ACP/1-DP/2
13/5/07

ГРУППА ЭКСПЕРТОВ ПО АВИАЦИОННОЙ СВЯЗИ (ACP)

ПЕРВОЕ СОВЕЩАНИЕ

Монреаль, 10–18 мая 2007 года

Пункт 2 повестки дня. Рассмотрение проекта *руководства по подробным техническим спецификациям для AMS(R)S*

ПРОЕКТ ДОКЛАДА

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Пункт 2 повестки дня. Рассмотрение проекта *руководства по подробным техническим спецификациям для AMS(R)S*

2.1. ВВЕДЕНИЕ

2.1.1 В рамках данного пункта повестки дня совещание рассмотрело доклад Рабочей группы М (РГ-М).

2.1.2 Совещание напомнило о том, что на совещании AMCP/8 (4–13 февраля 2003 года) РГ-М была поручена задача по рассмотрению возможности работы систем речевой связи в полосе очень высоких частот (ОВЧ) в режиме со смещением несущей в условиях разноса каналов 8,33 кГц. В ответ РГ-М представила на рассмотрение совещанию предложение об изменении Приложения 10 *"Авиационная электросвязь"*.

2.1.3 Одна из основных задач РГ-М заключалась в разработке руководства по авиационной подвижной спутниковой (маршрутной) службе (AMS(R)S). Во исполнение рекомендации 3/2 Рабочей группы полного состава Группы АСР (21–29 июня 2005 года) была создана Подгруппа по системе "Иридиум", на которую возложили задачу по разработке проекта руководства на основе пересмотренных Стандартов и Рекомендуемой практики (SARPS) для AMS(R)S, внесенных в Приложение 10 поправкой 82.

2.1.4 Подгруппе Рабочей группы М были поручены следующие задачи:

a) разработка нового технического руководства по системе "Иридиум" в сроки, обеспечивающие возможность реализации предложенной даты начала применения SARPS для AMS(R)S в ноябре 2007 года;

b) разработка руководства по внедрению в целях предоставления рекомендаций государствам относительно принятия системы в эксплуатацию;

c) определение требований к апробации, связанных с техническим руководством по системе "Иридиум", и проведение, при необходимости, соответствующей апробации;

d) введение системы контроля документации для определения и сопровождения основных документов;

e) координация с другими группами экспертов ИКАО, при необходимости, через Секретариат ИКАО;

f) обеспечение самой широкой представленности представителей отрасли в деятельности Подгруппы.

2.1.5 Для выполнения работ, связанных с AMS(R)S, Подгруппа РГ-М провела перечисленные ниже восемь совещаний:

a) АСР-РГ-М-Иридиум № 1: Монреаль, Канада, 20–22 сентября 2005 года;

b) АСР-РГ-М-Иридиум № 2: Монреаль, Канада, 1–3 ноября 2005 года;

c) АСР-РГ-М-Иридиум № 3: Монреаль, Канада, 15–17 февраля 2006 года;

d) АСР-РГ-М-Иридиум № 4: Монреаль, Канада, 17–19 мая 2006 года;

e) АСР-РГ-М-Иридиум № 5: Монреаль, Канада, 22–24 августа 2006 года;

f) АСР-РГ-М-Иридиум № 6: Монреаль, Канада, 24–26 октября 2006 года;

g) АСР-РГ-М-Иридиум № 7: Темпе, Аризона, США, 9–11 января 2007 года;

h) АСР-РГ-М-Иридиум № 8: Монреаль, Канада, 13–15 марта 2007 года.

2.1.6 Докладчиком этой Группы был г-н Роберт Дж. КЕРЖЕВСКИ из Соединенных Штатов Америки.

2.1.7 Совещание приступило к рассмотрению вышеупомянутого материала, о чем говорится в последующих пунктах.

2.2 РЕЖИМ РАБОТЫ СО СМЕЩЕНИЕМ НЕСУЩЕЙ В УСЛОВИЯХ РАЗНОСА КАНАЛОВ 8,33 КГЦ

2.2.1 Совещание рассмотрело материал, представленный РГ-М, в котором предлагается поправка к главе 2 части II *"Системы речевой связи"* тома III *"Системы связи"* Приложения 10, касающаяся режима работы системы ОВЧ-речевой связи со смещением несущей (CLIMAX) в условиях разноса каналов 8,33 кГц. Первоначально внесение Стандартов в Приложение 10, касающихся разноса ОВЧ-каналов 8,33 кГц, не предусматривало возможности работы в режиме с разносом каналов. Режим работы с разносом каналов является эффективным средством обеспечения связи "воздух – земля" в обширных географических районах. Эта технология активно используется в Европе, и в этой связи ряд существующих присвоений частот с использованием режима со смещением несущей в условиях разноса каналов 25 кГц нельзя использовать в условиях разноса каналов 8,33 кГц. Исследование, проведенное ЕВРОКОНТРОЛем, продемонстрировало возможность использования систем с двумя несущими в условиях разноса каналов 8,33 кГц, и в этой связи была высказана рекомендация о том, что такой вариант следует внести в Приложение 10. Совещание согласилось с предлагаемыми поправками к Приложению 10, изложенными в добавлении A.

RSPP **Рекомендация 2/1. Поправка к части II тома III Приложения 10, касающаяся использования систем со смещенной несущей в условиях разноса каналов 8,33 кГц**

Рекомендуется изменить часть II тома III Приложения 10, как показано в добавлении A к докладу по данному пункту повестки дня.

2.3 РУКОВОДСТВО ПО АВИАЦИОННОЙ ПОДВИЖНОЙ СПУТНИКОВОЙ (МАРШРУТНОЙ) СЛУЖБЕ

2.3.1 Участники совещания приняли к сведению информацию о том, что для выполнения порученных задач Подгруппа РГ-М разработала проект руководства по авиационной подвижной спутниковой (маршрутной) службе, состоящий из следующих частей:

2.3.1.1 Введение, представляющее собой краткую справку, содержащую исходную информацию, а также описание целей руководства и последующих частей руководства.

2.3.1.2 В части I содержится общее описание авиационной подвижной спутниковой связи, включая информацию о видах применения, требованиях пользователей, потенциальных эксплуатационных выгодах и информацию о деятельности по стандартизации, осуществляемой ИКАО и организациями авиационной отрасли. В этой части также содержится информация, касающаяся организационных аспектов служб AMS(R)S, SARPS для AMS(R)S и наличия радиочастотного спектра.

2.3.1.3 В части II руководства рассматривается авиационная подвижная спутниковая связь, обеспечиваемая спутниковой системой "Иридиум". В ней также содержится информация об обеспечении соответствия SARPS для AMS(R)S и эксплуатационным параметрам системы "Иридиум", имеющим отношение к стандарту на минимальные эксплуатационные характеристики авионики, обеспечивающей спутниковые системы следующего поколения, определяемые в документе RTCA DO-262.

2.3.1.4 В части III руководства содержится информация об авиационной подвижной спутниковой связи, предоставляемой "классическими" спутниковыми сетями Инмарсата и MTSAT.

2.3.2 Структура руководства предусматривает возможность включения информации о будущих спутниковых системах и сетях посредством внесения новых частей, аналогичных частям II и III, что исключает необходимость пересмотра существующих частей.

2.3.3 Особое внимание совещание обратило на части III руководства. Поскольку данная часть находится на начальном этапе разработки и пока не готова для рассмотрения настоящим совещанием, предполагается, что на более позднем этапе члены Группы экспертов будут согласовывать этот материал путем переписки. С учетом публикации руководства в сроки, обеспечивающие реализацию даты начала применения пересмотренных SARPS для AMS(R)S в ноябре 2007 года, участники совещания согласились со следующим:

a) часть III руководства следует завершить к 14 сентября 2007 года;

b) после завершения материал будет направлен всем членам Группы экспертов с просьбой представить замечания до 12 октября 2007 года;

c) в том случае, если до 12 октября 2007 года согласованная версия части III не будет готова, материал по AMSS, в настоящее время содержащийся в поправке 81 к Приложению 10, послужит основой для публикации части III (см. старый материал по AMSS, глава 4 плюс дополнение по адресу

http://www.icao.int/anb/panels/acp/WG/M/Iridium_swg/IRD-08/IRD-SWG08-WP07%20-%20). Этот материал будет размещен только на веб-сайте Группы ACP. Тем временем ИКАО необходимо опубликовать руководство без части III.

2.3.4 Совещание рассмотрело проект руководства и подготовило следующую рекомендацию:

Рекомендация 2/2. Публикация руководства по AMS(R)S

Материал, представленный в добавлении B к докладу по данному пункту повестки дня, рекомендуется опубликовать в качестве руководства ИКАО.

2.4 АПРОБАЦИЯ ТРЕБОВАНИЙ, СОДЕРЖАЩИХСЯ В SARPS AMS(R)S ДЛЯ СИСТЕМЫ "ИРИДИУМ"

2.4.1 В рамках круга полномочий Подгруппы РГ-М были определены требования к апробации, связанные с информацией, содержащейся в части II проекта руководства по AMS(R)S, и проведена соответствующая апробация. РГ-М рассмотрела доклад об апробации требований, содержащихся в SARPS AMS(R)S для системы "Иридиум"; были рассмотрены замечания и рекомендации Группы РГ-М.

2.4.2 Совещание приняло к сведению информацию о том, что все требования в пересмотренных SARPS AMS(R)S (применимые с 22 ноября 2007 года) апробированы в рамках проведения инспекций, анализа, моделирования, единичных проверок и летных испытаний. Полный доклад об апробации размещен на веб-сайте Группы ACP по адресу (http://www.icao.int/anb/panels/acp/meetings/acp1/ACP.1.WP.009.2.complete.en.pdf).

2.5 АСПЕКТЫ СОВМЕСТИМОСТИ СИСТЕМ ИНМАРСАТА/MTSAT И "ИРИДИУМ"

2.5.1 Участников совещания проинформировали о том, что в связи с эксплуатацией спутниковой системы "Иридиум" и "классических" спутниковых сетей авиационной связи (т. е. Инмарсат и MTSAT) в соседних полосах частот (1610–1626,5 МГц и 1626,5–1660,5 МГц соответственно) могут возникнуть помехи от "классических" сетей, работающих на соседних с системой "Иридиум" частотах. В этой связи "классические" сети не могут обеспечить соответствие требованию пересмотренных SARPS AMS(R)S (применимых с 22 ноября 2007 года), согласно которым:

4.3.2.1 Совокупные излучения AES, необходимые для выдерживания расчетных характеристик системы, регулируются в целях исключения вредных помех другими системами, необходимыми для обеспечения безопасности и регулярности аэронавигации и установленными на том же или другом воздушном судне.

Примечание 1. Вредные помехи могут создавать излучаемые сигналы и/или кондуктивные излучения, которые включают гармонические, дискретные побочные, интермодуляционные составляющие и шумовые излучения и не обязательно обусловлены только состоянием "передатчик включен".

Примечание 2. Требования к защите GNSS содержатся в томе I Приложения 10.

2.5.2 Совещание отметило, что для оценки потенциальных помех, включая фактическое использование радиочастотного (РЧ) спектра "классическими" сетями для связи AMS(R)S и конкретных стандартов, содержащихся в документах RTCA DO-210D, ARINC 741 и руководстве Инмарсата по определению систем, необходимо получить больший объем информации и провести исследование.

2.5.3 Совещание согласилось с тем, что данный вопрос необходимо рассмотреть в рамках деятельности Рабочей группы по сопровождению документации. Завершить эту задачу следует Специализированной подгруппе. Секретарь проинформирует членов Группы экспертов о том, когда будет проводиться это исследование. Данную задачу необходимо завершить до 31 августа 2007 года, с тем чтобы обеспечить возможность включения, при необходимости, любого соответствующего материала в руководство по AMS(R)S.

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ДОБАВЛЕНИЕ A

ПРЕДЛАГАЕМАЯ ПОПРАВКА К МЕЖДУНАРОДНЫМ СТАНДАРТАМ И РЕКОМЕНДУЕМОЙ ПРАКТИКЕ

АВИАЦИОННАЯ ЭЛЕКТРОСВЯЗЬ

ПРИЛОЖЕНИЕ 10
К КОНВЕНЦИИ О МЕЖДУНАРОДНОЙ ГРАЖДАНСКОЙ АВИАЦИИ

ТОМ III
(СИСТЕМЫ СВЯЗИ)

ЧАСТЬ II. СИСТЕМЫ РЕЧЕВОЙ СВЯЗИ
ГЛАВА 2 И ДОПОЛНЕНИЕ A

ПРИМЕЧАНИЯ ОТНОСИТЕЛЬНО ФОРМЫ ПРЕДСТАВЛЕНИЯ ПРЕДЛАГАЕМОЙ ПОПРАВКИ

В тексте поправки исключаемый текст зачеркивается, а новый текст затеняется, как показано ниже:

1.	~~Текст, подлежащий исключению, зачеркивается.~~	Текст, подлежащий исключению
2.	Новый текст, подлежащий включению, затеняется.	Новый текст, подлежащий включению
3.	~~Текст, подлежащий исключению, зачеркивается~~, а следующий за ним заменяющий текст затеняется.	Новый текст, заменяющий существующий текст

ГЛАВА 2. АВИАЦИОННАЯ ПОДВИЖНАЯ СЛУЖБА

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2.2 СИСТЕМНЫЕ ХАРАКТЕРИСТИКИ НАЗЕМНОГО ОБОРУДОВАНИЯ

2.2.1 Функция передачи

2.2.1.1 *Стабильность частоты*. Рабочая радиочастота не изменяется более чем на ±0,005% от присвоенной частоты. В тех случаях, когда в соответствии с положениями тома V вводится разнос каналов 25 кГц, рабочая радиочастота не отличается более чем на ±0,002% от присвоенной частоты. В тех случаях, когда в соответствии с положениями тома V вводится разнос каналов 8,33 кГц, рабочая радиочастота не отличается более чем на ±0,0001% от присвоенной частоты.

Примечание. Вышеуказанные требования к стабильности частоты ~~допуски не применимы~~ не достаточны для ~~к~~ систем~~ам~~ со смещенной несущей, использующих разнос каналов 25 кГц или больше.

2.2.1.1.1 Системы со смещенной несущей в условиях разноса каналов 8,33 25, 50 и 100 кГц. Стабильность отдельных несущих в системах по смещенной несущей является такой, что она обеспечивает предотвращение появления гетеродинных частот первого порядка величиной менее 4 кГц, и, кроме этого, максимальное отклонение внешних несущих от присвоенной несущей частоты не превышает 8 кГц. Системы со смещенной несущей, предназначенные для работы с разносом каналов 8,33 кГц, ограничиваются системами с двумя несущими, использующими смещение несущей на ±2,5 кГц. ~~не используются на каналах с разносом 8,33 кГц.~~

Примечание. Примеры требуемой стабильности отдельных несущих в системах со смещенной несущей можно найти в дополнении A к части II.

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2.3 СИСТЕМНЫЕ ХАРАКТЕРИСТИКИ БОРТОВОГО ОБОРУДОВАНИЯ

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2.3.2.2 ЧУВСТВИТЕЛЬНОСТЬ

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2.3.2.4 *Ширина полосы частот эффективного приема для приемных устройств с разносом каналов 8,33 кГц*. Настроенная на канал, который устанавливается в соответствии с положениями тома V и имеет ширину 8,33 кГц, приемная система обеспечивает ~~адекватный звуковой выходной сигнал, когда сигнал, указанный в п. 2.3.2.2 выше, имеет несущую частоту, отличающуюся не более чем на ±0,0005% от присвоенной частоты. Дополнительная информация о ширине полосы частот эффективного приема содержится в дополнении A к части II.~~ следующую ширину полосы эффективного приема:

a) в районах, где применяются системы со смещенной несущей, приемная система обеспечивает адекватный звуковой выходной сигнал, когда сигнал, указанный в п. 2.3.2.2 выше, имеет несущую частоту, составляющую ±2,5 кГц от присвоенной частоты;

b) в районах, где системы со смещенной несущей не применяются, приемная система обеспечивает адекватный звуковой выходной сигнал, когда сигнал, указанный в п. 2.3.2.2 выше, имеет несущую частоту, составляющую ±0,0005% от присвоенной частоты. Дополнительная информация относительно ширины полосы частот эффективного приема содержится в дополнении A к части II.

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2.3.2.7 **Рекомендация**. *Что касается приемников, которые отвечают требованиям, изложенным в п. 2.3.2.3 или 2.3.2.4 выше, и используются в районах, где предусматриваются системы со смещенной несущей, характеристики приемника должны быть такими, чтобы:*

a) звуковая частотная характеристика исключала возможность возникновения высокого уровня звуковых частот гетеродирования вследствие одновременного приема двух и более частот со смещенной несущей;

b) схемы загрубления приемника, если они имеются, работали удовлетворительно при наличии звуковых частот гетеродирования, возникающих вследствие одновременного приема двух и более частот со смещенной несущей.

. . .

ДОПОЛНЕНИЕ К К ЧАСТИ II.
ИНСТРУКТИВНЫЙ МАТЕРИАЛ ПО СИСТЕМАМ СВЯЗИ

. . .

1.2 Система со смещенной несущей в условиях разноса каналов 25, 50 и 100 кГц

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ENGLISH ONLY

APPENDIX B

MANUAL FOR AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE

MANUAL FOR AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE

Executive Summary

Satellite technology has a unique potential to satisfy many present and future communication, navigation and surveillance (CNS) needs. A key part of future system improvement is the introduction of air ground digital communication services which could provide substantial benefits in air traffic services (ATS) efficiency and capacity, satisfying the needs of air traffic safety as well. Important system considerations included world wide interoperability, access by all classes of aeronautical users, the need to accommodate evolutionary system growth in terms of functional capability and capacity in an adaptive manner, considering different requirements in different areas, and the potential for taking advantage of satellite service capability from different service providers.

The ICAO Aeronautical Communications Panel (ACP) has carried forward future air navigation systems planning that designated basic architectural concepts for using satellite communications, initially in oceanic and remote environments, and eventually in continental airspace. Progress in satellite communications for aeronautical safety is realized through the revision of Standards and Recommended Practices (SARPs) and guidance material by ICAO for the aeronautical mobile satellite (route) service (AMS(R)S), and through the interactions of ICAO with other international bodies to assure that resources are coordinated and available.

Acceptance of the applicability of data links to support air traffic services (ATS) as largely replacing voice communications requires assurance that all relevant elements of data link network(s) and sub-networks (such as a satellite sub-network) are properly coordinated and interoperable. AMS(R)S is considered a global satellite sub-network of the aeronautical telecommunications network (ATN) that provides end-to-end voice and data connectivity among end-users, such as air traffic controllers, pilots, aircraft operators. Interoperability with the ATN is assured by means of a standardized architecture for all elements of the ATN, based on ICAO SARPs and guidance material.

The objective of this Manual is to provide an overview of systems operating in the Aeronautical Mobile Satellite (Route) Service (AMS(R)S) and offer guidance on the consideration of satellite networks as a platform for AMS(R)S communications for the safety and regularity of flight. The Aeronautical Mobile Satellite (Route) Service is a service providing communications between the aircraft earth stations (on-board an aircraft) and ground stations through a satellite link for the safety, regularity and efficiency of flight. This manual is to be considered in conjunction with ICAO Standards and Recommended Practices (SARPs) as contained in Annex 10, Volume III, Part I, Chapter 4. This manual provides implementation guidance for specific satellite systems operating in the AMS(R)S.

About the document

The AMS(R)S manual is divided into the following parts:

Part I – General information on AMS(R)S

Part I contains a general description of aeronautical mobile satellite communications including information on applications, user requirements, potential operational benefits, information on standardization activities undertaken by ICAO and aviation industry bodies. Information on institutional guidelines related to AMS(R)S services, the Standards and Recommended Practices (SARPs) and AMS(R)S spectrum availability are provided.

Part II – Iridium Satellite Network

Part II of the manual deals with aeronautical mobile satellite communications provided by the Iridium satellite network. Information on the compliance with AMS(R)S SARPs and Iridium-specific performance parameters pertaining to minimum operation performance standard for avionics supporting next-generation satellite systems as specified in RTCA DO-262 is provided.

Part III – Inmarsat and MTSAT

Part III contains information on aeronautical mobile satellite communications provided by the “classic” Inmarsat and the MTSAT satellite networks.

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MANUAL FOR AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE Part 1

DRAFT v1.0

21 March 2007

Date & Version	Change
11/01/06 v0.1	Draft of Part 1 of ICAO AMS(R)S Manual
v.0.2	Tempe, AZ WG-07 meeting edits
v.0.3	additional material inserted by the Secretariat
v.1.0	Meeting 8 edits

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1 INTRODUCTION

1.1 Objective

The objectives of this part of the manual are to provide an overview of the Aeronautical Mobile Satellite (Route) Service (AMS(R)S) and offer guidance on the consideration of satellite networks as a platform for AMS(R)S communications for the safety and regularity of flight. This manual is to be considered in conjunction with ICAO Standards and Recommended Practices (SARPs) as contained in Annex 10, Volume III, Part I, Chapter 4 and subsequent sections of this document which provide implementation guidance for specific satellite systems.

1.2 Scope

This part contains a general description of aeronautical mobile satellite communications including information on applications, user requirements, potential operational benefits, and standardization activities undertaken by ICAO and aviation industry bodies. Information on institutional guidelines related to AMS(R)S services, the Standards and Recommended Practices (SARPs), and AMS(R)S spectrum issues are also included.

1.3 Historical

In the 1960s, the civil aviation community began careful studies of the practicability of satellite communications providing long distance communications, primarily as a replacement for high frequency (HF) communications over oceanic and remote areas. Early experimentation focused on the use of the very high frequency (VHF) spectrum (118 to 136 MHz).

Using the NASA ATS 3 experimental satellite, the aviation community demonstrated the feasibility of VHF satellite based communications in aviation. In 1968, ICAO established a panel of experts to explore the Application of Space Techniques Relating to Aviation (ASTRA). This panel studied the technical characteristics of an aeronautical satellite system. At that time, the aviation community considered that an initial, low capacity, satellite system could provide early relief to satisfy in particular the requirements for oceanic communications and would permit transition to a higher capacity satellite at a later stage as technology developed. These satellite systems were to operate in frequency bands, allocated on an exclusive basis to the aeronautical mobile satellite (route) service. Use of the bands for public correspondence (e.g. passenger communications) was not excluded.

During 1971 - 1973 and 1974 - 1975, several experiments were accomplished with the ATS 5 and ATS 6 satellites respectively. These tests demonstrated that at that time, it was feasible to use available technology for providing satellite communications to aircraft in the 1.5 / 1.6 GHz bands. A KC-135 aircraft was used to test the effect of direct path and multipath propagation with different antennae. Ranging and digital data demonstration tests were also performed. Aircraft tests were performed at various altitudes, elevation angles to the satellite and at various headings and speeds.

An international aeronautical satellite programme (AEROSAT) was planned in the early 1970s. AEROSAT was a programme to jointly plan, construct and manage a dedicated aeronautical experimental satellite system sponsored by Canada, the United States, and the European Space Agency (ESA) representing several European nations, under a memorandum of understanding signed in August 1974. Its objective was to develop and launch several satellites to perform a variety of experiments to determine preferred system characteristics of an operational system. The satellites were to be launched in the late 1970s. However the satellite cost grew much larger than anticipated and a downturn in world wide economic conditions, along with the lack of the expected traffic growth, caused the airlines to withdraw their support.

From 1978 to 1982, the Aviation Review Committee (ARC) managed a broad alternative system improvements study aimed at oceanic and remote overland areas, with the participation of more than twenty States and international organizations. The ARC identified the potential of automatic dependent surveillance (ADS) and air ground satellite data link communications based on a space segment shared with other (non-aeronautical) communication services.

In November 1983, following the ARC conclusions and recommendations, the ICAO Council established the Special Committee on Future Air Navigation Systems (FANS) to "study technical, operational, institutional and economic questions, including cost/benefit effects relating to future potential air navigation systems". FANS tasks included studying the application of satellite technology in aviation. In 1988, the FANS Committee concluded its work and recommended to ICAO the adoption of the global communication, navigation and surveillance/air traffic management (CNS/ATM) systems concept, largely based on satellite technology. The concept was consequently endorsed by the Tenth Air Navigation Conference in 1991.

The systems concept was further developed and refined by the Phase II of the FANS Committee which concluded its work in 1993. Its work included a study of the necessary institutional arrangements, development of a global co-ordinated implementation plan, an assessment of ongoing of research and development activities, and development guidelines for air traffic management (ATM) evolution. Noting the fact that implementation activities had already begun, the name “global CNS/ATM systems concept” was changed to “CNS/ATM systems”.

The future air navigation system was mainly based on:

a) a global navigation satellite system (GNSS) to allow aircraft en route to determine their present position world wide, based on signals transmitted by satellites;

b) an aeronautical mobile satellite service (AMSS) interoperable with SSR Mode S data link and VHF data link, in the framework of the aeronautical telecommunication network (ATN); and

c) ground-based ATM systems, including airspace management, flow management and air traffic services (ATS).

Satellite systems were planned to firstly be used in large areas with low density of air traffic such as remote and oceanic areas. In areas with higher air traffic density (e.g. terminal areas) compatible terrestrial based systems were part of the CNS/ATM.

This document, which is an updated and enhanced version of the "Global Co-ordinated Plan for Transition to the ICAO CNS/ATM Systems" contained in the Report of the Fourth Meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II) (Doc 9623), has been produced to include recently developed concepts and systems.

In its "Global Co-ordinated Plan for Transition to the ICAO CNS/ATM Systems" as contained in the report of the fourth meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II) (Doc 9623), the FANS Committee recognized that satellite technology had a unique potential to satisfy many present and future CNS needs. A key part of future system improvement would be the introduction of air-ground digital data communication services (data link firstly, and then voice) which could provide substantial benefits in ATS efficiency and capacity, satisfying the need for improved air traffic safety as well. Important system considerations included world wide interoperability, access by all classes of aeronautical users, the need to accommodate evolutionary system growth in terms of functional capability and capacity , consideration of different requirements in different areas, and the potential for taking advantage of satellite service capabilities offered by different service providers. Therefore, the committee defined the minimum necessary level of communication systems standardization to achieve the mentioned objectives and recommended the subsequent architecture in the FANS/4 Report.

Following Recommendation 7/1 (Development of SARPs and guidance material for aeronautical mobile satellite (R) service) from FANS/3, the Air Navigation Commission established in 1988 the Aeronautical Mobile Satellite Service Panel (AMSSP), to develop the SARPs and related guidance material based on the CNS/ATM developed by FANS.

The fourth meeting of the Aeronautical Mobile Communications Panel (AMCP/4, 1996) noted the near-future availability of non-geostationary-satellite systems (which were expected to provide mobile satellite communication services) as well as the potential for application of such services to a broad segment of the aviation community. The meeting considered the need to undertake a feasibility study of the potential of these systems for the provision of AMS(R)S. AMCP/5 (1998) concluded that the use of non-geostationary-satellite systems for AMS(R)S was feasible. Following AMCP/5 Recommendation 5/1, the panel developed specific draft SARPs and guidance material for such satellite systems. In 2003, the Aeronautical Communication Panel (ACP) which was created after a merging between the AMCP and the Aeronautical Telecommunications Network Panel (ATNP), started to review and combine the AMSS SARPs (specific to geostationary satellite systems such as Inmarsat and MTSAT) and the next-generation satellite systems SARPs. This work was completed in 2005 at the first meeting of the ACP Working Group of the Whole.

Amendment 82 to Annex 10, as adopted by Council in 2007, introduced for the first time generic SARPs for AMS(R)S which are independent of the technology employed within a satellite communications system, cover performance requirements for data and voice operations, and accommodate low-Earth orbit (LEO), medium Earth-orbit (MEO) and geostationary orbit (GSO) constellations. The SARPs and guidance material for AMS(R)S were structured as directed by Assembly Resolution A35-14, Appendix A. Technical specifications were divided into a "core"

SARPs element, complemented by additional material, as published in this manual, and by references to documents developed by recognized standards-making bodies (e.g. International Telecommunication Union (ITU) and RTCA).

2 SERVICES, USER REQUIREMENTS AND OPERATIONAL BENEFITS

2.1 Satellite communication services

2.1.1 General

Air traffic scenarios in various parts of the world widely differ and are likely to do so in the future. Global Air Traffic Management (ATM) systems must therefore be able to deal with diverse air traffic densities and different aircraft types, with vastly different performances and equipment fit; these variations, however, should not lead to undue diversity and potential incompatibility in avionics and ground segments.

In general, as new communication, navigation and surveillance systems provide for closer interaction between the ground and airborne systems before and during flight, air traffic management may allow for more flexible and efficient use of airspace and thus enhance air traffic safety and capacity.

Aeronautical communication services are classified as:

a) Safety and regularity communications, AMS(R)S, requiring high integrity and rapid response:

   1) safety-related communications carried out by the air traffic services (ATS) for air traffic control (ATC), flight information and alerting; and

   2) communications carried out by aircraft operators, which also affect air transport safety, regularity and efficiency (aeronautical operational control communications (AOC)); and

b) non-safety related communications:

   1) private correspondence of aeronautical operators (aeronautical administrative communications (AAC)); and

   2) public correspondence (aeronautical passenger communications (APC)).

2.1.1.1 Data communication

Since the earliest days of air traffic control, air-ground communication between the flight crew and the air traffic controller of the aircraft operator has been conducted through speech over radiotelephony on either HF or VHF. When radiotelephony channels become congested or, in the case of HF radio-telephone channels during HF propagation disturbances, voice communication availability and reliability can decrease to a point where flight safety and efficiency may be affected.

Despite the introduction of Secondary Surveillance Radar (SSR) and VHF digital link (VDL), both of which include limited air-to-ground data transfer and provides controller workload relief, the burden of voice communication on the air traffic controller and the pilot is still high. Moreover, large areas of the world are beyond the coverage of SSR and VHF. In those remote and oceanic areas, both tactical communication and position reports are being exchanged over HF circuits with variable quality.

Experience has shown that alleviation of the shortcomings in the voice communication systems is limited by factors on the ground. In particular, the saturation of manual air traffic control capabilities creates strong pressure for automated assistance in air traffic services, and because of this, increasing levels of automation are being incorporated in aircraft systems. Achieving full potential benefits of automation requires an increased information flow between the aircraft and ground systems. Moreover, a digital data link is an essential element of an advanced automated air traffic control environment.

It is currently envisaged that future air traffic management systems (on the ground and in the aircraft) make increased use of various physical links (e.g., HF data link, VHF data link and satellite data link) to allow for the (automatic) transmission of data from the aircraft to the ground and vice versa. Efficient use of this data lends towards a more universal value of its supporting services. It therefore is to the advantage of service providers and users to support international standardization of these data links and their applications.

Many useful safety and efficiency related applications can be implemented using air-ground data links. In order to be used for safety related services, an air-ground data link must have high integrity.

2.1.1.2 Voice communication

Whereas increased automation of data exchange between air and ground systems is expected, the use of voice communication will remain imperative. Emergency and non-routine problems, as well as urgent communications between pilot and air traffic controller, make voice communications a continuing requirement.

Aeronautical mobile services in continental areas continue to use VHF for line-of-sight voice communications. Oceanic and other remote areas at present rely on HF voice communications, which may imply the need for communication operators relaying communications between pilots and controllers.

A viable solution to overcome the limitations in current ATS and AOC voice communications, particularly in remote and oceanic areas, is the application of satellite-based communication systems.

2.1.2 Air traffic services (ATS)

An important application of satellite technology to civil aviation is the provision of communication services for ATS purposes, particularly in remote and oceanic areas, covering, *inter alia*, flight information service, alerting service and air traffic control service including area,

approach and aerodrome control services. The use of satellite systems for the delivery of services provides significant advances in benefits to air traffic services over those provided by HF and VHF. The enhancements offered by satellite-provided ATS are in both cost-savings and service quality. For example, whereas HF services can be unreliable due to propagation conditions and limited bandwidth, and VHF communication systems do not have extended coverage, satellite services can overcome most of these limitations.. Moreover, satellite services are global in nature and may include coverage of both the North and South Poles. The provision of air traffic services (ATS) in oceanic airspace differs in many aspects from that provided over land areas. Oceanic flights are conducted in airspace where no sovereign rights are exercised and where normally, in that airspace, more than one State is concerned with the provision of ATS. Therefore the planning of ATS for such operations is basically a matter of international concern. The development and implementation of the ICAO air navigation plans and the provision of ATS for such areas is entrusted by ICAO to designated States based on regional air navigation agreements.

Additional information is contained in the *Manual of Air Traffic Services Data Link Applications* (Doc 9694).

2.1.2.1 Air traffic control services (ATC)

The main objectives of the air traffic control services are to prevent collisions between aircraft and between aircraft and obstructions in the manoeuvring area and to expedite and maintain an orderly flow of air traffic. These objectives can be achieved by applying separation between aircraft and by issuing clearances to individual flights as close as possible to their stated intentions, taking into account the actual state of airspace utilization and within the general framework of measures for the control of air traffic flow when applicable.

Flight planning plays an important role in operations over oceanic airspace. Theoretically, the flight path from departure aerodrome to destination, along a great circle, would give the minimum distance track. However, wind speeds and directions and other meteorological aspects such as temperature, areas of clear air turbulence, etc., affect flight times and flight safety and therefore the optimum flight paths vary considerably from day to day. Additionally, the free choice of the desired flight path may be restricted by the need to maintain a particular flight level, Mach number or a specific track in an organized track system.

The fuel cost is a dominant part of the total cost of flight operations and is especially significant for long-distance flights. ATC can assist in fuel conservation and gas emission reduction by accepting a pilot’s request for a change of his current flight plan (if the traffic situation permits) which is normally a result of a change in the operational factors affecting the efficiency of his flight.

2.1.2.2 Flight information services (FIS)

Flight information services provide flight crews with compiled meteorological and operational flight information specifically relevant to the departure, approach and landing phases of flight.

2.1.2.3 Alerting services

The objective of the alerting service is to enable flight crews to notify appropriate organizations regarding aircraft in need of search and rescue aid and to assist such organizations as required.

2.1.2.4 Automated dependent surveillance (ADS)

The introduction of satellite communication technology, together with sufficiently accurate and reliable aircraft navigation, e.g., by Global Navigation Satellite System (GNSS), present ample opportunity to provide better surveillance services mostly in areas where such services lack efficiency - in particular over oceanic areas and other areas where the current systems (i.e., radars) prove difficult, uneconomic, or even impossible to implement.

ADS is an application whereby the information generated by an aircraft on board navigation system is automatically relayed from the aircraft, via satellite data link, to the air traffic services and displayed to the air traffic controller on a display similar to radar. The aircraft position report and other associated data can be derived automatically, and in almost real-time, by the air traffic control system, thus improving its safety and performance efficiency. Ground-to-air messages also will be required to control the ADS information flow.

2.1.2.5 Controller pilot data link communication (CPDLC)

One of the keys to the future air traffic management system lies with the two-way exchange of data, both between aircraft and the ATC system and between ATC systems. CPDLC is a means of communication between controller and pilot, using data link for ATC communications.

The CPDLC application provides the ATS facility with data link communications services. Sending a message by CPDLC consists of selecting the addressee, selecting and completing, if necessary, the appropriate message from a displayed menu or by other means which allow fast and efficient message selection, and executing the transmission. The messages defined herein include clearances, expected clearances, requests, reports and related ATC information. A “free-text” capability is also provided to exchange information not conforming to defined formats. Receiving the message will normally take place by display and/or printing of the message.

CPDLC will remedy a number of shortcomings of voice communication, such as voice channel congestion, misunderstanding due to bad voice quality and/or misinterpretation, and corruption of the signal due to simultaneous transmissions.

2.1.2.6 Automated downlink of airborne parameter services

The automated downlink of information available in the aircraft will support safety services. Such service may, for example, help detect inconsistencies between ATC-used flight plans and the one flight plan activated in the aircraft’s flight management system (FMS). Enhancement to existing surveillance functions on the ground can be facilitated by downlinking of specific tactical flight information such as current indicated heading, air speed, vertical rate of climb or descent, and wind vector.

2.1.3 Aeronautical operational control communications (AOC)

Aeronautical operational control is a safety service and defined in Annex 6 — *Operation of Aircraft*. Operational control provides for the right and duty of the aircraft operator to exercise authority over the initiation, continuation, diversion or termination of a flight in the interest of the safety of the aircraft and the regularity and efficiency of flight.

Operational control communications accommodate airline dispatch and flight operations department functions but may also interface with other airline departments such as engineering, maintenance and scheduling, in exercising or coordinating related functions.

Current experience with AOC has shown that a significant amount of messages are exchanged using data communications. AOC voice, however, will continue to be required. Based on expected increases in air traffic, AOC data communications will further grow as the result of both the increase in number of messages per aircraft and size and characteristics of the message content. AMS(R)S can assist in performing functions such as:

- Exceptional situation handling (aircraft/flight emergencies etc.);
- Flight planning;
- Weather information;
- Airport/airways operational information;
- Flight crew scheduling;
- Aircraft engine monitoring;
- In-flight maintenance problem reporting and solving; and
- Aircraft schedule.

Such AOC functions may operate via air-ground voice and data communications either through the cockpit crew or directly with airborne sensors or systems.

2.1.4 Non-safety services

Non-safety services include aeronautical administrative communication (AAC) and passenger correspondence (APC). Non-safety communication services may be authorized by administrations in certain frequency bands allocated to the AMS(R)S as long as they cease immediately, if necessary, to permit transmission of messages for safety and regularity of flights (i.e., ATS and AOC, according to priorities 1 to 6 of Article 51 of the ITU Radio Regulations).

2.2 User requirements

Air-ground satellite data communication plays a key role in the functional improvement of existing and new ATM functions, particularly in remote and oceanic areas.

In order to fulfil these operational requirements, these ATM functions require a certain level of quality of communication services. This level is specified in the communication, technical and operational characteristics required by the SARPs.

Satellite voice communications continue to be used, particularly in non-routine and emergency situations, and offer improved voice quality over HF-voice.

ATM-related communications (voice and data) are given high priority in transit through the satellite system and the ATN, as appropriate. The satellite system architecture supports ATS needs for handling both data and voice.

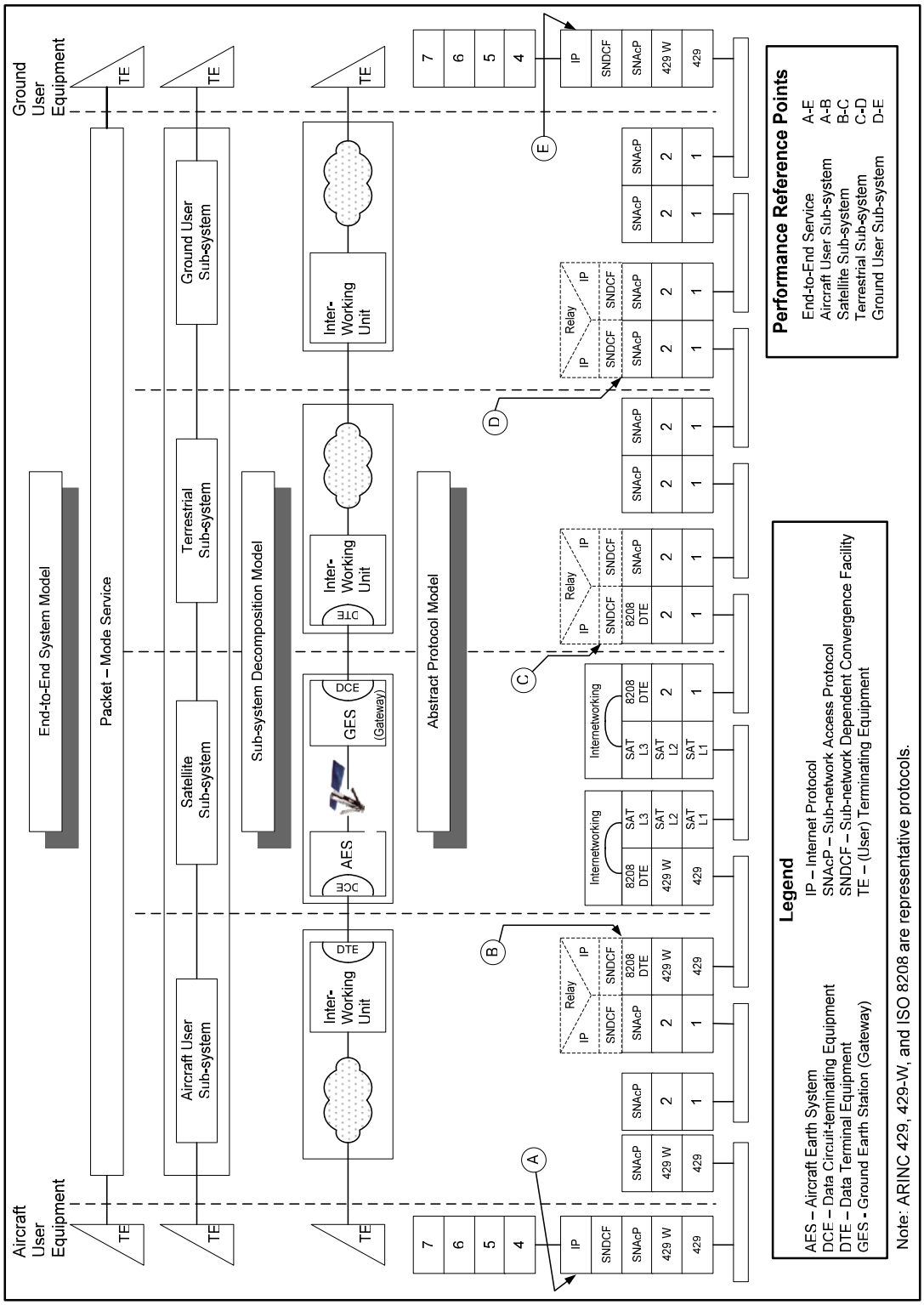
AMS(R)S requirements are to be derived from these characteristics, in terms of service reliability, availability, etc., to achieve the required standards of service. Primary service requirements for AMS(R)S are highlighted in the following subparagraphs.

2.2.1 Performance criteria for end-to-end applications

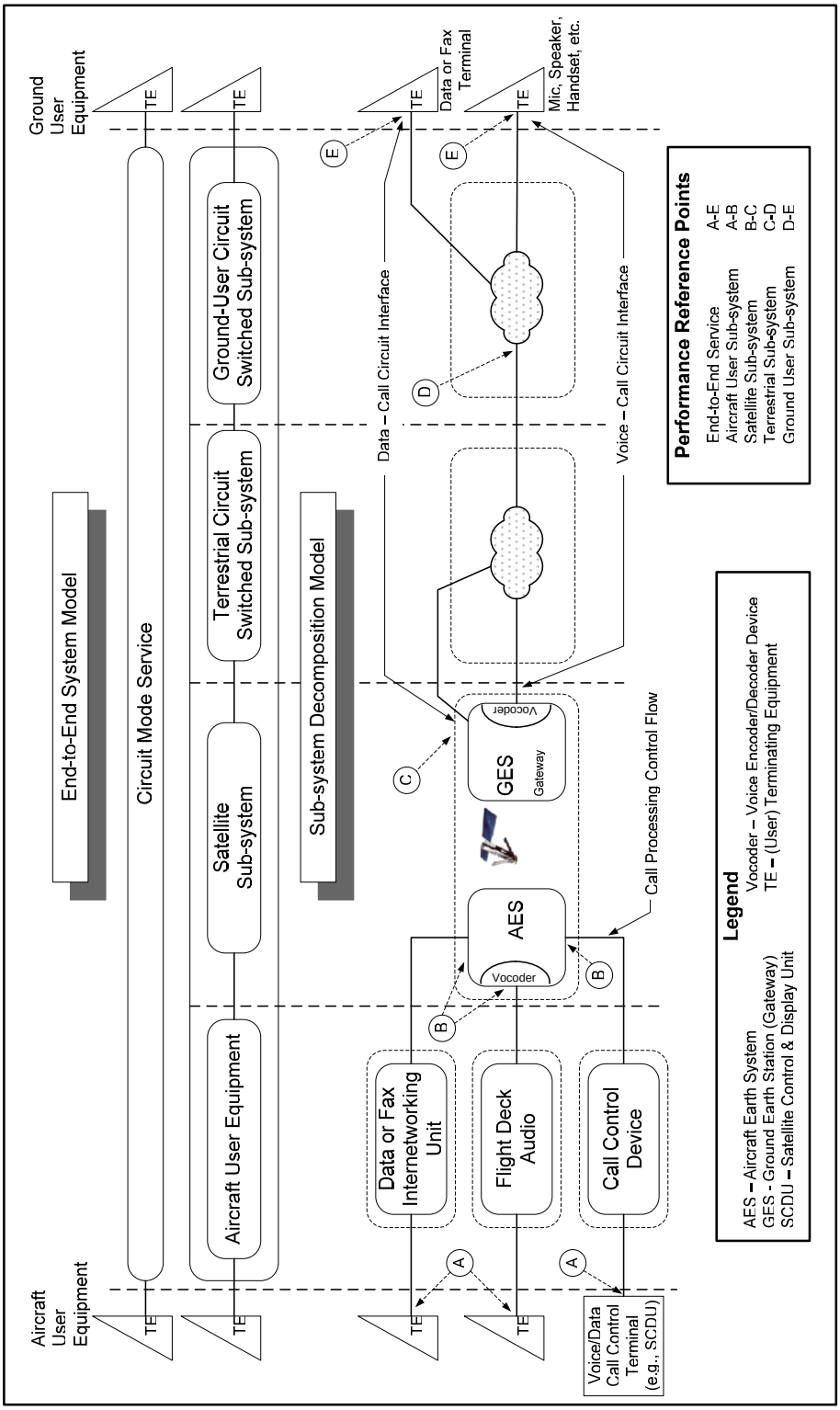
The aeronautical satellite communication system will support the categories of AMS(R)S communications according to the appropriate performance, integrity and availability criteria, taking into account a gradual increase in communication needs. Systems which allow for step-by-step and evolutionary implementation and growth are desirable.

AMS(R)S system performance parameters as defined in SARPs, are provided for the ATN satellite subnetwork (see Figure 2-1 between points B and D for Packet mode and Figure 2-2a between points B and C for circuit mode services). Additional information on ATN end-to-end performance between user terminals is contained in the *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) using ISO/OSI standards and protocols* (Doc 9880).

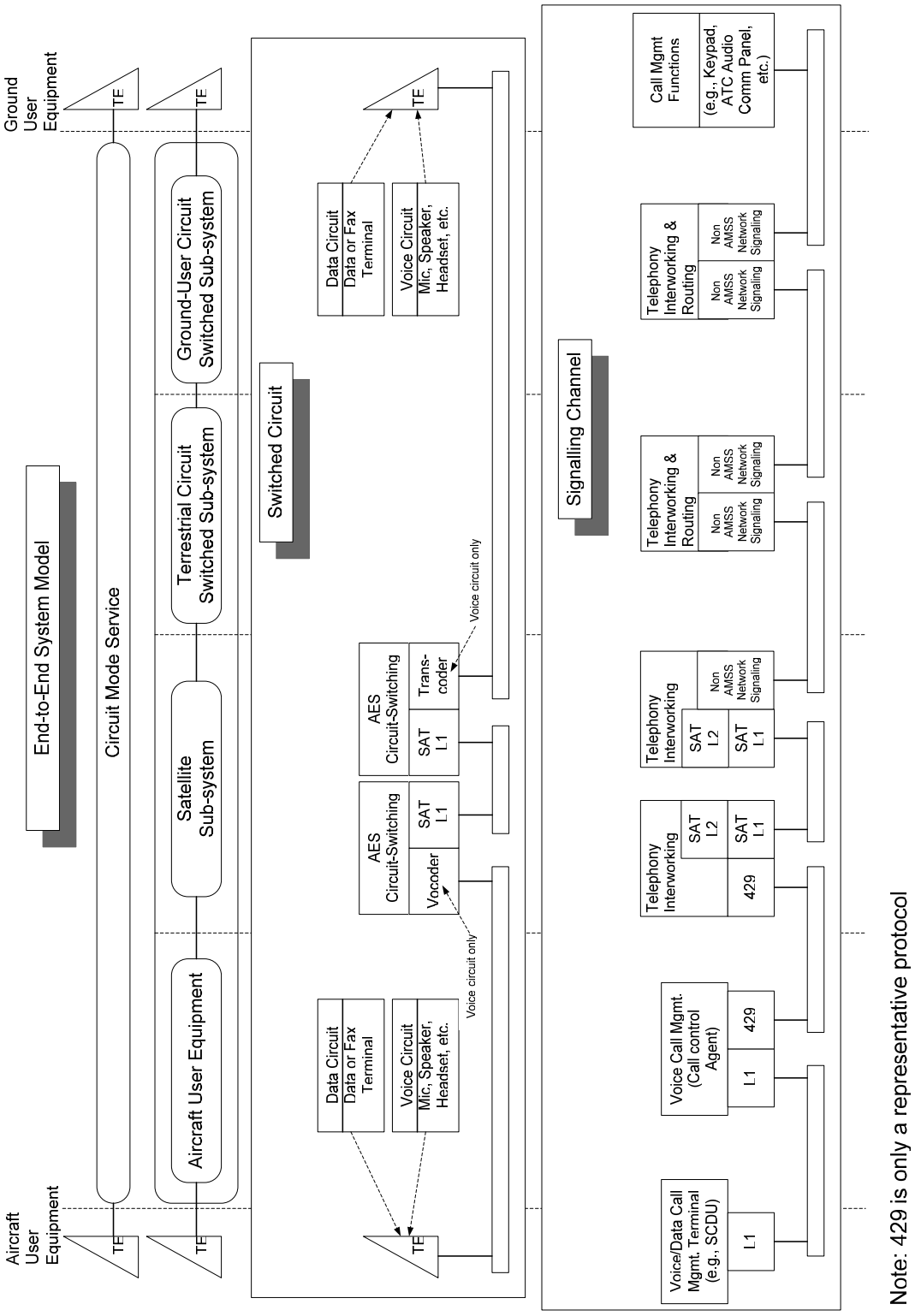
AMS(R)S data services are based primarily on the use of packet data communications. The Packet mode structure of the system and its four subsystems is shown in Figure 2-1. The AMS(R)S Circuit mode service primarily serves voice but also supports continuous data and facsimile services where these services are needed and appropriate. The system structure for Circuit mode services is depicted in Figures 2-2a and Figure 2-2b.



Packet-Mode Services System Structure
Figure 2-1



Circuit-Mode Services System Structure-Part A
Figure 2-2a



Circuit-Mode Services System Structure-Part B
Figure 2-2b

Measures of the service quality of the end-to-end system including the AMS(R)S subnetwork are detailed in the following subparagraphs.

2.2.1.1 Minimum available throughput

Throughput is defined as the amount of user data (per time unit) which can be transferred over the available links between the AES and the GES. The message transfer frequency (i.e., number of ADS reports per time unit), together with message length (i.e., number of bits in the ADS report) and the protocol overhead, determines the required throughput for ADS messages.

2.2.1.2 Maximum data transit delay

The satellite data transit delay for packet data communications is defined as the time between sending and receiving a message within the satellite system, using the AMS(R)S. In addition, ATN data transit delays (when the message is further sent through the ground-based ATN) need to be considered. Maximum data transit delay requirements are derived from the required communication performance parameters, or RCP, (i.e., time between generating and sending airborne data and receiving the data for processing on the ground).

2.2.2 Priority

Each AMS(R)S communication transaction is assigned a priority. This priority is dependent on the information type and is assigned by the associated user application in accordance with the internationally defined priorities in Annex 10.

The ATN sequences messages in order of priority. The AMS(R)S will provide a sequencing mechanism that complies with the priority assigned to a message.

2.2.3 Reliability/integrity

The AMS(R)S will have the integrity and reliability required for provision of safety communication. Users must be able to pass their messages reliably, regardless of the position or situation of the aircraft, with rapid access and minor transmission delay, but at an economic rate.

Reliability is defined as the probability that a satellite subnetwork will actually deliver the intended message within a set amount of time. The failure to deliver a message may result either from a complete breakdown of an essential component or because of detected errors which are unrecoverable.

Integrity is defined as the probability a message will be received without undetected errors.

It is necessary to establish performance standards for reliability, continuity, and integrity of service for the space segment, ground stations, and associated facilities. This will require application of ICAO SARPs and certification.

The consequences of loss of a satellite in an aeronautical air-ground communication system would be severe unless an adequately rapid changeover to back-up facilities could be achieved.

However, the past history of communication satellites has shown that, once operating in orbit, satellites are extremely reliable. Both satellite and ground equipment changeover will be required to occur within a very short time, depending on the critical nature of the safety service being supported. This implies that a mature system may require either hot standby redundancy of both space segment and earth station or alternative strategies relating to both space and earth segment facilities and equipment. Such strategies would need to ensure that the loss of one satellite would cause minimum disturbance to communication traffic and allow timely restoration of full services.

GES mean time between failures (MTBF) will be high and mean time to repair (MTTR) will be low, employing hot stand-by and uninterruptible power supplies (UPS) to ensure AMS(R)S continuity. Moreover system performance will be further enhanced due to the availability of technical support, e.g., logistics and maintenance staff.

The AES will also be able to cope adequately with a satellite failure, for example, by rapid acquisition of the signal from an alternate satellite or by tracking the signals from more than one satellite at all times.

Requirements for changeover time will be related to such parameters as the needed surveillance update rate in those cases where, for example, the communication system is supporting ADS.

As with all the avionics, the AES will be designed so that MTBF is as long as possible whereas the MTTR is as short as possible. These two requirements will apply to essential airborne units such as the satellite data unit, communication management unit, beam steering unit and the antenna sub-system. This may be achieved by main/hot standby configuration of the critical units stated above, as well as automated changeover mechanisms within each unit.

2.2.4 Protection

Protection is defined as the degree to which unauthorized parties are prevented from interfering with data transfer over the satellite sub-network.

For safety communications, the AMS(R)S, at the minimum, will provide protection against modification, addition or deletion of user data.

Measures need to be provided to grant protection from intentional and other harmful interference resulting from malfunction of aircraft earth stations (AES), ground earth stations (GES),- also referred to as Gateways - satellites, or from sources outside the system.

As an additional level of protection, critical services provided from an interfered satellite could be transferred to another satellite, if necessary by pre-empting lower priority services. Frequency management will be carried out automatically from ground control.

System performance monitoring in real time will be necessary at appropriate locations. Additionally, some protection from intentional jamming will be achieved with spot beam systems as the effect will be limited to the beam containing the interfering signal with minimal effect on adjacent beams.

2.2.5 Minimum area of connectivity

Operationally required connectivity determines the designated operational coverage area and may influence the location of GESs. In general, satellite systems are intended to provide long distance connectivity in areas which, for technical and/or economical reasons, cannot be serviced by terrestrial aeronautical air/ground communication systems.

In particular, connectivity is required between aircraft flying in oceanic airspace and oceanic area control centres. Additionally, remote areas require connectivity through satellite systems with area control centres (ACC). Connectivity requirements can, when technology permits, include other airspace, including continental airspace with high density air traffic and area control centres.

2.2.6 Costs and benefits

The initial cost of AES equipment varies widely depending on the class of service provided, e.g., core capability, data rate and voice capability. Moreover, aircraft operators have an interest in keeping cost and quantity of onboard equipment to a minimum. Any onboard equipment requirements should appropriately weigh costs and benefits ensuring that the minimum communications service standards are met and taking into account the desire for minimizing cost.

2.2.7 Interoperability

The AMS(R)S must be compatible and interoperable with external aircraft and ground systems and also must co-exist with other aviation data links in order to achieve significant cost and operational benefits. Prerequisites for interoperability are:

a) the definition of standard protocols at the network interface layer; and

b) a global addressing plan.

To achieve this interoperability, ICAO has defined a particular network protocol architecture through which various networks, including AMS(R)S, Mode S and VDL, can communicate. This is known as the aeronautical telecommunications network (ATN). Details are available in the *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN)* (Doc 9880).

2.3 Operational scenarios and anticipated benefits

2.3.1 General

The application of AMS(R)S in oceanic and remote areas should provide improved communications, surveillance and procedures. This will lead to improved safety, increased airspace efficiency including a potential for reduced separation, improved meteorological information, and reduced flight time, based on the use of more efficient flight profiles.

A reduction of longitudinal and lateral separation between aircraft requires enhanced communications/navigation/surveillance (CNS) capabilities in air traffic systems and on board of those aircraft. Enhanced CNS systems provide controllers with automated tools such as conflict

prediction and reporting to assist in separation assurance and with tools to better monitor flight plan conformance. Enhanced communication and surveillance systems also enable controllers and pilots to better communicate and manage weather deviations and contingency situations such as aircraft turn-backs and diversions.

Flight planning plays an important role in operations over oceanic airspace. Theoretically, the flight path from departure aerodrome to destination, along a great circle, would give the minimum distance track. However, wind speeds and directions and other meteorological aspects such as temperature, areas of clear air turbulence, etc., affect flight times and therefore the optimum flight paths vary considerably from day to day. Additionally, the free choice of the desired flight path may be restricted by the need to maintain a particular flight level, Mach number or a specific track in an organized track system.

The fuel cost is a dominant part of the total cost of flight operations and is especially significant for long-distance flights. ATC can assist in fuel conservation and gas emissions reduction by accepting a pilot's request for a change of his current flight plan (if the traffic situation permits) which is normally a result of a change in the operational factors affecting the efficiency of his flight.

For aircraft equipped with automated dependent surveillance (ADS), it allows to automatically report the aircraft's current position, based on information generated by an on-board navigation system, via satellite data link, to the air traffic services. Automated air traffic management systems together with graphical situational displays along with the ability to interface with controller pilot data link communication (CPDLC) air traffic controllers will be in a position to control traffic in oceanic and remote areas almost real time. These will change the way controller in these areas work by moving them from a flight data strip and mental traffic picture to real time "viewing" of traffic.

If there is any controller instruction/clearance to be passed on, the controller can use CPDLC to relay information such as climb, descent, maintain a particular mach speed etc into the cockpit. The total transaction time using satellite communication may be significantly less compared to using HF.

2.3.2 High air traffic density oceanic areas

Currently, in certain parts of the world, controllers in oceanic airspace rely on infrequent position reports that are manually read by the pilot from the airborne navigation equipment. The position reports are then transmitted on a communications medium (HF radio) to a receiving operator. The communications operator transcribes a teletype message from the voice report and sends it to the oceanic area control centre. Finally the teletype message is printed at the oceanic area control centre and manually delivered to the controller.

At present, these manually based operations are expected to be fully automated with the use of AMS(R)S. Due to the gradual progress in the airborne equipment, space segment, and ground segment (i.e., the transition from the low speed data link to the high speed data link and the gradual increase of satellite communication equipage), ATC systems are expected to evolve.

The AMS(R)S in oceanic areas with high air traffic density will provide capability for rapid access communications between the ground and the aircraft for both data and voice. This system will be able to accommodate ADS.

The evolution of ATM resulting from AMS(R)S (data and voice communications environment) is characterized by the improvement of traffic monitoring (surveillance accuracy); trajectory prediction; and conflict search and resolution, including short term conflict alert and will permit improvement of existing flight planning procedures.

Consequently, a reduction of longitudinal and lateral separation, an increase of tactical conflict resolution and better accommodation of optimal routes are expected.

2.3.3 Low air traffic density oceanic/continental en-route areas

AMS(R)S in oceanic and continental en route areas with low air traffic density shall provide the capability of rapid access communications between the ground and aircraft for both data and voice. The satellite communication service will be able to accommodate ADS.

The evolution of ATM resulting from AMS(R)S (data and voice communications environment) is characterized by the improvement of traffic monitoring (surveillance accuracy), trajectory prediction, conflict detection and resolution, and flight planning procedures. As a consequence, there will be an increase in tactical conflict resolution and improved accommodation of optimal routes.

2.3.4 High air traffic density continental en route areas

AMS(R)S in high air traffic density continental en route areas will provide the capability of immediate access communications between the ground and aircraft for both data and voice and will coexist with the VHF voice and data service. AMS(R)S will be able to accommodate ADS but also, as a surveillance system, will coexist with the SSR Mode A, C and S.

The evolution of air traffic management will include increased accommodation of optimum routes, accommodation of 3D navigation (improved definition of vertical profiles), 3D planning capability based on actual aircraft performance, advanced data communications exchange capability between ATC centres, trajectory prediction for flexible routing, improved conflict search and computer generated resolution advisory, improved short term conflict alert and resolution, air/ground data link communication capability, and improved trajectory prediction based on actual aircraft performance. All of this could be enhanced to accommodate 4D capabilities (where time is the fourth dimension of air navigation, negotiated between air and ground).

2.3.5 Terminal areas

AMS(R)S may be applied to terminal areas with low density traffic to provide the capability for immediate access communications between ground and aircraft for both data and voice. It may coexist with VHF voice and data, as well as SSR services.

3 STANDARDIZATION ACTIVITIES

3.1 General

In addition to the definition of SARPs by ICAO, as described in paragraph 4.3 below, standardization activities by other bodies are taking place, as presented below. Documents which define technical aspects of the individual aeronautical satellite system (including the functional requirements of ground and aircraft earth stations) are developed and maintained by the satellite sub-system operator.

3.2 AEEC (ARINC) characteristics

Airlines, air transport equipment manufacturers, and aviation service providers support the Airline Electronic Engineering Committee (AEEC) in developing systems and/or equipment to support industry standardization of common avionics signal characteristics, equipment mounting, and inter-equipment signal interfaces. ARINC 741, 761 and 781 are examples of system-level specifications that define, in detail, form, installation, and wiring and operational capability of the equipment and interchangeability. In addition, there are a number of specifications, such as ARINC 429, that define, in detail, standardized data bus, interface, or protocol requirements, which are used by system-level specifications, such as the aforementioned 741, 761 and 781. Avionics manufacturers and service providers shall make every attempt to subscribe to the pertinent standards and specifications in order to provide the highest degree of system and service commonality as possible.

3.3 Minimum operational performance standards (MOPS)

MOPS are the standards by which the airworthiness and functional performance of avionics equipment and installed systems are determined in the United States of America. They are developed in the public domain by RTCA and then adopted by the U.S. Federal Aviation Administration (FAA) as basic technical standards for equipment certified under their Technical Standard Order (TSO) programme. MOPS are used by manufacturers for bench, installation and flight testing. Other States have similar equipment approval procedures, often based on the RTCA MOPS or similar standards produced by other organizations.

RTCA has developed DO-262, “Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems.” Guidance on aeronautical mobile satellite service end-to-end system performance can be found in DO-215A.

3.4 Minimum aviation system performance standards (MASPS)

RTCA also develops MASPS which specify characteristics useful to designers, installers, manufacturers, service providers and users of systems intended for operational use within a defined airspace. The MASPS describe the system (subsystems/functions) and provide information needed to understand the rationale for system characteristics, operational goals, requirements and typical applications. Definitions and assumptions essential to proper understanding of the MASPS are provided as well as minimum system test procedures to verify system performance compliance (e.g., end-to-end performance verification).

RTCA has developed minimum aviation system performance standards (MASPS) DO-270 for "AMS(R)S as used in Aeronautical Data Links."

3.5 Satellite system access approval

Satellite sub-system operators require ground and aircraft earth station equipment to perform in accordance with their system access standards. Thus, it will be necessary for equipment manufacturers to obtain system access approval from those system operators in whose systems they expect their equipment to function. With respect to aircraft earth stations, where components are procured from different manufacturers and installed on board an aircraft by an aircraft manufacturer or the owner, the burden of obtaining system access approval from satellite sub-system operators may fall on the aircraft manufacturer or owner.

3.6 Avionics and certification

3.6.1 Avionics

Various avionics manufacturers are active in the field of the satellite AMS(R)S avionics. At the request of airlines, aircraft manufacturers who produce long range wide body aircraft are presently accepting options for satellite AMS(R)S installations on new aircraft.

3.6.2 Airworthiness certification

AMS(R)S aeronautical equipment cannot be operated unless certified as airworthy by the authorized agency of the State of its manufacture and, depending on treaty arrangements the State has with others, it must also be certified by the equivalent agencies of other States. The standards by which airworthiness is determined include RTCA MOPS, as noted above, and similar specifications produced by other international bodies such as EUROCAE or by the certification agencies themselves.

3.6.3 Type acceptance

With respect to radio transmission characteristics, type acceptance procedures are prepared by communications regulatory agencies, e.g., in the United States, the Federal Communications

Commission (FCC), and are conducted by manufacturers to assure that potential radiated interference is within specified limits. The technical characteristics of type acceptance are closely related to MOPS and their testing.

3.6.4 Licensing and permits

The control and regulation of the radio equipment in aircraft is an important function in the operation of radio. Correct operation of equipment in approved frequency bands and on assigned, operational frequencies must be assured throughout an aircraft's flight on national or international journeys. Performance standards for both telecommunication and air safety requirements are the means used to achieve conformity with international rules.

Individual AES are, by their nature, airborne radio stations; therefore, are expected to require some form of licensing by national radio regulatory authorities. Operator (e.g. pilot) permits may also be required.

3.7 Terrestrial Sub-system Service Providers

ICAO policy states that institutional arrangements should not prevent competition among different service providers. It is therefore inferred that the AMS(R)S would be offered to States, civil aviation administrations, airlines and others, by more than one service provider.

4 ICAO ACTIVITIES

4.1 Institutional arrangements

The institutional aspect of ATS communications by satellites is complex because State liability is concerned. The following guidelines were stressed by ICAO's Tenth Air Navigation Conference:

Guideline a): *Universal accessibility to air navigation safety services must be available without discrimination.*

This guideline is one of the fundamental principles underlying the philosophy of ICAO as the specialized agency of the United Nations for civil aviation. The application of the future Communications, Navigation and Surveillance (CNS) systems must not change this guideline, and, at this stage, it appears that it will not create new problems in this regard.

Guideline b): *The rights and responsibilities of States to control operations of aircraft within their sovereign airspace must not be compromised.*

This guideline is a fundamental tenet of international civil aviation philosophy, but it raises questions concerning the ability to utilize the "universal" capability of aircraft inherent in the application of modern technology. Satellite technology, in particular, makes it possible to improve the efficient utilization of airspace and the economic operation of international flights

across political boundaries. One of the foremost challenges of the future is likely to be to find practical ways to utilize these potential improvements without imposing unacceptable conditions regarding the sovereignty of national airspace. For example, where a State provides ATS communications through another State's ground earth station (GES) and other facilities, arrangements should avoid subordination of that State's ATS service.

Guideline c): *Arrangements must preserve, facilitate and not inhibit ICAO responsibility for the establishment of appropriate Standards, Recommended Practices and procedures in accordance with Article 37 of the Convention on International Civil Aviation.*

Article 37 of the Convention on International Civil Aviation recognizes the specialized safety needs of aircraft operations and designates ICAO as the body responsible for the adoption and application of air navigation safety Standards embodied in technical Annexes to the Convention. ICAO has long recognized the desirability, particularly for economic reasons, of aligning its technical Standards as closely as possible with similar specifications being developed by other international standardization bodies but has always retained its authority to diverge from other similar international technical standards should the need arise. The reasons for the inclusion of Article 37 in the Convention still exist, and ICAO is vigilant in carrying out its mandate in this area of activity.

Guideline d): *Arrangements must ensure the ability to protect safety communications from harmful interference.*

As the electromagnetic spectrum becomes more intensely used, the incidence of harmful interference to aircraft safety services has increased alarmingly, and it would appear prudent to assume that this trend will continue, and probably accelerate in the future. In modern satellite technology, and particularly on questions concerning use of the electromagnetic spectrum, there are strong pressures to ensure that non aviation users conform to critical specifications dictated by the safety requirements of the civil aviation community. The most effective place to deal with harmful interference is at its source, and ICAO has been doing its best to ensure that acceptable levels are established for spurious emissions allowable from activities in the electromagnetic spectrum of a growing number of users. The future CNS system will utilize previously unexploited parts of the electromagnetic spectrum, and may be susceptible to new forms of harmful interference, so that continuing efforts in coordination, research, application and regulatory enforcement will be required to retain established safety criteria. Arrangements should ensure that continuous oversight and control of the area's spectrum use is conducted so that harmful interference can be quickly detected and corrected.

Guideline e): *Arrangements must be adequately flexible to accommodate presently defined services and a range of future services.*

As in the introduction of any new system, users require assurance that there will be no degradation of existing services. Possibilities for additional services need to be introduced, and

such additions need to be implemented with minimum disruption to existing systems. Furthermore, institutional and organizational arrangements must also ensure the required flexibility. Safety message priority must be assured.

Guideline f): *Arrangements must facilitate the certification by States of those service providers whose services comply with ICAO Standards, Recommended Practices and procedures for the aeronautical mobile satellite (R) service (AMS(R)S).*

The certification process should ensure that services provided meet the appropriate ICAO SARPs, as well as any State requirements, such as financial responsibility, competence and capacity.

Guideline g): *Institutional arrangements should not prevent competition among different service providers that comply with ICAO SARPs.*

This guideline seeks to encourage competition in the provision of aeronautical mobile satellite service. In some areas, however, ATS administrations may wish to select and regulate the satellite system to be used, for reasons such as the existence of contracts with service providers, or special interfaces with service providers that operate through a particular satellite system.

Guideline h): *ICAO's responsibility for co ordination and use of AMS(R)S spectrum allocations must continue to be recognized.*

Where ICAO plays a role in the coordination and use of radio frequency spectrum within the aeronautical community, the ITU is responsible for the international allocation, coordination, registration and protection of frequency assignments.

While there has been little difficulty in the past with regard to recognition of ICAO's responsibility *vis-à-vis* Annex 10 provisions, frequency allocations have become extremely complex in today's environment, and users are placing different interpretations on the meaning of "responsibility."

Guideline i): *Arrangements must recognize States' responsibility and authority to enforce safety regulations.*

In the complexity of modern satellite systems, particularly in cases of satellite systems sharing resources with other services, the manner in which States' responsibility could be exercised becomes also more complex.

Guideline j): *Arrangements must ensure guaranteed priority of aeronautical mobile-satellite safety communications over aeronautical non-safety and non-aeronautical mobile-satellite communications in accordance with ICAO SARPs.*

This guideline is generally acknowledged as a requirement, but the provisions of guaranteed priority for aeronautical safety communications in any satellite system must be demonstrated in practice and under all satellite conditions before acceptance. Relevant details are being studied in the Aeronautical Communications Panel (ACP).

Guideline k): *Arrangements must be in place so that service providers, operating in the same area, co-operate to ensure that space segment resources are made available to handle AMS(R)S service.*

As message traffic increases for both aeronautical safety and non-safety service, situations may arise where one service provider runs out of resources (e.g. satellite power, spectrum, etc.) to support AMS(R)S, however, another service provider(s), providing service in the same area could support AMS(R)S. Under these conditions arrangements should be developed so that resources are made available to handle the AMS(R)S traffic of the first service provider through co operative use of the resources.

Guideline l): *Arrangements should enable all AMSS functions (ATS, AOC, AAC and APC) to be provided through common avionics equipment in the aircraft.*

This guideline has special significance for the civil aviation industry because of the special problems (technical and economical) involved with multiple airborne satellite installations.

Guideline m): *Arrangements should make all four identified satellite services (ATS, AOC, AAC and APC) available through any given satellite in any region of the world.*

This guideline is in recognition of the difficulties of installing multiple systems aboard aircraft. An aircraft should, as a matter of principle, not be required to access more than one satellite to obtain all four identified AMSS functions, (ATS, AOC, AAC and APC).

Guideline n): *Adequate arrangements should be made for recovery in the event of a significant malfunction or catastrophic failure of the satellite system.*

Where a single satellite system provider offers a service in an area, a back-up capability must be available within that system in the event of a significant malfunction or catastrophic failure. In the special case where more than one satellite system provider offers identical, or near identical, and technically compatible services in the same area, co-operative institutional arrangements may facilitate back-up service in the event of a significant malfunction or catastrophic failure in one of the systems.

Guideline o): *Policies governing charges levied on users must not inhibit or compromise the use of satellite based service for safety messages.*

Because of the importance and the pre-eminence of safety messages in aeronautical mobile communications, their use must be in accordance with regulations and without regard to the cost of individual transmissions. In implementing this guideline, the specific Annex 10 definition of what constitutes a safety message must be conveyed to the service provider of the AMSS system.

Guideline p): *Existing governmental or inter governmental agencies, modified if necessary, should be used to the extent practicable.*

This guideline states the practical fact that new agencies need not be established if existing agencies in present or modified form can do the job satisfactorily.

Guideline q): *Arrangements should allow the introduction of satellite services on an evolutionary growth basis.*

One of the practical difficulties in introducing any new aeronautical service is the implementation of required equipment in aircraft. Therefore, any system which allows for step-by-step and evolutionary implementation and growth is highly desirable.

Guideline r): *Arrangements should provide for the determination of liabilities.*

The determination of liabilities among the various service providers of the AMSS system is a task requiring inputs from work being done by other groups in ICAO. This guideline has been listed here as a reminder that liability issues could have a bearing on institutional arrangements.

Guideline s): *Arrangements must retain ATS authority to co ordinate and maintain control, directly or indirectly, over aeronautical mobile satellite communications according to message priorities established in the ITU Radio Regulations.*

This guideline pertains to the requirement for the ATS authority to retain authority and control over aeronautical safety communications and notes the need for a rigid examination and adequate demonstration that this vital function can be retained both in respect of dedicated aeronautical satellite systems and in generic satellite systems.

4.2 AMS(R)S spectrum issues

Under its Constitution and Convention, the International Telecommunications Union (ITU) has recognition and authority as the international body for telecommunications. The Radio Regulations (RR) are the instrument through which this specialization is expressed in internationally agreed terms for radio matters. The ITU Radio Regulations lay down the framework for international spectrum management and contain the Table of Frequency Allocations, which is effectively the worldwide agreement on the deployment and conditions of use of all radio frequencies in the radio frequency spectrum.

Spectrum for the provision of AMS(R)S is made available through agreements reached at World Radiocommunication Conferences (WRC) of the (ITU). These agreements are embodied in the Radio Regulations. Articles 1, 5, 9, and 11 of these regulations address the availability and protection of the spectrum for AMS(R)S. Article 1 defines Safety Service and the Mobile Satellite Service (MSS), which includes the AMS(R)S.

MSS primary allocations are required to be used by satellite systems and networks to provide AMS(R)S (RR Article 5). These allocations generally are used to provide uplinks and downlinks in the range 1.5 – 1.6 GHz. This frequency range has been divided into a number of MSS allocations which are being used by geostationary and non-geostationary satellite systems. The allocations for these systems include footnotes which are considered part of the allocation and provide an indication that these bands may be used for AMS(R)S. They also specify the requirement for frequency coordination between the MSS systems and with other services operating in the same frequency bands.

Frequency coordination is carried out in accordance with the provisions of Article 9 of the RR. The purpose of this coordination is to ensure that harmful interference is neither caused nor received by the MSS systems concerned. When coordination is successfully completed, the MSS systems are registered with the ITU (RR Article 11) and included in the International Frequency List. When this status is achieved, the systems are entitled to receive protection which also ensures the protection of AMS(R)S.

Additional information is contained in the *Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including Statement of Approved ICAO Policies* (Doc 9718).

4.3 Standards and Recommended Practices (SARPs)

During the review of the report of the eighth meeting of the Aeronautical Mobile Communications Panel (AMCP/8), the predecessor of the Aeronautical Communications Panel (ACP), the Air Navigation Commission requested the ACP to develop proposals for the reorganization of the AMSS SARPs (Annex 10, Volume III, Part I, Chapter 4) into a section with "core" SARPs, to be retained in Annex 10, and a set of detailed technical specifications for AMS(R)S, as required. In pursuing this work, the "core" functionality of the AMSS SARPs and the next-generation satellite system (NGSS) draft SARPs, which were developed at the seventh meeting of the AMCP (AMCP/7), were integrated into a single set of AMS(R)S SARPs. These AMS(R)S SARPs have replaced the AMSS and the (draft) NGSS SARPs.

Relevant detailed technical specifications for AMS(R)S have been developed by the ACP and are contained in this manual. In this process, as much as possible, reference has been made to relevant material already available through organizations such as RTCA and EUROCAE.

The AMS(R)S SARPs have been incorporated in Annex 10, Amendment 82 and became applicable on 22 November 2007.

4.4 Required communication performance (RCP)

The emergence of several types of data links for the conduct of air-ground data interchange, as well as for the support of specific navigation, surveillance and other functions, has raised the concern that the air navigation system is becoming too complex. Obviously, it would have been ideal to have a single air-ground communications system capable of handling all communications, navigation and surveillance requirements in all types of airspace and for all phases of flight in a cost effective manner. However, as no such technological solution has yet been found to meet all operational requirements, the aviation community has to consider all available as well as emerging communications systems, though some may only perform a single function or only serve a limited area.

The availability of several communications systems does provide a degree of flexibility to planning and implementation in different types of airspace; however, the proliferation of subnetworks will add to the complexity of the operation of air-ground communications. One solution to this problem is to do away with the specification of individual systems and instead, translate all relevant operational requirements in a certain airspace and scenario into a series of communications performance parameters. The term required communications performance (RCP) therefore refers to a set of well-quantified communications performance requirements, such as capacity, availability, error rate, and transit delay. Once RCP has been specified for an operational scenario in a given airspace, any single communications system, or combination of systems meeting the set parameters, can be considered as operationally acceptable.

Guidance material on RCP is contained in the *Manual on required communication performance (RCP)* (Doc 9869).

4.5 Aeronautical telecommunication network (ATN)

The concept of an ATN which was developed through ICAO and other aeronautical organizations supported the interoperability between the different types of air ground data links, e.g. Mode S, VHF data link and AMS(R)S. For packet data service, the AMS(R)S was considered as a subnetwork of the ATN. The ATN concept allowed for connectivity between air/ground data link subnetworks and terrestrial subnetworks, so integrating all the different aeronautical communication subnetworks, including the aeronautical fixed telecommunication needs.

In the ATN concept, the network aspects of each subnetwork are independent of the application environment, and certain parts of the avionics can be shared between the different air ground subnetworks. In particular, as data link application services evolve with time, it is important that the subnetwork characteristics remain the same.

To achieve this interoperability between data links, the international aviation community had decided to adhere to the open system interconnection (OSI) reference model developed by the International Organization for Standardization (ISO). In February 1993, the Air Navigation Commission (ANC) established the Aeronautical Telecommunication Network Panel (ATNP) to develop Standards and Recommended Practices (SARPs), guidance material and other relevant

documents for the ATN. Work was predicated on the predominant networking technology of that time, the OSI/ISO protocol suite. Since then, significant changes had occurred in the technology arena and in the air traffic management. Technologically, the worldwide acceptance of the Internet Protocol Suite (IPS) as internetworking protocol had led industry away from providing OSI-based commercial products. This resulted in numerous ICAO contracting states and aeronautical technical organizations to review their planned implementation of the OSI/ISO protocols; this was also the genesis for the current ICAO activities to include IPS in ATN SARPs.

The ATN and its associated application processes have been specifically designed to provide, in a manner transparent to the end-user, a reliable end-to-end communications service over dissimilar networks in support of air traffic services. ATN can also carry other communications service types, such as AOC communications, AAC and APC. Some other features of the ATN:

a) enhanced data security;

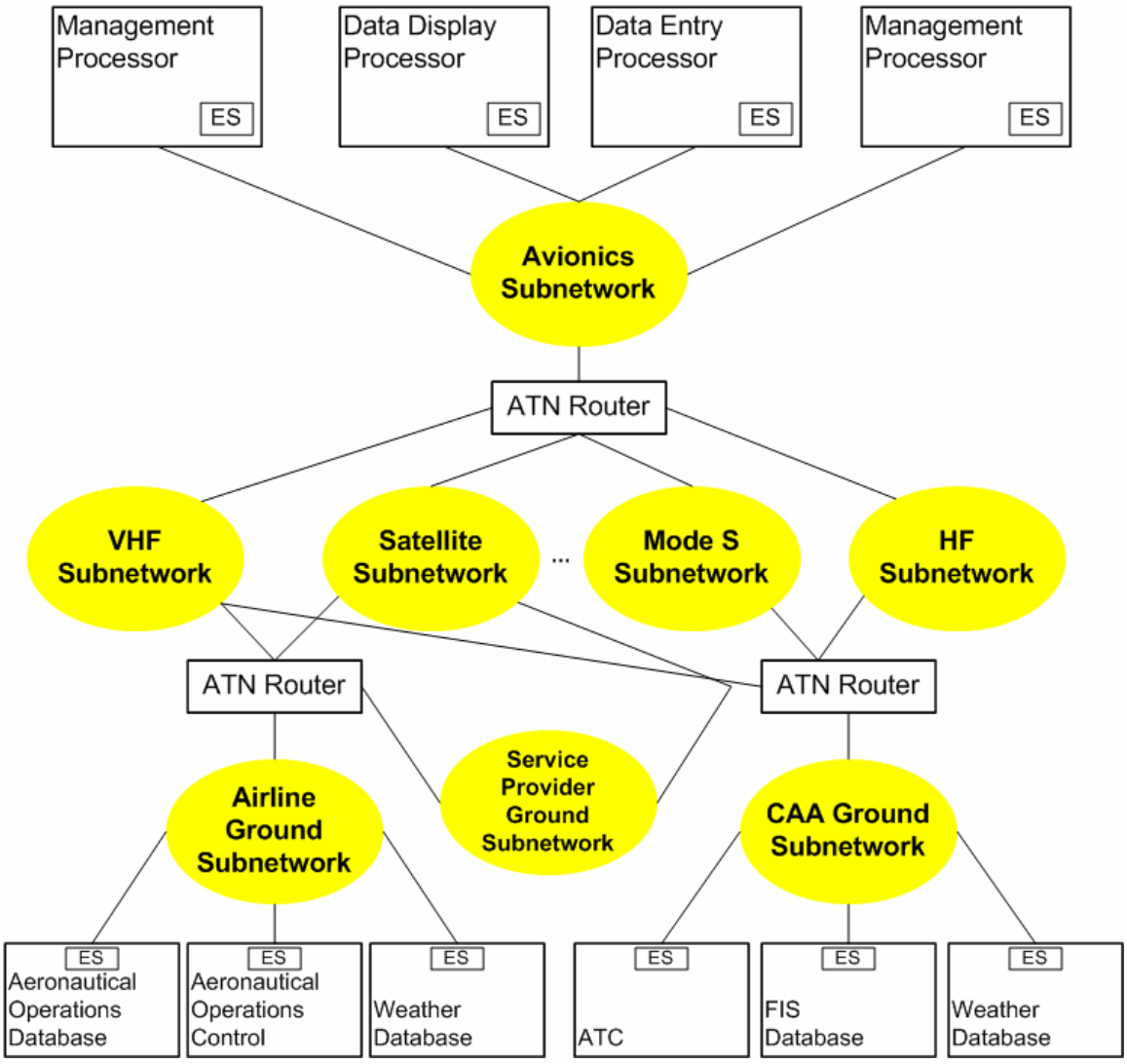
b) based on internationally recognized data communications Standards;

c) accommodates differing services (e.g. preferred air ground subnetwork);

d) allows the integration of public/private networks; and

e) makes efficient use of bandwidth, which is a limited resource in air-ground data links.

A diagram of the ATN architecture is given in Figure 4-1.



Overview of ATN Architecture

Figure 4-1

When a State or organization transitions to an ATN environment, consideration must be given to interfacing with systems of other States and organizations. Furthermore, the ground-to-air interface(s) will be to either an ATN aircraft or a FANS-1/A aircraft. An ATS unit which needs to exchange data with ATN aircraft should implement applications which are the ground-based peers of the aircraft applications. In addition, the ground ATN environment must be connected to the aircraft ATN environment via one or more mobile subnetworks. There are two possible ways to use a mobile subnetwork. The first is a direct connection from the ATS unit to the aircraft router. The second way is to use the air-ground router and mobile subnetwork of another organization. Communication with a FANS-1/A aircraft will be accomplished by an "accommodation software" in an ATS unit. All FANS-1/A accommodation-related work will be

done on the ground. Both ATN and FANS-1/A downlink messages will be processed without restriction, and uplink messages will arrive correctly at their intended destination (i.e. FANS-1/A to FANS-1/A aircraft and ATN to ATN aircraft). However, the FANS-1/A-only aircraft are not expected to be able to obtain the same operational services which will be offered to ATN aircraft.

Guidance material can be found in the *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) using ISO/OSI standards and protocols* (Doc 9880). This manual contains the detailed technical specifications for the ATN, based on relevant standards and protocols established by the International Organization for Standardization (ISO) and the Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T) for Open Systems Interconnection (OSI). It contains information on air-ground and ground-ground applications, Internet communication services, including upper layer communications service, directory service, security services, systems management and identifier registration. Additional information may be found in *Comprehensive Aeronautical Telecommunication Network (ATN) Manual* (Doc 9739). The ATN is currently migrating towards Internet Protocol suite (IPS) standards.

An opportunity offered to enable early use of current technology by the application of ARINC Specifications 622 (*ATS Data Link Applications Over ACARS Air-Ground Network*) and 623 (*Character-Oriented Air Traffic Service Applications*) over character-based data communication systems such as Aircraft Communications Addressing and Reporting System (ACARS) will provide for significant benefits in ATM. Several States are proceeding with implementation of ATS ground facilities to meet and take early advantage of aircraft CNS packages, both of which are based on the ARINC Specifications 622 and 623. The implementation plans recognize that eventual transition to the ATN is an objective and that ARINC Specifications 622 and 623 are intermediate interim steps designed to gain early CNS/ATM benefits from existing technology.

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MANUAL FOR ICAO AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE Part 2-IRIDIUM

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1 INTRODUCTION

1.1 Objective

The objective of this part of the manual is to provide detailed technical specifications and guidance material to International Civil Aviation Organisation (ICAO) Contracting States and the international civil aviation community on their consideration of the Iridium Satellite Network, acting as a subnetwork to the aeronautical telecommunication network (ATN), as a platform for offering aeronautical mobile satellite (route) service (AMS(R)S) communications for the safety and regularity of flight. This manual is to be considered in conjunction with the Standards and Recommended Practices (SARPs) as contained in Annex 10, Volume III, Part I, Chapter 4.

1.2 Scope

This part of the manual contains information about aeronautical mobile satellite communications using the Iridium Satellite system. Information about the Iridium Satellite Network, including system architecture, interoperability and technical characteristics, AMS(R)S system, as well space, ground and airborne equipment, is provided. Iridium-specific performance parameters and compliance with AMS(R)S SARPs are also described.

Chapter 1 **INTRODUCTION** provides a background of the ICAO Aeronautical Communications Panel (ACP) and the AMS(R)S SARPs and an overview of how the Iridium Satellite Network supports AMS(R)S.

Chapter 2 **IRIDIUM SATELLITE NETWORK** provides a detailed description of the Iridium Satellite Network.

Chapter 3 **IRIDIUM AMS(R)S SYSTEM** provides an overview of the integration of the Iridium satellite network into an AMS(R)S system providing end-to-end voice and data communication service.

Chapter 4 **IRIDIUM AMS(R)S STANDARDIZATION ACTIVITIES** Describes effort within the aviation industry standardization bodies to integrate Iridium AMS(R)S communications services and systems

Chapter 5 **COMPARISON OF AMS(R)S SARPS AND PROJECTED IRIDIUM PERFORMANCE** contains information provided by Iridium Satellite LLC on their compliance with ICAO AMS(R)S SARPs. Appendix A provides information on Iridium-specific performance parameters pertaining to the Minimum Operational Performances Standards (MOPS) for Avionics Supporting Next Generation Satellite Systems (NGSS) as specified in RTCA DO-262.

Chapter 6 **IMPLEMENTATION GUIDANCE** provides guidance material on the performance of the future Iridium AMS(R)S system, as it is focused primarily on the Iridium subnetwork.

1.3 Background

The ICAO ACP has carried forward future air navigation systems planning that designates basic architectural concepts for using satellite communications, initially in oceanic and remote environments and eventually in continental airspace. The progress towards satellite communications for aeronautical safety is realized through the revision of SARPs and guidance material by ICAO for AMS(R)S and through the interactions of ICAO with other international bodies to assure that resources are coordinated and available.

The Aeronautical Mobile Communications Panel (AMCP), the predecessor of the ACP, concluded at its 6th meeting in March 1999 that the Iridium Satellite Network broadly satisfied the set of acceptability criteria developed for next-generation satellite systems. This was before the more generic performance-oriented AMS(R)S SARPs were adopted by ICAO Council in 2007.

Part 1 of this manual provides a detailed description of ICAO activities and SARPs related to AMS(R)S. This section, Part 2, provides technical details of the Iridium network and implementation guidance for ICAO member States.

1.4 Terms

Throughout this document the Satellite Network Operations Provider may be referred to as Iridium, Iridium Satellite, or ISLLC. Refer to Appendix C for a complete list of definitions of the Satellite Network Operation Provider, Satellite Communications Services Provider and Terrestrial Network Service Provider and other terms related to Iridium AMS(R)S.

2 IRIDIUM SATELLITE NETWORK

2.1 Overview

Iridium Satellite Network, with its constellation of 66 low Earth orbit (LEO) satellites, is a global mobile satellite communication network, with complete coverage of the entire Earth, including polar regions, offering voice and data service to and from remote areas where no other form of communication is available.

As of February 2007, Iridium Satellite LLC had approximately 175,000 subscribers worldwide.

Iridium Satellite launched service in December 2000; Iridium World Data Services were launched in June 2001. World Data services include Dial-Up Data with a throughput rate of up to 2.4 Kbps, Direct Internet Data with a throughput rate of up to 10 Kbps, and the Router-Based Unrestricted Digital Interworking Connectivity Solution (RUDICS). Iridium Short Burst Data (SBD) service was added in June 2003.

Iridium Satellite operates its Satellite Network Operations Centre (SNOC) in Virginia, USA, with gateways in Arizona and Hawaii, USA. Telemetry, Tracking, and Control (TTAC) facilities are located in Arizona and Alaska, USA; and Yellowknife and Iqaluit, Canada; with an

additional TTAC facility planned for Svalbard, Norway, and backup facilities located around the globe.

ISLLC has contracted The Boeing Company to operate, maintain and monitor its satellite constellation. The Iridium constellation, gateway facilities, testing and development laboratories, TTAC facilities, as well as overall network and system health are being permanently monitored.

ISLLC also has contracted Celestica Inc. to manufacture its subscriber equipment, satellite handsets, L-band[1] Transceivers (LBT), and Short Burst Data (SBD) devices. The LBT and SBD devices are installed in the Iridium Satcom Data Units (SDUs).

System improvements in the satellite and user equipment have been introduced, providing improved voice quality and performance. Multiple tests and analyses have demonstrated satellite constellation longevity of at least 2014, yet plans already are underway for the manufacture and launch of the next generation constellation.

2.2 System Architecture

The Iridium Satellite Network is a satellite-based, wireless personal communications network, based on Global System for Mobile Communications standard (GSM), providing voice and data services to virtually any destination on earth.

The Iridium communication system comprises three principal components: the satellite network, the ground network and the Iridium subscriber products. The design of the Iridium network allows voice and data to be routed virtually anywhere in the world. Voice and data calls are relayed from one satellite to another until they reach the satellite above the Aircraft Earth Station (AES), which includes the Iridium SDU, and the signal is relayed back to Earth.

The key elements of the Iridium communication system are illustrated in Figure 2-1.

[1] For the purpose of this document, the term “L-band” specifically refers to the band 1616-1626.5 MHz.

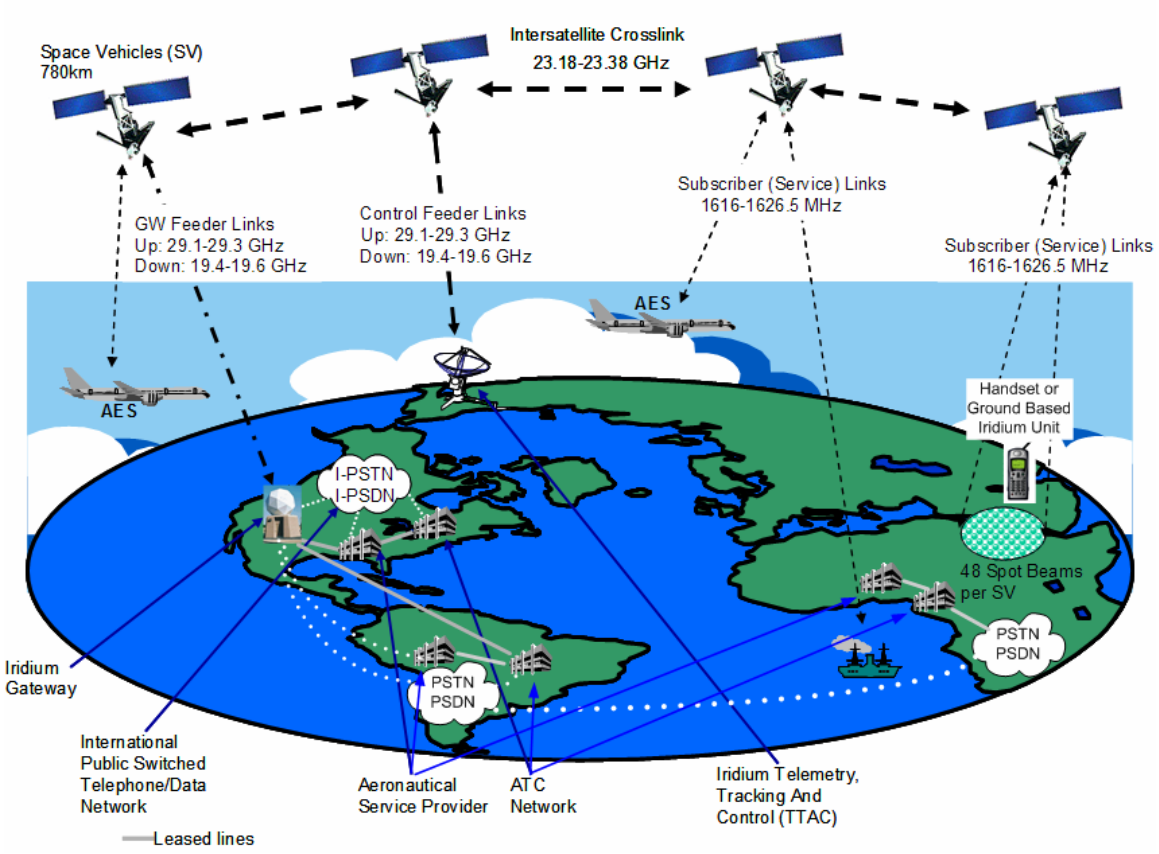


Figure 2-1 Key Elements of the Iridium AMS(R)S

2.2.1 Space Segment

The Iridium space segment utilizes a constellation of 66 operational satellites in low-Earth orbit, as shown in Figure 2-2. The satellites are located in six distinct planes in near-polar orbit at an altitude of approximately 780 km and circle the Earth approximately once every 100 minutes, travelling at a rate of roughly 27,088 km/h. The 11 mission satellites, which are evenly spaced within each plane, perform as nodes in the communication network. The six co-rotating planes are spaced 31.6 degrees apart in longitude, resulting in a spacing of 22 degrees between Plane 6 and the counter-rotating portion of Plane 1. Satellite positions in adjacent odd and even numbered planes are offset from each other by one-half of the satellite spacing. This constellation ensures that every region on the globe is covered by at least one satellite at all times. There are currently 10 additional satellites in-orbit spares ready to replace any unserviceable satellite in case of a failure.

Each satellite communicates with the AES, which includes the SDUs, through tightly focused antenna beams that form a continuous pattern on the Earth's surface. Each satellite uses three phased-array antennas for the user links, each of which contains an array of transmit/receive modules. The phased-array antennas of each satellite create 48 spot beams arranged in the configuration shown in Figure 2-3 covering a circular area with a diameter of approximately

4,700 km. These arrays are designed to provide user-link service by communicating within the 1616-1626.5 MHz band.

The near-polar orbits of Iridium satellites (commonly referred to as space vehicles or satellites) cause the satellites to be closer together as the sub-satellite latitude increases, as illustrated in Figure 2-2. This orbital motion, in turn, causes the coverage of neighbouring satellites to increasingly overlap as the satellites approach the poles. A consistent sharing of load among satellites is maintained at high latitudes by selectively deactivating outer-ring spot beams in each satellite. This beam control also results in reduced inter-satellite interference and increased availability in high latitudes due to overlapping coverage.

The Iridium Satellite Network architecture incorporates certain characteristics which allow the Space Segment communications link with subscriber equipment to be transferred from beam to beam and from satellite to satellite as such satellites move over the area where the subscriber is located. This transfer is transparent to the user, even during real-time communications.

Each satellite has four cross-link antennas to allow it to communicate with and route traffic to the two satellites that are fore and aft of it in the same orbital plane, as well as to neighbouring satellites in the adjacent co-rotating orbital planes. These inter-satellite links operate at approximately 23 GHz. Inter-satellite networking is a significant technical feature of the Iridium Satellite Network that enhances system reliability and capacity and reduces the number of gateways or Ground Earth Stations (GESs) required to provide global coverage to one with redundant back-up switch, processors and an earth terminal station which is physically separated from the primary GES.

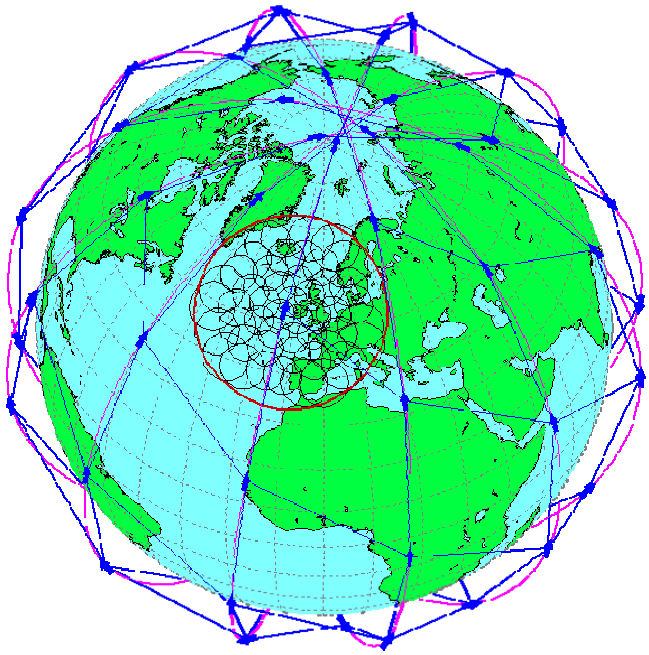


Figure 2-2 Iridium 66-Satellite Constellation

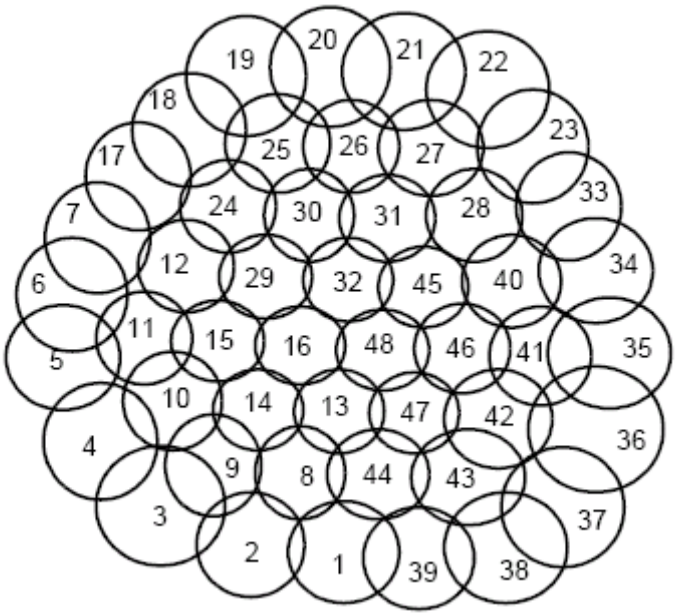


Figure 2-3 Iridium Spot-Beam Configuration

2.2.2 Terrestrial Segment

The terrestrial segment is comprised of the System Control Segment and Iridium Gateways that connect into the terrestrial telephone/data network.

The System Control Segment is the central management component for the Iridium system. It provides global operational support and control services for the satellite constellation, delivers satellite-tracking data to the Iridium Gateways, and performs the termination control function of messaging services.

The System Control Segment consists of three main components: four TTAC sites, the Operational Support Network (OSN), and the SNOC. The primary linkage between the System Control Segment, the satellites, and the gateways is via control feeder links and inter-satellite cross-links throughout the satellite constellation.

The Iridium Gateway provides call processing and control activities such as subscriber validation and access control for all calls. The gateway connects the Iridium satellite network to ground communication networks, such as the terrestrial Public Switched Telephone Networks (PSTNs) and Public Switched Data Networks (PSDNs), and communicates via ground-based antennas with the gateway feederlink antennas on the satellite. The gateway can also serve as a gateway to the ATN for forwarding ATN messages from the aircraft to the required Air Traffic Command (ATC) or Aircraft Operational Communication (AOC) unit or vice versa. The gateway includes a subscriber database used in call processing activities such as subscriber validation, keeps a record of all traffic, and generates call detail records used in billing.

2.3 Channel Classifications

Each Iridium communications channel consists of a time-slot and a carrier frequency. Channels provided by the system can be divided into two broad categories: system overhead channels and bearer service channels. Bearer service channels include traffic channels and messaging channels, while system overhead channels include ring alert channels, Broadcast Channels, acquisition and synchronization channels. A specific time-slot-and-frequency combination may be used for several types of channels, depending on what specific activity is appropriate at each instant. Each time-slot-and-frequency combination is only used for one purpose at a time. Figure 2-4 illustrates the hierarchy of Iridium channel types. Iridium aeronautical services utilize only the indicated channel types.

In the discussions that follow, the term "channel" will always refer to a time-slot-and-frequency combination. The terms "frequency" or "frequency access" will denote the specific radio frequency of an individual channel.

2.3.1 Overhead Channels

The Iridium Satellite Network has four overhead channels: 1) Ring Channel; 2) Broadcast Channel; 3) Acquisition Channel; and 4) Synchronization Channel.

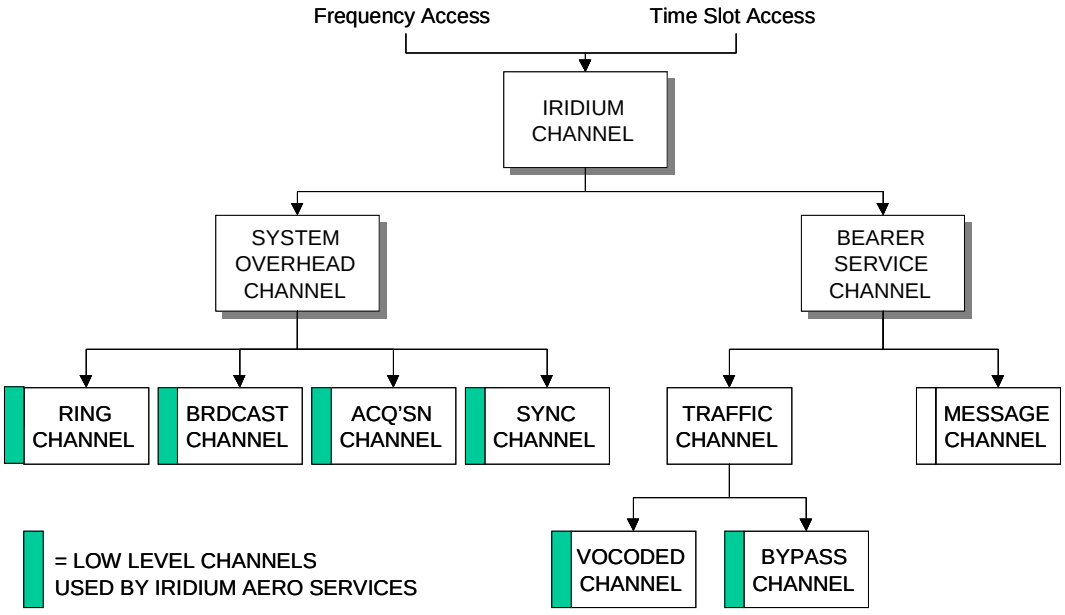


Figure 2-4 Iridium Channel Structure Hierarchy

The Ring Channel is a downlink-only channel used to send ring alert messages to individual subscriber units. Its downlink frequency is globally assigned in order to be the same known frequency throughout the world. The Ring Channel uses a time division format to send ring alert messages to multiple subscriber units in a single frame.

Broadcast Channels are downlink channels used to support the acquisition and handoff processes. These channels provide frequency, timing, and system information to SDUs before they attempt to transmit an acquisition request. In addition, Broadcast Channels provide downlink messages which acknowledge acquisition requests and make channel assignments. Finally, Broadcast Channels are used to implement selective acquisition blocking to prevent local system overloads.

Acquisition channels are uplink-only channels used by individual subscriber equipment to transmit an acquisition request. These channels use a slotted ALOHA random access process. The time and frequency error tolerances are larger for an Acquisition Channel to allow for initial frequency and timing uncertainties. SDUs determine which Acquisition Channels are active by monitoring the Broadcast Channel.

The Synchronization Channel is a duplex channel used by the SDU to achieve final synchronization with a satellite before it begins traffic channel operation. The Synchronization Channel occupies the same physical channel time slots and frequency accesses as the traffic channel that the SDU will occupy when the synch process is complete. During the synch process, the satellite measures the differential time of arrival (DTOA) and differential frequency of arrival (DFOA) of the uplink synch burst and sends correction information to the SDU in the downlink synch burst. A synchronization channel is assigned to an SDU by the satellite. The synchronization procedure is accomplished by the SDU transmitting an uplink burst which the satellite measures for time and frequency error relative to the assigned channel. The satellite sends time and frequency corrections for the latest uplink burst over the downlink channel. This process is repeated until the satellite determines that both the SDU transmit time and frequency are within the tolerance for a traffic channel. When this occurs, the satellite transmits a message to that effect to the SDU and reconfigures the channel for traffic channel operation.

2.3.2 Bearer Service Channels

The Iridium subscriber link provides two basic types of bearer service channels: traffic channels and messaging channels.

Messaging channels support downlink only simplex messaging service. This service carries numeric and alphanumeric messages to Message Termination Devices such as Iridium pagers. The Iridium aeronautical service does not utilize the simplex messaging services.

Traffic channels support duplex services which include portable mobile telephony and a variety of duplex bearer data services. Each traffic channel consists of an associated uplink and downlink channel. A duplex user has exclusive use of the assigned channels until service terminates or until handed off to a different channel.

2.4 Channel Multiplexing

Channels are implemented in the Iridium Satellite Network using a hybrid Time Division Multiple Access/Frequency Division Multiple Access (TDMA/FDMA) architecture based on Time Division Duplex (TDD) using a 90 millisecond frame. Channels are reused in different geographic locations by implementing acceptable co-channel interference constraints. A channel assignment comprises both a frequency carrier and time slot.

2.4.1 TDMA Frame Structure

The fundamental unit of the TDMA channel is a time-slot. Time-slots are organized into TDMA frames as illustrated in Figure 2-5. The frame consists of a 20.32 millisecond downlink simplex time-slot, followed by four 8.28 millisecond uplink time-slots and four downlink time-slots, which provide the duplex channel capability. The TDMA frame also includes various guard times to allow hardware set up and to provide tolerance for uplink channel operations.

The simplex time-slot supports the downlink-only, ring and messaging channels. The Acquisition, Synchronization, and Traffic channels use the uplink time-slots. The Broadcast, Synchronization, and Traffic channels use the downlink duplex time-slots.

There are 2250 symbols per TDMA frame at a channel burst modulation rate of 25 ksps. A 2400 bps traffic channel uses one uplink and one downlink time-slot per frame.

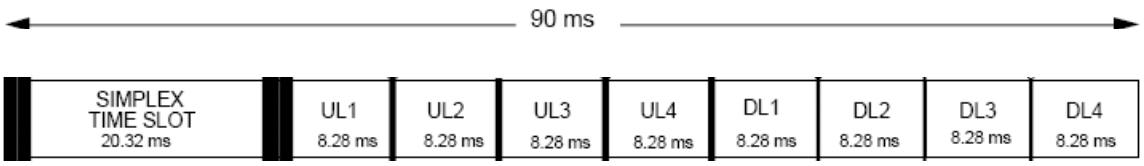


Figure 2-5 Iridium TDMA Structure

2.4.2 FDMA Frequency Plan

The fundamental unit of frequency in the FDMA structure is a frequency access that occupies a 41.667 kHz bandwidth. Each channel uses one frequency access. The frequency accesses are divided into the duplex channel band and the simplex channel band. The duplex channel band is further divided into sub-bands.

2.4.3 Duplex Channel Band

The frequency accesses used for duplex channels are organized into sub-bands, each of which contains eight frequency accesses. Each sub-band, therefore, occupies 333.333 kHz (8 x 41.667 kHz). In duplex operation, the Iridium Satellite Network is capable of operating with up to 30 sub-bands, containing a total of 240 frequency accesses. Table 2-1 shows the band edges for each of the 30 sub-bands. Iridium's current band usage includes sub-bands 8-30.

Table 2-1 Sub-Band Frequency Allocation

Sub-band	Lower Edge (MHz)	Upper Edge (MHz)
1	1616.000000	1616.333333
2	1616.333333	1616.666667
3	1616.666667	1617.000000
4	1617.000000	1617.333333
5	1617.333333	1617.666667
6	1617.666667	1618.000000
7	1618.000000	1618.333333
8	1618.333333	1618.666667
9	1618.666667	1619.000000
10	1619.000000	1619.333333
11	1619.333333	1619.666667
12	1619.666667	1620.000000
13	1620.000000	1620.333333
14	1620.333333	1620.666667
15	1620.666667	1621.000000
16	1621.000000	1621.333333
17	1621.333333	1621.666667
18	1621.666667	1622.000000
19	1622.000000	1622.333333
20	1622.333333	1622.666667
21	1622.666667	1623.000000
22	1623.000000	1623.333333
23	1623.333333	1623.666667
24	1623.666667	1624.000000
25	1624.000000	1624.333333
26	1624.333333	1624.666667
27	1624.666667	1625.000000
28	1625.000000	1625.333333
29	1625.333333	1625.666667
30	1625.666667	1626.000000

The Iridium Satellite Network reuses duplex channels from beam to beam when sufficient spatial isolation exists to avoid interference. Channel assignments are restricted so that interference is limited to acceptable levels. A reuse pair is the minimum group of duplex channels that can be assigned to an antenna beam. A reuse unit pair consists of an uplink reuse unit and a downlink reuse unit. A reuse unit consists of one time-slot and the eight contiguous frequency accesses of a sub-band for a total of eight channels. The frequency accesses are numbered 1 through 8 from lowest to highest frequency.

Table 2-2 lists the lower, upper and centre frequencies for each of the 8 frequency accesses within a reuse unit. These frequencies are relative to the lower edge of the sub-band defined in Table 2-1.

Reuse unit pairs can be assigned to a beam, reassigned or activated/deactivated at the beginning of each TDMA frame. Dynamic beam assignment and reclassification are used to provide additional capacity to beams that have heavy traffic loading.

Table 2-2 Reuse Unit Frequency Accesses

Frequency Access Number	Lower Edge Frequency (kHz)	Upper Edge Frequency (kHz)	Center Frequency (kHz)
1	0.000	41.667	20.833
2	41.667	83.333	62.500
3	83.333	125.000	104.167
4	125.000	166.667	145.833
5	166.667	208.333	187.500
6	208.333	250.000	229.167
7	250.000	291.667	270.833
8	291.667	333.333	312.500

2.4.4 Simplex Channel Band

A 12-frequency access band is reserved for the simplex (ring alert and messaging) channels. These channels are located in a globally allocated 500 kHz band between 1626.0 MHz and 1626.5 MHz. These frequency accesses are only used for downlink signals and they are the only frequencies that may be transmitted during the simplex time-slot. As shown in Table 2-3, four messaging channels and one ring alert channel are available during the simplex time-slot.

Table 2-3 Simplex Frequency Allocation

Channel Number	Center Frequency (MHz)	Allocation
1	1626.020833	Guard Channel
2	1626.062500	Guard Channel
3	1626.104167	Quaternary Messaging
4	1626.145833	Tertiary Messaging
5	1626.187500	Guard Channel
6	1626.229167	Guard Channel
7	1626.270833	Ring Alert
8	1626.312500	Guard Channel
9	1626.354167	Guard Channel
10	1626.395833	Secondary Messaging
11	1626.437500	Primary Messaging
12	1626.479167	Guard Channel

2.5 L-Band (1616-1626.5 MHz) Transmission Characteristics

2.5.1 Signal Format

All L-Band uplink and downlink transmissions used in the Iridium Satellite Network employ variations of 25 Kilosymbols-per-second (ksps) quadrature phase shift keying (QPSK) modulation and are implemented with 40% square root raised cosine pulse shaping. The variations of QPSK used include differential encoding (DE-QPSK) and binary phase shift keying (BPSK), which is treated as a special case of QPSK. Figure 2-6 illustrates the relevant FDMA frequency characteristics.

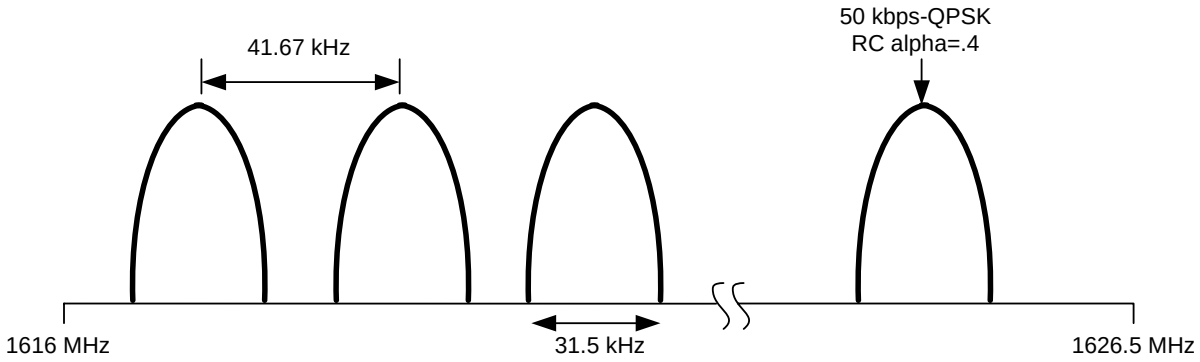


Figure 2-6 FDMA Frequency Plan

The modulation structure used for the uplink and downlink traffic data includes differential encoding to allow demodulators to rapidly reacquire phase and resolve phase ambiguities in case there is a momentary loss of phase-lock due to a link fade.

Downlink traffic, broadcast, synchronization, ring alert, and messaging channels all use DE-QPSK modulation with 40% square root raised cosine pulse shaping. In all cases, the burst transmission rate is 25 ksps and provides a burst data rate of 50 kilobits-per-second (kbps).

Uplink traffic channels use DE-QPSK modulation with 40% square root raised cosine pulse shaping and burst transmission rates of 25 ksps, or 50 kbps. Uplink acquisition and synchronization channels both use DE-BPSK with 40% square root raised cosine pulse shaping and burst transmission rates of 25 ksps, or 25 kbps. BPSK is used because it provides a 3 dB link advantage, which improves the burst acquisition probability.

Certain signaling, control, and traffic applications implement error correction coding to improve the link bit error rate, with characteristics tailored for certain traffic and signaling message applications. The vocoder algorithm provides its own interleaving and forward error correction. Most of the administrative transmissions used in granting access to and exerting control of the link implement their own internal error correction and interleaving.

The link protocol does not provide forward error correction to user generated data transmitted in the payload. Such data is protected from transmission errors by a 24-bit Frame Check Sequence transmitted in every traffic burst containing a data payload (as opposed to a voice payload). If the Frame Check Sequence does not validate that the payload data was correctly received, the L-Band Protocol implements error by retransmission of the Iridium frame. Erroneous information, i.e., payload data that does not satisfy the Frame Check Sequence, is not passed to the end user. Therefore, a decrease in channel quality which causes any increase in channel bit-error-rate results in an increase in the number of retransmissions and a corresponding decrease in the number of user-generated bits provided to the end user. Iridium data service has been designed to provide a minimum throughput of 2400 bps user-generated information.

Traffic channels operate with adaptive power control, as discussed below, which acts to limit power transmissions beyond what is required for appropriate voice and data quality.

2.5.2 Power Control

The L-Band link has been designed for a threshold channel bit error of 0.02, which is sufficient to support voice services. This level is achieved at an Eb/(No+Io) of 6.1 dB in clear line of sight conditions. The basic Iridium Satellite Network will operate with an average link margin of 15.5 dB above this level, as required to mitigate fading due to the Rayleigh multipath and shadowing typical of handheld phone operation in urban environments. Under good channel conditions, this level is reduced by adaptive power control. Even under adaptive power control, the link margin is maintained to mitigate fades that are too short in duration to be compensated by the power control loop.

Adaptive power control uses a closed loop algorithm in which the space vehicle and AES receivers measure the received energy per bit per noise power spectral density (Eb/No) and command the transmitters to adjust their transmitted power to the minimum value necessary to maintain high link quality. When the entire available link margin is not required to mitigate channel conditions, adaptive power control has the effect of reducing system power consumption. There are slight differences in the power control algorithms used for voice and data operations. For data operations, the algorithm is biased toward higher power levels and does not use adaptive power control, hence ensuring low channel bit error rates and high user throughput.

2.6 Call Processing

Call Processing in the Iridium Satellite Network consists of Acquisition, Access, Registration and Auto-Registration, Telephony, and Handoff.

2.6.1 Acquisition

Acquisition is the first step in obtaining service from the Iridium Satellite Network. It is the process of establishing a communication link between a satellite and the SDU. Acquisition by an SDU is necessary for registration, call setup, answering call terminations, or to initiate any service on the Iridium Satellite Network.

To enter the Iridium Satellite Network, a subscriber unit must go through an Acquisition sequence. The first steps in Acquisition are to achieve frame timing alignment, determine the

correct downlink time slot, and detect the Doppler shift of the received signal. Then the SDU must pre-correct the transmitted signal so the received signal, at the satellite, arrives during the correct receive time window and has, at most, a small Doppler offset.

To acquire the system, an SDU turns on its receiver and acquires the satellite Broadcast Channel transmission for the beam in which the SDU is located. The Ring Channel includes the broadcast time/frequency for each beam, and the SDU can use this to determine which channel to use. The decoded satellite broadcast (Broadcast Acquisition Information message) indicates to the SDU if Acquisition is permitted; this is done via the Acquisition Class control. Acquisition denial might occur as a result of network capacity or some other system constraints. If the network permits Acquisition, the SDU extracts the beam ID and selects a random Acquisition Channel.

The SDU estimates Doppler offset and predicts uplink timing based on beam ID. It pre-corrects its timing and frequency and then transmits a ranging burst (Acquisition Request message) to the satellite on the Acquisition Channel. Upon receipt of the Acquisition Request message from the SDU, the satellite calculates the time and frequency error of the received signal. It then sends a Channel Assignment message to the SDU along with time and frequency corrections.

After each transmission on the uplink Acquisition Channel, the SDU decodes the Broadcast Channel and checks for an acknowledgment of its request (Channel Assignment message) and makes sure its acquisition class is still allowed on the system. Receiving no acknowledgment after a request, the SDU repeats its request after a random time interval (Slotted Aloha) and on a random Acquisition Channel. This minimizes the number of collisions between the acquiring SDU and other SDUs attempting to use the Acquisition Channel.

The SDU, upon receiving the Channel Assignment message, immediately transitions to the new Sync Channel and acknowledges the change by sending a Sync Check message to the satellite. The satellite measures the time and frequency offset error of the received burst and responds with a Sync Report message. The Sync Report message contains a Sync Status information element. The satellite will set Sync Status to “Sync OK” if the time and frequency errors are within the tolerance for Traffic Channel operation. If the satellite sends a Repeat Burst in the Sync Status information element, the SDU adjusts its timing and frequency and retransmits a Sync Check message. If the satellite sends “Sync OK” in the Sync Report message, the SDU acknowledges by sending a Sync Check message and waits for a Sync/Traffic Switch message from the satellite. Upon receipt of the Sync/Traffic Switch message, the SDU exits the Acquisition process and initiates the Access process. The satellite then switches the Sync Channel to a Traffic Channel.

2.6.1.1 Acquisition Control

Under certain circumstances, it may be necessary to prevent users from making Acquisition attempts. Such situations may arise during states of emergency or in the event of a beam overload. During such times, the Broadcast Channel specifies, according to populations, which SDUs may attempt Acquisition. All subscribers are members of one out of ten randomly allocated populations, referred to as Acquisition Class 0 to 9. The subscriber equipment reads the Acquisition Class from the Subscriber Information Module (SIM) card that was programmed

when it was initially provisioned. In addition, subscribers may be members of one or more special categories (Acquisition Class 11 to 15), also held in the SDU. The system provides the capability to control a user's acquisition to the system based on the following Acquisition Classes:

15. ISLLC Use
14. Aeronautical Safety Service
13. Reserved
12. Reserved
11. Fire, Police, Rescue Agencies
10. Emergency Calls
0-9. Regular Subscribers (randomly allocated)

The use of acquisition classes allows the network operator to prevent overload of the acquisition or traffic channels. Any number of these classes may be barred from attempting Acquisition at any one time. If the subscriber is a member of at least one Acquisition Class that corresponds to a permitted class, the SDU proceeds with Acquisition.

2.6.2 Access

The Access process determines the SDUs location with respect to Service Control Areas defined in earth fixed coordinates. Based on the Service Control Area within which the SDU is found to be located and on the identity of the SDUs service provider (satellite communications service provider), a decision is made regarding whether or not to allow service, and which gateway should provide that service. The process is initiated immediately following Acquisition.

Location information may be reported by the SDU based on an external source such as an aircraft navigation system, or it may be determined by the Geolocation function contained within the Access function.

2.6.3 Registration and Auto-Registration

Registration is the process of the SDU communicating its location to the system, and requires the prior completion of Acquisition and Access. The registration process allows the network to maintain an estimate of the location of roaming users as part of mobility management. This location estimate is required to allow the network to notify the subscriber when an incoming call is available (i.e., 'ring' an SDU for a mobile terminated call). The SDU must be registered in the gateway serving its location to initiate or terminate a call. An SDU registration occurs for one of five reasons:

1. The SDU presently contains an invalid Temporary Mobile Subscriber Identification (TMSI) or Location Area Identity (LAI)
2. The TMSI presently assigned to an SDU expires
3. A call termination or origination is performed and, based on the new location, the SDU is told to re-register by the system
4. A mobile subscriber initiates a manual SDU registration procedure

5. The SDUs present location exceeds the re-registration distance from the point of its last registration.

The procedures used for SDU registration (Location Update) after acquisition and access are GSM procedures.

Auto-registration refers to the capability of an SDU to re-register with the network only on an as-needed basis. The SDU will automatically re-register with the system when it knows its current location exceeds a specified distance from the point it last registered. In order to make this decision, the SDU passively estimates both its location and its positional error, based upon information gathered from the Ring Channel of the passing satellites.

2.6.4 Telephony

Telephony is the process of establishing a connection between two telephone users and releasing the connection at the end of the call. For mobile terminated calls, Telephony also includes the process of alerting an SDU of an incoming call.

Functions supporting Telephony are distributed between the SDU, satellite and gateway components. The functions are partitioned to group similar procedures together. The SDU supports a set of protocols used to communicate among the components of the system. In order to reduce the complexity of individual components, the protocols are partitioned to group similar functionality together. The partition is shown in Figure 2-7 below.

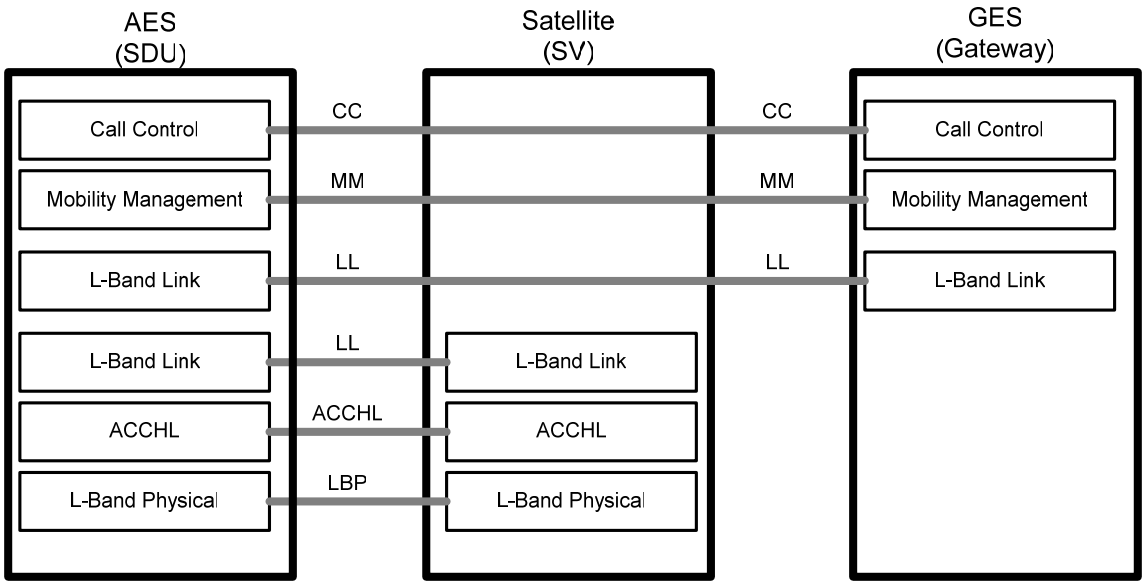


Figure 2-7 Protocol Partitions

Five protocol partitions are supported by the SDU:

1. Call Control (CC)
2. Mobility Management (MM)
3. L-Band Link (LL)
4. L-Band Physical (LBP)
5. Associated Control Channel, L-Band (ACCHL)

Call Control - The CC partition is equivalent to Call Control in the GSM standard. This includes Mobile Switching Centre to Mobile Subscriber (MSC-MS) signaling in the GSM Mobile Radio Interface CC sub-layer and associated procedures and the general Telephony Call Control capabilities included in a standard GSM switching subsystem.

Mobility Management - The MM partition is equivalent to Mobility Management in GSM. This includes the MSC-MS signaling in the GSM Mobile Radio Interface MM sub-layer and associated procedures, along with the portions of Mobile Application Part that support it.

L-Band Link - The LL control provides the functionality to control and monitor the air channels, determine access privileges, update system programmable data, and establish and release connections.

LL is responsible for the Call Processing-related signaling associated with Mobile origination or termination and provides for the signaling procedures associated with the Access portion of the Iridium Network. Additionally, LL controls the real-time aspects of radio resource management on the L-band link, such as the allocation and maintenance of L-band resources and handoff procedures.

L-Band Physical - LBP represents the control interface that exists between the satellite and the SDU. The primary distinguishing characteristic of LBP is that unlike ACCHL, the delivery of messages is not guaranteed. Examples of messages carried in this manner are ring alerts, directed messaging, Broadcast Channel messages, handoff candidates, handoff candidate lists, and Doppler/timing/power control corrections.

Associated Control Channel, L-Band - The ACCHL transmission protocol is used by all entities that need to (reliably) send data via the L-Band traffic channel burst between the satellite and the SDU. The ACCHL protocol permits sharing the traffic channel burst with other protocols. The ACCHL Logical Channel is bi-directional and uses portions of the uplink and downlink Traffic Channel, Link Control Word and the Payload Field between the satellite and the SDU. The Traffic Channel is described in the next section. The ACCHL protocol will transport variable size messages on the ACCHL Logical Channel and is used to guarantee the delivery of messages between the satellite and the SDU. It relies on LBP only in that LBP arbitrates the access to the physical layer when there is contention for the Physical Layer resources.

2.6.5 Handoff

The Iridium satellites, in low earth polar orbit, have highly directional antennas providing Iridium system access to SDUs. These antennas are configured to project multiple beams onto the surface of the earth. The beams move rapidly with respect to SDUs and with respect to other

satellites. Handoff, the process of automatically transferring a call in progress from one beam to another (or sometimes within a beam) to avoid adverse effects of either user or satellite movement in this highly mobile environment, is required in three situations. First, an SDU must be handed off between satellites as they move relative to the SDU (Inter-satellite).

Second, an SDU must be handed off between beams on a satellite as beam patterns move relative to the SDU (Intra-satellite). Last, an SDU must be handed off to another channel within a beam for frequency management and to reduce interference (Intra-beam). Although the Iridium system may force a handoff, handoff processing is primarily SDU initiated.

As a satellite moves away (for example, moves over the horizon) and a new satellite approaches (for example, comes into view over the horizon), an SDU must transfer from the current satellite (the losing satellite) to the new satellite (the gaining satellite). This Inter-satellite handoff, on the average, occurs approximately every five minutes during a telephone call. It may be initiated as frequently as five seconds or as long as 10 minutes, depending on link geometry.

As satellites move from the equator to a pole, the actual distance between adjacent satellites decreases to a few kilometers and then increases to several thousand kilometers as the satellites again approach the equator. To avoid radio interference, beams near the edges of a satellite's coverage field are turned off as the satellite approaches a pole and then turned on again as it approaches the equator. Additionally, the same radio channels are never available in adjacent beams on a satellite or between nearby satellites. Thus, as the satellite and its beams pass by, an SDU must frequently transition to a new beam. This Intra-satellite handoff occurs approximately every 50 seconds during a call.

As the inter-satellite geometry changes, radio channels must be reallocated among the beams to avoid interference. This process can cause an SDU to be handed off to a different channel in the same beam. This is called Intra-beam handoff. An SDU can also request an Intra-beam handoff to reduce interference. If the Iridium system detects an allocation change coming up where it will not have enough channels to support the number of current users, the satellite will ask for volunteers to handoff into other beams so calls will not have to be dropped when the resource change takes place. Handoffs made under these conditions are called Volunteer handoffs. Volunteer handoffs may result in one of two situations requiring handoff, namely Inter-satellite or Intra-satellite, but are initiated by the SDU (at the request of the Iridium system) rather than by the Iridium system itself.

2.7 Voice and Data Traffic Channel

Traffic channels provide two-way connections between space vehicles and subscriber equipment that support Iridium services. These channels transport the system voice and data services along with the signaling data necessary to maintain the connection and control the services.

The uplink and downlink Traffic Channels use identical burst structures. Each burst is 8.28 ms long and contains 414 channel bits. The bursts are divided into four major data fields: Preamble, Unique Word, Link Control Word and Payload Field. The preamble and unique word are used in the receiving demodulator for burst acquisition. The preamble and unique word patterns are different for the uplink and downlink. The Link Control Word provides a very low data rate signaling channel that is used to support link maintenance, the associated control channel and

handoff. The payload field furnishes the primary Traffic Channel that carries the mission data and signaling messages.

The Link Control Word field provides a low rate signaling channel used for control of the subscriber link. The uplink and downlink Traffic Channels use the same Link Control Word format. The Link Control Word is used to support link maintenance, handoff and the ACK/NAK of the associated control channel transmission protocol. The Link Control Word field is protected by forward error control (FEC) code.

The Traffic Channel payload field provides the primary Traffic Channel. This field carries the mission data and mission control data. This field supports a channel bit rate of 3466.67 bps. Typically error correction coding and other overhead functions provide a nominal information throughput on this channel of 2400 bps.

Mission data may be either vocoded voice data or data services. For voice service, the proprietary Iridium vocoder uses FEC to ensure good (based on mean opinion score for a basic telephony voice call, where 1 is bad and 5 is excellent, good is roughly a 4), or adequate, quality vocoded voice performance tailored for the Iridium communication channels. For data service, the L-band transport employs a frame check sequence to provide essentially error free data transport service.

The basic interface to the SDU and the circuit switched channel setup/teardown are provided at a modem application level using the Iridium AT command set[2]. Some Iridium data services also provide additional service specific interfaces to facilitate user access. In summary, the Iridium communication channel appears to the end users as an efficient and reliable data transport.

2.8 Iridium Data Services – RUDICS and SBD

2.8.1 Iridium RUDICS Service

The Iridium RUDICS service is an enhanced gateway termination and origination capability for circuit switched data calls across the Iridium Satellite network. RUDICS offers an optimized data connection service for various end to end data applications or solutions.

There are four key benefits of using RUDICS as part of a data solution over conventional PSTN circuit switched data connectivity or mobile-to-mobile data solutions:

1. Elimination of analog modem training time, hence faster connection establishment time.
2. Increased call connection quality, reliability, and maximized throughput.
3. Protocol independence.
4. Both Mobile Originated (MO) and Mobile Terminated (MT) calls are rated at the same rate.

[2] The Hayes command set, a specific programming language originally developed for the modems operated on telephone lines, is also called the AT commands, AT is short for attention.

Remote applications use AT Commands to control a circuit switched data capable SDU. Figure 2-8 illustrates the call set up process of a MO data call. Iridium pre-assigns RUDICS Server Number(s) to Satellite Communications Service Providers who assign and provision these numbers to customers. The remote application dials the customer's assigned RUDICS Server Number which connects the call through a telephony switch to the RUDICS server. Each SDU is authenticated using Calling Line Identification for the RUDICS Server Number that it dialed. Once authenticated, the call is routed over the terrestrial connection to a customer-specified Internet Protocol (IP) address and Port.. The RUDICS service supports the follow service transport types: transport control protocol/Internet protocol (TCP/IP) encapsulation, point to point protocol (PPP), and Multi-link PPP (MLPPP).

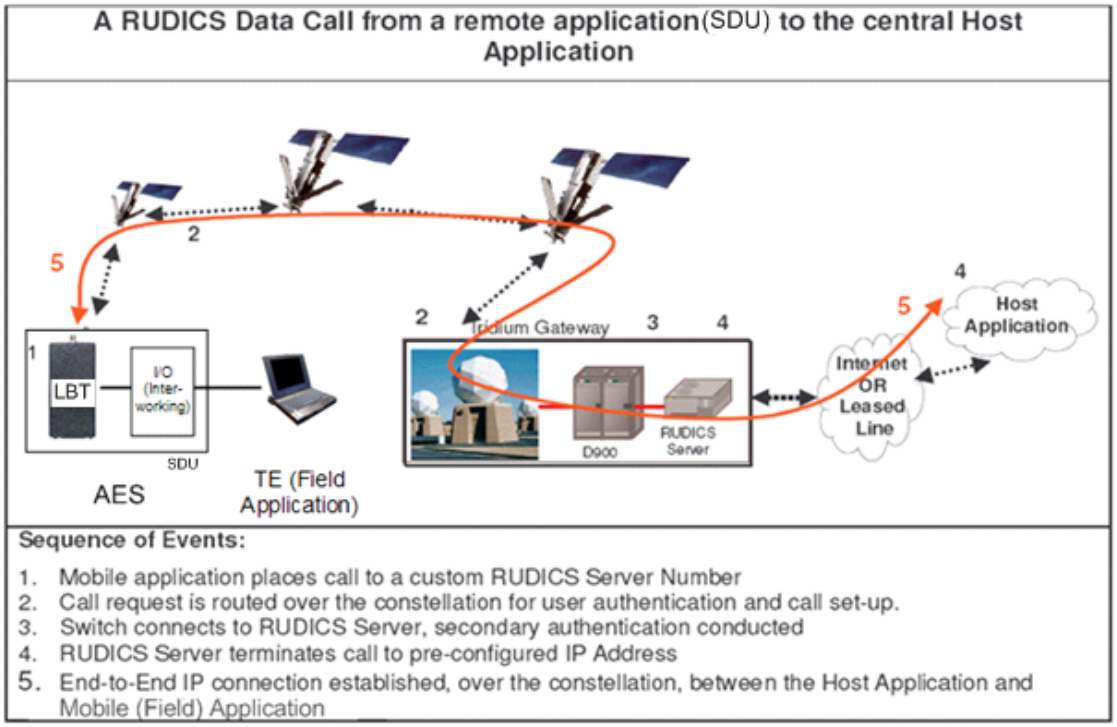


Figure 2-8 Iridium RUDICS Mobile Originated Data Call Setup

The Host application can make a MT call by opening a Telnet session to the RUDICS server. Once authenticated, a series of AT Commands are used to connect to the remote SDU and establish a circuit switched data call. MT access must specifically be requested at the time of the initial configuration and set up. Connectivity between the Iridium Gateway and the end user Host Server can be via a number of options, including:

- Internet
- Internet with Virtual Private Network
- Private leased line such as:

- Frame Relay
- T1/E1 Leased Line

Additionally, the RUDICS capability offers the capability for MLPPP. This is where multiple SDUs can be used to send data simultaneously and the data can be delivered in an N x 2400 bps PPP connection.

2.8.2 Iridium SBD Service

The Iridium Short Burst Data Service is a satellite network transport capability to transmit short data messages between (data) terminal equipment (TE) and a centralized host computing system. An MO SBD message can be up to 1960 bytes. An MT SBD message can be up to 1890 bytes.

Figure 2-9 shows the system architecture of the Iridium SBD service while Figure 2-10 depicts the MO call set up process. The original SBD service delivers SBD messages to email addresses provisioned on the SBD Subsystem. The newer SBD service added direct IP capability allowing SBD messages to be delivered directly to IP sockets provisioned on the SBD Subsystem. For an MT application, an SBD message is sent to the SBD Subsystem by the Host via the Internet or leased line. A Ring Alert is then sent by the SBD Subsystem to the addressed SDU to notify it of the arrival of a new message. The SDU then initiated a MO call to the SBD Subsystem to pull down the message.

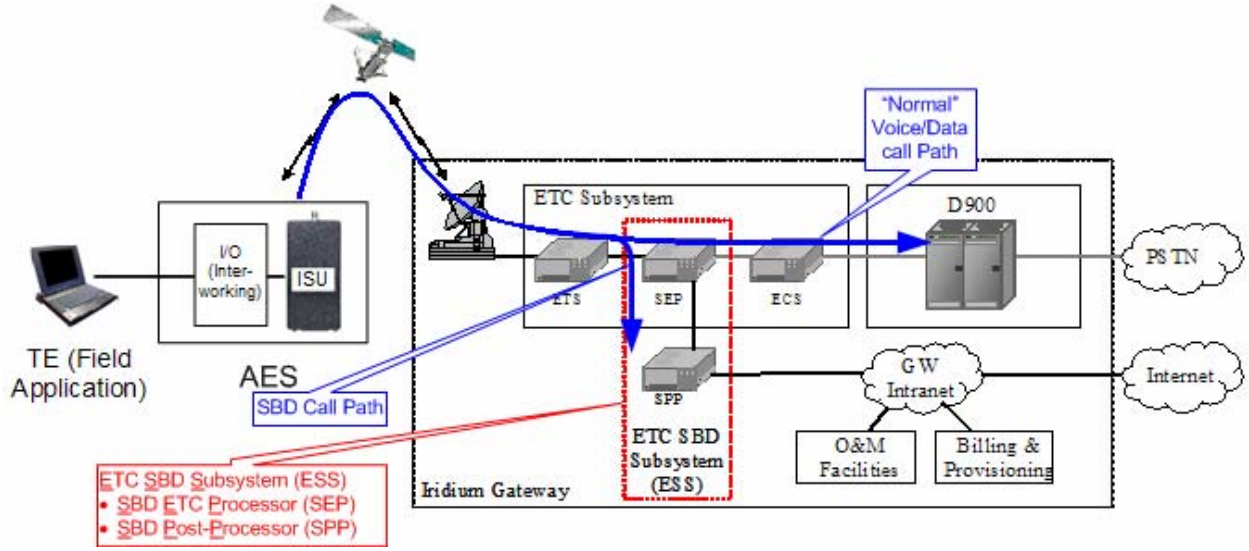
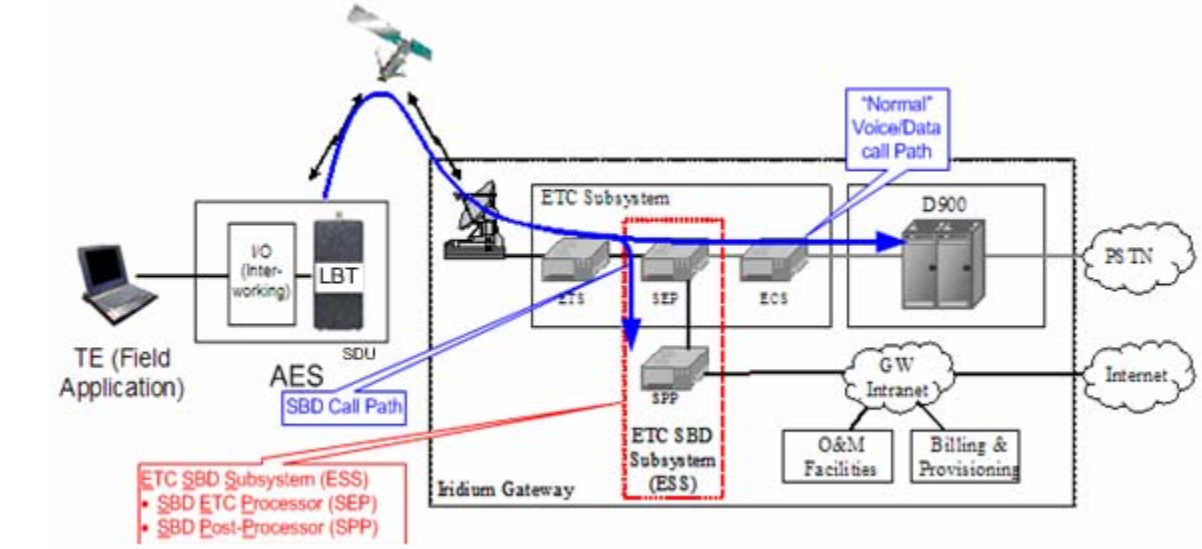
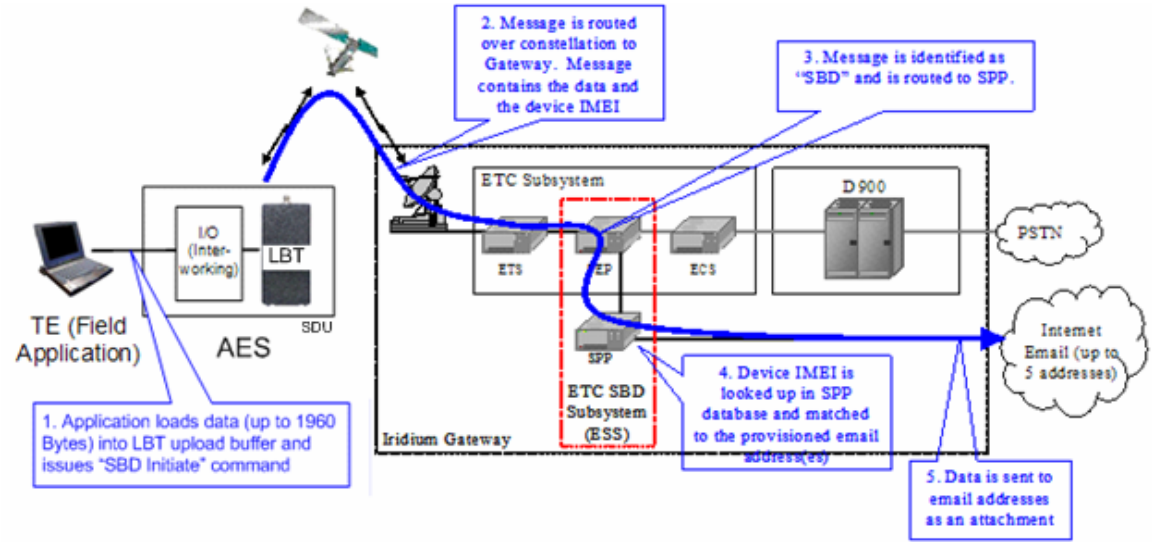


Figure 2-9 System Architecture of Iridium SBD Service

Since SBD message utilizes the Iridium signaling transport during the access phase of a circuit-switched voice call set up process, it has the benefits of additional FEC protection as well as on-the-air, off-the-air, packet delivery service.



(a)



(b)

Figure 2-10 Setting Up an MO SBD Call (a) Registration (b) Message Delivery

3 IRIDIUM AMS(R)S SYSTEM

End-to-end AMS(R)S data communication are provided by several sub-networks. Sub-networks may be classified as ground-ground (fixed), air-ground (mobile) or airborne sub-networks. More information on the aeronautical telecommunication network (ATN), including mobile sub-networks are contained in *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN)* (Doc 9705) and *Comprehensive Aeronautical Telecommunication Network (ATN) Manual* (Doc 9739).

Iridium AMS(R)S will comprise safety and non-safety communications. Safety communications refer to communications for Air Traffic Services (ATS) and Aeronautical Operational Control (AOC) to the flight deck. Non-safety communications to the cabin crew and passengers are known as Aeronautical Administrative Communications (AAC) and Aeronautical Public Correspondence (APC), respectively.

3.1 System overview

The major elements of an Iridium AMS(R)S system are the AES, Iridium space segment, GES or Gateway, and the network control stations. In addition, for data communication services, a ground-based server is required for connectivity between the Iridium satellite network and the aviation centric data communication network. The aviation network provides connectivity to the end user, e.g., air traffic service units, airline operations, flight departments and aviation support application services, such as meteorological information.

Use of the Iridium network for air traffic services, particularly in remote areas where connectivity between the Iridium gateway and responsible air traffic service units is difficult to achieve, could be facilitated by the deployment of ground based Iridium units. This set-up can support voice service but is not recommended for data communication services.

3.1.1 Aircraft Earth Station (AES)

An AES includes all avionics on board an aircraft necessary for implementing satellite communications. This includes modulators and demodulators, RF power amplifier, transmitter and receiver, and the antenna. An Iridium AES includes the SDU, consisting of one, or multiple, Iridium LBTs, which serve as radio transceivers and provide the actual modem and signal processing functions, Iridium satellite sub-network protocol management including circuit-switched voice/data management, and data and voice interfaces with other aircraft systems.

3.1.2 Space segment

Information on the Iridium satellite constellation is given in section 5.

3.1.3 Ground Earth Station (GES)

The GES, also referred to as a Gateway, provides appropriate interface between the space segment and the fixed voice and data networks, public switched telephone, and private networks (e.g ARINC, SITA).

4 IRIDIUM AMS(R)S STANDARDIZATION ACTIVITIES

4.1 Iridium Air Interface Specifications

The Iridium Air Interface Specifications define technical aspects of the Iridium aeronautical system (including the functional requirements of ground and aircraft earth stations). This document was developed and is maintained by Iridium LLC. In addition to these Iridium-developed specifications and the definition of SARPs by ICAO (*refer to section 1.3*), the paragraphs below describe standardization activities being undertaken by other bodies.

4.2 AEEC and ARINC Standards

The Airline Electronic Engineering Committee (AEEC), an international body of airline industry representatives, leads the development of technical standards for airborne electronic equipment including avionics. These standards are published through ARINC and located on the ARINC web site (www.arinc.com). Signal characteristics and procedures are defined in detail in ARINC Characteristic 761, *Second Generation Aviation Satellite Communications System, Aircraft Installation Provisions,* Part I (form, installation and wiring) and Part II (operational capability of the equipment and interchangeability). Additional relevant ARINC Specifications and Characteristics 429 (*Digital Information Transfer System (DITS*), 618 (*Air/Ground Character-Oriented Protocol Specifications)*, 619 (*ACARS Protocols for Avionic End Systems*), 620 (*Datalink Ground Systems Standard and Interface Specification (DGSS/IS*), 622 (*ATS Datalink Applications Over ACARS Air-Ground Network) and 637 (ATN Implementation Provisions, Part I, Protocols and Services*) will be reviewed and revised as needed.

4.3 Avionics and certification

Iridium has developed an LBT for use by avionics manufacturers. Iridium has established processes to control design and manufacturing, test procedures for all transceiver design and manufacturing elements, and change control processes for software development and releases. All LBTs undergo Iridium-specified standardized factory test procedures before being released for shipment. All LBT software revisions are tested prior to release.

The LBTs are provided to Iridium-approved avionics manufacturers who design their avionics units, SDUs, to contain the LBT(s) and provide the aircraft system interfaces. Avionics manufacturers are responsible for adherence to all applicable civil aviation regulatory agency requirements. Avionics manufacturers are responsible for all parts manufacturing authority and aircraft installation certification, which includes airworthiness and environmental testing. All new Iridium aviation products are tested per Iridium and manufacturer test procedures within the

Iridium Technical Support Center (TSC) prior to acceptance by Iridium for use with the Iridium system.

RTCA has developed DO-262 "Minimum Operational Performance Standards (MOPS) for Next Generation Satellite Systems". Compliance of aircraft earth stations, which include the SDU and antenna, with this standard should insure that the system can be installed and properly operated on board aircraft. In addition, ITU Recommendation, ITU-R M.1343 "Essential Technical Requirements of Mobile Earth Stations for Global Non-Geostationary Mobile-Satellite Service Systems in the bands 1-3 GHz," is applicable to this aircraft system.

RTCA also has developed DO-270 "Minimum Aviation System Performance Standards (MASPS) for AMS(R)S as used in Aeronautical Data Links."

4.4 Satellite system access approval

Iridium subscribers may be distinguished by several identifiers. Each user is assigned an international mobile network subscriber identifier (IMSI) which is a permanent number stored on the user's SIM card. To maintain subscriber confidentiality, the IMSI is only transmitted over the air when a valid Temporary Mobile Subscriber Identifier (TMSI) is unavailable. A TMSI is a temporary identifier assigned to a mobile subscriber and stored on the user's SIM card and at the gateway. The TMSI is periodically changed based on system parameters and is used to identify the user over the air. The Mobile Subscriber Integrated Services Digital Network Number (MSISDN) is the Iridium subscriber's phone number. Subscriber telephone numbers are assigned to the service provider who controls and allocates telephone numbers based upon business rules. The International Mobile Equipment Identifier (IMEI) is a permanent identifier assigned to each SDU, not to the Iridium subscriber (SIM card).

All new avionics are required to successfully complete ISLLC testing to insure the avionics properly interoperate within the Iridium network. In addition, all avionics providing ACARS service are required to successfully complete testing with their associate satellite communications SPs to insure the avionics interoperates properly with the ground based server and the SP's ACARS network. Avionics failing to successfully complete the ISLLC and ACARS qualification testing are not allowed access to the Iridium network until the avionics are re-designed and re-tested to insure compliance. Access to the Iridium network and to safety services is granted via controlled Iridium safety services subscriber SIM cards and look-up tables.

4.4.1 Airworthiness certification

All avionics are subject to the airworthiness regulations that apply to the aircraft in which the avionics are to be installed. Adherence to these civil aviation regulations for aircraft equipment and system installation(s) are provided by the avionics manufacturer and the installation entity providing the engineering and certification.

Several relevant documents should be consulted for the Iridium network and the LBT, with reference to the appendix of specifications.

4.4.2 Satellite communications service providers

Iridium has maintained an open position relative to exclusive offerings by a single satellite communications service provider, in compliance with ICAO policy which provides for competition among service providers. Iridium has maintained dialogue with a variety of service providers. Aviation safety services SPs must demonstrate the ability to properly support safety services, on an end-to-end basis and in a manner consistent with the published MASPS for AMS(R)S.

Iridium aviation satellite communications SPs shall provide the ground connectivity between the Iridium network and the aviation centric network, which connects with air traffic service providers, air transport operations and flight departments. In addition to connectivity to these networks, each SP approves certain avionics based on their documented communications protocol. These avionics may not be interchangeable amongst the SPs.

Aviation satellite communications SPs shall provide, at a minimum:

- Technical support
- Customer Care
- Product Support

5 COMPARISON OF AMS(R)S SARPS AND PROJECTED IRIDIUM PERFORMANCE

This section contains information provided by Iridium Satellite LLC regarding the Iridium satellite network's conformity with the AMS(R)S SARPs, specific to the subnetwork. Table 5-1 tabulates the AMS(R)S SARPs requirements and the associated Iridium-specific performance parameters.

Further validation activities have been undertaken by Iridium and provide supplementary information to Section 5 of this Manual. Actual ICAO verification of the Iridium AMS(R)S system's compliance with the AMS(R)S SARPs is beyond the scope of this Manual.

Compliance with RTCA DO-262 and DO-270 is one means of assuring that Iridium AMS(R)S will perform its intended functions satisfactorily under all aircraft conditions. Any regulatory application of RTCA DO-262 and DO-270 is the sole responsibility of appropriate national authorities.

5.1 General

The AMS(R)S SARPs require that an AMS(R)S system shall support packet data service, or voice service, or both. Iridium currently provides both voice and data services in the aviation sector. Iridium data is format neutral and can support both character and bit-oriented data traffic. Voice service is in use today on fixed and rotary wing aircraft.

5.2 RF Characteristics

5.2.1 Frequency Bands

Iridium subscriber links operate in the 1616-1626.5 MHz band, which is allocated to the Mobile Satellite Service (MSS) in the Earth-to-space direction on a primary basis and in the space-to-Earth direction on a secondary basis.

This band is also allocated on a primary basis to the AMS(R)S both in the Earth-to-space and the space-to-Earth directions, subject to agreement obtained under No. 9.21 (ITU Radio Regulations No. 5.367).

The spectrum used for the Iridium satellite service is regulated according to Nos. 5.359, 5.364, 5.365, 5.366, and 5.367 of the Radio Regulations. No. 5.364 specifies sharing conditions and coordination requirements for MSS (Iridium) earth stations in the Earth-to-space direction. No. 5.365 requires coordination for the space-to-Earth transmissions. The required coordinations have been carried out and the Iridium System service link spectrum was Notified to the ITU-BR in 1998. An indication of this may be found in the ITU-BR International Frequency List (IFL), and thereby the frequency assignments in the Notification are entitled to protection.

The system was brought into use in the mid 1990's. Coordination under No. 5.366 and 5.367 regarding use of satellite facilities on airplanes and use of the AMS(R)S on a primary allocation basis, respectively, have been carried out under the provisions of these regulations (No. 9.21).

Finally, coordination with Fixed services in the countries indicated in 5.359 has also been carried out. This regulation encourages the indicated countries to not authorize additional fixed stations in the band. [*AMS(R)S SARPs, 4.3.1*]

The Iridium Satellite Network also uses inter-satellite service links in the 23.18-23.38 GHz band. The Iridium feeder link utilizes a 19.4-19.6 GHz downlink band and a 29.1-29.3 GHz uplink band for communications between the Iridium Satellite and the Iridium Gateway/TTAC. Given the critical functions of these high capacity links, they were designed to provide high reliability and integrity

5.2.2 Emissions

The AMS(R)S SARPs require that the total emissions of the AES necessary to meet designed system performance shall be controlled to avoid harmful interference to other systems necessary to support safety and regularity of air navigation that are installed on the same or other aircraft.

The Iridium AMS(R)S AES are designed to meet the emission requirements of RTCA DO-262. This, together with a predefined AMS(R)S antenna-to-GNSS antenna isolation, should ensure that AMS(R)S equipment can be operated simultaneously and independently from other communication and navigation equipment installed on the same or other aircraft. [*AMS(R)S SARPs, 4.3.2*]

Over 5,000 aircraft are in service with installed Iridium systems. Prior to certification of aircraft installations, ground and flight tests are conducted to ensure safety of flight and to validate that the system maintains electromagnetic compatibility with other systems on board the aircraft.

The Iridium SDU is designed to meet the emission limits set out in ITU-R Recommendation M.1343, "Essential technical requirements of mobile earth stations for global non-geostationary mobile-satellite service systems in the bands 1-3 GHz", as well as national/regional type-approval specifications such as FCC Part 2 and Part 25 and ETSI EN301 441 specifications. U.S. Federal Communications Commission (FCC) and the European Telecommunications Standards Institute (ETSI) measurements of a standard Iridium SDU have shown that the Iridium SDU meets the specified emission limits.

Iridium AES equipment emissions are compliant with existing protection requirements for all existing onboard radio transceivers. Protection criteria requirements are currently driven by output from RTCA. Iridium continues to track these requirements as new aviation communications, navigation and surveillance (CNS) equipment becomes available.

5.2.3 Susceptibility

The Iridium AMS(R)S AES equipment shall operate properly in an interference environment causing a cumulative relative change in its receiver noise temperature ($\Delta T/T$) of 25 per cent. [*AMS(R)S SARPs, 4.3.3*]

A 25% increase in receiver noise temperature is equivalent to a 1.0 dB link margin degradation. This additional degradation due to interference is accounted for in the Iridium link budget. Service links are designed to provide a 15 dB margin.

5.3 Priority and Preemptive Access

The basis for Iridium AMS(R)S Priority, Precedence, and Pre-emption (PPP) is the set of mechanisms designed for, and already implemented in, the Iridium Satellite Network for signaling and system management purposes. The Iridium Satellite Network utilizes two resource management functions, Acquisition Class control and Priority Class control, to assure access to communication channels for priority users. [*AMS(R)S SARPs, 4.4*]

The acquisition process is one of several protocols completed between an SDU and the satellite constellation for each call set up regardless if the call is mobile originated (from aircraft) or mobile terminated (to aircraft). For a mobile originated call, the SDU will start the acquisition process once the call is placed. For mobile terminated call, the SDU will start the acquisition process upon the reception of a RING, indicating an incoming call from the GES.

Each satellite beam broadcasts which Acquisition Classes are allowed to acquire satellite resources on that beam. Only SDUs with the proper Acquisition Class (AC) are allowed to start the acquisition process. Acquisition Class ranges from 0-15. Default non-safety Iridium terminals use an Acquisition Class in the range of 0-9. AMS(R)S safety traffic will be assigned Acquisition Class 14.

Acquisition Class is mainly used for satellite load shedding. In a satellite beam with heavy traffic load, certain Acquisition Classes (e.g., AC 0-9) will be shut down to prohibit further traffic load on the satellite. To ensure AMS(R)S safety traffic will get through, Iridium will not shut down AC-14 for satellite load shedding.

The Acquisition Class affects how calls initially gain access to the satellite constellation while Priority Class provides continued access for safety-related calls.

The Iridium Satellite Network allows for four levels of priority. Each satellite has priority queuing for both channel assignment of new calls and handoff order of in-progress calls. High priority calls take precedence and are queued before low priority calls.

The four Iridium priority levels are mapped to the four-level AMS(R)S priority structure as specified by Table 2-7 of RTCA DO-262.

Iridium Priority 3 (AMS(R)S #4, Distress, Urgency, highest priority);
Iridium Priority 2 (AMS(R)S #3, Direction finding, Flight Safety);
Iridium Priority 1 (AMS(R)S #2, Other Safety and Regularity of Flight);
Iridium Priority 0 (AMS(R)S #1, AMSS Non-Safety, lowest priority).

In case of extreme system resource shortage, on-going low priority calls will be pre-empted by the system to allow access for higher priority call.

While the Iridium Acquisition Class Control and Priority Class Control provide internal system controls for internal PPP management, the Iridium AMS(R)S AES manufacturers and satellite communications service providers will need to provide the input/output queuing for call/message priority function at the Iridium network interfaces. These capabilities are intrinsic to the protocol machines that interface Iridium AMS(R)S with its external users and reside in the AMS(R)S AES and GES.

Currently both the Acquisition Class and Priority Class are encoded on a SIM card; hence the Acquisition Class and Priority Class are associated with a SIM card and an SDU that uses that SIM card. For AMS(R)S, the acquisition class and priority class will need to be associated with each AMS(R)S call (type) and will be controlled by the protocol software that sets up the call.

Iridium AMS(R)S AES and GES will support Priority, Precedence and Pre-emption to ensure that messages transmitted in accordance with Annex 10, Volume II, 5.1.8, including their order of priority, are not delayed by the transmission and/or reception of other types of messages. [*AMS(R)S SARPs, 4.4.1*]

All AMS(R)S data packets and all AMS(R)S voice calls will be identified as to their associated priority. [*AMS(R)S SARPs, 4.4.2*]

Within the same message category, the Iridium AMS(R)S service will provide voice communications priority over data communications. [*AMS(R)S SARPs, 4.4.3*]

5.4 Signal Acquisition and Tracking

The AMS(R)S SARPs require that Iridium AES, GES and satellites properly acquire and track service link signals when the aircraft is moving at a ground speed of up to 1500 km/h along any heading [*AMS(R)S SARPs, 4.5.1*] and when the component of the aircraft acceleration vector in the plane of the satellite orbit is up to 0.6 g. [*AMS(R)S SARPs, 4.5.2*]

The Iridium Satellite Network consists of fast moving LEO satellites and is designed to handle large Doppler frequency shift and Doppler rate of change. Signal acquisition and tracking functions are handled internally within the Iridium Satellite Network by the SDU and the satellites and are transparent to Iridium users.

Link synchronization is achieved by pre-correcting the SDU transmit timing and frequency so that uplink bursts arrive at the satellite in the correct time slot and on the correct frequency access for the assigned channel. This pre-correction is accomplished by adjusting the SDU timing and frequency in accordance with error feedback which is sent in the downlink maintenance messages by the satellite. The SDU will compensate for a maximum uplink carrier frequency Doppler shift of up to +/-37.5 KHz to achieve the specified uplink frequency of arrival requirements. The SDU receiver will accommodate a carrier frequency Doppler shift of up to +/-37.5 KHz.

Since the Iridium Satellite Network became operational, the Iridium SDUs have been demonstrated to maintain link connectivity in numerous test flights onboard jets and research rockets. A recent test involving the NASA Sounding Rocket was conducted in April 2004. An Iridium flight modem, consisting of an Iridium SDU and other electronics, sent data successfully and continuously from lift-off through 2 rocket stage burns, reaching a peak velocity of up to 1.5 km/sec (5400 km/h) and only cut out when the rocket tumbled at apogee (120 km). The flight modem reacquired after the first parachute deployed and data was sent until the rocket hit the ground with a reported force of 50 g's. The Iridium link was maintained on impact and the flight modem continued to transmit for another 25 minutes. This and other demonstrations show that Iridium communication links are robust for high speed flights with large Doppler offset and Doppler rate of change.

5.5 Performance Requirements

5.5.1 Designated Operational Coverage

Iridium Satellite Network provides mobile communication with operational pole to pole coverage of the entire Earth. [*AMS(R)S SARPs, 4.6.1.1*]

5.5.2 Failure Notification

The AMS(R)S SARPs require that in the event of a service failure, the Iridium AMS(R)S system shall provide timely predictions of the time, location and duration of any resultant outages until full service is restored. [*AMS(R)S SARPs, 4.6.2.1*] The system shall annunciate a loss of

communications capability within 30 seconds of the time when it detects such a loss. [*AMS(R)S SARPs, 4.6.2.2*]

As an operational network serving subscribers all over the globe, the Iridium Satellite Network is being permanently monitored by its Network Operation and Maintenance Contractor. There are methods and processes in place for network outage detection, prediction, reporting, warning, and remediation. The current processes ensure that the Iridium AMS(R)S system will annunciate a loss of communications capability within 30 seconds.

5.5.3 AES Requirements

The Iridium AMS(R)S AES should meet the relevant voice and data performance requirements of the AMS(R)S SARPs for aircraft in straight and level flight throughout the designated operational coverage of the Iridium satellite system. [*AMS(R)S SARPs, 4.6.3.1*]

The Iridium AMS(R)S AES should meet the relevant voice and data performance requirements of the AMS(R)S SARPs for aircraft attitudes of +20/-5 degrees of pitch and +/- 25 degrees of roll throughout the designated operational coverage of the Iridium satellite system [*AMS(R)S SARPs, 4.6.3.1.1*]

Further validation of the ability of AES equipment to meet sections 4.6.4 and 4.6.5 of the SARP's shall be demonstrated during acceptance testing.

There are four levels of acceptance testing required for the AES equipment

- Avionics Manufacturer system testing (lab, ground and flight test)
- Iridium Satellite testing
- Satellite Communications SP testing
- Aeronautical terrestrial network SP (e.g., ARINC and SITA) (Data only)

During the installation of the Iridium system aboard aircraft, it is usual practice to conduct both ground safety of flight testing and flight testing where the Iridium system is tested during higher than normal flight attitudes to insure the system functions properly while maintaining safety of flight.

5.5.4 Packet Data Service Performance

The AMS(R)S SARPs require that an AMS(R)S system providing a packet-data service shall be capable of operating as a constituent mobile sub-network of the ATN. The role of the ATN is to define an environment within which reliable end-to-end data transfer may take place, spanning the airborne, air/ground and ground-based data sub-networks while providing interoperability among those networks. The Iridium Satellite Network supports the transparent transfer of data between adjacent inter-network entities. This includes the transparent transfer of global ATN addresses and quality of service information, as well as user data. The AMS(R)S sub-network interface to an ATN router occurs within the ATN network layer, thus control information for the data link and physical layers is not passed from sub-network to sub-network. Hence, the sub-network may utilize non-ATN conforming protocols within these layers while maintaining ATN

protocol architecture conformance within the network layer. Whilst it is not strictly required to adopt a common standard sub-network interface protocol for all air/ground sub-networks, it greatly simplifies the implementation and validation of the inter-network process since only a single communication software package is required to service the interface with the different air/ground sub-networks. The ISO 8208 packet level protocol has been adopted as the standard for this interface. A sub-network interface protocol for an Iridium AMS(R)S has not yet been specified by ICAO. Thus, compliance of the Iridium Satellite Network with AMS(R)S SARPs requires the specification and development of an appropriate sub-network interface protocol. [*AMS(R)S SARPs 4.6.4.1.1*]

The Iridium RUDICS and SBD data services are advantageous for different AMS(R)S applications. RUDICS offers the shortest call establishment time among all standard Iridium circuit-switch data services. SBD, though also based on circuit switch channels, offers a data transport service which has a number of characteristics very similar to a packet data call. The following performance parameters are based on statistics accumulated over many years of Iridium Satellite Network operation.

The Iridium data service RUDICS is based on circuit-switch mode. A data circuit is established, and the channel stays up until the connection is torn down. The connection establishment time for a RUDICS call ranges from 10-14 seconds. Once the circuit is established, the channel provides a reliable transport service of 2.4 kbps, at a minimum, with a more typical throughput of around 2.6 kbps.

Since the Iridium SBD service utilizes only the Access phase of the normal Iridium call establishment, it does not traverse the full path of the Iridium Gateway to the switch and thus, has a shorter call establishment delay. A SBD call can send data immediately upon completion of the Acquisition process, which, on average, is about 1.5 sec. Therefore, the average call establishment time is about 1.5 sec for mobile-originated SBD and 3.6 sec for mobile-terminated SBD, assuming an average RING alert duration of 2.1 sec in a typical operating environment. Since SBD utilizes the signaling channel payload (with FEC protection) rather than the normal traffic channel payload, its average throughput is around 1.2. kbps, which is less than that of standard Iridium data services such as RUDICS.

Since the Iridium Satellite Network provides AMS(R)S packet data service it shall meet the delay and integrity requirements as stated below. [*AMS(R)S SARPs 4.6.4.1*]

5.5.4.1 Delay Parameters

Based on accumulated Iridium satellite network performance statistics, the connection establishment delay of a RUDICS based packet data call are expected to be less than 30 sec. and the connection establishment delay of an SBD based packet data call less than 9 sec. [*AMS(R)S SARPs, 4.6.4.1.2.1*]

With a sub-network service data unit (SNSDU) length of 128 octets, the Iridium satellite sub-network supports the following data transit delay values:

For RUDICS based packet data service, the expected data transit delay (average transfer delay) of a 128-byte payload will be around 128x8/2400 = 0.43 sec. For SBD based packet data service, the expected data transit delay of a 128-byte message will be around 128x8/1200 = 0.86 sec. Hence, the data transit delay of the highest priority packet should be less than 5 sec. regardless of whether it is from AES or GES. [*AMS(R)S SARPs, 4.6.4.1.2.3, 4.6.4.1.2.4*]

Based on earlier discussion and the average data transfer delay value, the 95th percentile transfer delay should be less than 15 seconds for the highest priority data service whether to or from aircraft. [*AMS(R)S SARPs, 4.6.4.1.2.5, 4.6.4.1.2.6*]

Based on operational experience and performance statistics, most calls are released within 2 sec. Hence, connection release delay for all calls should be less than 5 sec. [*AMS(R)S SARPs, 4.6.4.1.2.7*]

5.5.4.2 Integrity

The AMS(R)S SARPs specify packet data service integrity by residual error rate. It further defines residual error rate as the combination of the probabilities of undetected error, undetected loss of an SNSDU, and an undetected duplicate SNSDU.

Regarding probabilities of undetected loss and undetected duplicate, both the Iridium circuit switch data transport and the Iridium SBD protocol employ message sequence number and automatic repeat request (ARQ) retransmission at the Iridium protocol data unit (PDU) level. For SBD, a message sequence number (MSN) is also applied at the SNSDU level. These mechanisms will ensure that the required probabilities for undetected loss and undetected duplicate of an SNSDU can be met.

Probability of undetected error is the packet error rate.

RUDICS employs a 24-bit frame check sequence, and the user payload field in an Iridium PDU is 248 bits. To transport a 128-byte data packet, it would take 5 Iridium PDUs. Analysis indicates the probability of a 128-byte data packet transmitting in error is about $3x10^{-7}$. The packet error rate can be further reduced if an additional protocol layer with additional error detection capability is employed. It is assumed that a packet error rate of $3x10^{-7}$ can be achieved with no further enhancement by other protocol layers.

The SBD service uses the Iridium signaling channel for data transport and is a guaranteed delivery service with multiple layers of error protection. It employs forward error control in the form of BCH[3] coding in addition to selective ARQ. By design, the SBD data transport has a better packet error rate performance than circuit switch data transport.

It is expected that Iridium AMS(R)S packet data can provide a residual error rate no greater than 10^{-6} per SNSDU, whether to or from aircraft. [*AMS(R)S SARPs, 4.6.4.1.3.1, 4.6.4.1.3.2*]

For the Iridium AMS(R)S, a probability of a sub-network connection (SNC) provider-invoked release is expected to be less than 10^{-4} over any one-hour interval [*AMS(R)S SARPs, 4.6.4.1.3.3*];

[3] Bose, Ray-Chaudhuri, Hocquenghem (a type of error control code)

a probability of an SNC provider-invoked reset is expected to be less than 10^{-1} over any one-hour interval. [*AMS(R)S SARPs, 4.6.4.1.3.4*]

5.5.5 Voice Service Performance

The AMS(R)S SARPs require that Iridium AMS(R)S voice service shall meet the requirements outlined in the following subsections. Note that ICAO is currently considering these provisions in light of the introduction of new technologies. [*AMS(R)S SARPs, 4.6.5.1*]

5.5.5.1 Call Processing Delay

Based on Iridium satellite network operational experience and performance statistics, most mobile-originated and mobile-terminated voice calls take 12 sec and 14 sec to set up, respectively.

For Iridium AMS(R)S, the 95th percentile of time delay for a GES to present a call origination event to the terrestrial network inter-working interface after a call origination event has arrived at the AES interface is not expected to be greater than 20 seconds. [*AMS(R)S SARPs, 4.6.5.1.1.1*]

For Iridium AMS(R)S, the 95th percentile of time delay for an AES to present a call origination event at its aircraft interface after a call origination event has arrived at the terrestrial network inter-working interface is not expected to be greater than 20 seconds. [*AMS(R)S SARPs, 4.6.5.1.1.2*]

5.5.5.2 Voice Quality

The Iridium SDU incorporates a 2.4 kbps Advanced Multi-Band Excitation (AMBE) vocoder developed by Digital Voice System Inc. (DVSI). This vocoder is tailored to the Iridium communication channel and provides good quality audio performance with a nominal Mean Opinion Score (MOS) of 3.5 under typical non-aeronautical operating and channel conditions.

Iridium terminals have been installed and successfully operated on various types of aircrafts including helicopters. Additional qualitative testing will be completed to measure and validate Iridium AMS(R)S voice quality [*AMS(R)S SARPs, 4.6.5.1.2.1*]

An Iridium voice call delay analysis estimated a total one-way voice transfer delay over the Iridium satellite network of about 374 msec. That delay value compares well with measurements undertaken by Iridium LLC. Additional data regarding Iridium voice call delay will be gathered and documented as part of Iridium AMS(R)S verification efforts.

For the Iridium AMS(R)S voice service, a total voice call transfer delay within the AMS(R)S sub-network is expected to be no greater than 0.375 second. [*AMS(R)S SARPs, 4.6.5.1.2.2*]

5.5.5.3 Voice Capacity

Iridium AMS(R)S will have sufficient available voice traffic channel resources such that an AES- or GES-originated AMS(R)S voice call presented to the system shall experience a probability of blockage of no more than 10^{-2}. [*AMS(R)S SARPs, 4.6.5.1.3.1*]

Based on the Communications Operating Concept and Requirements (COCR Study) for the Future Radio System, version 1.0, commissioned by the FAA and EuroControl, it is expected

that Iridium AMS(R)S will have sufficient available voice traffic channel resources for oceanic and remote operations for both Phase 1 and 2 (projected out past the year 2025) such that an AES- or GES-originated AMS(R)S voice call presented to the system shall experience a probability of blockage of no more than 10^{-2}.

5.5.6 Security

The Iridium Satellite Network, being an operational satellite service, employs various security measures against external attack and tampering.

Iridium Channel Security

The complexity of the Iridium network air interfaces makes message interception or tampering very difficult.

To successfully monitor an L-band channel, an eavesdropper must be located within the transmit range of the SDU being monitored, approximately 10 to 30 km from the transmitting SDU in a ground use scenario and approximately 250 to 350 km from an AES in flight. SDU downlink L-Band transmissions could be received over a much wider area. A single satellite beam covers an area of about 400 km in diameter.

Air Interface

The complexity of the Iridium air interface would make the development of an Iridium L-Band monitoring device very challenging. Among the complications are:

- Iridium's air interface is proprietary
- Large, continually changing Doppler shifts
- Frequent inter-beam and inter-satellite handoffs
- Time-division multiplexed burst mode channels
- Complicated modulation, interleaving and coding

Feederlink Interface

A sophisticated monitoring device would be needed in the general proximity of an Iridium gateway to receive the feederlink channel. The complexity of the feederlink interface poses a formidable technical challenge for prospective eavesdroppers. Among the technical complications are:

- Large, continually changing Doppler shifts
- High capacity, ~3 Mbps channels
- High-gain tracking antenna required
- Must reacquire new satellite every 10 minutes

Fraud Protection

Fraud Protection is provided during the Access process. During this process, the gateway determines if the requesting SDU is providing its own geographical location. If true, the system requests a check of the geographical location provided by the requesting SDU with the Beam ID the SDU is using. If the beam coverage location associated with the Beam ID does not match

with the SDU-provided location, the system sets a fraud flag. The system then sends the SDU the "Access Decision Notification" message with the indicator set to "access denied" and service is denied, with the exception of emergency calls.

The Iridium authentication process is adapted without change directly from GSM specifications.

Note: There is nothing to prevent encryption at the field application level.

It is expected that the Iridium system will provide protection against external attacks on service due to security measures in place at its gateways and facilities, as well as built-in protections in its air interface and authentication process. [*AMS(R)S SARPs, 4.6.6.2*]

Note: Additional security measures are provided through the aviation centric networks (e.g., ARINC and SITA) which are outside the scope of this report.

Physical Security
The Iridium Gateway(s), its Master Control Facility, and its Telemetry, Tracking And Control stations are all secured facilities providing protection against unauthorized entry.

These security aspects of the Iridium Satellite Network provide the same level of protection against certain types of denial of service, such as intentional flooding of traffic, as currently implemented in the GSM.

It is expected that the Iridium satellite network will provide very high levels of protection at the physical and network levels. [*AMS(R)S SARPs, 4.6.6.3*]

In order to safeguard the Iridium Satellite network, command and control of access to the Iridium constellation is limited to the Iridium SNOC and the Iridium Technical Support Center (TSC), which access and load the constellation control software.

Secure access is provided at the SNOC and TSC including 7x24 guards (SNOC only) with multiple-door badge access restrictions and password-protected Mission LAN access; firewalled connections also are in place to protect against unauthorized access.

Outside of these sites, malicious corrupt software loading would require Iridium-specific TTAC and Mission LAN hardware and software, which are not readily available. This equipment and software are rare and would be extremely difficult to obtain and properly configure to access the constellation.

Additionally, the probability of unauthorized personnel being able to cause permanent damage to a satellite by uploading malicious software is mitigated due to the following factors:

1. Unauthorized personnel would need access to detailed information about software product upload directories, command and verification formats, etc., that are specified in detailed procedures and checklists. Without this information, malicious software would not be accepted by the satellite.

2. The satellite commanding requirements are so esoteric that extensive training and practice is required before an upload can be successfully performed.

3. The satellite itself has multiple computers, so that any malicious software would have to be loaded to multiple satellite computers successfully in order to do any permanent damage.

5.6 System Interfaces

AMS(R)S SARPs require that an AMS(R)S system providing packet-data service shall be capable of operating as a constituent mobile sub-network of the ATN. The Iridium Satellite Network supports the transparent transfer of data between adjacent inter-network entities. This includes the transparent transfer of global ATN addresses (e.g., 24-bit aircraft addresses) and quality of service information, as well as user data. A sub-network interface protocol for Iridium AMS(R)S has not yet been specified by ICAO. Thus, compliance of the Iridium Satellite Network with AMS(R)S SARPs requires the specification and development of an appropriate sub-network interface protocol.

Iridium will work with its AMS(R)S service providers and AES manufacturers to ensure that the Iridium AMS(R)S system will allow sub-network users to address AMS(R)S communications to specific aircraft by means of the ICAO 24-bit aircraft address [*AMS(R)S SARPs, 4.7.1*] and will provide an interface to the ATN as well as a connectivity notification (CN) function. [*AMS(R)S SARPs, 4.7.2.1, 4.7.2.2*]

Aircraft avionics shall be tested in accordance with satellite communications SP test plan for avionics prior to approval and certification as a qualified safety services system for packet data services.

Table 5-1 Iridium AMS(R)S System Parameters per ICAO AMS(R)S SARPs

AMS(R)S SARPs Reference	AMS(R)S SARP Contents	Iridium Subnetwork Value[4]	Additional Comments on Performance
4.2	General	N/A	Placeholder
4.2.1	AMS(R)S shall conform to ICAO Chapter 4	Yes	-
4.2.1.1	Support packet data, voice, or both	Yes; Both	By design.
4.2.2	Mandatory equipage	N/A for service provider	-
4.2.3	2 year's notice	N/A for service provider	-
4.2.4	Recommendation consider worldwide implementation	N/A for service provider	-
4.3	RF Characteristics	N/A	Placeholder
4.3.1	Frequency Bands	N/A	Placeholder
4.3.1.1	Only in frequency bands allocated to AMS(R)S and protected by ITU RR	Yes; 1616-1626.5 MHz	-
4.3.2	Emissions	N/A	Placeholder
4.3.2.1	Limit emissions to control harmful interference on same aircraft	Yes	Analysis, unit testing, and aircraft installation testing Reference DO-294A
4.3.2.2	Shall not cause harmful interference to AMS(R)S on other aircraft	N/A	Placeholder
4.3.2.2.1	Emissions shall not cause harmful interference to an AES providing AMS(R)S on a different airplane	Yes	Analysis, unit testing, and aircraft installation testing Reference DO-262 and DO-294A
4.3.3	Susceptibility	N/A	Placeholder
4.3.3.1	Shall operate properly in cumulative $\Delta T/T$ of 25%	Yes	Analysis and LBT design
4.4	Priority and Pre-emptive Access	N/A	Placeholder
4.4.1	Priority and pre-emptive access	Yes	Avionics compliance with RTCA DO-262 and Iridium network support of PPP
4.4.2	All AMS(R)S packets and voice calls shall be identified by priority	Yes	Avionics compliance with RTCA DO-262 and Iridium network support of PPP
4.4.3	Within the same msg category, voice has priority over data	Yes	Avionics compliance with RTCA DO-262 and Iridium network support of PPP
4.5	Signal Acquisition and Tracking	N/A	Placeholder
4.5.1	Properly track signal for A/C at 800 kt. along any heading	Yes	Verified by operational experience.

[4] Iridium supplied values.

AMS(R)S SARPs Reference	AMS(R)S SARP Contents	Iridium Subnetwork Value[4]	Additional Comments on Performance
4.5.1.1	Recommendation for 1500 kts.	Yes	Verified by flight test.
4.5.2	Properly track with 0.6 g acceleration in plane of orbit	Yes	Verified by flight test.
4.5.2.1	Recommendation 1.2 g	Yes	Verified by flight test.
4.6	Performance Requirements	N/A	Placeholder
4.6.1	Designated Operational Coverage	N/A	Placeholder
4.6.1.1	Provide AMS(R)S throughout Designated Operational Coverage	Yes	Verified by operational experience.
4.6.2	Failure Notification	N/A	Placeholder
4.6.2.1	Provide timely predictions of service failure-induced outages	Yes	Currently provides
4.6.2.2	System failure annunciation within 30s	Yes	Verified by sub-system testing
4.6.3	AES Requirements		Placeholder
4.6.3.1	Meet performance in straight and level flight	Yes	Supports flight envelope throughout DOC. Compliance of 4.6.4 and 4.6.5 are provided in their respective sub-sections
4.6.3.1.1	Recommendation for +20/-5 pitch ant +/-25 roll	Yes	Supports flight envelope throughout DOC. Compliance of 4.6.4 and 4.6.5 are provided in their respective sub-sections
4.6.4	Pkt Data Svc Performance	N/A	Placeholder
4.6.4.1	Requirements on AMS(R)S packet data	Yes	See sub-sections.
4.6.4.1.1	Capable of mobile subnetwork in ATN	Yes	Sub-network supports character and bit oriented protocols in support end-to-end system
4.6.4.1.2	Delay Parameters	N/A	Placeholder
4.6.4.1.2.1	Connection establishment delay < 70 seconds	Yes < 30s RUDICS < 9s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network CDF 95%ile values charted in support of validation process
4.6.4.1.2.1.1	Recommendation Connection establishment delay < 50 seconds	Yes < 15s RUDICS < 9s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network CDF 95%ile values charted in support of validation process
4.6.4.1.2.2	Transit delay based on SNSDU of 128 octets and defined as average values	Yes <1s RUDICS <3s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network averaged values in support of validation process
4.6.4.1.2.3	From A/C highest priority < 40 seconds	Yes <1s RUDICS <3s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network averaged values in support of validation process
4.6.4.1.2.3.1	Recommendation from A/C highest priority < 23 seconds	Yes <1s RUDICS <3s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network averaged values in support of validation process
4.6.4.1.2.3.2	Recommendation from A/C lowest priority < 28 seconds	Yes <1s RUDICS <3s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network averaged values in support of validation process

AMS(R)S SARPs Reference	AMS(R)S SARP Contents	Iridium Subnetwork Value[4]	Additional Comments on Performance
4.6.4.1.2.4	To A/C high priority < 12 seconds	Yes <2s RUDICS <3s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network averaged values in support of validation process
4.6.4.1.2.4.1	Recommendation To A/C lowest priority < 28 seconds	Yes <2s RUDICS <3s SBD	Iridium subnetwork performance verified by Auto-dialer data. Sub-network averaged values in support of validation process
4.6.4.1.2.5	From A/C Data transfer delay 95%ile highest priority < 80 seconds	Yes <2s RUDICS <6s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.2.5.1	Recommendation From A/C Data transfer delay 95%ile highest priority < 40 seconds	Yes <2s RUDICS <6s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.2.5.2	Recommendation From A/C Data transfer delay 95%ile lowest priority < 60 seconds	Yes <2s RUDICS <6s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.2.6	To A/C Data transfer delay 95%ile high priority < 15 seconds	Yes <2s RUDICS <6s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.2.6.1	Recommendation To A/C Data transfer delay 95%ile low priority < 30 seconds	Yes <2s RUDICS <1s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.2.7	Connection release time 95%ile < 30 seconds	Yes <2s RUDICS <6s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.2.7.1	Recommendation connection release time 95%ile < 25 seconds	Yes <2s RUDICS <6s SBD	Iridium subnetwork performance verified by current performance data. Sub-network CDF 95%ile values charted using auto-dialer data collected in support of validation process
4.6.4.1.3	Integrity	N/A	Placeholder
4.6.4.1.3.1	Residual error rate from A/C < 10^{-4}/SNSDU	< 10^{-6}	Verified by current performance data. (M)
4.6.4.1.3.1.1	Recommend RER from A/C < 10^{-6}/SNSDU	< 10^{-6}	Verified by current performance data. (M)
4.6.4.1.3.2	RER to A/C < 10^{-6} /SNSDU	< 10^{-6}	Verified by current performance data.
4.6.4.1.3.3	Pr{SNC provider invoked release}< 10^{-4}/hr	SBD-N/A RUDICS< 10^{-4}/hr	SBD is connectionless protocol for FANS1/A datalink and does not apply
4.6.4.1.3.4	Pr{SNC provider invoked reset}< 10^{-1}/hr	NA	Not applicable to Iridium Network
4.6.5	Voice Service Performance	N/A	Placeholder
4.6.5.1	Requirements for AMS(R)S voice service	Yes	See sub-paragraphs for compliance
4.6.5.1.1	Call Delay Processing	N/A	Placeholder

AMS(R)S SARPs Reference	AMS(R)S SARP Contents	Iridium Subnetwork Value[4]	Additional Comments on Performance
4.6.5.1.1.1	AES call origination delay 95%ile < 20 seconds	≤16s	Iridium subnetwork performance verified by current performance data. CDF statistics provided for 95%ile value verification.
4.6.5.1.1.2	GES call origination delay 95%ile < 20 seconds	≤ 19s	Iridium subnetwork performance verified by current performance data. CDF statistics provided for 95%ile value verification.
4.6.5.1.2	Voice Quality	N/A	Placeholder
4.6.5.1.2.1	Voice intelligibility suitable for intended operational and ambient noise environment	Yes	To be verified by AES manufacturer.
4.6.5.1.2.2	Total allowable transfer delay within AMS(R)S subnetwork < 0.485 second	< 0.375s	Verified by current performance data.
4.6.5.1.2.3	Recommendation to consider effects of tandem vocoders	-	Recommendation to take into account effects of tandem vocoders and other analog/digital conversions must be taken on a "as encountered" basis. Testing and analysis cannot take into account all permutations
4.6.5.1.3	Voice Capacity	N/A	Placeholder
4.6.5.1.3.1	Sufficient voice traffic channel resources for Pr{blockage < 0.01} for AES or GES originated calls	< 0.01	Analysis provided for all regions based on FAA/EuroControl COCR study, Ver 1.0
4.6.6	Security	N/A	Placeholder
4.6.6.1	Protect messages from tampering	Yes	-
4.6.6.2	Protect against denial of service, degradation, or reduction of capacity due to external attacks	Yes	-
4.6.6.3	Protect against unauthorized entry	Yes	-
4.7	System Interfaces	N/A	Placeholder
4.7.1	Address AMS(R)S by means of 24 bit ICAO address	Yes	By design.
4.7.2	Pkt Data Svc Interfaces	N/A	Placeholder
4.7.2.1	If the system provides packet data service, it shall provide an interface to the ATN	Yes	By design.
4.7.2.2	If the system provides packet data service, it shall provide an CN function	Yes	By design.

6 IMPLEMENTATION GUIDANCE

6.1 Theory of Operation

The Iridium aviation satellite communications system can provide voice and data services for aviation safety services. In support of this service, a new type of avionics, an SDU, will be deployed and will interoperate with the Iridium global satellite communications system and existing aircraft voice and data communication systems. In addition, a ground-based server will be deployed by Iridium-approved satellite communications service provider(s) for data service. This server will provide connectivity with existing aviation data networks, such as ARINC and SITA, in support of AAC, AOC, and ATC data communications.

The three main components of the aviation safety service are as follows:

- Iridium network
- Iridium-based Avionics (SDU)
- Iridium ground-based Data Server

There is a fourth pre-existing component of the aviation safety service, the aviation data network. This network(s) has been in existence for a number of years, evolving to meet the changing needs of the aviation industry. This network will not be described in detail but may be referenced throughout this document. SITA or ARINC should be contacted directly for further details about the aviation network.

The end-to-end voice service is shown in Figure 6-1, Iridium Aviation Safety Services Air-to Ground Voice, End-to-End Model. This model also applies to ground-to-air voice service.

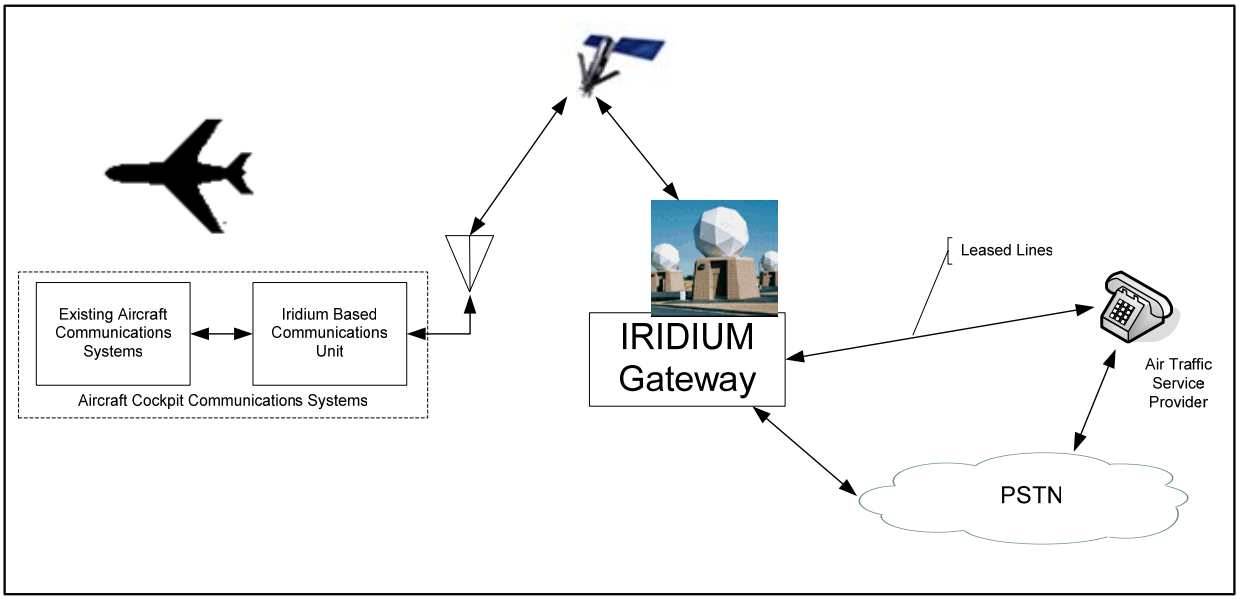


FIGURE 6-1

Iridium Aviation Safety Services Air-to-Ground Voice (End-to-End Model)

The end-to-end voice service is shown in Figure 6-2, Iridium Aviation Safety Services Air-to-Air Voice, End-to-End Model.

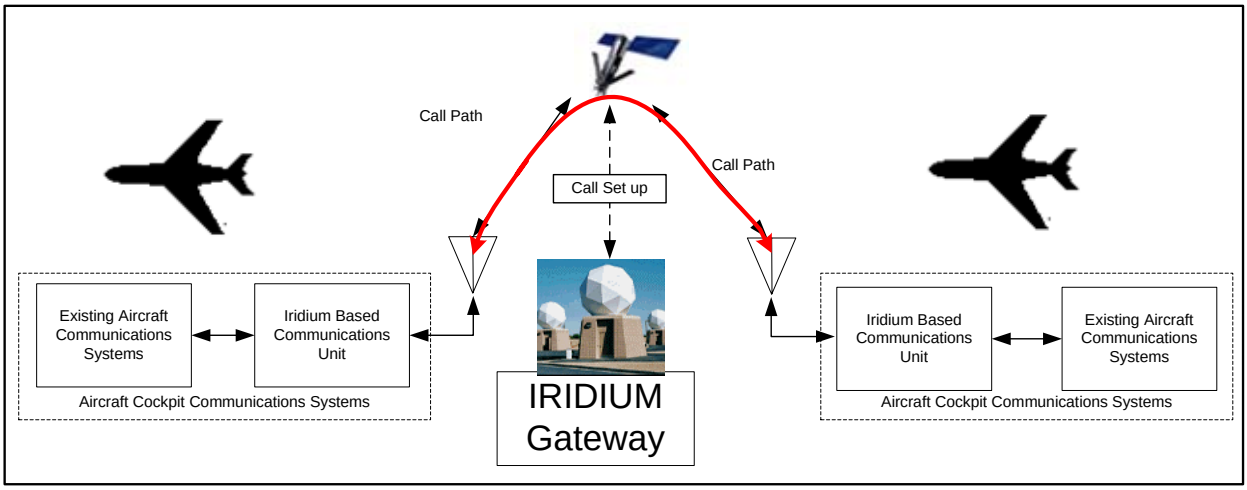


FIGURE 6-2
Iridium Aviation Safety Services Air-to-Air Voice
End-to-End Model

The end-to-end voice service is shown in Figure 6-3, Iridium Aviation Safety Services Air-to-Ground Data, End-to-End Model. This model also applies to ground-to-air data service.

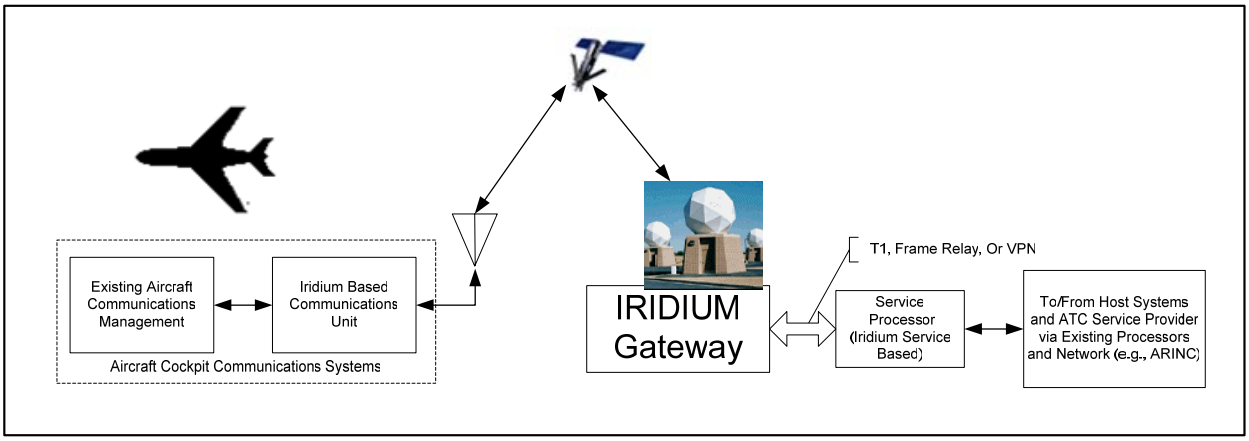


FIGURE 6-3
Iridium Aviation Safety Services Air-to-Ground Data
End-to-End Model

The end-to-end voice service is shown in Figure 6-4, Iridium Aviation Safety Services Air-to-Air Data, End-to-End Model.

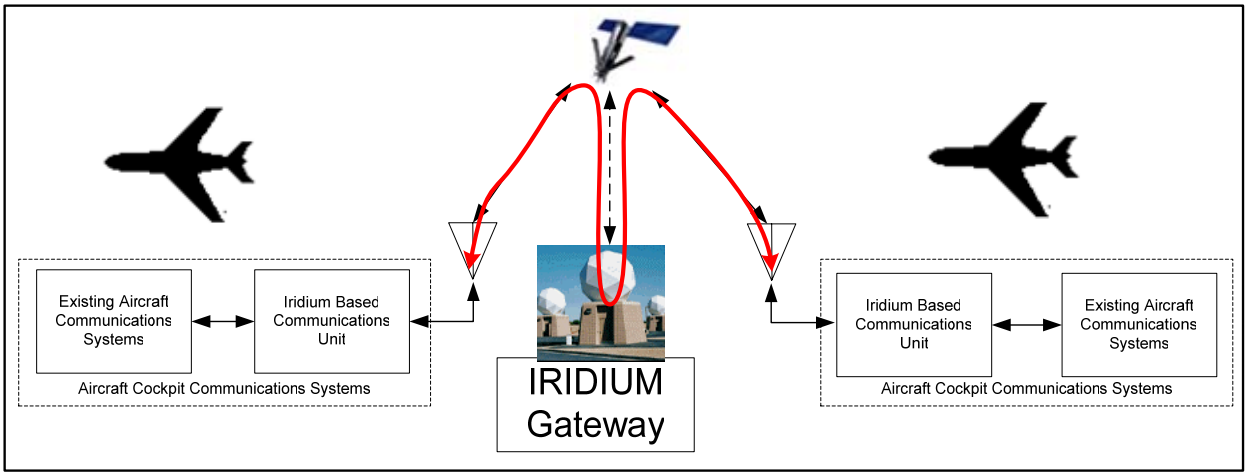


FIGURE 6-4
Iridium Aviation Safety Services Air-to-Air Data End-to-End Model

6.2 Iridium network

The Iridium network is a global satellite communications system. The system supports voice, data, fax, and messaging traffic to and from subscriber equipment across the world or to a PSTN through the Iridium gateway. The services supporting safety services are basic voice calling (telephony), short burst data, and RUDICS.

Basic Telephony – Allows an Iridium subscriber, when properly provisioned in the GSM switch and using a valid handset (or LBT) and SIM card, to place or receive calls.

Short Burst Data (SBD/ESS) Service – A packet bearer capability (non-GSM) that provides a non-circuit switched, high-capacity ACK'ed means of transmitting and receiving packets of data (up to 1960 bytes) to and from compatible SBD subscriber devices across the Iridium network to a specified IP address.

RUDICS – Allows custom devices in the field to connect to servers on the WWW by encapsulating the transmitted data in TCP/IP. It provides nothing more than a pipe through which to transmit customer data.

Section 2 of this Manual includes a description of the Iridium network.

6.3 Subscriber Segment (Avionics)

The avionics required to support the Iridium network consist of an SDU and antenna(s). The SDU consists of the Iridium LBT and the I/O processing to properly interface with the existing aircraft voice and/or data communications systems. Further details can be found in Section 6.8 of this Manual.

These aircraft systems include the cockpit audio control and recording systems, the aircraft communication and reporting system, ACARS (as applicable for data service), multi-purpose control and display units (e.g., CDU and MCDU), and a communication management system (e.g., MU and CMU).

Iridium has developed a derivative of the Iridium telephone handset, referred to as an L-band transceiver (LBT), for use by avionics manufacturers. Iridium has established processes to control design and manufacturing, test procedures for all transceiver (LBT) design and manufacturing elements, and change control processes for software development and releases. All LBT's go through these standardized factory test procedures before being released for shipment. All LBT software revisions are tested prior to release.

LBTs are provided to Iridium-approved avionics manufacturers who design their avionics units, or SDU's, to contain the LBT and provide the aircraft system interfaces. Avionics manufacturers are responsible for adherence to all applicable civil aviation regulatory agency requirements. Avionics manufacturers are responsible for all parts manufacturing authority and aircraft installation certification, which includes airworthiness and environmental testing.

RTCA has developed minimum operations performance standards, RTCA DO-262, for aircraft avionics systems supporting next generation satellite systems. Compliance of an aircraft earth station, which includes the SDU and antenna, with this standard should insure that the system can be installed and properly operated on board aircraft. In addition, ITU Recommendation ITU-R M.1343 "Essential Technical Requirements of Mobile Earth Stations for Global Non-Geostationary Mobile-Satellite Service Systems in the bands 1-3 GHz" is applicable to this aircraft system.

The SDU and the ground-based data server, provided by the aviation safety service SP, shall be harmonized to properly support data exchanges, via a published interface control document (ICD), developed jointly between the avionics manufacturer and the ground-based data server host/developer.

The SDU will be capable of recognizing prioritized call selection by the cockpit crew and issuing the appropriate commands to initiate priority calling.

In addition, the SDU shall obtain and transmit the aircraft's 24-bit ICAO address. A typical scenario for supporting the 24-bit ICAO address would be that the SDU would be externally wired (strapped) with the aircraft unique 24-bit address. Upon initiation, the SDU would transmit the aircraft information, which includes the ICAO address through the Iridium network to provide identification to the ATN.

6.3.1.1 Iridium Identifiers

Iridium subscribers may be distinguished by several identifiers. Each user is assigned an IMSI which is a permanent number stored on the user's SIM card. To maintain subscriber confidentiality, the IMSI is only transmitted over the air when a valid TMSI is unavailable. A TMSI is a temporary identifier assigned to a mobile subscriber and stored on the user's SIM card and at the gateway. The TMSI is periodically changed based on system parameters and is used to identify the user over the air. The MSISDN is the Iridium subscriber's phone number. The IMEI is a permanent identifier assigned to each SDU, not to the Iridium subscriber (SIM card).

6.4 Iridium Ground Based Data Server

The ground-based data server serves as the conduit and traffic controller for data communications between the aircraft SDU and the aviation centric networks (e.g., ARINC and SITA networks), and/or leased lines to air traffic service providers in support of AAC, AOC and ATC messaging. This messaging is currently supported by the ACARS data service with plans to evolve to support ATN. The Iridium SBD and RUDICS data services support both character and bit-oriented communications protocols used by ACARS, which currently utilizes character-oriented protocols with plans to migrate to bit-oriented protocols. ATN utilizes bit-oriented protocols which only can be supported by Iridium data services.

The server will support 24-bit ICAO addressing. The entire system shall provide for message delivery assurance protocols, via message delivery acknowledgement and re-transmissions.

6.5 Services Supported

The Iridium network carries voice and data traffic to and from Iridium subscriber-equipped aircraft across the world or to a public switched telephone network (or directly through leased lines). Only validated aircraft SDUs are allowed to use the system, except for emergency communications, in which all SDUs are allowed to place distress calls.

6.6 Voice Service

Every voice call must involve an ISU (resident inside the SDU), whether the call is Iridium subscriber (aircraft) to subscriber (aircraft), subscriber (aircraft) to PSTN number (ground-based user), or PSTN number (ground-based user) to subscriber (aircraft).

The Iridium SDU sets up a circuit-switched voice or data call by dialing a voice or data call number using the Iridium AT command: `ATDnx..x` where `n` is a Dial Modifier and `x` is a number.

One example of how to make and disconnect a voice call is given below:

- ATD1234567890; (dial remote phone)
- OK (call connected; phone stays in command mode)
- < ... conversation ... >
- ATH (hangup call)

- OK

One example of how to make a data call is given below:

- AT+CBST=6,0,1 (asynchronous modem 4800 bps and IRLP)
- OK
- AT+CR=1 (enable reporting)
- OK
- ATD1234567890 (dial remote modem)
- +CR: REL ASYNC
- CONNECT 9600 (call connected at DTE rate of 9600)

The Iridium SDU is capable of accepting mobile terminated data calls. The following is a sequence of commands that can be used to establish the connection:

- RING (indicates arrival of call request)
- ATA (manually answer the call)
- CONNECT 9600 (call connected at DTE rate of 9600)
- To automatically answer a call, register 0 should be set to a non-zero value.
- ATS0=2
- RING
- CONNECT 9600 (call connected at DTE rate of 9600)

The Iridium SDU AT Command Reference provides descriptions of all the Iridium AT commands for proper interfacing to the SDU.

Key elements of call handling, shown in Figure 6-5, are identical for all calls. These elements are:

1) Acquiring a traffic channel on a satellite (Acquisition) by the subscriber unit (such as the aircraft SDU)
2) Accessing the gateway (Access) is the process of obtaining the SDU's access to the Iridium network which can include:
    - Geolocation - Call processing location determination
    - Aircraft SDU Parameter Download
    - Registration/Location update
    - Authentication of SDU's SIM including TMSI assignment (Authentication)
3) Call Establishment is the processes of setting up a call which include:
    - Originating a call from an SDU (MOC) or PSTN via the gateway (MTC)
    - Terminating a call at an SDU (MTC) or PSTN number via the gateway (MOC)
4) Call Maintenance is the process of maintaining a connection which include Handoff, Reconfiguration (cut through/intercept/grounding).
5) Call Release

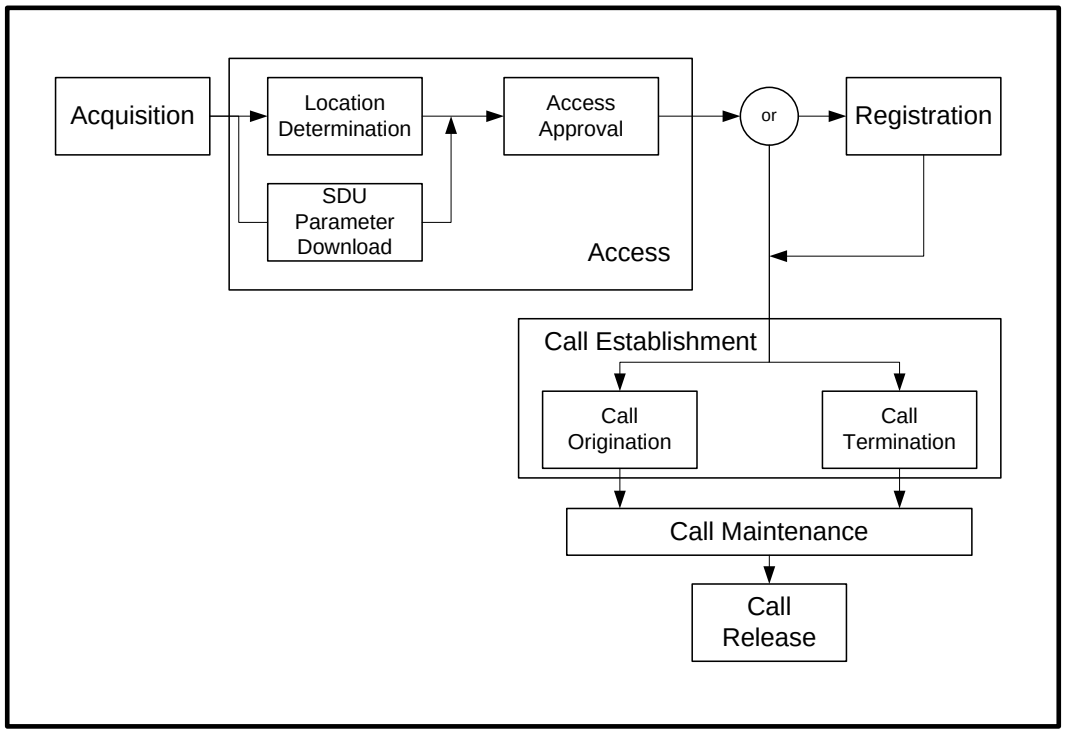


FIGURE 6-5

Call Handling Elements

6.6.1.1 Acquisition

Acquisition is the process of the SDU obtaining a bi-directional communications channel, called a Traffic Channel, between the SDU and a satellite. The process is initiated either by the SDU user taking action to request a service that requires a channel, or by the SDU via CDU, MCDU or cockpit handset ring tone responding to a Ring Alert that ultimately notifies the cockpit of an incoming call.

Acquisition is the first step in obtaining service from the Iridium network. It is the process of establishing a communication link between a satellite and SDU. Acquisition by an SDU is necessary for registration, call setup, answering call terminations, or to initiate any service on the Iridium network.

Under certain circumstances, it is necessary to prevent users from making Acquisition attempts. Such situations may arise during states of emergency or in the event of a beam overload. During such times, the Broadcast Channel specifies, according to populations, which Iridium subscribers may attempt Acquisition (based on acquisition class).

The subscriber equipment reads the Acquisition Class from the SIM card that was programmed when initially provisioned. The system provides the capability to control a user's acquisition to the system based on the following acquisition classes:

15. Iridium LLC Use
14. Aeronautical Safety Services
13. Reserved
12. Reserved
11. Fire, Police, Rescue Agencies
10. Emergency Calls
0-9. Regular Subscribers (Randomly allocated)

The use of acquisition classes allows the network operator to prevent overload of the acquisition or traffic channels. Any number of these classes may be barred from attempting Acquisition at any one time. If the subscriber is a member of at least one Acquisition Class that corresponds to a permitted class, the satcom data unit proceeds with Acquisition.

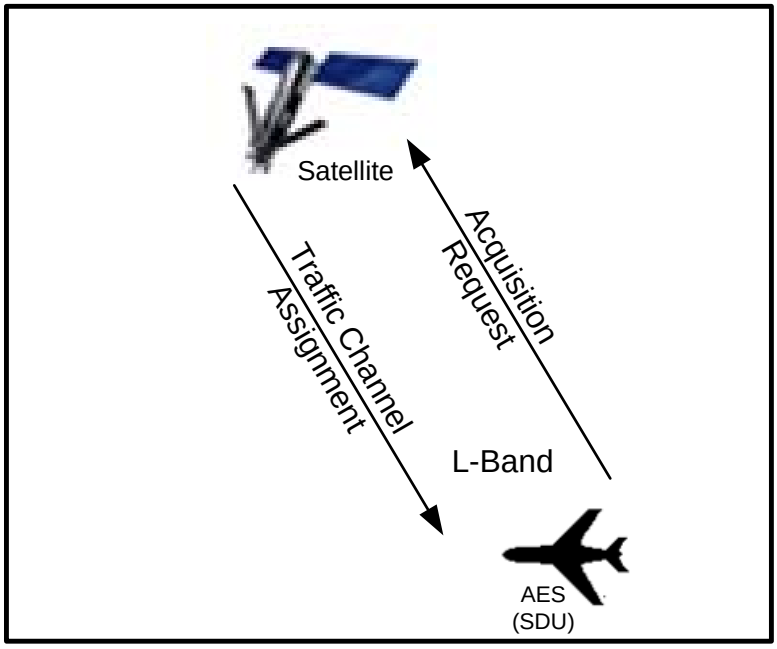


FIGURE 6-6
Acquisition

Acquisition consists of establishing a link between the SDU and the satellite and acquisition control, as shown in Figure 6-6, above.

6.6.1.2 Access

The Access process determines the SDU's location with respect to Service Control Areas defined in Earth Fixed Coordinates. Based on the Service Control Area within which the SDU is found

to be located and on the identity of the SDU's Service Provider, a decision is made regarding whether or not to allow service. The process, shown in Figure 6-7 below, is initiated immediately following Acquisition.

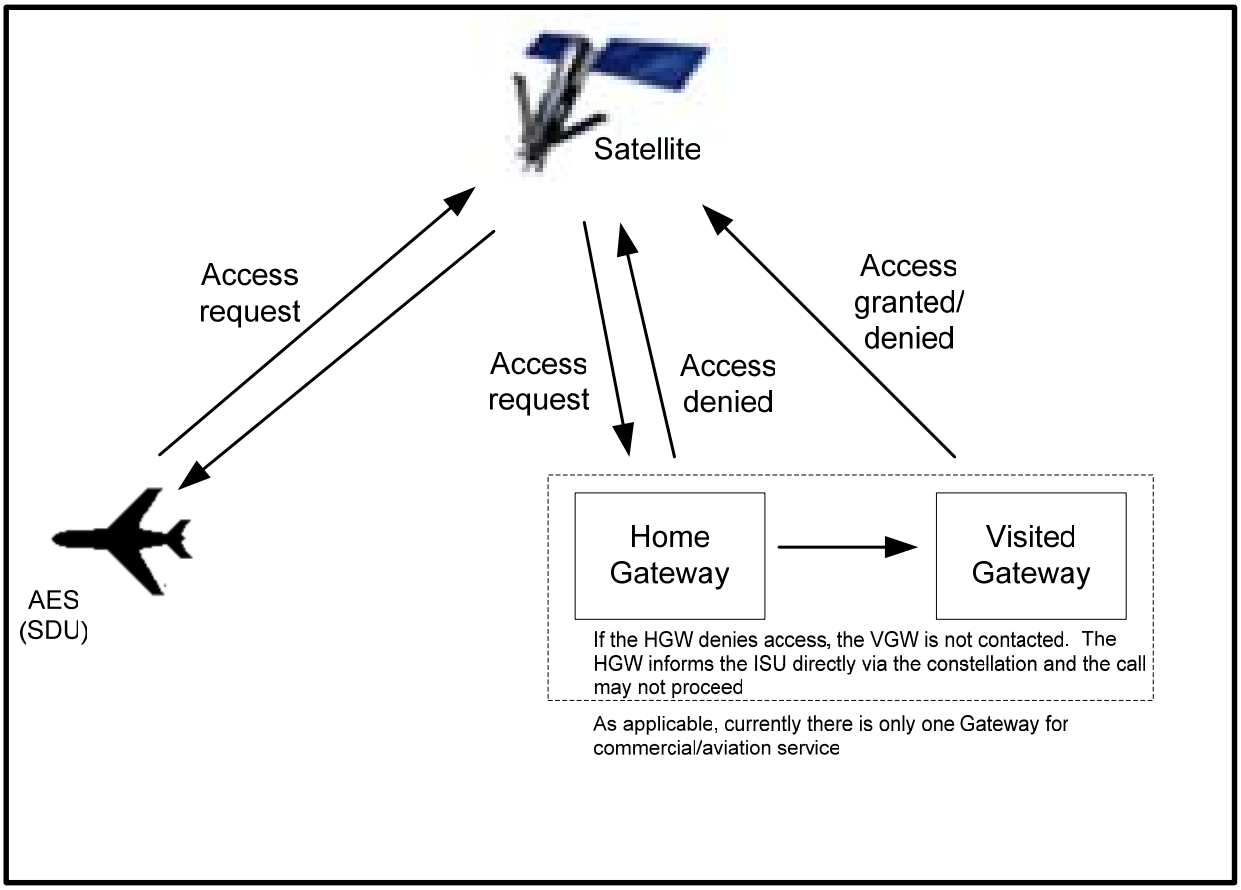


FIGURE 6-7
Access

Location information may be reported by the SDU based on an external source such as Global Positioning System (GPS) or the aircraft's navigation system, or it may be determined by the Geolocation function contained within the Access function. The Geolocation function uses Call Processing Location Determination (CPLD) to provide an estimate of the user's location. The system's accuracy in determining location depends upon the relative geometry of the aircraft and satellite constellation, accuracy of measurements made by the aircraft, accuracy of measurements made by the satellite, and algorithm calculations.

Iridium supports a method for a sovereign country to deny services to classes of subscribers roaming into its territory. Services will be denied if the Iridium network determines that the aircraft is in an unauthorized area.

After location is determined, the Access approval-denial process starts when the SDU sends the "Access Request" through the satellite and to the gateway. Based on the calculated geographic location of the user, the gateway checks the user's current Service Control Area (SCA) against the user's satellite communications service provider ID access information for that SCA. The gateway downloads the SDU configuration parameters to update any changes that may have been made, and the gateway determines the registration parameters as specified for the SDU's Location Area Code (LAC) to determine if the aircraft needs to re-register. If there are no access restrictions for the aircraft (SDU), an "Access Decision Notification" is sent and the gateway indicates to the SDU if Access has been denied or approved. If approved, the gateway provides satellite path information to the SDU.

If access is denied, one of the following denial cause values will be provided via the Access Decision Notification from the gateway:

- Unknown
- Restricted area
- Indeterminable area
- Subscriber parameter unknown
- Insufficient resources
- Protocol error
- Access guard timer expiration
- NIL LAC
- Access Denied
- None

6.6.1.3 Call Establishment

Subsequent to gaining access to a gateway, the SDU must register with the gateway, if it has not already done so. There are three reasons for a re-registration, which is determined by the gateway:

1) The aircraft has moved from one gateway to another
2) The aircraft has moved from one LAC to another
3) The aircraft has moved away from its old position by more than the re-registration distance as specified by the LAC. That is, the relocation distance calculated by the gateway is greater than the re-registration distance for the LAC.

Call control – If the aircraft originates the call, it will then send the dialed number to the visiting gateway (as applicable) and the gateway will process the dialed number. The gateway verifies the aircraft SDU's SIM card to authenticate that the business rules for the aircraft are valid. If

the SDU's SIM card is authorized to place the call, then the gateway will allocate the resources to support the call, such as the circuits, transcoders and trunks.

The gateway then alerts the SDU that the called party is ringing (provides a ring tone to the user's ear piece).

After a speech path has been created via the satellite, the visiting gateway is removed from the speech path, which is referred to as "cut-through". Cut-through is not done for data calls, supplemental and fax services. Cut-through reduces voice path time delay and conserves K-band resources.

When the called party answers the call, the gateway informs the SDU that the called party has answered the call and the ring tone is disabled.

6.6.1.4 Call Maintenance

Once the call has been established, the Iridium network nodes involved with the call enter a maintenance state. In this state, the network maintains the connection between the nodes. As the satellites orbit overhead, the network passes the traffic channel from satellite to satellite, a process referred to as "handoff".

The Iridium network satellites have highly directional antennas providing Iridium network access to aircraft SDUs. These antennas are configured to project multiple beams onto the surface of the earth. Handoff is the process of an aircraft (SDU) moving from its current Traffic Channel to a different Traffic Channel, usually because satellite motion has resulted in the current Traffic Channel no longer being suitable for continuing service. The handoff process is required in three situations:

1) An aircraft SDU must be handed off between satellites as they move relative to the aircraft (Inter-satellite).
2) An aircraft SDU must be handed off between beams on a satellite as beam patterns move relative to the aircraft (Intra-satellite).
3) As the inter-satellite geometry changes, radio channels are reallocated among the beams to manage interference. This process can cause an aircraft SDU to be handed off to a different channel in the same beam (Intra-beam).

6.6.1.5 Call Release

Call release occurs when one of the connected parties goes on-hook or the network detects a call-terminating fault. In either case, the originator of the release generates a release message which transverses through all nodes involved in the call. A release acknowledgement is sent back through the network, each node drops the call, and all resources being used for the call are released.

The gateway generates billing records of the call and stores this information within the gateway. Billing records are later sent to the appropriate billing centers.

6.6.2 Data Link

The Iridium network supports two types of data service for aviation safety service, short burst data (SBD) and router UDI connectivity service (RUDICS). Some LBTs fully support the use of both of these services, whereas other LBT models support SBD only. Use of either type of data exchanges shall be seamless to the end-user.

6.6.2.1 SBD

Iridium's Short Burst Data Service (SBD) is a simple and efficient satellite network transport capability to transmit short data messages between the aircraft data management unit (e.g., MU and CMU) and the ground-based data server. A mobile originated, or aircraft originated, SBD message can be between 1 and 1960 bytes (for example, there is a 340 bytes maximum for a 9601 LBT). A mobile terminated, or aircraft bound, SBD message can be between 1 and 1890 bytes (for example, there is a 270 bytes maximum for a 9601 LBT).

The interface between the Field Application and the ISU (both contained within the SDU) is a serial connection with extended proprietary AT commands.

For a Mobile Originated SBD Message (MO-SBD):

- The message is loaded into the MO buffer in the SDU using the +SBDWB or +SBDWT AT Commands
- A message transfer session between the SDU and the gateway is initiated using the AT Command +SBDI

For a Mobile Terminated SBD Message (MT-SBD):

- The SDU initiates a Mailbox Check using the AT Command +SBDI and when the message is received from the gateway
- To retrieve from the MT buffer in the SDU by the Field Application using the +SBDRB or +SBDRT AT Commands.

All safety services aircraft originated (MO) and aircraft terminated (MT) messages between the vendor application (Ground-based service processor) and the Iridium network gateway utilize a Virtual Private Network (VPN) and leased line routing of messages to provide additional security, capacity and/or redundancy. Additionally, Iridium subscriber (aircraft or ground-based subscriber) to Iridium subscriber (aircraft or ground-based subscriber) messages remain entirely within the Iridium network infrastructure, which provides a high level of security.

The primary elements of the end-to-end SBD architecture are shown in Figure 6-9, below. Specifically, the elements consist of the satellite data unit (SDU) Field Application (FA), the Iridium network, and the Vendor Application (VA).

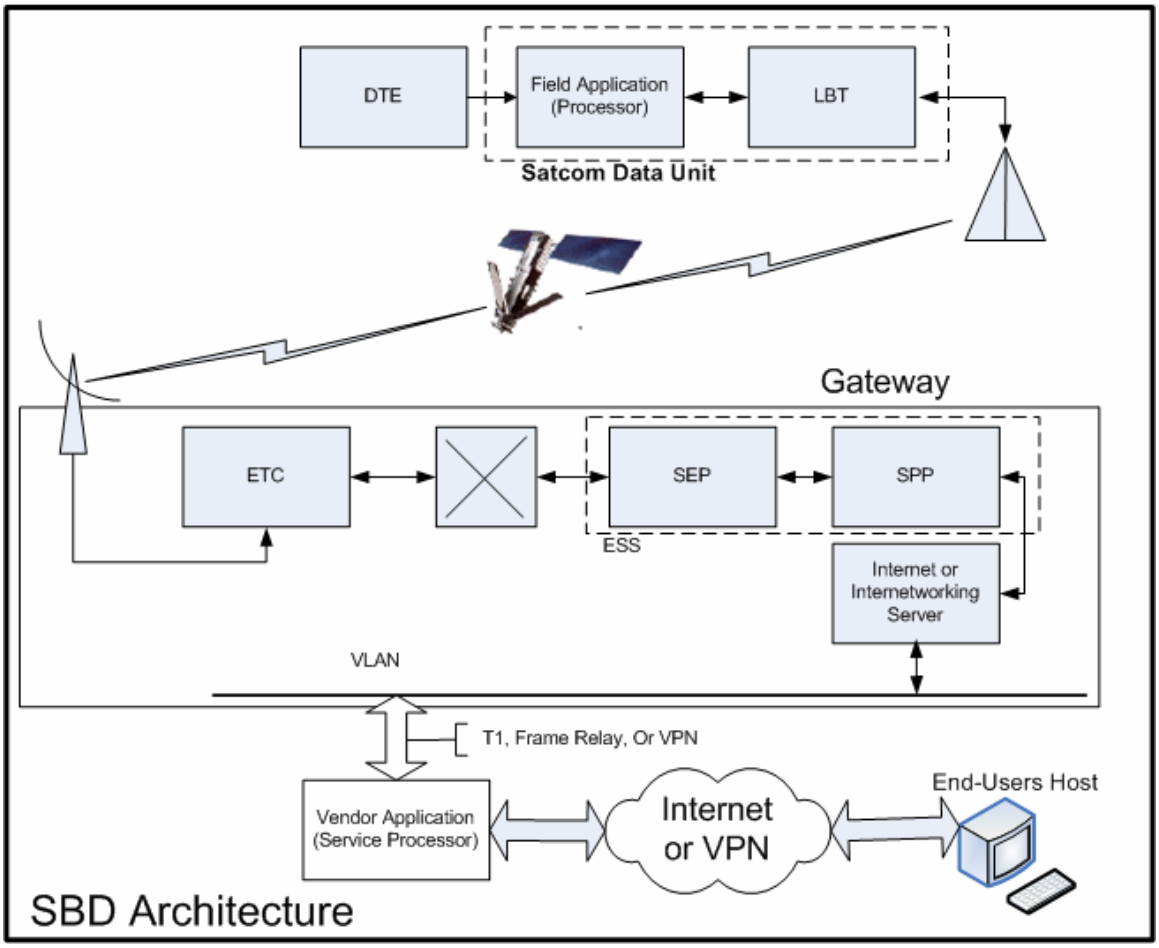


FIGURE 6-8
SBD Architecture

The Field Application represents the hardware and software that is defined by the avionics manufacturer which in synchronized with the Vendor Application, or ground based service processor, to perform data exchanges such as ACARS, or collecting and transmitting aircraft location information. The SDU includes the Iridium LBT with the SBD feature available in firmware, aircraft communication interfaces, and memory and processor logic.

The interface between the Vendor Application and the Iridium network gateway uses standard Internet protocols to send and receive messages.

6.6.2.2 RUDICS

Iridium's RUDICS is a circuit-switched data service designed to be incorporated into an integrated data solution. Integrated data solutions are applications such as remote asset monitoring, control, and data file transfer. Often these applications are designed to support hundreds or thousands of remote units. RUDICS is designed to take advantage of the global

nature of the Iridium communications system and combine that with a modern digital connection between the Iridium gateway and the ground-based service processor, or Host Application.

RUDICS provides a circuit-switched data service, a data pipe, by which to transmit and receive customer data. The service can be configured on a customer basis for PPP or MLPP depending on application or customer's request. The customer must be properly provisioned in both the SSS and the RUDICS ACS (access control server) in order to use this service. Access is provided from the Iridium network to the Internet or dedicated circuits (or visa versa).

An example of how to make a data call is given below:

- AT+CBST=6,0,1 (asynchronous modem 4800 bps and IRLP)
- OK
- AT+CR=1 (enable reporting)
- OK
- ATD1234567890 (dial remote modem)
- +CR: REL ASYNC
- CONNECT 9600 (call connected at DTE rate of 9600)

Service can be configured to limit access to user group functionality whereby only those configured for a particular destination will be able to reach that destination.

The primary elements of the end-to-end RUDICS architecture are shown in Figure 6-9, below. Specifically, the elements consist of the Field Application, the Iridium Subscriber Unit, the Iridium satellite constellation, the standard telephony units and the RUDICS server located at the Iridium gateway, the VPN, and the Vendor Application, or ground based service processor.

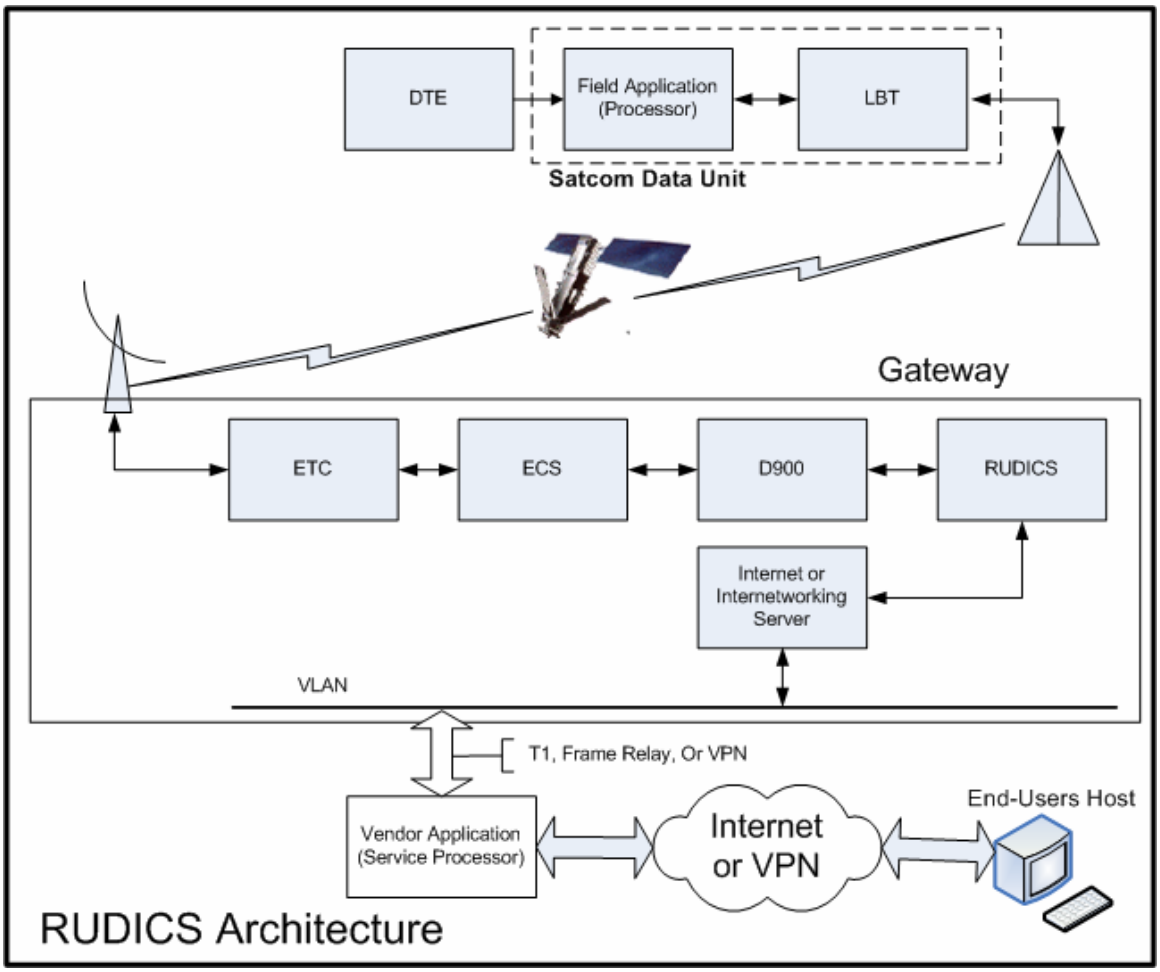


FIGURE 6-9

RUDICS Architecture

The standard sequence of events for a mobile originated call:

1) Mobile application places a call to a custom RUDICS Server Number
2) Call request is routed over the constellation for user authentication and call set-up
3) Switch connects to RUDICS Server, secondary authentication conducted
4) RUDICS Server terminates call to pre-configured IP Address
5) End-to-End IP connection established, over the constellation, between the Host Application and Mobile Application.

The standard sequence of events for a mobile terminated call:

1) Host application places telnet call to RUDICS Server
2) RUDICS Server Authenticates Host
3) Call request is routed to the switch for call set-up
4) Call request is routed over the constellation for user authentication and call set-up

5) Mobile Application answers call. End-to-End IP connection established, over the constellation, between the Host Application and Mobile Application.

RUDICS uses routers to allow termination and origination of circuit switched data calls to and from a specific IP address via a Telnet protocol. The capability is designed to support applications that have many field devices and one central host application. The service allows field devices to directly call the host application and the host application is able to directly call the field devices. Connectivity between the Iridium gateway and the Host Application can take place through a variety of methods, including Internet, Virtual Private Network (VPN) and Leased Line. Aviation safety services may only utilize approved VPN connectivity and leased lines, in a redundant fashion.

6.7 OPERATION

6.7.1 Connectivity

End-to-end voice services should take into account the quality of service provided by the PSTN and/or use of leased telecommunications lines to achieve compliance with the AMS(R)S SARPs.

6.7.2 Calling Characteristics

The Iridium network was modeled after the telecommunications industry standard GSM telephone system. The Iridium network system architecture provides a short voice delay, with worst case estimates (one-way voice transfer delay) calculated to be less than 375 msec. This number may vary due to end-user PBX's and the end-user's telecommunication company connection/configurations.

Call set-up time, call establishment rates, and dropped call rates are monitored and reported on a periodic basis.

6.7.3 Security

All physical properties within Iridium Satellite are maintained in a secure fashion with extra secure measures, including locked passages with access on an "as-needed" basis, deployed at the gateway, Satellite network operations center and technical support center.

In addition, the following security measures have been taken to assure secure network services:

- Handling of Misdirected Calls and Protection of GTA Communications consists of validation of authorized calling telephone number and validation of authorized personal identification number (PIN) for calls placed to the aircraft cockpit. This feature is based on the ability of the avionics, which is an option on some models, to block out calls from telephone numbers not listed in a pre-loaded authorized telephone number list. One number on the authorized calling list shall be an Iridium-provided number which requires PIN entry. The caller, calling into the Iridium provided telephone number must then enter the prescribed PIN. The user is

allowed three attempts to enter the proper PIN. After the third attempt, the call process is halted and the caller must re-dial the aircraft telephone number and re-enter the PIN sequence.

- Fraud Protection is provided during the Access process. During this process, the gateway determines if the requesting SDU is providing its own geographical location. If true, the system requests a check of the geographical location provided by the requesting SDU with the Beam ID the SDU is using. If the beam coverage location associated with the Beam ID does not match with the SDU provided location, the system sets a fraud flag. The system then sends the SDU the "Access Decision Notification" message with the indicator set to "access denied," and service is denied, with the exception of emergency calls.
- Denial of Service due to unauthorized usage is supported during the Access, Registration and Authentication processes. These rules can be made available to the proper authorities on an "as needed" basis.

6.7.4 Quality of Service Measurement

Service quality is measured by a number of devices, which are referred to as auto-dialers. These auto-dialers are deployed around the world and are configured to automatically place calls through the Iridium network. As each call is dialed, the system starts a timer. As the call process proceeds and the call is established, the connection time is stopped and the total time to connect is recorded. If the call is dropped prematurely, the premature call is recorded, as well the recording of properly terminated calls.

Iridium has set up approximately 25 Auto-Dialers around the world, in both the northern and southern hemispheres. Each Auto-Dialer is connected to a computer that runs a script placing calls through the system and records the results. Since 1998, 365 days per year, each Auto-dialer attempts over 1440 calls per day, which equates to 525,600 calls per auto-dialer per year, or well over 10 million calls attempted each year using the 25 auto-dialers.

The following key performance indicators are monitored closely:

- Call Set-up
- Call Establishment Rates
- Drop Rates
- Drop Rate vs. Call Duration
- Data Throughput
- Data Error Rate

6.7.5 System Outages and Maintenance

Iridium has processes and procedures in place to minimize the impact of an outage or planned outages due to system maintenance. In addition to the spare satellites in orbit in each plane, Iridium has redundant gateway processors in place to negate processor hardware failures, as well as redundant telecommunication lines.

Iridium's satellite communications service providers are required to have similar equipment and telecom line redundancy, as well as processes and procedures in place to handle outages. These SPs are also required to synchronize their maintenance outage windows and trouble ticket systems with Iridium to minimize the impact of outages on the end-users.

The aviation satellite communications SP is the initial contact point for service issues. Iridium has processes in place to handle service issues when the SPs cannot resolve an issue.

Any significant service outage (including loss of an SV) results in issuance of a network advisory notification. The notification specifies the satellite ID number involved. A number of commercial, off-the-shelf (COTS) computer software tools are available to allow users to track the identified satellite. A screen shot of one available tracking tool is shown in Figure 6-10 below.

Should it be determined that the outage will persist for a lengthy period of time (e.g., loss of a satellite in a plane that has no spares readily available), ISLLC attempts to fill in as much as possible of the missing L-band footprint by developing and uploading new beam laydown tables to the constellation.

If a spare satellite is available in the same plane, it can usually be maneuvered into the vacant slot in a few days time, but that also requires generation and upload of new beam laydown tables because of the change in satellite node ID.

Iridium Satellite can provide recommendations on suitable COTS satellite tracking software.

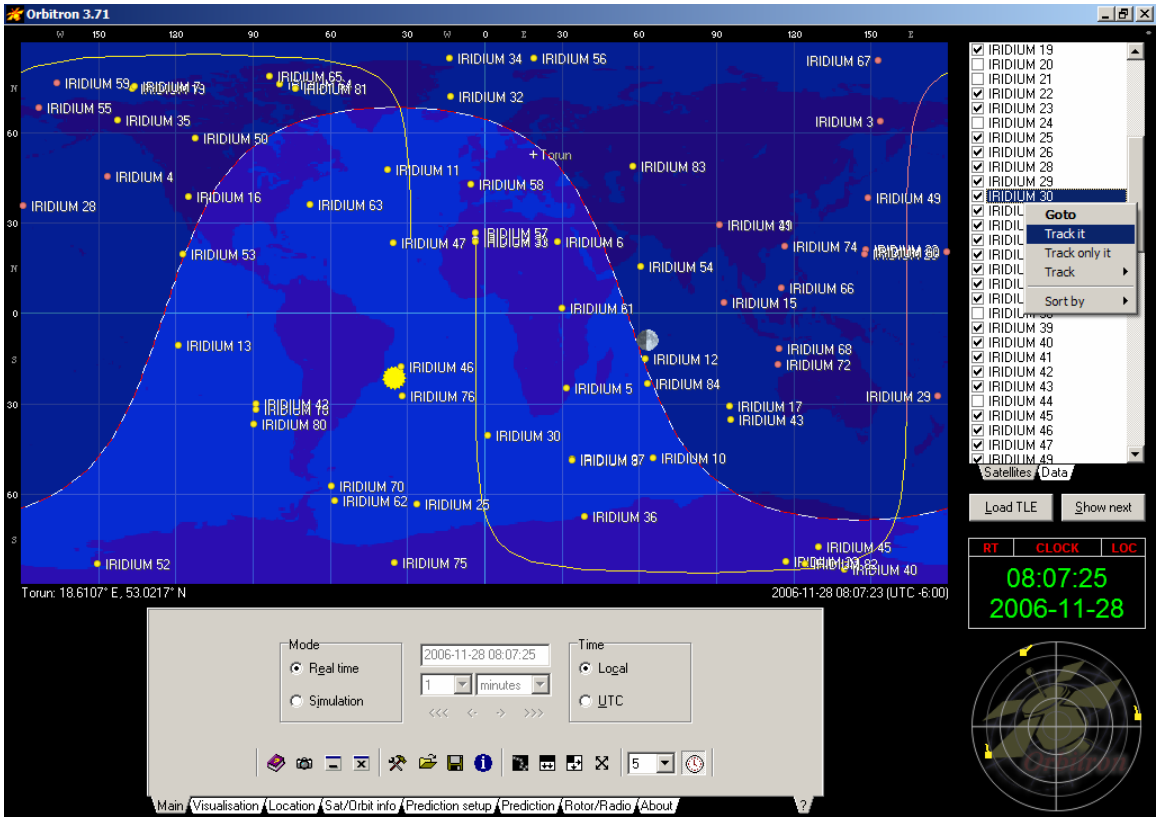


FIGURE 6-10
COTS Satellite Tracking Application Screenshot

6.7.5.1 Planned Outages

Iridium has established a scheduled maintenance window [Window] for GES facilities. It should be noted that scheduled maintenance windows are not utilized each week, the entire maintenance window may not be utilized, and the maintenance activity may not impact the entire network or services. Iridium will endeavor to sustain service during the maintenance activity to minimize impact on end-user operations.

If Iridium intends to utilize the Window, Iridium will endeavor to send an email notification to Iridium SPs by close of business MST on the Tuesday immediately prior to the Window. The email notification shall indicate the type of potential service impact (e.g., voice, billing). A corresponding email notification will be sent once the maintenance has been completed.

If Iridium does not intend to utilize the Window, no notification will be sent. Iridium will always attempt to minimize the duration of the actual outage. Depending on the nature of the maintenance, service may be completely unavailable for the entire maintenance window or for

varying periods of time within the Window. Depending on the nature of the maintenance, Mobile Originated Messages may be stored in the gateway resulting in increased latency during this period. Iridium aviation satellite communications SPs are required to coordinate maintenance activities to coincide with Iridium's maintenance window and to provide notification to end-users.

6.7.5.2 Unplanned Outages

In the event of an unplanned outage affecting service, Iridium will issue an email notification to SPs upon detecting such a loss of service. Depending on the nature of the outage, the initial notification email may contain the following:

- Approximate start time of the outage
- End time of the outage

6.7.5.3 Notifications

Notifications will be provided to the SPs and end-users, as required for planned maintenance, service outage and service restoration.

6.8 AVIONICS

Iridium avionics are based on the Iridium-supplied LBT, with one voice/data channel for each LBT, as shown in Figure 6-11, Two Channel Avionics Block Diagram. The LBT provides, at minimum, the following:

- Seamless, low latency link with the Iridium network
- Vocoder, to insure a consistent quality
- Data linkage with the SBD and RUDICS processors at the gateway to ease integration and insure seamless service
- SIM card, to assure that safety-related aeronautical services obtain timely access to the resources needed within the Iridium AMS(R)S, which includes provision for Priority, Precedence and Preemption (PPP) of system resources and support of acquisition class 14
- Sub-miniature D connector for interfacing with the avionics interworkings
- AT Command structure to control the LBT
- Transmission of the 24-bit ICAO aircraft address

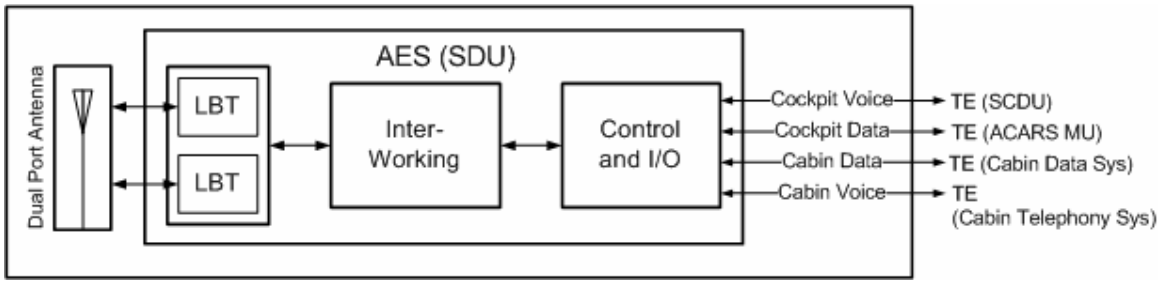


FIGURE 6-11
Two Channel Avionics Block Diagram

All avionics shall be tested and approved by the aviation satellite communications SP to assure proper interaction through the Iridium network and adherence to published communications protocols. Only those avionics tested and approved by both Iridium and the satellite communications SP are provided with the safety services SIM card.

6.9 Requirements Definition

All avionics are subject to the airworthiness regulations that apply to the aircraft in which the avionics are to be installed, as directed by applicable civil aviation authorities. Adherence to these civil aviation regulations for aircraft system installation(s) are provided by the avionics manufacturer and the installation entity providing the engineering and certification of the installation engineering and certification package required for a Type Certificate (TC), a new aircraft, or a Supplemental Type Certificate (STC) for modification of an aircraft.

The appendix of specifications of several relevant Iridium network and LBT documents should be consulted for additional information.

6.10 Aircraft Installation

RTCA DO-160, *Environmental Conditions and Test Procedures for Airborne Equipment* provides guidelines on aircraft radio installation location, or qualified equivalent. In the event that an Iridium system and other Mobile Satellite Service (MSS) system are co-located on the same aircraft, simultaneous operation may require additional interference mitigation techniques. For example, in the case of Inmarsat/MTSAT, significant isolation is required between the Inmarsat/MTSAT transmitter and Iridium receiver. This could be achieved by the installation of a Type-D or Type-E or equivalent diplexer, as specified in ARINC 741 or 781.

6.10.1 Aircraft Antenna Mounting

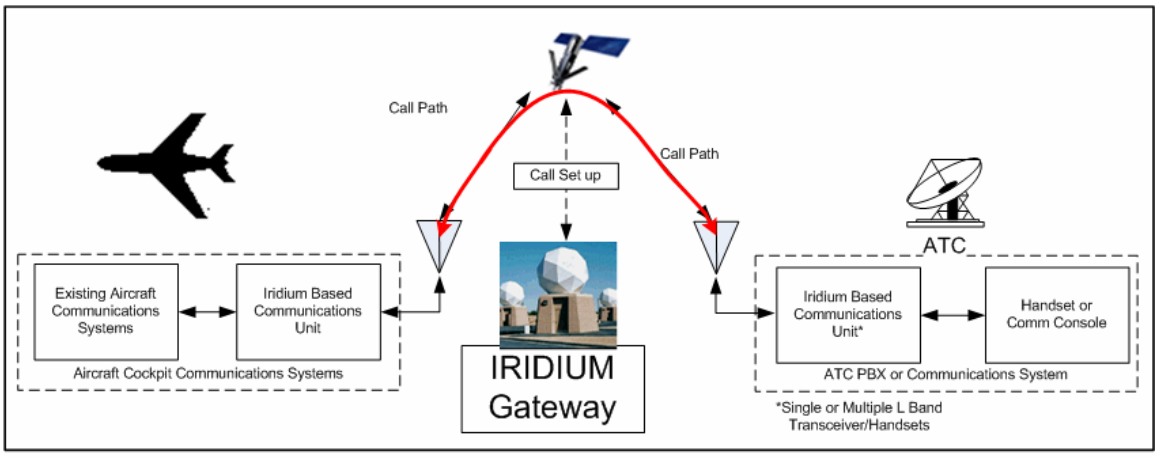
The Iridium antenna(s) shall be installed on top of the aircraft, as close to aircraft centerline as possible, with sufficient physical separation between the Iridium antenna and all other communication, navigation and surveillance system antennas. The Iridium antenna shall be mounted such that the installation provides the clearest line-of-sight path to the satellites with the highest amount of unobstructed view to the horizon and maximum allowable separation from any other installed MSS system antenna(s). It is recommended that a site survey of the aircraft

be conducted prior to installation to insure that the Iridium equipment will operate properly in coexistence with other MSS systems. As per the requirements of obtaining an aircraft supplemental type certificate or type certificate for a new aircraft, ground and flight testing of the Iridium network shall be conducted to insure interoperability with all other communication, navigation and surveillance systems and to insure the Iridium network installation provides adequate electromagnetic compatibility for safety of flight (EMC/SOF).

6.11 IRIDUM GROUND BASED SERVICES

Iridium has a number of ground-based communications systems manufactured by various equipment manufacturers which are available for air traffic service providers. These systems can be equipped with a special aviation safety services SIM card to enable these aviation systems to have the highest acquisition class in the event of load shedding.

Where leased telecommunications lines are not available, the Iridium ground-based system may provide the primary circuit mode channel(s), as shown in Figure 6-12.



IRIDIUM Aviation Safety Services- Voice
Aircraft to Air Traffic Service Provider Service Model

FIGURE 6-12

Note: Data can be supported, however ACARS/ATN protocols require specialized data terminal equipment, and aircraft messaging should be routed through the aeronautical terrestrial service to insure proper message routing and tracking.

6.12 PROCESS FOR IMPLEMENTING FUTURE SERVICES

Iridium and Iridium SPs will coordinate the need for new services and features. The Iridium SPs shall work with the end-users, civil aviation authorities and air traffic service providers to gain an understanding of the aviation community's needs and priorities.

Iridium will annually publish a list of services and features planned for the upcoming year, based on estimated quarterly system upgrades. This list will be made available on the Iridium website and will be made available to Iridium's value added manufacturers, resellers, service providers and end-users, including air traffic service providers.

Iridium will take into consideration backward compatibility with in-service transceivers and avionics when developing new features.

APPENDIX A-II: AIRCRAFT EARTH STATION RF CHARACTERISTICS

In the United States, the Federal Aviation Administration's (FAA) Technical Standard Order, TSO-C159, states that "Avionics Supporting Next Generation Satellite Systems (NGSS)" identified and manufactured on or after the effective date (20 September 2004) of the TSO must meet the minimum operational performance standards (MOPS) specified in RTCA DO-262.

RTCA DO-262 is a normative specification dealing mainly with RF characteristics and performance of AES supporting NGSS. Each NGSS is to provide system-specific performance specification so that RF performance of AES built for that particular satellite system could be tested and verified.

Table A-1 tabulates some of the system-specific performance parameters for the Iridium communication satellite system per RTCA DO-262. Iridium will work with its AES manufacturers in understanding the MOPS and the Iridium-specific system parameters.

Table A-II-1 Iridium AMS(R)S System Parameters per RTCA DO-262

Symbol	Characteristics	System Specific Value	Paragraph Reference
A_{RSV}	System-specific axial ratio for space vehicle. This parameter is used only to compute the gain necessary to overcome losses due to mismatch of the axial ratios.	3.5 dB	DO-262 2.2.3.1.1.2
f_{RMX}	Maximum operating frequency for space vehicle transmissions (AES reception)	1626.5 MHz	DO-262 2.2.3.1.1.4
f_{RMN}	Minimum operating frequency for space vehicle transmissions (AES reception)	1616.0 MHz	DO-262 2.2.3.1.1.4
f_{TMX}	Maximum operating frequency for AES transmissions	1626.5 MHz	DO-262 2.2.3.1.1.4
f_{TMN}	Minimum operating frequency for AES transmissions	1616.0 MHz	DO-262 2.2.3.1.1.4
f_M	Channel modulation rate	50 kbps	DO-262
P	Nominal polarization of AES antenna	RHCP	DO-262 2.2.3.1.1.1.2
P_{NC}	Maximum output power allowed during intervals when no transceiver channel is transmitting	-77 dBW / 100 kHz	DO-262 2.2.3.1.2.1.7
S_D	Minimum data channel carrier level for sensitivity test	-114 dBm	DO-262 2.2.3.1.2.2.1.1
S_{HSNT}	Maximum level of harmonic, spurious and noise allowed within the designated transmit band	-35 dBW / 100 kHz	DO-262 2.2.3.1.2.1.5
S_{HSNR}	Maximum level of harmonic spurious and noise within the designated receive band	-35 dBW / 100 kHz	DO-262 2.2.3.1.2.1.5
S_{IMT}	Maximum level of 2-tone intermodulation products allowed within the designated transmit band	N/A, no multi-carrier IM expected	DO-262 2.2.3.1.2.1.4
S_{IMR}	Maximum level of 2-tone intermodulation products allowed within the designated receive band	N/A, no multi-carrier IM expected	DO-262 2.2.3.1.2.1.4
S_{UW}	Maximum level of undesired wideband noise from interfering sources external to the NGSS system that can be accepted within the designated receive band, expressed as a power spectral density	-174 dBm/Hz	DO-262 2.2.3.1.2.2.6

Symbol	Characteristics	System Specific Value	Paragraph Reference
S_{UN}	Maximum level of undesired narrowband interference from interfering sources external to the NGSS system that can be accepted within the designated receive band, expressed as an absolute power level.	-128 dBm	DO-262 2.2.3.1.2.2.6
S_V	Minimum voice channel carrier level for sensitivity test	-114 dBm	DO-262 2.2.3.1.2.2.1.2
Θ_{SA}	Minimum separation angle between the line of sight to two satellites within the NGSS constellation	N/A(1)	DO-262 2.2.3.1.1.8
A_{RA}	Maximum axial ratio for AES antenna	4 dB at 8 deg. elevation; 3 dB at zenith	DO-262 2.2.3.1.1.2
D/U	Minimum pattern discrimination between two potential satellite positions above the minimum elevation angle, Θ_{MIN}	N/A	DO-262 2.2.3.1.1.8
ϕ_{Δ}	Maximum phase discontinuity permitted between beam positions of a steered AES antenna.	N/A	DO-262 2.2.3.1.1.9.1
G_{MAX}	Maximum gain of the aeronautical antenna pattern in the upper hemisphere above the minimum elevation angle Θ_{MIN}	3 dBic	DO-262 2.2.3.1.1.1.3
G_{MIN}	Minimum gain of the aeronautical antenna pattern in the upper hemisphere above minimum elevation angle Θ_{MIN}	-3.5 dBic	DO-262 2.2.3.1.1.1.3
L_{MAX}	Maximum cable loss between AES antenna port and the AES transceiver input port	3 dB	DO-262 2.2.3.1.2.2
L_{MSG}	Maximum length in octets of user data sequence using Data 2 transmissions	TBD	DO-262 2.2.3.6.2
L_{SNDP}	Maximum length in octets of user data contained in a maximum length sub-network dependent protocol data block	TBD	DO-262 2.2.3.3.1
N_D	Maximum number of simultaneous data carriers	2(2)	DO-262 2.2.3.1.2.1.1
N_V	Maximum number of simultaneous voice carriers	2(2)	DO-262 2.2.3.1.2.1.1

Symbol	Characteristics	System Specific Value	Paragraph Reference
P_D	Maximum single carrier power for each of N_D data carriers in a multi-carrier capable AES	5.5 W	DO-262 2.2.3.1.2.1.1
P_{RNG}	Range over which the AES transmit power must be controlled	+0 to –8 dB relative to P_D, Iridium internal controlled	DO-262 2.2.3.1.2.1.8
$P_{SC\text{-}SC}$	Maximum burst output power of single carrier AES	8.5 dBW	DO-262 2.2.3.1.2.1.2
P_{STEP}	Maximum acceptable step size for controlling AES transmit power	1 dB step, Iridium internal controlled	DO-262 2.2.3.1.2.1.8
P_V	Maximum single carrier power for each of N_V voice carriers in a multi-carrier capable AES	5.5 dBW	DO-262 2.2.3.1.2.1.1
$R_{SC\text{-}UD}$	Minimum average single channel user data rate sustainable at a residual packet error rate of 10^{-6}	2.4 kbps	DO-262 2.2.3.1.2.2.1.1
Θ_{MIN}	Minimum elevation angle for satellite coverage	8.2 deg.	DO-262 2.2.3.1.1.1.1
τ_{SW}	Maximum switching time between electronically steered antenna patterns.	N/A	DO-262 2.2.3.1.1.9.2
ρ_{RA}	Minimum exclusion zone radius necessary for protection of Radio Astronomy	N/A	DO-262 2.2.3.1.2.1.6.2
C/M	Carrier-to-multipath discrimination ratio measured at the minimum elevation angle	6 dB	DO-262 2.2.3.1.1.7
V_{SWR}	Maximum Voltage Standing Wave Ratio measured at a single input port of the AES antenna	1.8:1	DO-262 2.2.3.1.1.5

Notes:

(1) Line of sight separation angle depends on latitude and specific location of the terminal.

(2) In general, this is left to the AES manufacturer as long as other RF performance parameters are within specifications. Assuming a dual-carrier antenna unit, $N_D + N_V$ shall be less than or equal to 2.

APPENDIX B-II: ACRONYMS

AAC	Aeronautical Administrative Conmmunications
AC	Acquisition Class
AES	Aircraft Earth Station
AOC	Aeronautical Operational Control
APC	Aeronautical Passenger Communications
ARQ	Automatic Repeat Request
AT	AT (Attention) command set or Hayes command set
ATC	Air Traffic Control
ATS	Air Traffic Services
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
BCH	Bose, Ray-Chaudhuri, Hocquenghem (a type of error control code)
COTS	Commercial, Off the Shelf
CPDLC	Controller-Pilot Datalink Communication
CPLD	Call Processing Location Determination
DL	Downlink
DFOA	Differential Frequency of Arrival
DTOA	Differential Time of Arrival
ECS	Earth Terminal Controller - Communication Subsystem
ET	Earth Terminal
ETC	Earth Terminal Controller
ETS	Earth Terminal Controller- Transmission Subsystem
FA	Field Application
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Control
GES	Ground Earth Station (or Gateway)
GPS	Global Positioning System
GSM	Global System for Mobile Communication (Groupe Special Mobile)
GSS	Gateway SBD Subsystem
IMSI	International Mobile Subscriber Identification
ISC	International Switching Center
ISDN	Integrated Services Digital Network
ISLLC	Iridium Satellite LLC
ITU	International Telecommunications Union

kbps	Kilobits-per-second
ksps	Kilosymbols-per-second
LBT	L-band Transceiver
LEO	Low Earth Orbit
MO	Mobile Originated
MOC	Message Origination Controller
MOS	Mean Opinion Score (*see definitions*)
MSN	Message Sequence Number
MSS	Mobile Satellite Service
MT	Mobile Terminated
NGSS	Next Generation Satellite System
PLMN	Public Land Mobile Network
PSDN	Public Switched Data Network
PSTN	Public Switched Telephone Network
RUDICS	Router-Based Unrestricted Digital Interworking Connectivity Solution
SBD	Short Burst Data
SDU	Satcom Data Unit or Satellite Data Unit
SEP	SBD ETC Processor
SIM	Subscriber Information Module
SNOC	Satellite Network Operation Center
SNSDU	Subnetwork Service Data Unit
SSS	Switching Subsystem
SV	Space Vehicle
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TTAC	Telemetry Tracking and Control/Command
UL	Uplink
VA	Vendor Application

APPENDIX C-II: DEFINITIONS

AES - Aircraft Earth Station is the avionics on board an aircraft necessary for satellite communications. This includes modulator and demodulators, RF power amplifier, transmitter and receiver and the antenna. Iridium AES may consist of multiple Satcom Data Units (SDU), or L-Band Transceivers (LBT), which serve as radio transceivers, provide the actual modem and signal processing functions, as well as Iridium satellite sub-network protocol management including circuit-switched voice/data management, and provide data and voice interfaces with other aircraft systems.

Availability - is the proportion of time a system is in a functioning condition which is computed as (Observation Time-Total Outage Time)/Observation Time

GSM - Global System for Mobile communications is a sophisticated cellular system used worldwide which was designed in Europe. It uses a *TDMA* air interface

Integrity - is the probability of a message being received without undetected errors.

MOS - Mean Opinion Score provides a numerical measure of the quality of human speech at the destination end of the circuit. The scheme uses subjective tests (opinionated scores) that are mathematically averaged to obtain a quantitative indicator of the system performance.

To determine MOS, a number of listeners rate the quality of test sentences read aloud over the communications circuit by male and female speakers. A listener gives each sentence a rating as follows: (1) bad; (2) poor; (3) fair; (4) good; (5) excellent. The MOS is the arithmetic mean of all the individual scores, and can range from 1 (worst) to 5 (best).

MTBF - Mean Time Between Failure is the "average" time between failures, the reciprocal of the failure rate in the special case when failure rate is constant. Calculations of MTBF assume that a system is "renewed", i.e., fixed, after each failure and then returned to service immediately after failure

MTTR - Mean Time to Repair is the average time required to perform corrective maintenance on a product or system. This kind of maintainability prediction analyzes how long repairs and maintenance tasks will take in the event of a system failure.

Priority, Precedence and Preemption - Each element of the AMS(R)S Subsystem (including AESs, GESs and the constellation) shall conform with applicable International and National Radio Regulations and aviation regulations governing the precedence and protection of aeronautical mobile safety communications. Each AMS(R)S system shall address each requirement of this section in its system-specific normative attachment to this document with a complete description of the mechanisms enabling the system to meet the requirements.

Priority Levels - The AMS(R)S system and, as appropriate, its elements, shall support not fewer than three AMS(R)S priority levels at the subnetwork interfaces. If the system accepts non-safety blocks for transmission, at least one (lowest) priority level shall be added for non-safety traffic. If the system accepts blocks for transmission that contain either no priority indicator or a null priority indication, each such block shall be marked upon entry with a non-safety priority level and shall be treated as such in subsequent processing within the system. The AMS(R)S system shall forward a block priority indicator to the succeeding subsystem or end-user terminal.
Note: *For the purpose of this document the three AMS(R)S priorities are designated as Distress/Urgency (highest safety priority), Flight Safety, and Other Safety (lowest safety priority). Non-safety traffic is designated as Non-Safety.*

Precedence - Each AES and GES shall ensure that higher priority blocks are not delayed by the transmission and/or reception of lower priority messages.

Preemption
Lower priority messages shall be preempted, if necessary, to allow higher priority blocks to be transmitted and received.
Notes: 1. *For example, if a lower priority block is occupying limited AMSS resources when a higher priority block is received, then transmission of the lower priority block should be interrupted, if necessary and feasible, to permit transmission of the higher priority block.*
2. *The priority assigned to a voice or data block will be determined by the initiating user or his terminal equipment.*

Reliability - is the probability that a satellite subnetwork actually delivers the intended message. The failure to deliver a message may result either from a complete breakdown of an essential component or because of detected errors which are unrecoverable.

Satellite Communications Service Provider – typically provides the inter-working unit of the terrestrial sub-system as depicted in Manual Part I, Fig. 2-1, within Segment C-D, which connects the satellite ground earth station, or Gateway, and the terrestrial network in support of AMS(R)S.

Satellite Network Operations Provider – typically provides the satellite sub-system, as depicted in Manual Part I, Fig. 2-1, within Segment B-C, which includes the satellite(s) and may or may not include the ground earth stations or Gateway.

Terrestrial Network Service Provider – typically provides the aviation centric terrestrial sub-system, as depicted in Manual Part I, Fig. 2-1, within Segment C-D, which provides connectivity to the end-users, such as air traffic service providers, airlines, and flight departments.

MANUAL FOR
AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE
Part 3

DRAFT v1.0

21 March 2007

A preliminary unedited DRAFT version of this part of the AMS(R)S manual has been posted to the ACP website at:

http://www.icao.int/anb/panels/acp/WG/M/Iridium_swg/IRD-08/IRD-SWG08-WP07%20-%20Old_AMSS_material_Ch.4_plus_Attachment.doc

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AMS(R)S Standards and Recommended Practices (SARPs) as contained in Annex 10, Volume III, Part I, Chapter 4 take in any case precedence over material contained in this document.

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