requirements for the SBB voice service compared to Classic Aero are:

- To present Caller Line Identity for Ground to Air (G2A) calls to the cockpit.
- Provision of four levels of priority on Ground to Air (G2A) calls rather than three. The additional level is Emergency (also known as distress/urgency).

3.3.4.2 SBB Voice Service Description

3.3.4.2.1 Design Solution

The key attributes of the SBB voice service design are:

1. All G2A calls are delivered to the New York or London Meet me Points (MMPs) using a single number for the aircraft that is based on the ICAO 24-bit aircraft address.

2. Mobility management is handled by the inherent 3G mobility management of the SBB network. Hence a G2A call only needs to be delivered to the SBB network, and the SBB system will locate the aircraft and deliver the call.
3. Air to Ground (A2G) calls are delivered by Inmarsat into the PSTN (same as Classic/I4).
4. The first call always uses the CS domain on both A2G and G2A calls.
5. The second call uses VoIP via the PS domain if the CS domain is busy.
6. VoIP servers are implemented in the AES and Inmarsat ground infrastructure.
7. VoIP calls are handled on the ground interconnect as CS.
8. VoIP is delivered on the air interface by RTP on a secondary streaming PDP context (with priority).
9. VoIP is controlled on the air interface by SIP on a primary standard PDP context (with priority).
10. The VoIP voice codec is G.729A.
11. The priority of G2A calls is signalled on the CNP to MMP interface through a priority digit in the called party number.
12. The priority of G2A calls is signalled on the GMSC to MSC interface through (1) the use of MLPP and (2) the addition of a priority digit prefixed to the calling party number. The soft switch provides both these number translations.
13. eMLPP is used on the air interface for CS domain 'network priority' processing. ARP is used on the air interface for PS domain 'network priority' processing.
14. The AES determines pre-emption of existing calls to that AES for A2G and G2A calls. For G2A calls, the AES uses priority information signalled in the Calling Party number to process priority.
15. The BSS allocates, during the activation process, an MSISDN to a SBB AES that includes the ICAO 24-bit aircraft address.
16. Caller Line Identity is presented in both CS and PS G2A calls.
17. Dual AES is supported (for future growth).

3.3.4.2.2 Second Voice Channel

SBB is a 3GPP system which means the BGAN MSC can only provide one voice call per device. The second channel of voice is provided via the PS infrastructure using Voice over IP (VoIP). The VoIP 2nd voice channel operates as an overflow mode. That is (1) on the ground side, all SBB voice is accessed via the SBB CS domain to the MSC, and (2) only if a CS voice channel is not available is the call sent via the SBB 3G PS domain as VoIP.

On power up of the AES, a background class PDP primary context is established by the AES for VoIP signaling using SIP. The voice speech is carried using a streaming class secondary PDP context which is set up on a per call basis. This context is established with sufficient QoS to support the voice codec and associated user-plane overheads. The priority level for both PDP contexts is determined by the subscribed ARP level, thus ensuring that radio access network pre-emption of resources may be triggered if a network congestion scenario exists.

3.3.4.2.3 Priority and Pre-emption

Four levels of priority are required for both G2A and A2G calls for the voice service, and this priority is presented to the cockpit for display to the pilot. Additional information on priority and pre-emption is found in Section 3.4.9.

Priority and pre-emption mechanisms operate both at the aircraft level (calls to/from that aircraft) and at the network level (calls to/from other aircraft or other BGAN users).

The AES has the responsibility of carrying out priority and pre-emption processing for calls to/from the aircraft. If an incoming (new) G2A or a A2G voice call is at a higher level of priority than an existing call, and both circuits between the AES and the cockpit switch are occupied, then the AES triggers the automatic release of the existing lower priority voice call to facilitate the presentation of the incoming higher priority voice call to the cockpit switch. The AES implements four levels of priority processing.

For CS voice calls, in the event of network congestion, the network triggers pre-emption of any lower priority call to facilitate the presentation of the higher priority voice call. The technology to support this is via the use of the enhanced Multi-Level Precedence and Pre-emption (eMLPP) mechanism. The network implements four levels of priority processing for CS calls.

For PS voice calls, in the event of network congestion, the 3GPP Allocation/Retention Priority (ARP) attribute is used to trigger pre-emption of any lower priority PS call (whether data or VoIP). However on the air interface, the priority of ATS/AOC/AAC PS calls is set to the same value, and hence only APC PS calls are pre-empted in the network.

The signalling on the SBB 3G CS service uses 3G eMLPP (enhanced MLPP), and this is mapped to the air interface as shown below:

	Classic Aero Q level (for comparison)	**Priority Level As used in DO210 Table 2-14**	**MLPP ISUP code for G2A**	**eMLPP code for A2G**
Distress Urgency	Q15	1	0	0
Air Traffic Service	Q12	2	1	1
Airline Operational Control	Q10	3	2	2
Airline Administrative Control	Q10	3	2	2
Airline Passenger Communications	Q9	4	3	3

Table 3-3: CS Priority Levels

3.3.4.2.4 SBB Voice Service Architecture Diagram

Figure 3-17 presents the voice service architecture for provision of cockpit voice services for SBB incorporating both the BGAN CS network capability and the VoIP multivoice infrastructure in the PS domain.

3.3.4.2.4.1 Ground to Air Calls

For Ground to Air calls, the CNPs provide two part dialers[11], also known as Interactive Voice Response (IVR) systems where the user dials an access number, e.g. an 0800 number, and is then prompted for a password, the call priority, and the ICAO 24-bit aircraft address of the aircraft. The IVR generates the aircraft phone number of the form 870 5 *p ICAO*, where *p* indicates the call priority and *ICAO* is the octal representation of the ICAO 24-bit aircraft address. The CNP delivers the call to the SBB Voice Meet Me Point using a leased line. Use of the leased line and of a password for access to the IVR ensures that only bona fide users can make calls to the pilot, which is a security requirement.

The flood dialer dials the required number for both Classic Aero[12] (94, 95, 96, 97) and SBB (98) routes, with 98 being added for SBB. The call is eventually bridged to the first entity that answers the call. The transit switch, on receipt of the 98 number, forwards this call on to the Soft-Switch for number translation. The soft-switch will extract the ICAO number and map this to the provisioned MSISDN[13] of the format (870 77 44 *ICAO*). The soft-switch will also extract the priority digit, *p*, and prefix this to the Calling Party Number and also map this to the relevant MLPP value within the call setup signalling. Once this procedure is complete, the call with the modified numbering is passed back to the GMSC for onwards routing via the BGAN system. The GMSC uses the MSISDN and retrieves the terminal location from the HLR based on the mapped IMSI. Once the location is known, the call is passed to the relevant MSC, using a roaming number retrieved from the VLR. A call is then alerted via the CS domain (Call Waiting feature having been enabled at AES activation for the IMSI). If the CS route is busy, then the call is forwarded towards the VoIP domain and the call is then placed via the PS domain for presentation to the cockpit.

Upon receipt of the call setup message, the AES determines the appropriate behavior, depending upon the call priority level, and whether the CS domain is already occupied in a voice call. If the CS domain is already occupied, and the AES determines that it is necessary to accept the call, the AES will instruct the CS domain to forward the call via VoIP operating over the PS domain by returning a busy notification triggering call forward on busy. In this way the AES can receive multiple calls via the combination of the CS domain and VoIP over PS domains. If an incoming call is signalled and the AES is currently utilizing both voice circuits, it will make a pre-emption decision based on the presented priority level. If there is a lower priority call in progress, the AES will pre-empt the lower priority call to allow presentation of the higher priority call. If there are no candidate lower priority calls, then the incoming call will be rejected.

3.3.4.2.4.2 Air to Ground Calls

Processing for A2G calls is simpler than for G2A calls. On receipt of a request to initiate a call from the cockpit, the AES terminates, if needed, any existing calls to allow a higher priority call. The AES places the call via the CS domain if the CS domain trunk is available or via the VoIP over PS domain if the CS trunk is in use. The priority of a VoIP call is signalled to the ground by prefixing the *p* digit to the calling party number.

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[11] The text assumes the CNP provides the 2-part dialling function. Alternatively some CNPs may elect to contract Inmarsat to provide such capability on their behalf – this is shown in figure Figure 3-17 as the dashed box titled Inmarsat 2-part dialler.

[12] Classic Aero is not shown in Figure 3-17.

[13] The MSISDN is the 'phone number' of the AES, and the number that must be presented to the MSC.

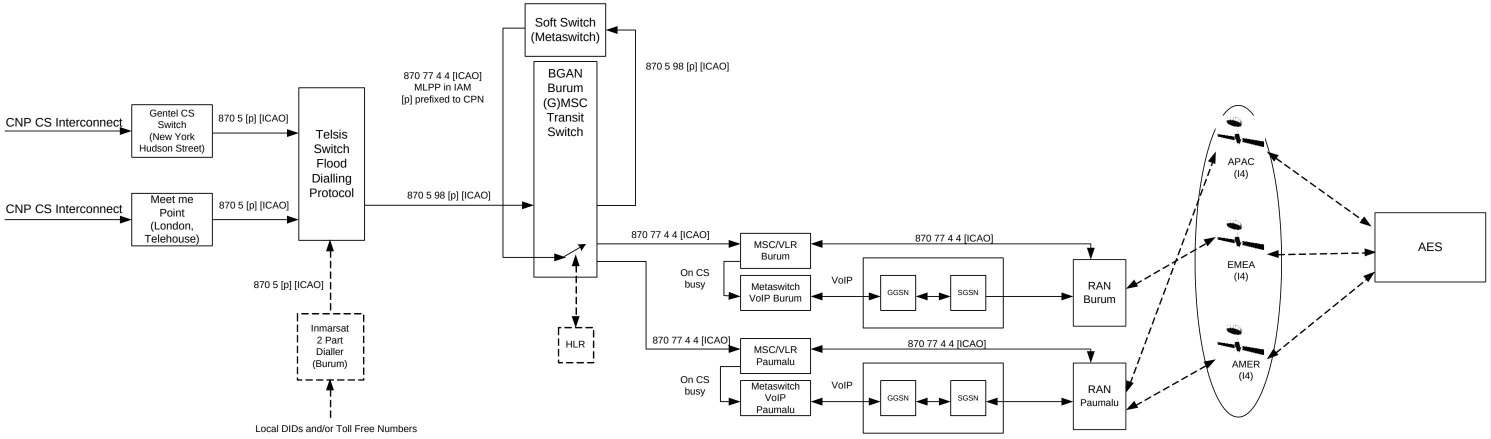

Figure 3-17: Voice Service Architecture

3.3.5 Prioritized IP

The SBB Prioritized IP service is virtually unchanged from the SBB 3G bearer service.

Key differences are:

1. The AES signals the required priority of a PDP context within the PDP context set up command using the AT commands (the interface is defined in Appendix 5 to ARINC Characteristic 781).
2. The RNS provides priority on the air interface.
3. There is a private data pipe from the CNP to the GGSN.

In addition the following controls are provided to ensure that only bona fide users can access priority capability.

1. In an AES, certain physical pins on the ARINC 600 connector are allocated to priority service. The priority field referred above will only be passed on to the air interface if it is received on a priority interface (e.g 'cockpit Ethernet port'). This is an extension of concepts already embodied in ARINC 741 equipment for both voice and data Classic Aero service.
2. The prioritized IP data service is only allowed with SIMs provisioned for that level of priority.

3.4 Air Interface

This subsection provides key information on the bespoke air interface known as IAI-2 (Inmarsat Air Interface 2).

3.4.1 Frequency Range

The forward (to aircraft) user link operates in the frequency range 1518-1559MHz. Some AES and the I4 satellites only support a frequency range of 1525-1559MHz. Alphasat supports the full frequency range.

The return (from aircraft) user link operates in the frequency range 1626.5-1660.5 and 1668-1675MHz. Some AES and the I4 satellites only support a frequency range of 1626.5-1660.5MHz. Alphasat supports the full frequency range.

3.4.2 Polarization

Right Hand Circular Polarization is used for both the forward (to aircraft) and return (from aircraft) user links.

3.4.3 Bearers

The SBB air interface supports a matrix of carriers and bursts of different modulation type, symbol rate and code rate. Inmarsat configuration settings and the RAN determine which bearers and code rate are used on a dynamic basis. In SBB terminology carriers and bursts are known collectively as bearers.

SBB RF bearers in the forward (to aircraft) direction are a continuous transmission of time division multiplexed (TDM) carriers shared between a number of users. RF bearers in the return direction (from aircraft) are based on time division multiple access (TDMA) between a number of users.

Power efficient QPSK (Quadrature Phase Shift Keying) and bandwidth efficient 16 and 64 QAM (Quadrature Amplitude Modulation) modulation is used, together with a number of frame burst durations. Symbol rates between 8.4 kilo symbols per second (kSym/s) and 168 kSym/s are used with each symbol rate being a fraction or multiple of 33.6 kSym/s. Variable coding rate is used with rates corresponding to 1 dB changes in C/No. In the main the bearers operate at constant power and as the C/No varies the coding rate (and hence the user data rate) is adjusted accordingly. Bearers use Raised Root Cosine (RRC) filtering with rolloff of α=0.13 for T5[14] and T2.5 bearers and α=0.25 for other bearers. Channel spacing for the 151.2 and 168 kSym/s bearers is 200kHz. Other bearers are spaced as fractions of 200kHz.

The forward and return bearer types are shown in Table 3-4.

Symbol Rate/ 33.6 kSym/s	**Forward**		**Return**					
Modulation	**QPSK**	**QAM**	**QPSK**			**QAM**		
Frame Period	**80 ms**		**5 ms**	**20 ms**	**80 ms**	**5 ms**	**20 ms**	**80 ms**
Shared Access Bearers								
0.25	Y							
0.5				Y	Y			
1.0	Y	Y		Y	Y	Y	Y	
2.0			Y	Y		Y	Y	
4.5		Y	Y	Y		Y	Y	
Dedicated (High Data Rate) Bearers								
2.5		Y			Y			Y
5.0		Y			Y			Y

Table 3-4: Forward and Return Bearer Types

3.4.4 Bearer Layout and Scheduling

A forward direction bearer is a carrier transmitting a continuous stream of 80 ms data frames at constant power, and constant symbol rate and modulation type. Each of the 80 ms frames consists of one, four or eight blocks of data. These blocks of data are known as Forward Error Correction (FEC) blocks because each block is independently encoded using a powerful turbo-code algorithm[15], and each block can have an independent FEC code rate. Each 80 ms frame is preceded by a unique-word pattern. An AES tunes to a forward bearer and decodes every FEC block on the bearer unless the code rate of the block is too high. Protocol Data Units (PDUs) are either addressed to an individual connection of an AES or are broadcast to all AES (eg bulletin board).

The slotted aloha mechanism is used by AES to send small status messages to the RNC listing the current amount of data queued for each of their connections and how long those data have been waiting. The RNC then uses this information to allocate return capacity taking into account the needs of every other connection. The decisions taken by the RNC are then reflected in the subsequent return schedules issued to the AES.

The RNS plans the layout of the forward and return carriers and ensures that all traffic is delivered in an appropriate and timely manner. Individual carriers multiplex traffic from multiple AES; from BGAN and FleetBroadband terminals; and for all SBB services.

In each beam, AESs and bearers are managed collectively by an RNC function known as bearer control. Bearer control manages the bearers in a beam and allocates capacity to the various connections such as circuit switched calls and packet data sessions. A single AES may have one or more active connections. Multiple AESs and their associated connections are concurrently served by a bearer control.

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[14] T5 and T2.5 are bearers with symbol rate of 5 and 2.5 times 33.5kSym/s.

[15] Turbo coding is a powerful forward error correcting code technique that can achieve near-optimum channel capacity. First described in 1993, turbo-codes are related to the convolutional codes employed in the Inmarsat Classic Aero service.

Bearer control will periodically retune AESs between bearers to ensure that traffic demand is distributed. If the load on a bearer could be supported on fewer satellite channels it will move AESs to concentrate them on fewer bearers and return the unused channels. There is no restriction on moving a AES with an IP connection. Forward and return load smoothing is carried out independently.

Figure 3-18 illustrates the forward frame structure.

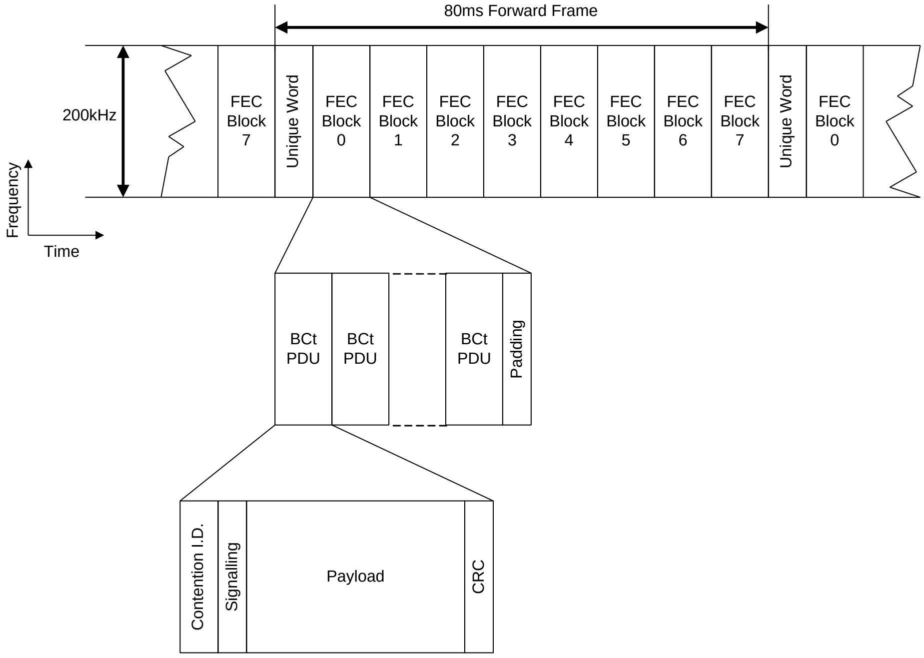

Figure 3-18: Typical Forward (to Aircraft) Narrow Beam Frame Format

Each AES return burst is sent at a coding rate appropriate to its currently reported link conditions. AES transmit traffic bursts within a schedule of timeslots as instructed by the RAN. The schedule tells AES which return direction timeslots are reserved for each connection and what bearer type should be used for each timeslot. The return schedule also advertises a proportion of timeslots available for all AES to use for random access by means of a slotted aloha mechanism

The return schedule instructs AES to send bursts at intervals relative to the start of the forward frame in which the return schedule is broadcast. Depending on its geographic location, an AES will need to add a further self-imposed delay (SID) to its bursts to ensure that they do not overlap with those from other terminals upon arrival at the satellite. A terminal must use its position to calculate the SID. Thus, AES requires a position input, which may be derived from GPS, Galileo, or an Inertial Navigation System.

As with the forward direction, the RNC prepares the return layout at regular intervals, typically every 40 ms or 80ms. The goal of the layout algorithm is to organize time slots for the AES bursts to squeeze the maximum capacity out of each satellite channel over the period of the layout interval.

Figure 3-19 shows an example of a layout over an 80 ms interval. In this example the RNC reserves thirteen slots for four burst types for the connections that the scheduling algorithm has chosen to serve during the interval.

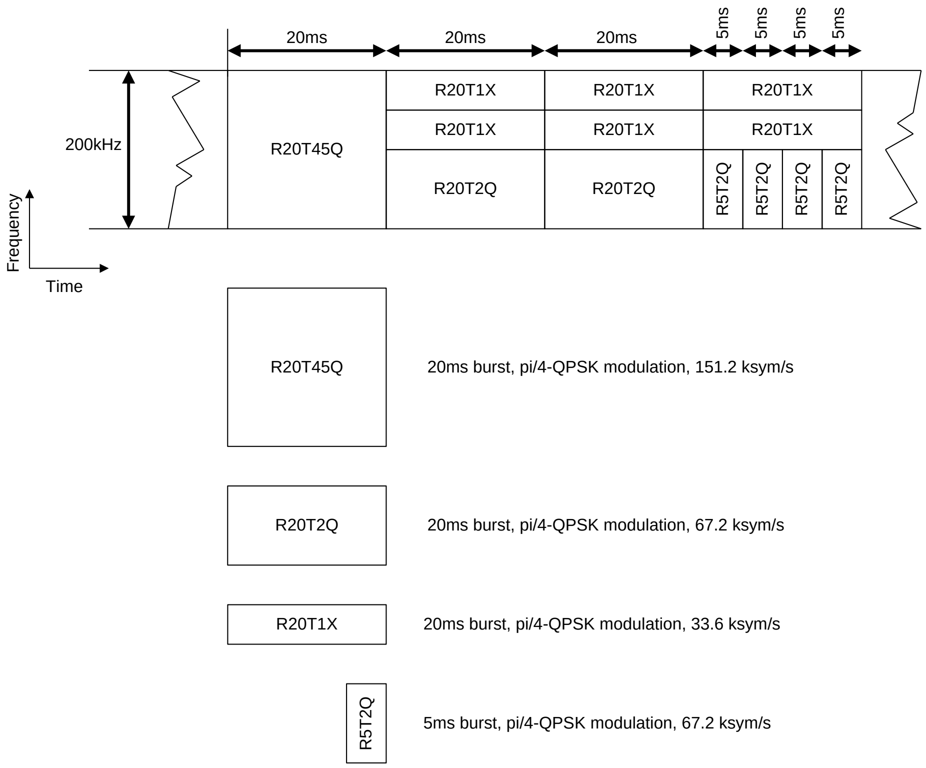

Figure 3-19: Example Return (from Aircraft) Direction Layout in a Narrow Beam

3.4.5 Admission Control

The RNC performs admission control when deciding whether to allow a new connection onto a bearer control. If a connection can be added without violating the quality of service of the existing connections it is permitted. If capacity is not available then the RNC requests extra capacity from the GRM. If there is no extra capacity then the connection must be rejected or a lower priority user pre-empted.

3.4.6 Link adaptation

The SBB air interface uses link adaptation to increase the capacity of SBB bearers. Rather than fixing the data rates for all AES, link adaptation gives higher data rates to those AES with a better radio link. Thus AES with higher EIRP and G/T and those with good link conditions can take advantage of favorable link conditions to send or receive at a higher data rate.

The receiver (either the RNC or the AES depending on the direction of transmission) constantly measures the received link quality and periodically reports this information back to the sender. If the average link quality rises above the level required to achieve a packet error rate of 0.1%, the sender increases the transmission rate. If the average error rate falls below 0.1% then the sender reduces the transmission rate.

The sender adjusts its transmission rate by selecting one of a range of puncturing matrices to apply to each turbo-coded block of data prior to sending it. The air interface can operate with a coding rate as low as 1/3 (i.e. sending two bits of redundancy in addition to each bit of data) and as high as nearly 1 (i.e. negligible redundancy).

Thus, an AES can operate over a wide range of link conditions from 40.5 dB C/N_0 in the worst case to 65.5 dB C/N_0 in the best case.

Although there is no scope to vary the data rate delivered by a circuit switched connection such as voice, link adaptation ensures that circuit switched connections consume as little capacity as possible to meet the target grade of service. For variable bit rate packet switched connections (i.e. standard class IP), link adaptation constantly delivers a peak bit rate to each connection as high as permitted by its link quality.

Packet traffic is transmitted in “reliable mode”, i.e. any packets lost on the satellite link are automatically retransmitted and re-ordered before being delivered. Reliable mode will incur a certain amount of random delay jitter when retransmissions occur but this does not significantly add to the inherent jitter that occurs in a packet data connection over a satellite link using TCP.

For users that need to minimize delay jitter on their IP traffic and can tolerate a packet loss rate of 0.1% (e.g. certain real-time applications or transport protocols) a guaranteed bit rate service, called streaming, that operates in unreliable mode is provided.

The RNC dictates what code rate the AES must use in the return bursts to maintain the target packet error rate.

3.4.7 Global, Regional and Narrow Spot beams

SBB uses three types of satellite beam: global, regional and narrow spot. The global beam is only used in the forward direction and is used to distribute a bulletin board, while the regional and narrow beams are used in forward and return directions. Normally user traffic is carried in the narrow beams, while the global and regional beams are used for log-on and other signaling, although in certain circumstances user traffic is carried in regional beams.

There are 19 regional beams operating with 3 color frequency reuse and typically 192 narrow beams operating with 4 color frequency reuse.

The use of the beams is shown in Figure 3-20.

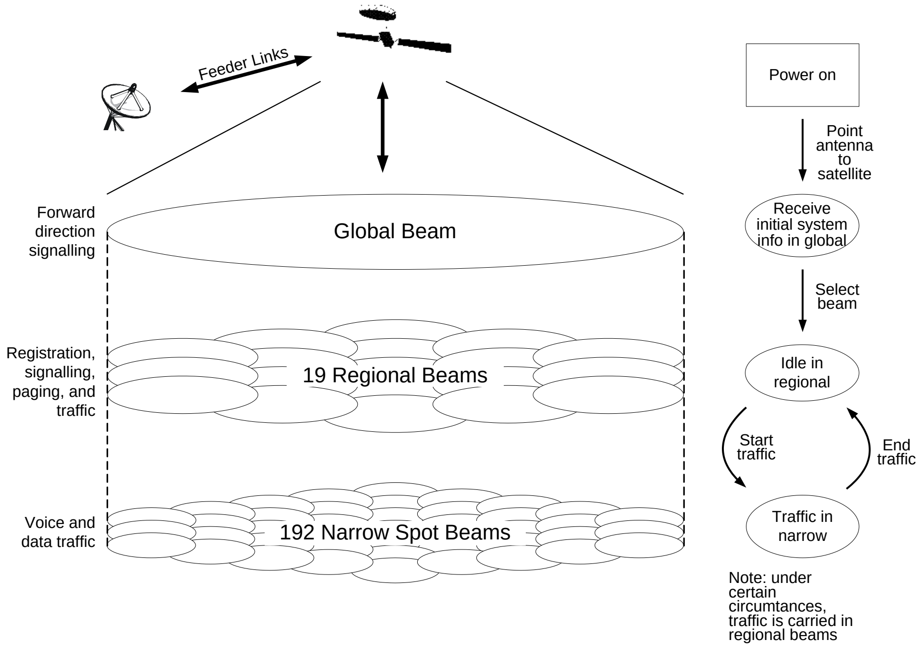

Figure 3-20: SBB Beam Hierarchy and AES Behavior

Handover between all beams within a satellite is supported within the network. Handover between satellites is not supported by the network and hence is implemented by the AES. During satellite handover there is a loss of communication between the air and ground.

3.4.8 Dynamic Capacity Allocation

SBB radio resource is managed by a group of distributed entities which control the capacity. Figure 3-21 illustrates a simplified view of the relationship between these entities. Resource management is performed at both the global and local levels, by the Global Resource Manager (GRM) and Local Resource Manager (LRM) entities, respectively. Specifically capacity can be moved from spot beam to spot beam to optimize system capacity on a real time basis.

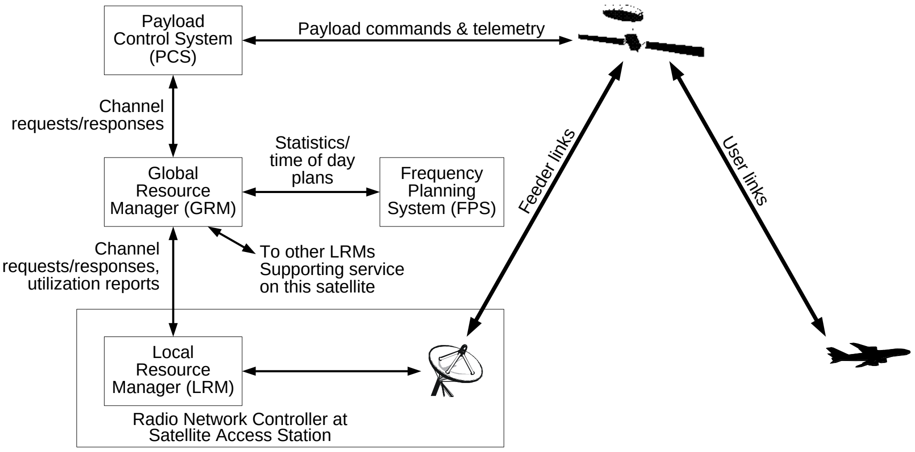

Figure 3-21: SBB Top Level Radio Resource Management Entities

The Radio Network Controller (RNC) at the Satellite Access Station manages the radio resource for individual AES.

The Local Resource Manager (LRM) is an entity within the RNC. It continuously measures the demand in each spot beam and decides if the number of satellite channels serving each regional or narrow beam is adequate to meet demand. If there is unmet demand in a beam the LRM will ask the Global Resource Manager (GRM) for more channels. If the LRM has unused channels it will return them to the GRM.

The GRM manages the radio resource for the entire satellite. Its role is to arbitrate between the competing demands of the various services on the satellite. The GRM provides capacity dynamically to LRMs when they make requests (such as the SBB traffic bearers in the narrow beams which are deployed on demand). If an LRM makes a request for capacity in a beam where the GRM has no capacity, the GRM will ask the Payload Control System (PCS) to switch a satellite channel into the beam. Such reconfigurations take no more than a couple of seconds.

The spacecraft DSP based payload maps 200kHz blocks of spectrum within the two feeder links (RHCP & LHCP) to 200kHz blocks of spectrum within a particular spot beam. The commands are sent by the PCS using the TT&C channel. In reality there is a further ‘beam forming‘ step since each of the 192 spot beams are formed by the weighting applied to the 120 feeder elements on the spacecraft.

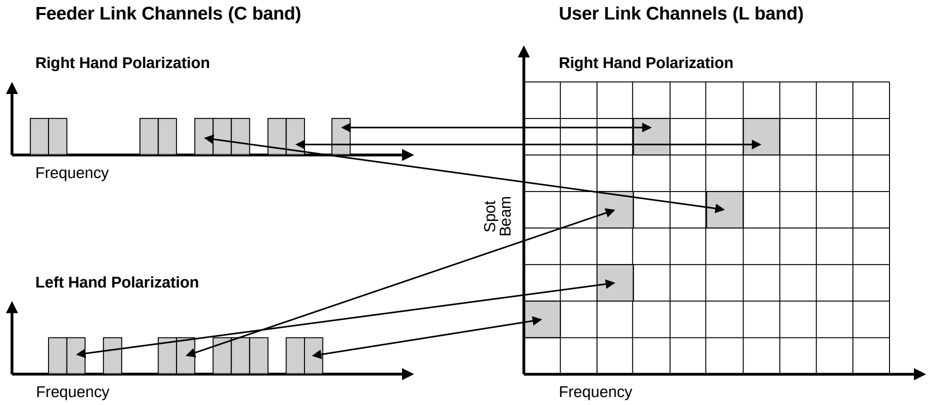

Figure 3-22: Feeder Link to Mobile Link Mapping

The GRM gathers utilization statistics from the LRMs. These statistics are used for capacity planning by the Frequency Planning System (FPS).

The FPS analyses the trends in demand and uses the results to forecast demand over the next 24 hours and further into the future. The FPS then periodically issues updated frequency plans to the GRM. The GRM then applies these plans, reconfiguring the channels used on the satellite payload and the LRMs to ensure that capacity is available in beams ahead of peaks in demand.

By anticipating peaks and troughs by pre-configuring approximately the correct number of channels to each beam over the course of a day, satellite capacity can be deployed more quickly with greater frequency re-use and less congestion.

3.4.9 Priority and Preemption

SBB uses the 3G principles of Quality of Service (QoS) to provide priority and preemption capability. QoS is similar to the ICAO concept of Required Communication Performance (RCP).

In the PS domain a key QoS parameter is the Allocation/Retention Priority (ARP) which specifies the relative importance compared to other connections for allocation and retention of capacity within bearers. The admission control function (3.4.5) is associated with the *allocation* while the bearer control function (3.4.4) is associated with *retention*. Capacity is allocated on a per packet basis. The ARP is requested per PDP context[16]. SBB AES request an ARP value of 1 (high priority) whilst non safety BGAN family terminals are limited to ARP values of 2 (normal priority) and 3 (low priority). The Core Network verifies that a terminal is eligible for the requested priority. Both admission control and bearer control use the ARP value to prioritize and if necessary preempt lower priority users thus ensuring that SBB AES achieve the appropriate performance even in congestion situations.

In the CS domain the enhanced Multi-Level Precedence and Pre-emption (eMLPP) attribute is used rather than ARP. Again admission control and bearer control use eMLPP to prioritize and if necessary preempt lower priority users thus ensuring that SBB AES achieve the appropriate performance even in congestion situations. Section 3.3.4.2.3 provides further details on the voice priority behavior including VoIP.

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[16] A SBB AES will have multiple PDP contexts. A separate PDP context is set up for each of: the ACARS service, the VoIP channel, and the Priority IP service. All are set to ARP of 1.

In addition when an SBB safety AES requests registration to the Radio Access Network, the terminal is identified as a safety terminal and is accepted on to the network with priority. This is particularly relevant during “registration storms” after, for example, ground station site switches.

3.5 Redundancy including fallback to Classic Aero

The AES is designed to automatically and seamlessly take advantage of additional satellite and ground infrastructure if and when it becomes available. In addition SBB is designed for tight interoperability with the Classic Aero service operating on the I3 and I4 satellites, and an AES with Classic reversion capability may seamlessly switch between the three networks. The primary mode of operation is SBB, followed by Classic Aero/I4, followed by Classic Aero/I3. The AES has prime responsibility to detect a network and service problem and initiate a switch to other SBB components or to Classic Aero. Figure 3-23 shows the SBB, Classic/I4 and Classic/I3 infrastructure at SBB service introduction.

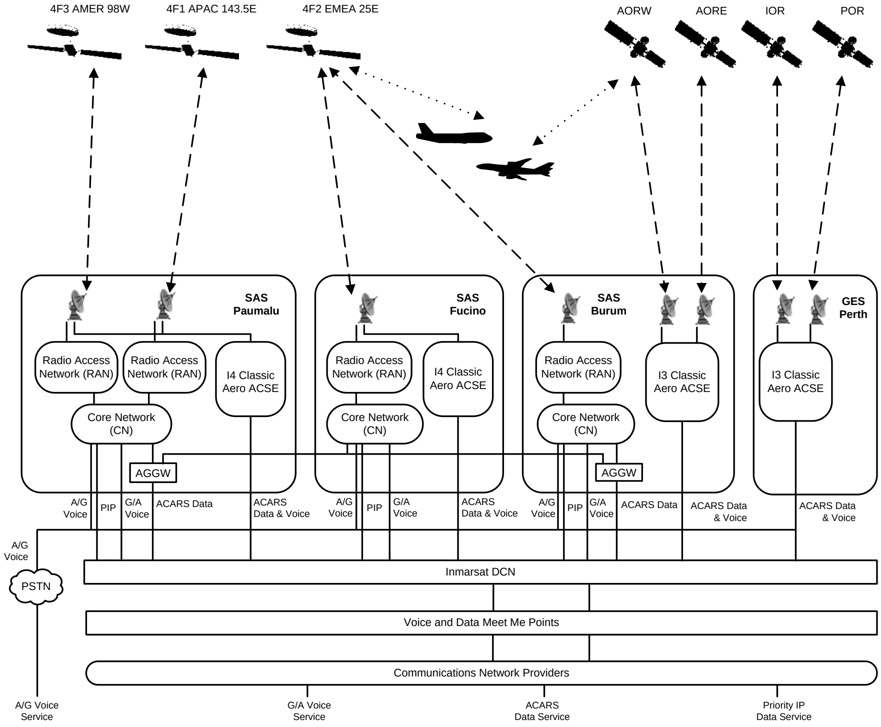

Figure 3-23: SBB and Classic Aero Redundancy

3.6 Operating Environment

3.6.1 Ancillary Terrestrial Component (ATCt)

In 2003, the Federal Communications Commission (FCC) authorized the use of spectrum in the ranges of 1525-1559 MHz and 1626.5-1660.5 MHz for Ancillary Terrestrial Component (ATCt), a wireless terrestrial service designed to operate in an integrated fashion with Mobile Satellite Services (MSS). This frequency band overlaps that used to provide both DO-210D-compliant AMS(R)S/AMSS and SBB-based AMS(R)S/AMSS, thereby creating the potential for co-channel and adjacent channel interference to these services in North American airspace. The FCC set limits on ATCt to protect aeronautical communications and the FCC's ATCt licensee in these bands entered into a coordination agreement with Inmarsat that includes further limits on co-channel and adjacent channel operations. In addition, the industry initiated work to assess the impact of this decision and SC-222 was set up to address SBB Safety Services and Ancillary Terrestrial Component (ATCt).

The minimum performance standards contained in DO-210D and DO-262B are intended to assure proper operation of Inmarsat AMS(R)S on all aircraft in FAA-controlled procedural airspace beyond line of sight of any significant concentration of ATCt base stations, and therefore well clear of any operationally significant ATCt-induced interference. Procedural airspace is the only FAA-controlled airspace where satellite services are currently utilized for AMS(R)S. For applications where AMS(R)S or AMSS is used *solely* in procedural airspace, no ATCt-specific modifications are required to an AES.

Aircraft seeking to use installed AMS(R)S equipment for provision of AMSS and aircraft seeking to verify AMS(R)S communication capability within the continental United States are cautioned that, as ATCt is deployed, additional resilience may be required to avoid ATCt-induced interference when either in the air over a highly-dense deployment of ATCt base stations or on the ground in close proximity to an ATCt base station. This caution applies to both Classic and SBB-based equipment. Appendix B of this attachment provides the potential levels of such interference in these environments together with the relevant ATCt interference models.

3.6.2 Iridium AMS(R)S on the same aircraft

The minimum performance standards contained in this document are intended to assure proper operation of Inmarsat safety services on all aircraft, and compatibility of such services with other communication, navigation, and surveillance radios operating on the same aircraft and in the same airpace. A significant caveat to this intent is the ability to support simultaneous independent operation of both Iridium and Inmarsat AES terminals on the same aircraft without a demonstrated means of cooperation. Owners, operators and installers are cautioned that simultaneous independent operation of Inmarsat and Iridium AES equipment on the same aircraft has the potential to cause significant interference to all Iridium AMSS and AMS(R)S services. This caution applies to Inmarsat equipment that is compliant with RTCA DO-210D, including all changes, ARINC Characteristic 741, ARINC Characteristic 761, ARINC Characteristic 781, and the AES requirements on SBB-based service equipment described in DO-262B. At the time of publication of this document, simultaneous independent operation of Inmarsat and Iridium equipment on the same aircraft had been reported in special cases. However, no generally applicable and technically feasible means of mitigating the potential for interference could be identified.

This caveat specifically excludes installations where Inmarsat and Iridium are intended for use in separate airspace. For example, no special installation or other considerations are required for Iridium use in polar airspace that is outside of the coverage volume of the Inmarsat services described in this document.

At the time of publication of this document, there is no regulatory guidance nor AMS(R)S operational need to require Inmarsat and Iridium systems to work simultaneously on the same aircraft. Some operators may choose to use Iridium and Inmarsat as backup or in a non-simultaneous mode of operation.

3.6.3 Iridium AMS(R)S in the same airspace

The caveats of the previous paragraph apply to simultaneous independent operation of Inmarsat and Iridium AMS(R)S or AMSS on the same aircraft. ICAO Aeronautical Communications Panel, Working Group M in 2008 accepted analyses indicating that Inmarsat safety and non safety communication services do not induce harmful interference to Iridium AMS(R)S equipment on other aircraft operating under 30/30 nautical mile separation in procedural airspace.

4 VERIFICATION PLAN

4.1 System Test Capability

4.1.1 ACARS Service

Based on experience of FANS1/A operating over Classic Aero, the SBB design for the ACARS service includes: the addition of test points so that latency measurements can be better made, the decoding of end system timestamps in the FANS1/A ADS and CPDLC messages, the collection of latency data in the satellite network, the ability to present graphically performance data in accordance with the methodology in GOLD appendix D, and the ability to isolate problems to specific aircraft/operators/avionics type/avionics software version.

For uplink messages to the aircraft, the AES measures the time that the message is delivered to the CMU, and this time is sent to the AGGW as part of the AGGW to AAGW protocol.

For downlink messages from the aircraft, the AES measures the time that a message is received from the CMU, and this time is transmitted to the AGGW as part of the AGGW to AAGW protocol.

Time synchronization of the AES for the above timestamps is carried out by the satellite network distributing time which is synchronized to UTC.

In addition to time information, all ACARS messages to and from the aircraft are stamped with the aircraft position, altitude, velocity and heading and this data is transmitted by the aircraft to the AGGW as part of the AGGW to AAGW protocol.

The type of aircraft, satcom avionics type, satcom avionics software version, satcom antenna type, and satcom antenna version are transmitted by the aircraft to the AGGW as part of the AGGW to AAGW protocol. This facilitates problem investigation.

Figure 4-1, Figure 4-2 and Table 4-1 show the various timing test points, and latency computations that are made by Inmarsat.

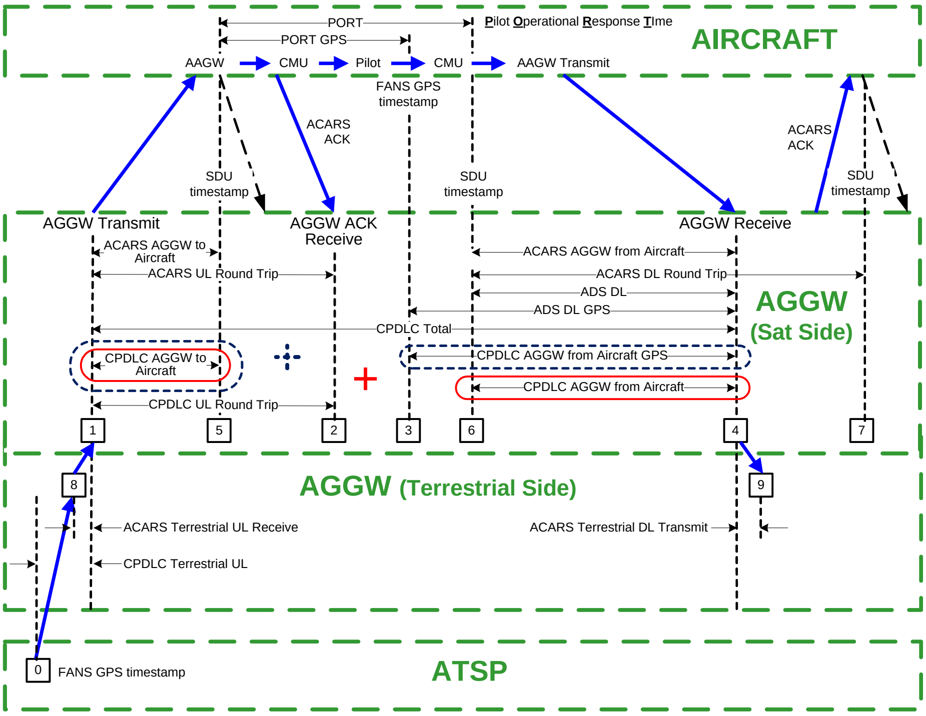

Figure 4-1: SBB ACARS Timing Diagrams

Label	Date/Time	Description	Originator	OAMS ICD Time Label
0	**ATSP UL**	Timestamp in CPDLC UL message from ATSP	ATSP	CPDLC Terrestrial UL
1	**UL Sent**	CPDLC clearance sent to aircraft = AGGW Transmit	AGGW	ACARS/CPDLC UL
2	**MAS Received**	MAS for CPDLC clearance received = AGGW ACK Receive	AGGW	ACARS/CPDLC UL ACK
3	**WILCO Sent**	Timestamp in CPDLC or ADS DL message from aircraft	FANS/GPS	ACARS/ADS/CPDLC DL Transmit
4	**WILCO Received**	WILCO reply for CPDLC clearance received = AGGW Receive	AGGW	ACARS/ADS/CPDLC DL Receive
5	**Sent to CMU**	Delivery to CMU (from gw_acars_ack)	AAGW	ACARS/CPDLC UL AES Receive
6	**DL Timestamp**	WILCO reply sent = Delivery from CMU (from ac_acars_msg)	AAGW	ADS/CPDLC DL Transmit GPS
7	**Received at CMU**	Delivery to CMU (from gw_acars_ack)	AAGW	ACARS DL AES ACK Receive
8	**Terrestrial UL**	AGGW receives terrestrial UL message	AGGW	ACARS Terrestrial UL Receive
9	**Terrestrial DL**	AGGW transmits terrestrial DL message	AGGW	ACARS Terrestrial DL Transmit

Figure 4-2: SBB ACARS Timing Points

Latency	Time	Latency Calculation Start/End Time	Calculation
ACARS AGGW to Aircraft	**1**	AGGW sends gw_acars_msg containing ACARS message	**5 – 1**
	5	"Time of delivery to CMU" from ac_acars_ack with matching ACARS UL message	
ACARS UL Round Trip	**1**	AGGW sends gw_acars_msg containing ACARS message	**2 – 1**
	2	AGGW receives ac_acars_ack with matching ACARS UL message	
ACARS AGGW from Aircraft	**6**	"Time of delivery from CMU" from ac_acars_msg containing ACARS DL message	**4 – 6**
	4	AGGW receives ac_acars_msg containing ACARS DL message	
ACARS DL	**6**	"Time of delivery from CMU" from ac_acars_msg containing ACARS DL message	**4 – 6**
	4	AGGW receives ac_acars_msg containing ACARS DL message	
ACARS DL Round Trip	**6**	"Time of delivery from CMU" from ac_acars_msg containing ACARS DL message	**7 – 6**
	7	"Time of delivery to CMU" from ac_acars_ack with matching ACARS ACK UL message	
ACARS Terrestrial UL Receive	**8**	AGGW receives terrestrial UL message (not in figure)	**1 – 8**
	1	AGGW sends gw_acars_msg containing ACARS message	
ACARS Terrestrial DL Transmit	**4**	AGGW receives ac_acars_msg containing ACARS DL message	**9 – 4**
	9	AGGW sends terrestrial DL message (not in figure)	
ADS DL	**6**	"Time of delivery from CMU" from ac_acars_msg containing ADS DL message	**4 – 6**
	4	AGGW receives ac_acars_msg containing ADS DL message	
ADS DL GPS	**3**	FANS GPS timestamp in ADS DL message	**4 – 3**
	4	AGGW receives ac_acars_msg containing ADS DL message	
CPDLC Total	**1**	AGGW sends gw_acars_msg containing CPDLC message	**4 – 1**
	4	AGGW receives ac_acars_msg containing CPDLC DL message	
CPDLC UL Round Trip	**1**	AGGW sends gw_acars_msg containing CPDLC message	**2 – 1**
	2	AGGW receives ac_acars_ack with matching CPDLC UL message	
CPDLC AGGW to Aircraft	**1**	AGGW sends gw_acars_msg containing CPDLC message	**5 – 1**
	5	"Time of delivery to CMU" from ac_acars_ack with matching CPDLC UL message	
CPDLC AGGW from Aircraft GPS	**3**	FANS GPS timestamp in CPDLC DL message	**4 – 3**
	4	AGGW receives ac_acars_msg containing CPDLC DL message	
CPDLC AGGW from Aircraft	**6**	"Time of delivery from CMU" from ac_acars_msg containing CPDLC DL message	**4 – 6**
	4	AGGW receives ac_acars_msg containing CPDLC DL message	
CPDLC Terrestrial UL	**0**	ATC timestamp in CPDLC UL message received at terrestrial link (not in figure)	**1 – 0**
	1	AGGW sends gw_acars_msg containing CPDLC message	
CPDLC ACTP GPS		CPDLC AGGW to Aircraft + CPDLC AGGW from Aircraft GPS	**(5 – 1) + (4 – 3)**
CPDLC ACTP		CPDLC AGGW to Aircraft + CPDLC AGGW from Aircraft	**(5 – 1) + (4 – 6)**
CPDLC PORT/Pilot & CMU GPS		CPDLC Total – CPDLC ACTP GPS	Equivalent to **3 – 5**
CPDLC PORT/Pilot & CMU		CPDLC Total – CPDLC ACTP	Equivalent to **6 – 5**

Table 4-1: SBB ACARS Latency Measurements

4.1.2 Voice Service

In contrast to the ACARS service, it is not feasible to add easily timing test points to the voice service. Firstly the voice service is in essence built on standard COTS voice protocols whereas the ACARS service has a bespoke inter gateway message system to which timing points can be easily added, and secondly voice systems don't add time stamps for latency etc. Instead typically each entity timestamps based on local time. Further in most voice systems the key time is when the call is answered rather than when it rings, and so the time of ringing is typically not recorded.

Hence there is limited voice test capability built into the system to measure the performance parameters in the main body of the MASPS. Instead most tests have to be undertaken by 'instrumenting' the AES and ground systems and running 'laboratory tests' albeit over the satellite – hence post implementation monitoring of many voice parameters is not practical.

An open issue is whether the two part dialing systems can be modified to record both the time a Ground to Air call is initiated from the ground and the time when the ringing occurs so that call set up times can be measured for all Ground to Air calls.

4.2 Detailed Pre-Approval Verification Plan

Note: The verification technique codes are described in Section 4.1 of the main body of this document.

The number of aircraft, types of aircraft, types of satcom avionics, Flight Information Regions (FIRs), flight hours, period of time, number of ADS messages, number of CPDLC messages, number of voice calls etc will be agreed with ATSPs at the beginning of the operational trials described below.

4.2.1 D10 - RCP240 CPDLC TT

Verification technique: OT

Requirements D10-D80 will be verified by collecting latency information on all ADS/CPDLC messages from a number of aircraft over a period of time and then plotting this data graphically in accordance with the methodology described in Appendix D of GOLD where the FANS1/A timestamps from the aircraft (based on GPS time) are decoded which allows the computation of latency of messages.

The data will be collected at three points:

1. By Inmarsat at the AGGW.
2. By the CNPs
3. By ATSPs.

Latency data collected by Inmarsat will be based on both the timestamps from the FANS1/A on aircraft applications, and also the timestamps that are appended by the AES when messages are sent/received from the CMU.

4.2.2 D20 - RCP240 CPDLC ET

See 4.2.1.

4.2.3 D30 - RSP180 ADS TT

See 4.2.1.

4.2.4 D40 - RSP180 ADS ET

See 4.2.1.

4.2.5 D50 - RCP400 CPDLC TT

See 4.2.1.

4.2.6 D60 - RCP400 CPDLC ET

See 4.2.1.

4.2.7 D70 - RSP400 ADS TT

See 4.2.1.

4.2.8 D80 - RSP400 ADS ET

See 4.2.1.

4.2.9 D90 - ADS & CPDLC Availability Safety

Verification technique: OT

Availability will be determined by keeping a log of outages over a period of time and computing the Network Availability as:

$$1 - \frac{\sum \text{Operationally significant unplanned outage duration}}{\text{Elapsed time}}$$

The log will include the time of the start of the outage, the time of the end of the outage, the outage duration, the scope of the outage in terms of FIRs/satellite regions/CNPs, the nature of outage (whether voice or data or both, whether effects all traffic or just ability of aircraft to log on etc), whether aircraft equipped with dual SBB/Classic avionics were affected, the time Inmarsat notified the outage to CNPs, and the time each CNP notified the outage to ATSPs.

Where an outage only affects part of the network, then the length of the outage is prorated. Thus if in one year there was one outage of one day which only affected one satellite out of three, then the overall network availability would be 1-1/(365*3). The same approach is applied if there is an outage over a smaller geographic area such as a regional beam.

The log and availability computation will be made for both aircraft equipped with SBB only avionics, and for those equipped with SBB/Classic avionics.

4.2.10 D100 - ADS & CPDLC Availability Efficiency

See 4.2.9.

4.2.11 D110 - RCP240 & RSP180 Number Unplanned Outages Safety

Verification technique: OT

This requirement will be verified by examination of the log collected as described in 4.2.9.

4.2.12 D120 - RCP400 & RSP400 Number Unplanned Outages

Verification technique: OT

This requirement will be verified by examination of the log collected as described in 4.2.9.

4.2.13 D130 - RCP240 & RSP180 Number Unplanned Outages Efficiency

Verification technique: OT

This requirement will be verified by examination of the log collected as described in 4.2.9.

4.2.14 D140 - RCP240 & RSP180 Unplanned Notification Time

Verification technique: OT

This requirement will be verified by examination of the log collected as described in 4.2.9.

4.2.15 D150 - RCP400 & RSP400 Unplanned Notification Time

Verification technique: OT

This requirement will be verified by examination of the log collected as described in 4.2.9.

4.2.16 D160 - ADS & CPDLC Data Addressing

Verification technique: OT

This requirement will be verified by observing that ADS and CPDL messages are delivered to/from the correct aircraft.

4.2.17 D170 - ADS & CPDLC Data Test Points

Verification technique: OT

These test points in the system are described in Section 4.1.1. No further verification is planned.

4.2.18 D180 - ADS & CPDLC Data Analysis

Verification technique: OT

This requirement will be verified by the ability to provide the test evidence to satisfy requirements D10 to D80.

4.2.19 V10 - Voice G/A Call Set Up 95%

Verification technique: BT and OT

A limited number of tests will be carried out to show the timing in CNP's Call Data Records (CDRs) for 'ringing' on the aircraft is accurate by recording the actual ringing time at the AES and comparing to the CDRs. These tests will be run with an AES in the laboratory but operating over the satellite.

Verification will then be carried out in operational trails by analyzing the Call Data Records.

4.2.20 V20 - Voice G/A Call Set Up 99%

See 4.2.19

4.2.21 V30 - Voice A/G Call Set Up 95%

Verification technique: BT

Since no definitive indication of when the pilot initiated a call is provided in the signaling, this test cannot be run in operational trials. Instead a limited number of calls (100 A2G calls and 100 G2A calls) will be run with an AES in the laboratory but operating over the satellite with the ground network. Calls will be placed using an auto dialer. The time when the call is initiated and of ground ringing will be recorded with special test equipment. Each call will be for 120 seconds since this is the defined timeperiod for 'Dropped Call Rate' in Section 1.7 of the main body of this document. The time between calls will be chosen such that the results are not biased by any 'memory effects' in the system.

The data will be analyzed to determined compliance with the following requirements:

- V30 - Voice A/G Call Set Up 95%
- V40 - Voice A/G Call Set Up 99%
- V50 - Voice Dropped Call Rate

4.2.22 V40 - Voice A/G Call Set Up 99%

See 4.2.21.

4.2.23 V50 - Voice Dropped Call Rate

4.2.21.

4.2.24 V60 - Voice Grade of Service

Verification technique: OT and A

1. Call Data Records from both Inmarsat and CNPs will be processed to determine the GOS during operational trials.
2. An analysis will be carried out to show that the 2012 voice traffic carried over Inmarsat's Classic Aero network can be carried over the SBB network. The analysis will include spectrum, channel unit, voice codec and voice switching systems. The analysis will also determine approximately how much additional capacity is available both in terms of what is currently operational and in terms of growth capacity.

4.2.25 V70 - Voice Quality

Verification technique: BT and A

The overwhelming contributor to voice quality degradation is the low-bitrate speech codec employed on the link between the AES and Inmarsat's terrestrial earth station. Therefore it will be demonstrated that the speech codec algorithm employed meets the requirement when DRT tested with trained human listeners in accordance with ANSI/ASA S3.2-2009 and in realistic over-the-air bit error rate conditions. This will be demonstrated separately for each of the codec types in use for circuit-switched and packet-switched (VoIP) speech services.

In addition, it will be shown by analysis that further significant speech quality degradation does not occur between the speech encoder/decoder at Inmarsat's terrestrial earth station and the boundary of the CNP's network, for example by showing that the G.711[17] standard is adhered to throughout this segment without additional speech transcoding.

4.2.26 V80 - Voice Latency

Verification technique: BT

Simultaneous acoustic recordings will be made of speech-like sounds transmitted between the handset of an AES and a second audio device (e.g. a handset or microphone/loudspeaker connected to an E1/T1 break-out tester) connected to the terrestrial interface under test. These tests will be run with an AES in the laboratory but operating over the satellite. Alternatively this test may be conducted remotely from the terrestrial interface under test if the latency of the intervening link is known or, if this latency is not known, the requirement is met anyway (including this unknown latency). For convenience the AES will be co-located with this second audio device for this test. Using these recordings the relative timing of occurrence of particular sounds at the sending and receiving ends of the call will be measured, and hence the latency determined. The average latencies of at least ten test calls in each direction will be determined.

4.2.27 V90 - Voice Availability

Verification technique: OT

Voice availability will be verified in the same manner as data availability which is described in Section 4.2.9.

4.2.28 V100 - Voice Number Unplanned Outages

See 4.2.27.

4.2.29 V110 - Voice Unplanned Notification Time

See 4.2.27.

4.2.30 V120 - Voice Addressing

Verification technique: OT

This requirement will be verified by observing that voice calls are delivered to/from the correct aircraft.

4.2.31 V130 - Voice Security

Verification technique: BT and A

This test will be run with an AES in the laboratory but operating over the satellite with the ground network.

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[17] G711 is the most commonly found voice companding system in voice trunk networks and is an ITU standard. G.711 uses a sampling rate of 8,000 samples per second, and uses non-uniform (logarithmic) quantization with 8 bits used to represent each sample, resulting in a 64 kbit/s bit rate. G711 delivers toll quality voice.

Initially it will be confirmed that it is possible to dial the aircraft from the ground using the prescribed method.

The following test cases will be run to ensure that none of these result in a successful call to the AES.

1. Call the AES' MSISDN from the PSTN.
2. Ask a non aero Inmarsat Distribution Partner to set up a call to Inmarsat's GMSC using the AES' MSISDN.
3. Make a call using a CNP's two part dialer without entering a password.
4. Make a call using a CNP's two part dialer and entering an incorrect password.

In addition an analysis will be carried out of the 'routes' set up in the Inmarsat GMSC to ensure that the special SBB MSISDN format can only be reached from CNP's trunks.

4.2.32 V140 - Voice CLI and Priority Indication

Verification technique: BT

This test will be run with an AES in the laboratory but operating over the satellite with the ground network.

Ground to air calls will be made at each of the four priorities each with caller line identity provided, and with caller line identify withheld (8 calls), and it will be verified that the appropriate CLI and priority level is displayed on the AES

4.2.33 V150 - Voice Priority Levels

Verification technique: BT

This test will be run with an AES in the laboratory but operating over the satellite with the ground network, with the AES supporting two voice channels.

Calls at all four priority levels for both Ground to Air and Air to Ground will be made. Ground to air calls will be initiated via the CNP's two part dialers.

The following will be verified.

1. Test case: Set up CS call. With no pre-existing calls to the AES in progress confirm A2G and G2A calls can be set up at any priority level. (8 calls).
2. Test case: Set up PS call. With an existing AOC/AAC G2A call in progress, make calls at all combinations of priority levels and direction, and confirm successful. (8 calls).
3. Test case: CS priority processing for same AES. With a first call AOC/AAC G2A, and a second call ATS A2G, make calls at all combinations of priority levels and direction, and confirm behavior is as expected (APC and AOC/AAC call fails, ATS and EMG call pre-empts AOC/AAC call). (8 calls).
4. Test case: PS priority processing for same AES. With a first call ATS A2G, and a second call AOC/AAC G2A, make calls at all combinations of priority levels and direction, and confirm behavior is as expected (APC and AOC/AAC call fails, ATS and EMG call pre-empts AOC/AAC call). (8 calls).
5. Test case: CS priority processing in network. If possible configure the network so that the network thinks that there is no spare network capacity,

and hence network pre-emption should be operational. With no pre-existing calls to the AES under test, demonstrate that for a new CS call in either direction at AOC/AAC triggers pre-emption of a BGAN user, a SBB non safety user, and a SBB safety user with a cockpit G2A APC call in progress. (6 calls).

6. Test case: PS priority processing in network. If possible configure the network so that the network thinks that there is no spare network capacity, and hence network pre-emption should be operational. With a pre-existing A2G call to the AES under test, demonstrate that for a new call in either direction at AOC/AAC triggers pre-emption of a BGAN VoIP user, a SBB non safety VoIP user, and a SBB safety VoIP user with a cockpit G2A APC call in progress. (6 calls).

4.3 Post Implementation Monitoring Plan

4.3.1 ACARS

Data will be collected and analyzed as described in 4.2 for requirements D10-D150 with reports provided every month (tbc).

4.3.2 Voice

Data will be collected and analyzed as described in 4.2 for requirements V10, V20, V90, V100 and V110 with reports provided every month (tbc).

Appendix A: Glossary of Acronyms and Definitions

3G	3rd Generation
A	Analysis
A/D	Analog to Digital
A2G	Air to Ground
A/G	Air to Ground
AAC	Airline Administrative Control
AAGW	ACARS Aircraft Gateway
ACARS	Aircraft Communications Addressing and Reporting System
ACSE	Access Control and Signaling Equipment
ADS	Automatic Dependent Surveillance
ADS-C	Automatic Dependent Surveillance – Contract
AEEC	Airlines Electronic Engineering Committee
AES	Aircraft Earth Station
AGGW	ACARS Ground Gateway
AISD	Aircraft Information Systems Domain
AMBE	Advanced Multi-band Excitation
AMER	Americas
AMS(R)S	**4.3.3** Aeronautic Mobile Satellite (Route) Services
AMSS	Aeronautic Mobile Satellite Services
ANSI	American National Standards Institute
AOC	Airline Operational Control
APAC	Asia-Pacific
APC	Aeronautical Passenger Communications
ARINC	Aeronautical Radio, Incorporate
ARP	Allocation/Retention Priority
ASA	American Standards Association
ATCt	Ancillary Terrestrial Component
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
AVP	Attribute Value Pair
BCt	Bearer Control
BGAN	Broadband Global Area Network
BSS	Business Support System
BSU	Beam Steering Unit
BT	Bench Test
C/No	Carrier to Noise
C	Compliant

CDR	Call Data Record
CLI	Caller Line Identification
CLIC	C band Link Integrity Checker
CMCF	Central Maintenance Computing Function
CMU	Communication Management Unit
CN	Core Network
CNP	Communication Network Provider
COTS	Custom Of The Shelf
CPDLC	Controller-pilot data link communications
CPN	Called Party Number
CS	Circuit Switched
CSP	Communication Service Provider
CUS	Channel Unit Subsystem
D/A	Digital to Analog
dB	Decibel
DCN	Data Communication Network
DL	Downlink
DLNA	Diplexer/Low Noise Amplifier
DNS	Domain Name Server
DRT	Diagnostic Rhyme Test
DSP	Digital Signal Processor
EFB	Electronic Flight Bag
EIRP	Equivalent Isotropically Radiated Power
ELGA	Enhanced Low Gain Antenna
EMEA	Europe Middle East and Africa
EMG	Emergency
eMLPP	Enhanced Multi Level Precedence and Pre-emption
FANS	Future Air Navigation System
FANS1/A	FANS1/A is the name for the current implementation of FANS in procedural airspace. FANS1 is the Boeing implementation while FANSA is the Airbus implementation.
FEC	Forward Error Correction
FIR	Flight Information Region
FMHPA	Flange Mount High Power Amplifier
FPS	Frequency Planning Subsystem
FT	Flight Test
G/A	Ground to Air
G/T	Gain to Noise Temperature ratio
G2A	Ground to Air
GES	Ground Earth Station
GGSN	Gateway GPRS Support Node

GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema (Глобальная Навигационная Спутниковая Система)
GMSC	Gateway-MSC
GNSS	Global Navigation Satellite Systems
GOLD	Global Operational Data Link Document
GOS	Grade Of Service
GPS	Global Positioning System
GRM	Global Resource Manager
GUI	Graphical User Interface
GW	Gateway
HGA	High Gain Antenna
HLD	High Power Amplifier/ Diplexer/Low Noise Amplifier
HLR	Home Location Register
HQ	Head Quarter
I	Inspection
I3	Inmarsat-3
I4	Inmarsat-4
IAM	Initial Address Message
ICAO	International Civil Aviation Organization
ID	Identification
IF	Intermediate Frequency
IGA	Intermediate Gain Antenna
IMSI	International Mobile Subscriber Identity
INet	Input Networks
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU	International Telecommunications Union
IVR	Interactive Voice Response
kSym/s	kilo Symbols per second
LHCP	Left Hand Circular Polarization
LNA	Low Noise Amplifier
LRM	Local Resource Manager
MAS	Message Assurance
MLPP	Multi Level Precedence and Pre-emption
MMP	Meet Me Point
MPA	Multi Port Amplifier
MASPS	Minimum Aviation System Performance Standards
MOPS	Minimum Operational Performance Standards
MSC	Mobile Switching Center
MSISDN	Mobile Subscriber Integrated Services Digital Network-Number

MSS	Mobile Satellite Services
NC	Non Compliant
NOC	Network Operations Centre
NT	(Ground) Network Test
NY	New York
ONets	Output Networks
OR	Ocean Region
OT	Operational Test
PCS	Payload Control System
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PIN	Personal Identification Number
PIP	Prioritized IP
PMC	Program Management Committee
PORT	Pilot Operational Response Time
PS	Packet Switched
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
QoS	Quality of Service
RAN	Radio Access Network
RCP	Required Communication Performance
RDI	Restricted Digital Information
RF	Radio Frequency
RFS	Radio Frequency Subsystem
RHCP	Right Hand Circular Polarization
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RRC	Raised Root Cosine
RSP	Required Surveillance Performance
RTCA	Radio Technical Commission for Aeronautics
RTP	Real-time Transport Protocol
Rx	Receiver
SARPS	(ICAO) Standards and Recommended Practices
SAS	Satellite Access Station
SAW	Surface Acoustic Wave
SBAS	Satellite Based Augmentation System
SBB	SwiftBroadband
SDU	Satellite Data Unit
SGSN	Serving GPRS Support Node

SID	Self-Imposed Delay
SIP	Session Initiation Protocol
SITA	**4.3.4** Société Internationale de Télécommunications Aéronautiques
SSP	Satellite Service Provider
SSPA	Solid State Power Amplifiers
SSR	Secondary Surveillance Radar
SVGM	Satellite Voice Guidance Material
TCP	Transmission Control Protocol
TCP/IP	TCP over IP
TDM	Time Division Multiplex
TDMA	Time Division Multiplex Access
TE	Terminal Equipment
TT&C	Telemetry Tracking and Control
Tx	Transmit
UDI	Unrestricted Digital Information
UE	User Equipment
UL	Up Link
UMTS	Universal Mobile Telecommunications System
UT	User Terminal
UTC	Coordinated Universal Time
VHF	Very High Frequency
VIP	Virtual IP (Address)
VLR	Visitor Location Register
VoIP	Voice Over IP
WILCO	Will Comply

Appendix B: Interference Model for Emissions Associated with Ancillary Terrestrial Component (ATCt) Ground Stations

This is found in a separate word file

END OF WORD FILE