AEEC

Together "We Set the Standard."

To	AeroMACS Working Group	**Date**	November 5, 2015
From	José Godoy jose.godoy@sae-itc.org tel +1 240-334-2583	**Reference**	15-144/AMX-001 lth

Subject **Draft Circulation**
Draft 1 of ARINC Project Paper 766: *Aeronautical Mobile Airport Communication System (AeroMACS) Transceiver and Aircraft Installation Standards*

Summary

The ARINC IA staff prepared Draft 1 following the AeroMACS Working Group Web Conference held September 3, 2015. This draft includes inputs prepared by Honeywell.

The goal of the AeroMACS Working Group is to develop **ARINC Project Paper 766** - *AeroMACS Transceiver and Aircraft Installation Standards*, per APIM 11-013A. The project paper defines an airborne AeroMACS radio capable of operating in the protected aeronautical C-band frequencies of 5091 MHz to 5150 MHz. The transceiver is expected to support Airport Surface Network (ASN) services, per the IEEE 802.16 WiMAX protocol.

ARINC Project Paper 766 defines the AeroMACS radio, electrical interfaces, form factor and fit dimensions. Antenna performance and mounting characteristics guidance will be included in the standard.

Many sections of this draft appear with yellow highlighting to identify topics in need of discussion and update.

This draft will be reviewed at the next AeroMACS Working Group meeting scheduled for November 12-13, 2015 in Cocoa Beach, Florida.

Action The ARINC IA staff requests comments on the attached draft. Comments should be sent to José Godoy before December 5, 2015. Comments provided before November 10, 2015 will be considered at the meeting in Cocoa Beach, Florida.

cc DLK, DLUF, NIS, SAI

SAE Industry Technologies Consortia (SAE-ITC)
16701 Melford Blvd., Suite 120
Bowie, Maryland 20715 USA

DRAFT 1

OF

ARINC PROJECT PAPER 766

AERONAUTICAL MOBILE AIRPORT COMMUNICATION SYSTEM

(AEROMACS)

This draft dated: November 5, 2015

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION AND DESCRIPTION

The aviation industry has expressed the desire to upgrade aging airport surface communication infrastructure with an advanced digital network leveraging the Internet Protocol Suite (IPS) and appropriate security interlocks. The Federal Aviation Administration (FAA) and EUROCONTROL have identified the Aeronautical Mobile Airport Communications System (AeroMACS) to support this ever growing need for increased data communications and information sharing on the airport surface. AeroMACS will help to achieve the necessary efficiency gains by providing increased transmission of Air Traffic Control (ATC) and Airline Operations Communications (AOC) on the airport surface.

This document defines the airborne avionics equipment capable of providing AeroMACS connectivity to the aircraft.

1.1 Purpose and Scope

The AeroMACS Radio Unit (ARU) is used to form a wireless Local Area Network (LAN) connection between the aircraft LAN and a ground-based LAN, typically at an airport. The ARU bridges the two networks using the IEEE 802.16e family of standards. The ARU is expected to support new capabilities, such as file server access from aircraft terminals, terminal emulation sessions to a ground based host, file transfers, and Internet access.

This document contains the physical form(s) and fit dimensions, the electrical interface definition, and a description of the functions, operations and interfaces of an AeroMACS Radio Unit (ARU) intended for installation in commercial aircraft. The intent of this document is to provide general and specific design guidance for the development of ARUs for airline use. This document defines two stand-alone device configurations which differ only in terms of form and fit. The functions of both forms are intended to be the same.

This document describes the desired operational capability. This document defines the standards necessary for interchangeability and interoperability.

In addition, the functions defined by this document may be integrated in other equipment that provides the ARU functional capability.

Functional aspects are defined in various documents, including the following:

RTCA DO-345/EUROCAE ED-222: *AeroMACS Profiles*

RTCA DO-346/EUROCAE ED-223: *AeroMACS Minimum Operational Performance Standards (MOPS)*

ICAO ANNEX-*10, Volume-III, Chapter 7:* *AeroMACS Standards and Recommended Practices (SARPs)*

ICAO AeroMACS Technical Manual

This document defines two form factors for AeroMACS Radio Unit (ARU). The first is based on ARINC 600 packaging and is intended for installation in the electrical equipment (EE) bay of the aircraft. The other is a flange mount unit intended for installation in other areas of the aircraft, such as above the ceiling panels in the crown of the fuselage without cooling air. Both form factors provide the same functions. There are advantages and disadvantages to each form factor. It is up to the operator to specify the type of installation that best suits their needs.

Example AeroMACS architectures are provided in Appendix A to this document.

1.0 INTRODUCTION AND DESCRIPTION

The ARU provides a broadband wireless network connection between the Aircraft Control Domain (ACD) and/or Aircraft Information Services Domain (AISD) and ground-based ATS and/or AOC end systems when the aircraft is on the airport surface.

1.1.1 Overview of AeroMACS Radio Unit (ARU)

The airborne AeroMACS Radio Unit (ARU) forms the connection between the aircraft and a ground-based AeroMACS network located at an airport.

The ARU is intended to support data communications to and from the aircraft such as Controller Pilot Data Link Communication (CPDLC), Flight Information Services (FIS), D-Taxi, Automatic Dependent Surveillance – Broadcast (ADS-B) on the airport surface, and Airline Operational Control (AOC) functionality such as Aircraft Communications Addressing and Reporting System ACARS messaging, support Electronic Flight Bag (EFB) applications, Flight Operations Quality Assurance (FOQA) data downloads, navigation database updates, software uploads, and other data communications that support safety and regularity of flight.

The ARU should operate when the aircraft is on the ground and serve as a data communication medium capable of complementing existing air-to-ground systems such as VHF Digital Link (VDL) Mode 2 (VDLM2), Satellite Communication (Satcom), L-band Digital Aeronautical Communication System (LDACS) for ACD applications, and the various Gatelink technologies used for AISD applications.

The intended function of the ARU is to transmit and receive only while the aircraft is on the ground. The ARU must support a method that allows it to be controlled from an external device that can command the ARU to turn on or turn off its RF transmitter consistent with the aircraft being on or off the ground.

The ARU uses an aircraft antenna capable of transmitting and receiving the RF signals in the licensed 5000 MHz to 5150 MHz AeroMACS spectrum, which is globally allocated by International Telecommunication Union – Recommendations (ITU-R) and the International Civil Aviation Organization (ICAO). Antennas are defined in Section 7 and Attachment 7 of this document. This document does not preclude the implementation of an ARU that supports a multiple antenna arrangement (diversity) provided that all other standards are met.

RTCA DO-346, AeroMACS MOPS provides additional information on this technology.

1.2 Organization of this Document

The purpose of this document is to provide general and specific guidance for the development and installation of an ARU. As such, this guidance covers the standards necessary to achieve interchangeability, including mechanical packaging and connector. See Section 2, Interchangeability Standards.

Section 1 provides an Introduction and Description of the AeroMACS.

Section 2 provides Interchangeability Standards.

Section 3 provides System Design Information, including architecture and configurations.

Section 4 identifies the Functional Capabilities that may be provided.

Section 5 describes the Interfaces and Protocols necessary to provide the Functions.

Section 6 addresses provisions for Maintenance and Test capabilities.

Section 7 describes AeroMACS Antenna Characteristics.

There are several attachments and appendices to this document, which contain numerous figures, tables, and other related referenced information.

1.3 Relationship to Other Documents

This document introduces the functionality, protocols, and interfaces of the AeroMACS often by way of reference to other documents. The latest version of the referenced document should be used unless a specific version is identified.

ARINC Specification 429: *Digital Information Transfer System (DITS)*

ARINC Specification 600: *Air Transport Avionics Equipment Interfaces*

ARINC Report 609: *Design Guidance for Aircraft Electrical Power Systems*

ARINC Report 615A: *Software Data Loader using Ethernet Interface*

ARINC Report 660B: *CNS/ATM Avionics Architectures Supporting NextGen/SESAR Concepts*

ARINC Specification 664: *Aircraft Data Network Part 2 – Ethernet Physical and Data Link Layer Specification*

ARINC Specification 664: *Aircraft Data Network Part 7 – Avionics Full-Duplex Switched Ethernet Network*

ARINC Characteristic 758: *Communications Management Unit (CMU)*

ARINC Characteristic 765: *Ethernet Switch Unit (ESU)*

ARINC Report 811: *Commercial Aircraft Information Security Concepts of Operation Process Framework*

ARINC Report 821: *Aircraft Network Server System (NSS) Functional Definition*

ARINC Specification 822: *Aircraft/Ground IP Communication*

ARINC Specification 834: *Aircraft Data Interface Function (ADIF)*

ICAO ANNEX-*10, Volume-III, Chapter 7*: *AeroMACS SARPs*

ICAO AeroMACS Technical Manual

IEEE 802.3: *Ethernet LAN*

IEEE 802.16e: *Wi-MAX*

RTCA DO-160G/EUROCAE ED-14G: *Environmental Conditions and Test Procedures for Airborne Equipment*

RTCA DO-178C/EUROCAE ED-12C: *Software Considerations for Airborne Equipment*

RTCA DO-254/EUROCAE ED-80*: Design Assurance Guidance for Airborne Electronic Hardware*

RTCA DO-345/EUROCAE ED-222: *AeroMACS Profiles*

RTCA DO-346/EUROCAE ED-223*: AeroMACS MOPS*

1.0 INTRODUCTION AND DESCRIPTION

The basic signal-in-space definitions such as modulation as well as the Channel Sense and Transmitter-Receiver Interaction Performance standards are defined in the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) for AeroMACS. The ICAO SARPs for AeroMACS also defines the basic protocol suite. Additional interoperability information is contained in RTCA DO-345.

COMMENTARY

A copy of the ICAO SARPS and associated Guidance Material may be obtained upon request to the Secretariat of the ICAO Aeronautical Mobile Communications Panel (AMCP) by writing to:

ICAO
Air Navigation Bureau (ANB)
999 University Street
Montreal, Quebec, Canada H3C 5H7

1.4 AeroMACS System Overview

AeroMACS is a broadband wireless communications system that can support aircraft safety and regularity of flight communication for both fixed and mobile applications on the airport surface. It is based on the mature Wi-MAX standard (IEEE 802.16e) and operates in the protected aviation spectrum band from 5091 MHz to 5150 MHz. The AeroMACS Minimum Operational Performance Standards (MOPS) and the AeroMACS Profile document have been jointly developed and approved by RTCA and EUROCAE. The International Civil Aviation Organization (ICAO) has approved the AeroMACS Standards and Recommended Practices (SARPS), which will help promote interoperability and global harmonization.

The initial applications will likely be used to support Electronic Flight Bags (EFB).

AeroMACS operates in the C-band (5091 MHz to 5150 MHz) airport surface network of the Aeronautical Future Communication Infrastructure.

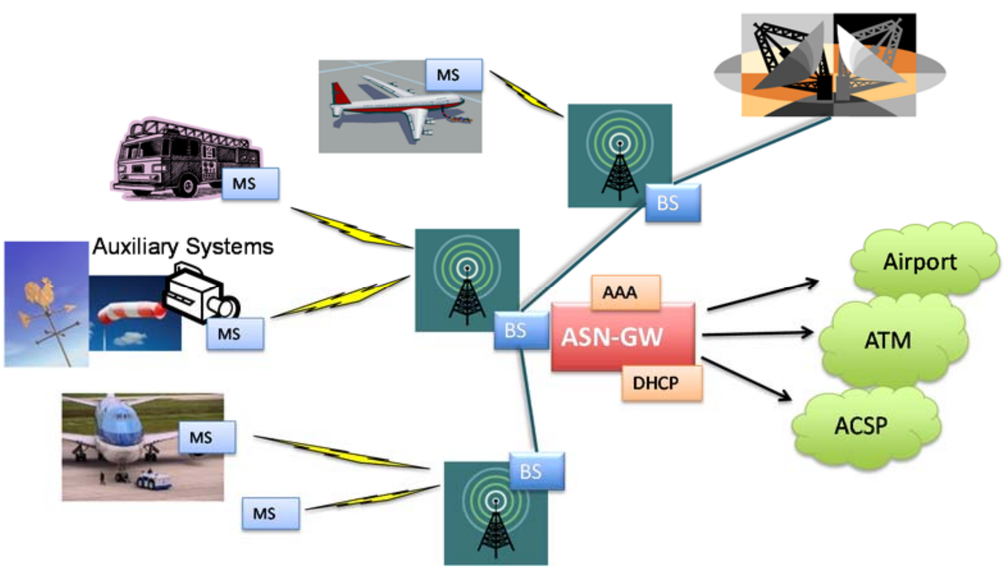


Figure 1-1 – AeroMACS Network Illustration

1.0 INTRODUCTION AND DESCRIPTION

AeroMACS uses Internet Protocol (IP) data communication to provide Air Traffic Management (ATM) services. AeroMACS can also be used to provide services outside the ATM domain, such as weather advisory and Aeronautical Information Services (AIS). In addition, AeroMACS can enable and support System Wide Information Management (SWIM) type services in the airport surface environment.

AeroMACS provides on-board communication support to both Aircraft Control Domain (ACD) and Aeronautical Information Services Domain (AISD) applications. However, proper domain separation, partitioning, security, integrity and separation of data are required in order to accommodate communication with flight deck and non-flight deck applications.

This document focuses specifically on the AeroMACS Radio Unit (ARU) form, fit and function standards, also referred to as the mobile station.

Because AeroMACS has the capacity to support a wide range of air traffic applications providing connectivity for fixed and mobile assets across the airport area, hundreds of potential applications have been identified to support the following operational domains:

- Air Traffic Control (ATC) / Air Traffic Management (ATM) applications
- Airline operations applications such as AOC
- Airport infrastructure applications

1.4.1 AeroMACS Radio Unit (ARU) Functional Definition

The primary function of the AeroMACS Radio Unit (ARU) is to provide wireless connectivity between the aircraft networks and the ground-based networks. The ground-based networks could be located at an airport, hanger, fixed based operation (FBO) facility, flight operations facility, and so forth. The ARU must support connectivity while the aircraft is on the ground and in the terminal area.

The ARU wireless LAN interface will comply with the IEEE 802.16e family of standards. It is expected that ARU implementations will make extensive use of Commercial Off-The-Shelf (COTS) technology.

The ARU must support a roaming function whereby the aircraft can establish and maintain connection to the ground-based AeroMACS infrastructure. The ARU will connect to an AeroMACS Base Station (BS) located at an airport and the associated wireless infrastructure to form the IEEE 802.16e compliant wireless LAN between the aircraft and the ground as depicted in Figure 1-1.

It is expected that the ground-based AeroMACS infrastructure will be implemented using the IEEE 802.16e compliant BS as defined in ICAO SARPS, RTCA/EUROCAE MOPS and MASPS. The BS at the airport provide a bridging function to the ground-based LAN. Each BS creates a RF coverage cell. As aircraft move into the coverage cell of a BS, the ARU on the aircraft establishes a connection to this BS. An infrastructure of multiple Base stations connected to the ground-based LAN forms a set of coverage cells, which allow the aircraft to maintain connection while in taxi. The ARU on the aircraft seamlessly connects to and disconnects from base stations as the aircraft moves into new coverage areas and exits previously covered areas.

To complete the bridging function on the aircraft, the ARU should provide a wired interface connection to the various avionics on the aircraft which may include equipment operating in the Aircraft Control Domain (ACD) and/or Airline Information

1.0 INTRODUCTION AND DESCRIPTION

Services Domain (AISD) based on functional, performance, and security requirements for the network.

The ARU uses an antenna that is capable of transmitting and receiving the RF signals in the AeroMACS band. The antenna is further defined in Section 7. This document does not preclude the implementation of an ARU that supports a multiple input multiple output (MIMO) antenna arrangement (diversity) provided that all other standards are met, including the RTCA DO-346 MOPS standards for MIMO.

The ARU includes support for external on/off control, a local monitor configuration function, and status output.

The intended function of the ARU is to operate (i.e., transmit RF) only while the aircraft is on the ground. The ARU must support a method that allows it to be controlled from an external device that can command the ARU to turn on or off RF transmissions consistent with the aircraft status (airborne or on the ground).

The AeroMACS Radio Unit (ARU), as defined in MASPS/MOPS, will connect the Avionic ACD and/or AISD Applications with the AeroMACS Network communication services.

As such, the ARU will provide an IP CS (Convergence Sublayer) service to the Avionic Applications. Optional, for ARINC 429 connection to CMU?

The ARU provides the functionalities and services as shown in Figure 1-2 and as specified in the MOPS/MASPS. This is the baseline functionality for the ARU.

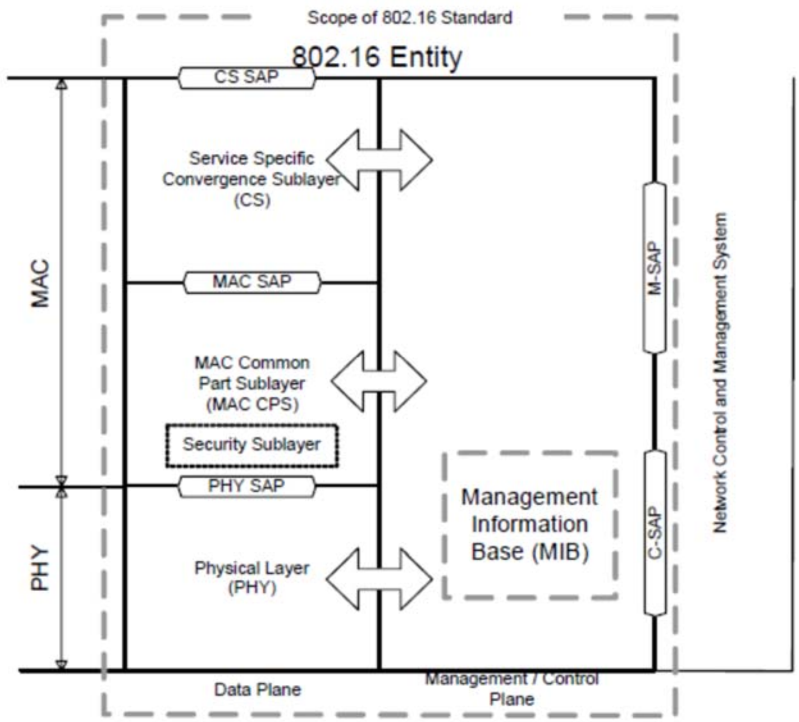


Figure 1-2 – Baseline AeroMACS Radio Unit Functionality per MOPs/MASPS.

1.4.1.1 AeroMACS Growth Concept

Aircraft systems are built to satisfy specific functions based on an airline customer specification and related industry standards. The supplier is responsible for defining all aspects of system behavior and thereafter maintaining the system configuration. This approach works very well for auto-pilots, flight deck displays and other systems that are associated with the aircraft. However, this is fundamentally opposite of the way that modern commercial computer networks are conceived and designed.

Commercial computer networks are built from components that can be combined and interconnected to create a purpose-driven platform upon which network services and applications can be executed. Commercial networks are defined to achieve specific minimum computing, throughput and routing capacity necessary to meet user requirements. System functionality is satisfied by applications that execute on the network platform.

Commercial computer networks can be modified or extended as user requirements change through the addition of new applications. If application resource requirements exceed the capacity of the existing network platform then the platform is extended to accommodate the new requirements.

Airborne networks, like their ground-based equivalents, are comprised of computational resources, mass storage, environmental interfaces, network distribution technologies and clients. Airborne networks can range from simple, function specific implementations to multi-domain networks.

Airborne networks may include connection to ground-based networks. Clients may be aircraft-operations specific such as Electronic Flight Bags (EFB) and Portable Electronic Devices (PEDs).

1.4.2 ARU Form Factors

The AeroMACS Radio Unit (ARU) may be one of two configurations. One configuration consists of an antenna (possibly with a preamp) mounted on top of the fuselage and a 2 MCU unit installed in the aircraft EE bay.

The other configuration consists of a passive antenna mounted on top of the fuselage and a flange mount unit located within 10 feet of the antenna.

Both form factors will require a means to configure, test, diagnose and troubleshoot the unit in the shop and on the aircraft.

Section 2.2 provides the details of both form factors.

1.4.3 Aircraft Local Area Network (LAN)

The primary function of the aircraft LAN is to provide a data communication network between the various Ethernet devices used to support the AeroMACS functional applications. It is expected that the aircraft LAN will use standard communications protocols compliant with ARINC Specification 664.

1.4.4 Antenna

A single antenna mounted on top of the fuselage, near the centerline, receives signals from the AeroMACS Base Station (BS) when the aircraft is on the ground. See section 7 for details.

1.5 Interchangeability

Interchangeability is desired between ARUs with like form factors (i.e., 2 MCU) with other 2 MCU units, and flange mount units with other flange mount units. The standards necessary to ensure this level of interchangeability for the ARU is set forth in Section 2 of this document.

Interchangeability is desired between AeroMACS aircraft antennas. The standards necessary to ensure this level of interchangeability for the AeroMACS antenna are set forth in Section 7 of this characteristic.

1.6 Regulatory Approval

This equipment could form part of an ATC data link system where the safe operation of the aircraft in the airport environment may be predicated on the reliability of the overall system.

This equipment is part of an aircraft information system conveying data intended for use by the flight crew and/or avionics systems. The equipment should meet all applicable International Civil Aviation Organization (ICAO), European Aviation Safety Agency (EASA), and Federal Aviation Administration (FAA) regulatory requirements. This document does not and cannot set forth the specific requirements that the equipment must meet to be assured of approval. However, some considerations and guidelines that may facilitate the certification process are given in section 3.0.

1.7 Integrity and Availability

The ARU software must comply with RTCA DO-178C Level D. Portions of the hardware may be required to comply with the requirements of RTCA DO-254.

COMMENTARY

Equipment manufacturers should note that this document aims to encourage them to produce high Mean Time Between Removal (MTBR), high performance equipment. They are at liberty to accomplish this by the use of design techniques they consider to be the most appropriate. Their airline customers are more interested in the end result than in the means to achieve it.

The anticipated operational use of the system demands the utmost attention to the need for reliability in all phases of system design, production, installation, and operation of the ARU and antenna. It is not the purpose of this Document to define specific Mean Time Between Failure (MTBF) or Mean Time Between Unscheduled Removal (MTBUR) requirements. However, it is of paramount importance to the airlines to operate a trouble free unit with minimum impact on scheduling and maintenance. A special emphasis should be given to total system quality, including built-in testing, ramp testing and shop testing to increase the MTBUR.

COMMENTARY

MTBUR has a profound effect on airline operations, despite a high MTBF. It is anticipated that specific reliability expectations will be negotiated between individual airlines and equipment manufacturers. A high MTBF (e.g., greater than 40,000 flight hours) is expected. Ideally, MTBUR should approach MTBF.

Airlines also have a high interest in reducing No Fault Found (NFF) rates with a goal of less than 20%.

COMMENTARY

Airlines have a heightened interest in identifying and correcting the root cause(s) of unnecessary LRU removals, many of which result in a NFF disposition. Each NFF occurrence represents an unacceptable additional and excessive cost of ownership to the airline. All efforts in the developmental process to eliminate NFF occurrences will go toward improving the MTBUR.

1.8 Testability and Maintainability

The total system quality should include adequate ability for the operator to test and maintain the ARU effectively. The designer should confer with the user to establish goals and guidelines for testability to minimize unnecessary removals. The use of advanced Built-In Test Equipment, ramp-testing equipment and adequate documentation will help the operators improve MTBUR. For airline operations, MTBUR is at least as important, perhaps more so, than MTBF. Testability should provide for the rapid identification of the root cause(s) of repeat removals and ultimate elimination of unconfirmed faults.

For shop maintainability, the design of physical access and functional partitioning of the ARU should be such to minimize repair time. Where possible, excessive unit disassembly should not be required for internal component replacement. Full and complete documentation included in a Component Maintenance Manual (CMM) will also facilitate effective maintainability.

Both form factors will require a means to configure, test, diagnose and troubleshoot the unit in the shop and on the aircraft.

1.8.1 Front Panel Indicators

The presence of front panel indicators can facilitate the testability and maintainability of the equipment. The nature and manner in which any information is displayed is left to the creativity and imagination of the designers. Indicators that show whether power is applied or not and unit status (failed, operational, etc.) are useful but not required.

2.0 INTERCHANGEABILITY STANDARDS

2.1 Interchangeability Objectives

This section sets forth the specific form factor, mounting provisions (including common mounting trays), defined connector pins, defined indexed keying pins, interwiring, input, and output interfaces and power supply characteristics for both ARU form factors.

Manufacturers should recognize the practical advantages of developing equipment in accordance with the standards set forth in this document.

2.2 Form Factors, Connectors, and Index Pin Coding

This document specifies two form factors and their respective properties such as connectors and index pin codes when applicable.

2.2.1 2 MCU Form Factor

The ARU should comply with the dimensional standards in ARINC Specification 600, “Air Transport Avionics Equipment Interfaces,” for the 2 MCU form factor. The ARU should also comply with ARINC Specification 600 with respect to weight, racking attachments, front and rear projections, cooling, and power consumption.

The ARU should be provided with a low insertion force, size 2 shell ARINC 600 service connector. This connector should be located on the center grid of the rear panel. The service interconnections are assigned to the middle plug (MP) and top plug (TP) inserts. The power and RF interconnections are assigned to the bottom plug (BP) insert.

Index pin code TDB should be used, see Attachment 2.

2.2.2 Flange Mount Unit Form Factor

This standard defines a flange mount unit form factor intended for installation near the antenna which eliminates the need for an active antenna or preamplifier.

The dimensions for the flange mount unit are shown in Figure 2.2.2-1 and are similar to those specified for the TWLU defined by Section 7 of ARINC Characteristic 763-3.

Width: 6.85 inches (174 mm) excluding connectors

Length: 11.5 inches (292 mm) including the flange mounts

Height: 2.5 inches max (102 mm)

Note that ARINC Characteristic 763 specifies 4 inches max height.

Flange thickness: 0.25 max?

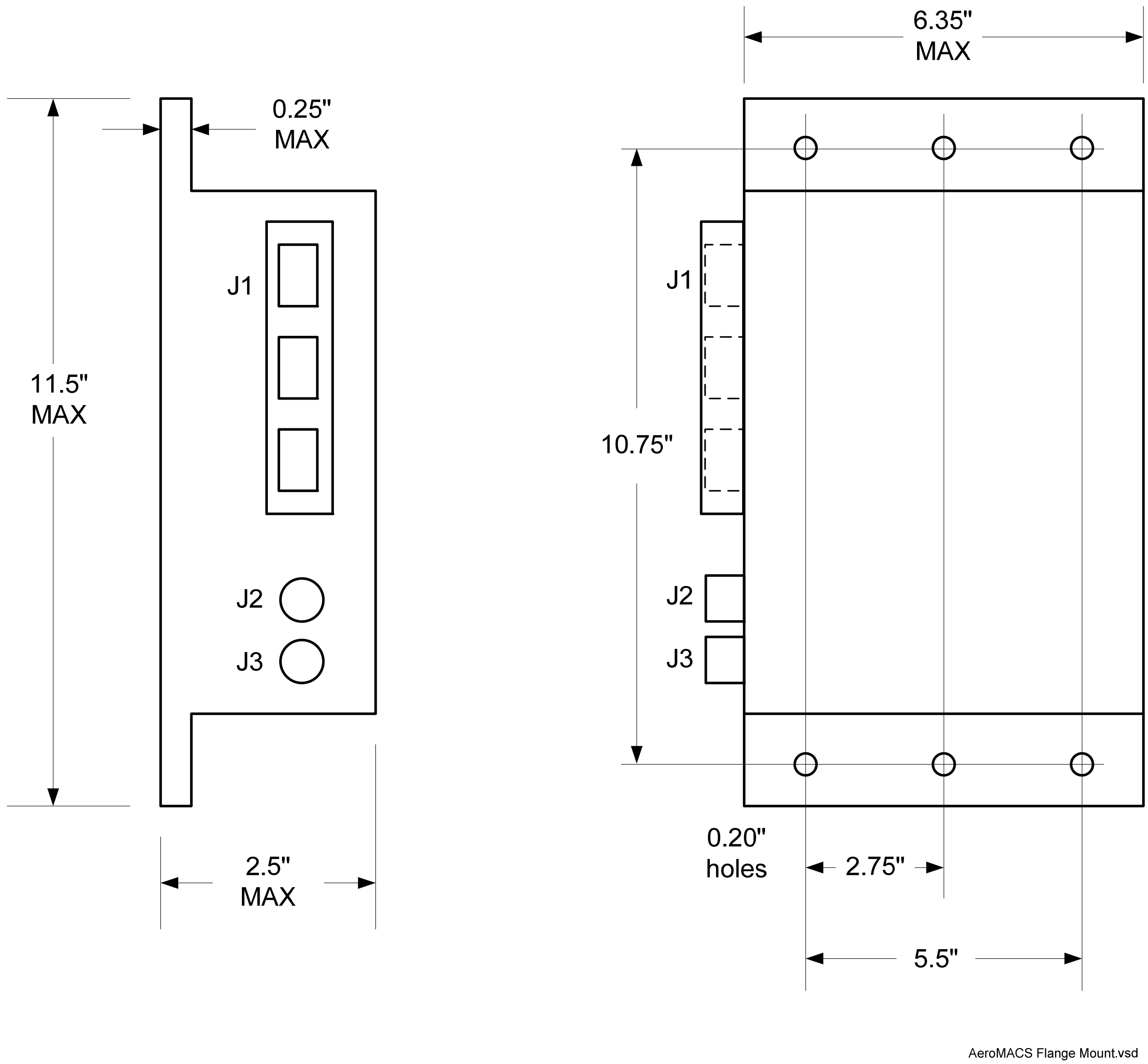


Figure 2.2.2-1 Flange Mount Unit Form Factor

The flange mounts should have three holes in each flange for mounting the unit. The middle hole should be centered with respect to the flange width. The two outside mounting holes should be 2.75 inches from the center of the middle mounting hole. The mounting holes should be centered and 10.75 inches apart along the unit's length.

The mounting screws or bolts should be of sufficient strength to sustain the unit under the maximum acceleration expected in the aircraft under normal and emergency conditions.

Connectors may protrude outside of the defined form-factor envelope at the approximate locations shown in Figure 2.2.2-1. Connector J1 contains the power and control signals, see Attachment 3 for pin assignments. Connector J2 is a standard female TNC type connector for connecting to the antenna cable.

Connector J3, when provided, is a standard female TNC type connector. Connector 3 is optional. Connector 3 is only used when the ARU supports a MIMO antenna and a MIMO antenna is installed on the aircraft.

Both the main (J2) and optional (J3) RF connectors should be clearly identified.

An optional test connector (J4) may be located on the same face as the other connectors in a location that minimizes interfering with installing and connecting the ARU to the aircraft cabling.

2.3 Power

For either form factor, the power source may be either 115 Vac, single phase ac 360 to 800 Hz power, or 28 Vdc power. Some units may be designed for only one type of power. It's not required to support both types of power. The aircraft ac power supply characteristics, utilization, equipment design limitations, and general guidance are set forth in **ARINC Report 413A:** *Guidance for Aircraft Electrical Power Utilization and Transient Protection*, and **ARINC Report 607:** *Design Guidance for Avionic Equipment.*

Aircraft wiring should be provided for **<u>either</u>** AC or DC power **<u>but not both</u>** in the same aircraft.

Equipment designers should take precautions to prevent anomalous operation of equipment during and after interruptions or transients in the aircraft power system. The equipment should, as a design goal, continue normal operation while sourcing current to all active guidance and flag outputs during power interruptions of up to 200 milliseconds duration for 115 Vac installations and 150 milliseconds duration for 28 Vdc installations. If the equipment shuts down during a power interruption, normal operation should resume without the need to recycle circuit breakers or clear memories when power is restored.

COMMENTARY

Consideration should be given to designs that provide even greater tolerance to power transients or short power losses, in order to minimize inconvenience caused by Operating System housekeeping and recovery activities. Some aircraft are equipped with power switching gear that does not meet industry specs and which exhibit power interrupts of up to 800 ms when switching between aircraft power and ground power.

The system should be designed to implement a clean shutdown sequence upon power outages that exceed the system's tolerance. The shutdown sequence should be designed to prevent data loss or file corruption.

2.3.1 Batteries

The use of batteries is discouraged. If batteries are used in the equipment designs, manufacturers should consider a design that allows battery removal and replacement without removal of the ARU from the aircraft.

COMMENTARY

Airline experience has shown that batteries have proven to be maintenance problems in avionics equipment. Manufacturers may consider the use of batteries to hold-up memory devices through power transients or long term power outages. Batteries might also be utilized to maintain real time clock circuits or for other purposes. However, the airlines encourage manufacturers to use design solutions other than batteries for these functions.

2.4 ARU Connectors

Similar connectivity is provided by both form factors. Attachment 2 and section 2.4.1 defines the connections for the 2 MCU form factor. Attachment 3 and section 2.4.2 defines the connections for the flange mount unit.

2.4.1 2 MCU ARINC 600 Rear Connector

The 2 MCU form factor should utilize a common ARINC 600 Size 2 rear connector.

Consider switching from Quadrax contacts to size 22 contacts for Ethernet. This could reduce shell size to 1.

2.4.1.1 Bottom Insert

The bottom insert contains the DC power, chassis ground, and RF antenna connections. The insert name is 5C2 (Radiall) and it contains contacts for:

- Two #5 contacts for the antenna coax connections,
- One #12 pin for chassis ground
- Two #16 for 28 Vdc power and return.

Pin assignments are shown in Table 2.4.1.1-1 and Attachment 2 Table 2-3.

Table 2.4.1.1-1 – 2 MCU ARINC 600 Connector Bottom Insert Pin Assignments

Contact	Signal Name
2	+28 Vdc
4	+28 Vdc Ground
3	Aircraft Chassis Ground
1	RF 1 Coaxial Size 5
5	Optional RF 2 Coaxial Size 5 for MIMO antenna

Pins BP2 and BP4 are for 28 VDC power when used.

Chassis ground is pin BP3.

Bottom insert pins BP1 and BP5 contain coaxial connectors associated with radio frequency signals

The ARU RF Coax input impedance should be a nominal 50 ohms over the AeroMACS frequency range.

Manufacturers may choose to implement two RF coax pins in Bottom Plug pins BP1 and BP5 for connection of two antennas (MIMO) in support of antenna diversity algorithms. Implementations that support two-antenna diversity should function without modification (other than a possible configuration setting change) with only a single antenna connection using pin BP1.

If the designer decides to not implement MIMO then pin BP5 on the ARU may remain unpopulated. Both RF connections are only required when the ARU supports the use of a MIMO antenna. The ARU should provide at least one RF pin (BP1) for connection of coax cable fed to an antenna externally mounted on the aircraft.

2.4.1.2 Middle Insert

The middle insert should be Arrangement TBD. Arrangement TBD provides two #8 pins for the Quadrax pins and TBD pins for other signals such as discrete and ARINC 429.

2.4.1.2.1 Middle Insert –Ethernet

Quadrax connectors should be used for all Ethernet connections. A single four pin Quadrax connector can support 100Base-TX Ethernet.

The Ethernet port should support auto-negotiation of 100 or 10 Mbps. Quadrax pin assignments for 100Base-TX are shown in Figure 2.4.1.2.1-1.

One of the Quadrax contact is used to communicate with the ACD and the other Quadrax contact is used to communicate with the AISD.

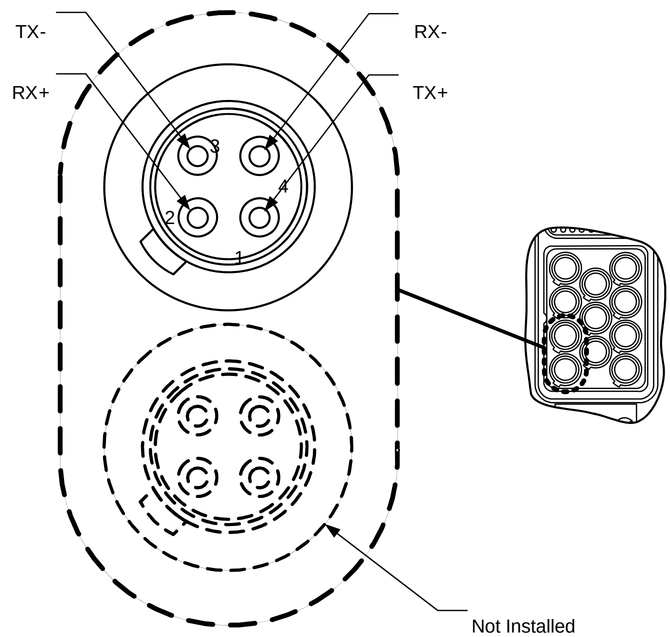


Figure 2.4.1.2.1-1 – Quadrax contact Pin Configuration for 100Base-TX

Since only 100Base-TX Ethernet is implemented in the ARU, the Quadrax connectors do not have to be used in pairs. Quadrax connectors should be used for all Ethernet connections. A single four pin Quadrax connector can support 100Base-TX Ethernet.

Middle insert Quadrax connectors may not be fully populated depending on component definition, however, all components should maintain the Quadrax layout defined in Table 2-5 for family commonality.

2.4.1.3 Top Insert

The top insert should be Arrangement TBD.

2.4.2 Flange Mount Unit Connectors

The flange mount configuration has two or three connectors depending on the type of antenna installed. J1 is the main connector with connections for power, Quadrax, ARINC 429, and discrete (everything but RF). Connector J2 and optional J3 provide RF connections to the antenna(s).

2.4.2.1 Flange Mount Unit Connector J1

The main connector (J1) for the flange mount ARU is a Radiall EPXB2 connector as shown in Figure 2.4.2.1-1. This connector utilizes Quadrax pins capable of supporting speeds up to 100Mbps. The connector has two inserts similar to an ARINC 600 connecter. The top/left insert should be populated with insert name 10Q2 (insert code E). The 10Q2 insert has two size 8 Quadrax contacts and eight size 20 contacts. The bottom/right most insert should be populated with insert name 40 (insert code X) which has 40 size 22 contacts

The ARU connector series EPXB2 as follows:

- Radiall P/N TBD or equivalent (connector body)
- Radiall P/N EPXBT10Q2PB or equivalent (A insert)
- Radiall P/N EPXBT40PB or equivalent (B insert)

The mating connector is:

- Radiall P/N TBD or equivalent (connector body)
- Radiall P/N EPXBE10Q2SB or equivalent (A insert)
- Radiall P/N EPXBT40SA or equivalent (B insert)

The connector polarization jackscrew should be set to Position B.

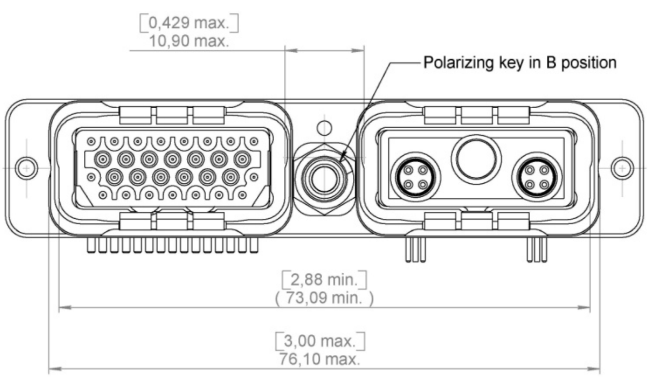


Figure 2.4.2.1-1 – Flange Mount Unit Connector J1 (WRONG INSERTS SHOWN)

2.4.2.2 Flange Mount Unit RF Connectors, J2 and J3

The ARU should use a standard female TNC type connector for the RF antenna interface(s). Both the main (J2) RF connector and optional (J3) RF connector of the ARU should be clearly identified. All ARU connectors may protrude outside of the defined form-factor envelope at the approximate location shown in Figure 2.2.2-1.

J3 is optional for installations that use MIMO. If MIMO is not implemented, then J3 may be omitted.

2.5 Environmental Conditions

The ARU should conform to the requirements of RTCA DO-160G/EUROCAE ED-14: *Environmental Conditions and Test Procedures for Airborne Equipment*. Attachment 4 to this document tabulates the relevant environmental categories in RTCA DO-160G/ED-14 for the 2 MCU ARU, the flange mount ARU and the antenna.

2.6 Cooling

This section provides guidance for ARU cooling.

2.6.1 2-MCU Form Factor Cooling

The 2 MCU form factor is expected to be designed to comply with ARINC Specification 600 cooling requirements (i.e., required pressure drop) regardless of whether it needs cooling air. The 2 MCU package should be capable of accepting cooling airflow from either bottom-to-top or top-to-bottom for maximum installation choices by the systems integrator. The coolant air pressure drop through the equipment should be 5 ±3 mm of water at standard conditions of 1013.25 mbars. If the 2 MCU ARU does not need cooling air then it should still be designed to expend this pressure drop. Adherence to the pressure drop standard is needed to allow interchangeability of equipment and to maintain the proper cooling air flow in the EE bay.

The 2 MCU ARU should dissipate less than of 50 watts of power.

A loss of cooling should not cause total loss of functionality, although a partial reduction in functionality is acceptable.

If the ARU requires cooling air, then the installation should provide an air flow rate of 13.6 kg/hr of 40 °C (max) air.

2.6.2 Flange Mount Unit Form Factor Cooling

The flange mount ARU should be designed to operate in a remote environment. It should be designed to operate without active cooling. The flange mount ARU should dissipate less than of 40 watts of power.

2.7 Weight

The 2 MCU form factor should be designed to weigh less than 12 pounds (5.5 kg).

The flange mount unit should be designed to weigh less than 10 pounds (4.5 kg).

2.8 Grounding and Bonding

Avionics equipment and airframe manufacturers should comply with Section 3.2.4, Electrical Bonding Interface, of ARINC Specification 600.

2.9 ARINC Standard Interfaces

The standard electrical inputs and outputs from the systems should be in the form of a digital format or switch contact.

Certain basic standards established herein are applicable to many signals. Signals should conform to the standards set forth in the subsections below.

2.9.1 Standard "Open"

The standard "open" signal is characterized by a resistance of 100,000 ohms or more with respect to signal common.

COMMENTARY

In some installations, a single switch is used to supply a logic input to several LRUs. One or more of these LRUs may utilize a pull-up resistor in its input circuitry. The result is that an “open” may be accompanied by the presence of + 27.5 Vdc nominal. The signal could range from 12 to 36 Vdc.

2.9.2 Standard “Ground”

A standard “ground” signal may be generated by either a solid state or mechanical type switch. For mechanical switch-type circuitry, a resistance of 10 ohms or less to signal common would represent the “ground” condition. Semiconductor circuitry should exhibit a voltage of 3.5 Vdc or less with respect to signal common in the “ground” condition.

2.9.3 Standard Discrete Input

A standard discrete input should recognize incoming signals having two possible states, “open” and “ground”. The characteristics of these two states are defined in Sections 2.9.1 and 2.9.2 of this document. The maximum current flow in the steady state “ground” state should not exceed 20 mA.

The “true” condition may be represented by either of the two states (ground or open) depending on the aircraft configuration.

The maximum input capacitance to ground should be less than 1 microfarad.

COMMENTARY

Past installations have used a large number of voltage levels and resistance’s for discrete states. In addition, the assignments of “Valid” and “Invalid” states for the various voltage levels and resistance’s were sometimes interchanged, which caused additional complications. In this document, a single definition of discrete levels is being used in an attempt to “standardize” conditions for discrete signals.

The voltage levels and impedance used are, in general, acceptable to hardware manufacturers and airlines. This definition of Discrete is also being used in the other 700-Series Characteristics. However, there are a few exceptions for special conditions.

The discrete inputs to the ARU are expected to take the form of switches mounted on the airframe component (weight-on-wheels, flap, including gear, etc.) from which the input is desired. These switches can either connect the Discrete Input pins on the connector to airframe dc ground or leave them open circuit as necessary to reflect the physical condition of the related components.

The ARU design should provide the dc signal to be switched. Typically, this is done through a pull-up resistor connected to the discrete input. The equipment input should sense the voltage on each input to determine the state (open or closed) of each associated switch.

The selection of the values of voltages and resistances, which define the state of an input, is based on the assumption that the Discrete

Input utilizes a ground-seeking circuit. When the circuit senses a low resistance (10 ohms or less) or a voltage of less than 3.5 Vdc, the current flow from the input should signify a “ground” state. When a voltage level between 18.5 and 36 Vdc is present or a resistance of 100,000 ohms or greater is presented at the input, little or no current should flow. The input may utilize an internal pull-up to provide for better noise immunity when a true “open” is present at the input. This type of input circuit seems to be favored among both manufacturers and users.

Because the probability is quite high that the sensors (switches) are providing similar information to a number of users, the probability is also high that unwanted signals may be impressed on the inputs from other equipment, especially when the switches are in the open condition. For this reason, equipment manufacturers are advised to base their logic sensing on the “ground” state of each input. Also, both avionics suppliers and airframe manufacturers are cautioned concerning the need for isolation to prevent sneak circuits from “contaminating” the logic. Typically diode isolation is used in the avionics equipment to prevent this from happening.

The maximum input capacitance requirement was added because some implementations included an excessive amount of capacitance which caused current spikes which, in some cases, caused current spikes that tripped over current circuits.

2.9.4 Standard Discrete Output

A standard Discrete output should exhibit two states, “open” and “ground” as defined in Sections 2.9.1 and 2.9.2. In the “open” state, the design should present an output resistance of at least 100,000 ohms. In the “ground” state the design should be able to sink at least 20 milliamperes of steady state current. Non-standard current sinking capability may be defined.

COMMENTARY

The designer is cautioned that discrete input capacitance and discrete output slew rates have caused current spikes which in some cases caused the over current protection circuits of the output drivers to activate.

2.9.5 Standard Program Pin Input

Program pins may be assigned to the ARU connector for the purpose of identifying a specific aircraft configuration or to select (enable) optional performance.

COMMENTARY

Program pins may be used for a variety of purposes. Program pins enable a piece of equipment to be used over a greater number of airframe types. One way this is done is by identifying the unique characteristics of the airframe in which the unit is installed. Another way is to identify the location (left, right, center) of the unit. Often program pins are used to enable (turn on) options for alternate or extended performance characteristics.

The encoding logic of the program pin relies upon two possible states of the designated input pin. One state is an “open” as defined in Section 2.9.1 of this Document. The other state is a “ground” (short circuit i.e., 10 ohms or less) to the pin designated as the “program-common” pin.

COMMENTARY

Normally, the “primary” location or “usual”, “common” or “standard” function is defined by the “open” logic and the optional response is programmed (encoded) by connection.

2.9.6 Ethernet Ports

The Ethernet ports should comply with ARINC Specification 664 Part 2. The Ethernet ports should support 100Base-TX.

COMMENTARY

ARINC Specification 664 defines compliant and non-compliant IEEE 802.3 Ethernet interfaces. These interfaces are expected to be used with ARU and with traditional avionics equipment respectively. ACD and AISD networks are expected to be compliant networks. For general Ethernet design guidance, ARINC Specification 664 should be referenced.

Some aircraft use a variant of Ethernet called Avionics Full-Duplex Switched Ethernet as documented in Part 7 of ARINC Specification 664.

The 100Base-TX PHY employs a full duplex baseband transmission over two pairs of 100-ohm wire. Each of the two pairs is a full duplex channel supporting an effective data rate of 100 Mbps simultaneously.

COMMENTARY

1000Base-T was originally considered but then changed to 100Base-TX because of the following guidance in ARINC Specification 664 Part 2 “The performance requirements for the aircraft cabling and connectors are more restrictive for 1000Base-T operation, as compared to those required for 10Base-T or 100Base-TX systems. The deployment of 1000Base-T on commercial aircraft requires special emphasis on component selection and wire assembly processes. For data rates greater than 100 Mbps, fiber optic solutions are generally preferred.”

3.0 SYSTEM DESIGN CONSIDERATIONS

3.1 AeroMACS Avionic System Architecture

The use of AeroMACS is relevant to both the ACD and AISD domains, to support ATM and AOC applications.

See Appendix A for a discussion of various AeroMACS communication architectures and scenarios assuming current and future ACD and AISD architectures, each one representing a possible ARU implementation.

3.1.1 ARU "On/Off" Control

Operation of the RF portion of the ARU is only allowed while the aircraft is on the ground. This document defines an ARU interface to control the "on/off" mode of the ARU transceiver. The "on/off" control logic should be implemented within the ARU to supply (or not supply) power to the ARU transceiver based on the aircraft status (airborne or not airborne) as indicated by the discrete inputs.

The ARU should provide two standard open/ground discrete inputs for external signals, such as Weight-On-Wheels (WOW) or Air/Ground Strut Switch or from other avionics like the Failure Warning Computer (FWC) to indicate the aircraft status. The ARU transceiver should be powered <u>only</u> when both "on/off" control discrete inputs are in the grounded state thus indicating that the aircraft is on the ground. When either discrete input is open then the ARU transceiver should be powered down. Other functions within the ARU, such as BIT or health monitoring/reporting, may remain powered up and operational during flight as long as all RF transmissions are inhibited.

3.1.2 ACD and AISD

There are two data domains of interest with respect to AeroMACS; the Aircraft Control Domain (ACD) and the Airline Information Services Domain (AISD).

The ACD includes traditional avionics equipment providing safety services to the flight crew. This may include data services such FANS 1/A, ARINC Specification 623, and FMC AOC applications. The ACD also includes ACARS AOC data from the CMU such as OOOI message, crew info, as well as data from other types of avionics equipment. It is expected that the ACD will continue to expand to include FANS 2/B (Aeronautical Telecommunication Network (ATN)) and eventually FANS build 2 applications.

The AISD data consists of IP-based messaging from an AISD IP router. These are non-safety services that may be related to aircraft dispatch and airline communication. The EFB with IP connections to the AISD IP router may be part of the AISD network.

In-Flight Entertainment (IFE) falls into the Passenger Information and Entertainment System (PIES) domain, and is considered to be outside the scope of this standard.

The designer is encouraged to consider what hardware (CPU, memory, etc.) will be required to support and interface with the ATN/IPS router envisioned to be installed in the ACD, and include the appropriate hardware provisions so that the upgrade may be limited to a software upgrade.

If the ARU has the appropriate security, data segregation and control design then the ARU could simultaneously be connected to the ACD and the AISD. This approach is very similar to solutions currently envisaged for the introduction of IP-based satellite communication services in the ACD (e.g., Iridium and Inmarsat-Swift Broad band (SBB)).

Since AeroMACS is a native-IP system, it could be connected directly to the AISD Open-IP router. The connectivity with the ACD ACARS+ATN router would be by an appropriate SubNetwork Dependent Convergence Function Layer. A similar solution has been already tested and validated under the SANDRA Project, allowing interoperability between ARUs and ATN/OSI routers. Reference material from SANDRA project is TBD.

A security capability, on top AeroMACS security framework, should be implemented at IP level. ARU security capabilities should encompass:

- Data Authentication, Ciphering and Integrity check functions, to improve privacy and integrity of data.
- A Firewall function to segregate the back of the aircraft from the ACD and AISD domains and denying the Open-IP router access to the ACD and AISD domains.

To provide domain separation, security requirements in a single ARU may increase the complexity of the ARU compared to having two ARUs. One approach is to have a single ARU serving both ACD/AISD and non-ACD/AISD Users as shown in Figures 3.1.2-2 and 3.1.2-3. Some designers may opt for a simpler ARU design and install separate ARUs for the ACD/AISD and non-ACD/AISD Users as shown in Figures 3.1.2-1 and 3.1.2-4.

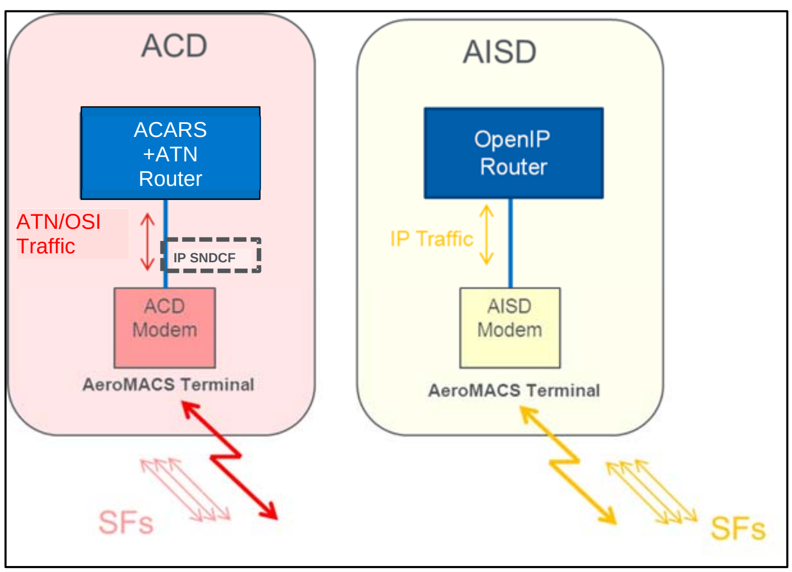


Figure 3.1.2-1 Separate AeroMACS Radio Units for ACD (ACARS and ATN) and AISD

3.0 SYSTEM DESIGN CONSIDERATIONS

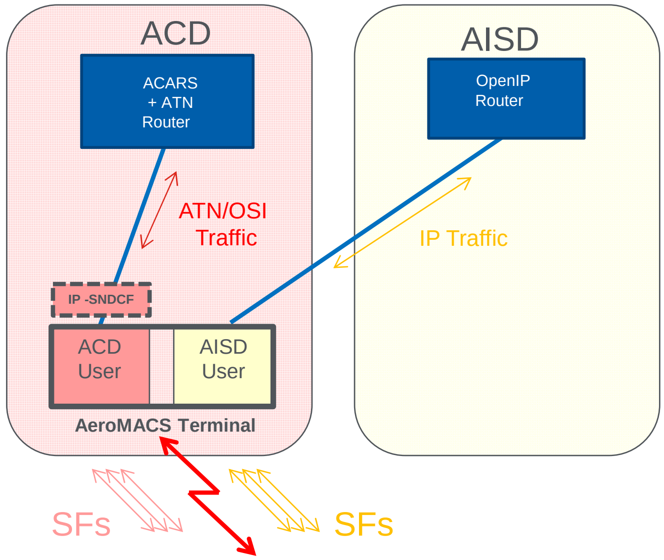


Figure 3.1.2-2 One ARU connected to ACD and AISD

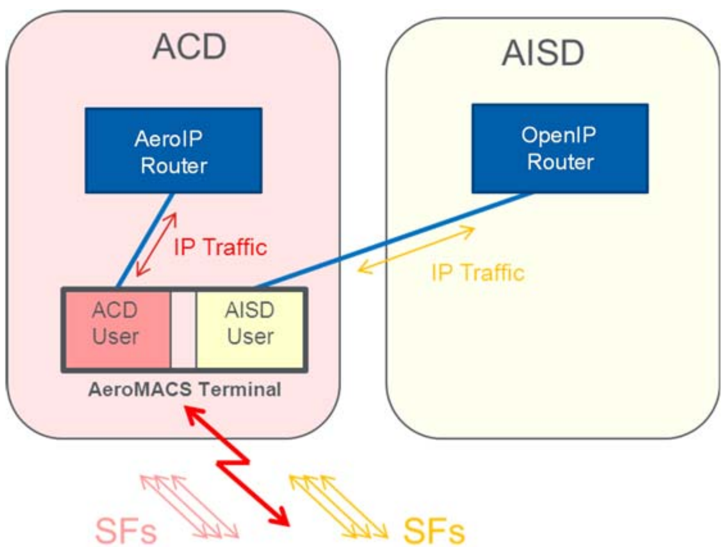


Figure 3.1.2-3 One ARU with IP connections to ACD and AISD

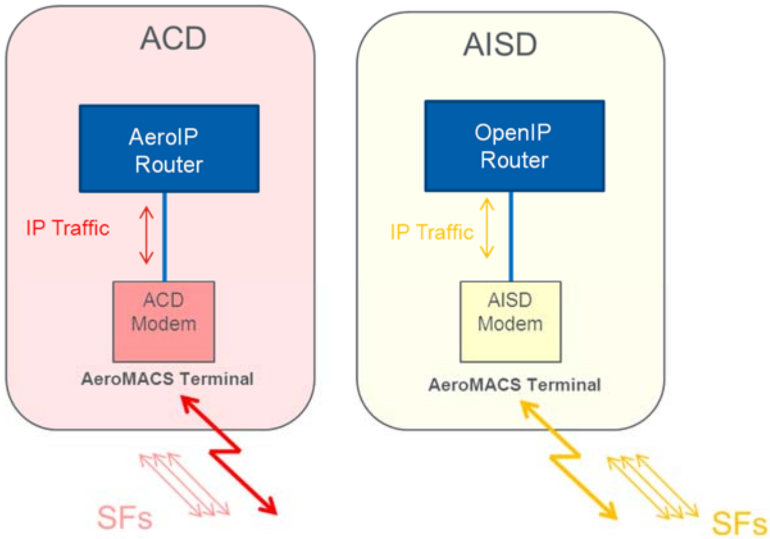


Figure 3.1.2-4 Separate AeroMACS Radio Units with IP connections with ACD and AISD

3.1.3 SubNetwork Dependent Convergence Function Layer

SubNetwork Dependent Convergence Function Layer. A similar solution has been already tested and validated under the SANDRA Project, allowing interoperability between the ARUs and ATN/OSI routers.

Bridge between legacy avionics (such as CMU and ACARS) and IP network like AeroMACS. (Refer to ATN IPS APIM work product?)

3.2 System Flexibility

The ARU should be designed using established industry standards and open systems architecture that may be frequently and easily upgraded at a reasonable cost. The ARU should use widely available COTS components.

3.3 Certification and Partitioning Considerations

The ARU will contain software that provides functions that are expected to evolve over time.

The ARU should be capable of reporting its software configuration to the Network Management Service. Any software component that is loaded into an ARU should include a pattern recognition (checksum, CRC or other similar error detection) which should be validated by the Network Management Service to verify that the software database elements are correctly loaded. The specific means by which validation is performed should be compatible with the criticality level of the specific software component. The Network Management Service should also verify that all other previously loaded components are not affected following the load of a specific software component.

To support certification of the ARU, qualification tests should be performed to validate the operational characteristics of its intended functions. In addition to the testing described in RTCA DO-160 and RTCA DO-178, the supplier should conduct various qualification tests developed by airframe manufacturers and service providers as part of the activities to obtain airworthiness approval.

Recommended Design Assurance Level (DAL) for AeroMACS hardware and software is RTCA DO-178C Level D.

3.4 ARU Operational Software and Data Loading

The ARU should have the means to update its operational software programs and data bases electronically. The objective of data loading is to facilitate modifications to various software components within the ARU without the need to remove the units from the aircraft, and to avoid disrupting normal aircraft operations.

The ARU software and data may be loaded using the most economic means available. ARU software uploads are not specifically required to meet ARINC Report 615 or ARINC Report 615A software loading provisions. The current media include, but are not limited to CD-ROM, DVD, and file transfer using wired or wireless LAN.

4.0 FUNCTIONAL CAPABILITY

4.1 Functional Description

This section describes the functional aspects of the ARU without specific regard to the mechanics of protocols and interfaces, which are used to support those functions.

See Section 5 for details of the interfaces and protocols provided, and Section 6 for functions related to maintenance and support of the ARU.

The ARU functions as a flexible data communication system implemented as an extension to, or as an alternative for, a wired LAN. In the airport environment, the ARU will extend (bridge) an aircraft network to a ground-based network (wired or wireless, airline or Civil Aviation Authority (CAA)). The ARU will alleviate the need for network wires between the aircraft and the airport (e.g., jetway).

The RTCA DO-346 MOPS describes additional ARU functional capabilities.

4.1.1 Roaming

4.1.1.1 Airport Roaming

The use of a wireless connection between aircraft and airport will seamlessly support a connection while the aircraft is moving. See Figure 4.1.1.1-1. With an airport infrastructure of multiple wireless Base stations forming separate cells with some coverage overlap, aircraft may remain connected to the ground-based airport LAN as they move around the airport during taxi.

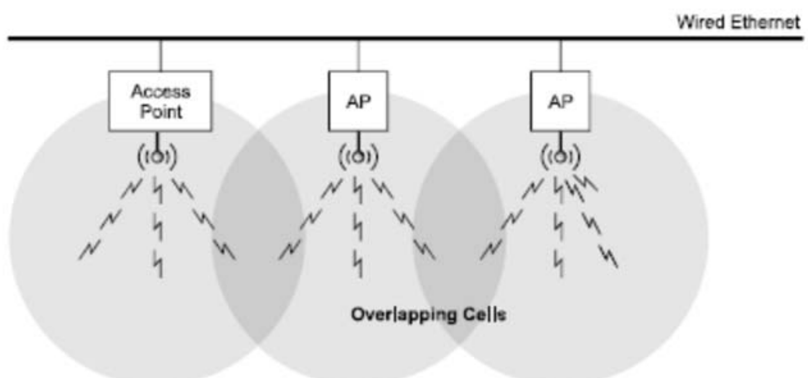


Figure 4.1.1.1-1 - typical Overlapping wireless base station coverage

4.1.1.2 Country Roaming

The airlines expect that the AeroMACS network will be identical worldwide. This is the key to worldwide use and interoperability. The wireless LAN connection should satisfy the needs of airlines that fly between airports located in different countries. The ARU should automatically adapt to the local regulations of each country. This document does not specify these local regulations. IEEE 802.16e provides additional guidance.

4.1.2 SubNetwork Dependent Convergence Function Layer

SubNetwork Dependent Convergence Function Layer. A similar solution has been already tested and validated under the SANDRA Project, allowing interoperability between ARUs and ATN/OSI routers.

Bridge between legacy avionics (such as CMU and ACARS) and IP network like AeroMACS. (Refer to ATN IPS APIM work product?)

4.1.3 100Base-TX Ethernet

Refer to ARINC Specification 664 Part 2.

Half duplex or full duplex? Determine at run time? Other considerations?

4.1.4 Others TBD

4.2 Control and Display

MOPS Section 4.1.2 states “with the equipment operating, verify that the displays required for the selection and annunciation of various communication modes/functions of operation are operating and readable”. Also see MOPS section 4.2.2

MOPS Section 4.1.3 states “Cockpit control(s) required for proper operation of the equipment shall be available for use.” Also see mops section 4.2.3: “the communication controls shall be operated, as required, to verify satisfactory equipment response”

MOPS Section 4.2.4 states “send a test message”

MOPS Section 4.2.5 states “all equipment failure annunciators shall be tested during pre-flight” is a requirement for the EICAS/ECAM/CDS. The ARINC 429 status word(s) provided by the ARU provide the info for the display system.

4.3 Configuration

Some configuration possibilities are provided by the program pins defined in section.

Other configuration method(s) maybe required to select various AeroMACS configuration options such as SSID especially if the operator wants to use a private network instead of the airport’s network.

4.4 Security

Refer to ARINC Report 811 and ARINC Report 821?

4.5 Maintenance

The ARU should include maintenance and network service client interface features to enable the ARU to securely communicate, be centrally or remotely monitored, and troubleshot using the available network services.

The ARU BIT should also be remotely executable from the aircraft management function with results accessible for central testing, reporting and maintenance purposes.

In order to minimize network maintenance complexity, ARINC Report 624 defines a Central Maintenance Service as part of the Network Management Service to collect all BITE information and derive a system-level BITE by correlation of the individual component BITE information. The data are collectively presented in a central Management Information Base (MIB) in a hierarchical structure.

The ARU should host its own local Management Information Base (MIB), accessible by SNMPv2 or later, as described in ARINC Report 821. As a minimum, the local MIB should include BIT procedures and access to maintenance logs.

The ARU MIB should include the following types of information:

- Hardware part number
- Software part number(s)
- Hardware status
- Configuration Status
- Application and Process Status
- Resource Status
- Functional Status
- TBD…..

A standard MIB for SS is present in IEEE 802.16-2009. PAR 13.1.6.

5.0 INTERFACES AND PROTOCOLS

5.1 Discrete Inputs

5.1.1 RF Transmitter On/Off Discrete Inputs

The RF transmitter On/Off discrete inputs control whether the RF transmitter is powered (operational) or not.

When either one or both discrete inputs are open circuit then the RF transmitter is disabled (unpowered, inhibited).

When both discrete inputs are grounded then the RF transmitter is powered and active thus permitting communication with AeroMACS base stations located at the airport.

The signal(s) that drive these ARU inputs should ONLY ground the ARU discrete inputs when the aircraft is on the ground. Aircraft signals such as Weight On Wheels (WOW) switch or strut switch are appropriate for driving these ARU inputs. Other possible signal sources are:

- Flight deck switch which would give pilot explicit control for better or worse
- TBD?

Flange mount unit pins are defined to be TBD and TBD.

2 MCU form factor pins are TBD and TBD

TWLU has up to 4, do we need more than 2?.

5.1.2 SDI Program Pins

Two (one?) SDI program pins is defined so that two or more ARUs can be installed on the same aircraft.

SDI 1	SDI 2	ARU location
Open	Open	1
Open	Grounded	2
Grounded	Open	3
Grounded	Grounded	4

Or Is 2 sufficient?

SDI 1	ARU location
Open	1
Grounded	2

The ARU should read the SDI Program pin(s) at power up or when reset. The ARU may read the SDI Program pin periodically for BIT purposes and report intermittent connectivity.

Flange mount unit pin is TBD.

2 MCU form factor pin is TBD.

5.1.3 Reset Discrete Input

The Reset discrete input provides a means by which an external discrete signal can reset the ARU.

When the Reset discrete input is grounded then the ARU is reset and remains in the reset state as long as the Reset discrete is grounded.

When the Reset discrete input is released (open circuit) then operation begins with a full initialization of ARU memory.

Flange mount unit pin is TBD.

2 MCU form factor pin is TBD.

5.1.4 GPS ARINC 429 Receiver Configuration

If the GPS ARINC 429 receiver configuration pin is open circuit then that indicates that the GPS data source is transmitting using ARINC 429 high-speed (100kbps).

If the GPS ARINC 429 receiver configuration program pin is grounded then that indicates that the GPS data source is transmitting using ARINC 429 low-speed (12.5-14 kbps).

The ARU should read the GPS ARINC 429 receiver configuration program pin at power up or when reset. The ARU may read the GPS ARINC 429 receiver configuration program pin periodically for BIT purposes and report intermittent connectivity.

Flange mount unit pin is TBD.

2 MCU form factor pin is TBD.

5.1.5 Optional MIMO Program Pin

The optional MIMO program pin may be implemented to explicitly inform the ARU whether or not it is connected to a single antenna or two antennas for MIMO.

If the optional MIMO program pin is grounded then that indicates that the aircraft is equipped with MIMO antennas. If the ARU is capable of utilizing the MIMO antenna then it will. If the ARU does not support MIMO then it does not matter whether the optional MIMO Program pin is grounded or open.

If the optional MIMO program pin is open, that indicates that the aircraft is equipped with a single AeroMACS antenna.

The ARU should read the optional MIMO program pin at power up or when reset. The ARU may read the optional MIMO program pin periodically for BIT purposes and report intermittent connectivity.

Flange mount unit pin is TBD.

2 MCU form factor pin is TBD.

5.1.6 CMC ARINC 429 Speed Select

Ask Airbus whether this is really needed?

The CMC ARINC 429 speed select program pin indicates whether the ARINC 429 Tx and Rx used to communicate with the Central Maintenance computer(s) should operate at high-speed (100 kbps) or low-speed (12.5 kbps).

IF the CMC ARINC 429 speed select program pin is grounded then that indicates that low-speed ARINC 429 should be used.

IF the CMC ARINC 429 speed select program pin is grounded then that indicates that high-speed ARINC 429 should be used.

The ARU should read the CMC ARINC 429 speed select program pin at power up or when reset. The ARU may read the CMC ARINC 429 speed select program pin periodically for BIT purposes and report intermittent connectivity.

Flange mount unit pin is TBD.

2 MCU form factor pin is TBD.

5.2 Discrete Outputs

5.2.1 Unit Status (Fault) Output

The Unit Status discrete output indicates whether the ARU thinks it is operational or not.

If the Unit Status discrete output is grounded that indicates the ARU status is either not normal (Failed) because a serious fault was detected by BIT or the Reset discrete input is grounded.

When the Unit Status discrete output is open circuit that indicates the ARU is normal.

The states of the Transmitter On/Off discrete inputs input should not affect the state of the Unit Status Discrete output.

When the Reset discrete input is grounded and as long as it remains grounded then the Unit Status discrete output should be grounded also to indicate that normal operation is suspended until the Reset discrete goes open circuit then the Unit status discrete output should transition to open circuit at an appropriate time during the restart process.

Flange mount unit pin is TBD.

2 MCU form factor pin is TBD.

5.3 ARINC 429 Interfaces

5.3.1 GPS ARINC 429 Interface

ARINC 429 receiver #1 is assigned to pins TBD and is expected to be connected to a source of GPS data. The ARU collects UTC and date data from GPS. An accurate source of UTC is required by the AeroMACS wireless protocol. UTC and date may also be used to time stamp entries in the internal status/fault log. Other data provided by GPS, such as altitude, latitude and longitude may be useful to acquire. There is a discrete input program pin (GPS 429 receiver configuration, see Section 5.1.4) to indicate whether the GPS source is transmitting at high-speed or low-speed ARINC 429.

If the GPS 429 receiver configuration program pin is open circuit then that indicates that the GPS data source is transmitting using ARINC 429 high-speed (100 kbps).

If the GPS 429 receiver configuration program pin is grounded then that indicates that the GPS data source is transmitting using ARINC 429 low-speed (12.5-14 kbps).

5.3.2 ARU ARINC 429 Broadcast Words

Every ARU ARINC 429 transmitter should transmit the ARU broadcast words/labels defined in the following subsections, including the reserved ARINC 429 transmitters

All ARU broadcast labels 172, 270 and 377 should use the following SSM definition:

SSM	31	30
Normal	0	0
NCD	0	1
Functional test	1	0
Failure warning	1	1

5.3.2.1 ARU Label 172

Proposed Label 172 bit definition (same as power point):

Bits	Function	Comments
1-8	Label 172 octal	
9-16	SAL	Same value for all units installed since only one is wired to CMU. SAL to be assigned TBD, ARINC 619 or ARINC 429?
17-29	Pad	Set to zero (or as defined below?)
30-31	SSM	
32	Parity (odd)	

Maybe include ARINC 429 input status?

Or MIMO supported?

17	GPS input	1=active, 0=inactive
18	CFDIU 1 input	1=active, 0=inactive
19	CFDIU 2 input	1=active
20	CMU 1 input	1=active
21	CMU 2 input	1=active
22	Supports MIMO	1 = yes, 0 = no

5.3.2.2 ARU Label 270

Proposed Label 270 bit definition (same as power point).

Move bits 25-29 to label 172 or 377? Or create label 350?

Add bit to indicate MIMO antennas detected?

Bits	Function	Comments
1-8	Label 270 octal	
9-10	SDI	If SDI 1 program pin is gnd then bit 9 is 1 else 0. If SDI 2 program pin is gnd then bit 10 is 1 else 0.
11	Status	Fault =1, ok=0
12	Antenna 1 coax status	If VSWR > 5 then set to 1 else 0
13	Antenna 2 coax status	If VSWR > 5 then set to 1 else 0. set to 0 if antenna 2 is not used

Bits	Function	Comments
14	Radio on/off	0=radio on, 1=radio off. Reflects status of discrete input
15	Xmit on/off	0=xmit enabled, 1= xmit inhibited. Reflects status of discrete input
16	Connected	0=connected to BS, 1 = no connection
17	Signal detected	0=signal detected, 1=no signal detected
18-24	Reserved	Set to zero. SUGGESTIONS?
25	GPS input	1=active, 0=inactive
26	CFDIU/CMC 1 input	1=active, 0=inactive
27	CFDIU/CMC 2 input	1=active
28	CMU 1 input	1=active
29	CMU 2 input	1=active
30-31	SSM	
32	Parity (odd)	

5.3.2.3 ARU Label 377

Proposed Label 377 bit definition (same as power point):

Bits	Function	Comments
1-8	Label 377 octal	
9-10	SDI	If SDI 1 program pin is gnd then bit 9 is 1 else 0. If SDI 2 program pin is gnd then bit 10 is 1 else 0.
11-22	Equipment class	TBD ARINC
23-29	Pad	Set to zero. SUGGESTIONS?
30-31	SSM	
32	Parity (odd)	

5.3.2.4 Others Labels TBD 350?

5.3.3 CMU ARINC 429 interface

ARINC Characteristic 758 defines a high-speed ARINC 429 interface for Gatelink which could be used to connect the CMU and ARU.

COMMENTARY

At the time of this writing the interface definition is incomplete and may require updates to ARINC Specification 618, ARINC Specification 619, ARINC Characteristic 758, and other documents.

ARINC Characteristic 758 contains provisions for dual CMU installations therefore the ARU should have two ARINC 429 receivers dedicated to CMU 1 and CMU 2. As shown in Attachment 2, CMU 1 and Table 5.3.3-1. One ARINC 429 receiver should be wired to CMU 1 as shown in Table 5.3.3-1. The other ARINC 429 receiver should be wired to CMU 2 as shown in Table 5.3.3-1.

Table 5.3.3-1 CMU-ARU ARINC 429 Connections

ARU I/O	2 MCU pins	Flange mount pins	CMU pins
ARINC 429 output to CMU 1 & 2	TBD	TBD	CMU 1 and CMU 2 MP-08J,K
ARINC 429 RX for CMU 1	TBD	TBD	CMU 1 TP-13H,J
ARINC 429 RX for CMU 2	TBD	TBD	CMU 2 TP-13H,J

The ARU has one ARINC 429 transmitter which should be connected to both CMUs as shown in Table 5.3.3-1. The ARINC 429 transmitter should be configured for high-speed ARINC 429.

The ARU should transmit the ARINC 429 broadcast labels defined in Section 5.3.2.

ARINC 429 file transfers to the CMU should use the CMU's System address label (SAL) of 304 octal per ARINC Specification 619. Since there is only one SAL for CMU 1 and CMU 2 and the same transmitter is connected to both CMUs then it is expected that only the master CMU will process the received file.

1. Is this limitation (ARU can only communicate with only active CMU, not Standby CMU) ok?
2. If not then alternatives:
   a. Maybe separate ARINC 429 transmit in each ARU, one for each CMU?
   b. Assign second SAL to CMU only for use with ARU?
3. Maybe both CMU process received file?
4. Master CMU transfers the file/data to the standby CMU

The ARU should accept file transfers that contain its SAL of TBD per ARINC Specification 619 from either CMU regardless of whether it's the master or standby CMU.

The ARU and the CMU should use high-speed ARINC 429 Williamsburg version 3 file transfer protocol as defined in ARINC Specification 429 Part 3.

A suitable data format (GFI) for ACARS messages is defined as TBD. Other GFIs for other types of data/messages (not ACARS) such as ATN or data loading for example TBD?

5.3.4 CMC/CFDIU ARINC 429 Interface

To be provided by Airbus

5.4 Ethernet Interfaces

The ARU should be designed to operate with any equipment that supports ARINC Specification 664 Part 2 compliant 100Base-TX Ethernet.

5.4.1 ACD Ethernet Interfaces

The Quadrax pins in the upper section of the connector (insert/plug A) should be used for communicating with ACD and AISD devices.

5.4.2 AISD Ethernet Interface

The Quadrax pins in the middle section of the connector (insert/plug B) should be used for communicating with non-ACD and non-AISD devices.

6.0 MAINTENANCE AND TEST

6.1 Built-In Test Provisions

6.1.1 General Discussion

A primary focus for the specification of the ARU design is the integrity, maintainability, availability and ease of installation for the ARU under various configuration options. Through use of comprehensive Built-In Test (BIT) capabilities and attention to a maintainable design in the definition of this system, maintenance costs, and repair time can be minimized. In addition, the ARU will make use of comprehensive network and equipment monitoring through use of Simple Network Management Protocol (SNMP). This will allow for remote access to the ARU using Commercial Off-The-Shelf (COTS) systems to help reduce maintenance and engineering labor and costs.

The ARU BIT design, and associated Built-In Test-Equipment (BITE) should facilitate bench testing. Error modes encountered on the aircraft should be reproducible in the shop. Error messages should be closely related to and assist in bench testing, allowing the error to be duplicated. System faults should be classified based on their effect on the system as debilitating or non-debilitating. All errors detected should be kept in non-volatile storage capable of recording a minimum of 40 non-repeated faults.

BIT functions should be performed upon return to service (or after a power off cycle) and on a continuous basis. The ARU should be capable of manual initiation of a comprehensive self-test as a part of the BIT design.

BIT fault reports should enable the operator to isolate the cause of a fault and provide adequate information for repair of the system.

Options, applications or other software elements that are disabled in the delivered system will not be included in the self-test or continuous BIT.

The self-contained fault detection should incorporate non-volatile memory and logic to identify true hardware faults based on historical trends.

The system should also incorporate built-in debugging tools, annunciators, test buttons, and/or memory readout, to facilitate troubleshooting. These tools should be categorized for line maintenance or engineering use, as appropriate.

COMMENTARY

It is important to remember that ALL aspects of the testing program (i.e., BIT, ramp, shop testing) contribute to the reliable and profitable operation of a system by the end users. The ability of the system to identify faults and facilitate their repair has a profound effect on maintainability and overall reliability. Attention to a close relationship between aircraft faults and shop testing should help in reducing the number of unscheduled removals.

6.1.2 Self-Contained Fault Detection and Reporting

All elements of ARU should provide self-contained fault detection and reporting capabilities as a part of the BIT design. The ARU should be capable of displaying and reporting fault data or BIT status results when installed on the aircraft.

COMMENTARY

BIT status can be reported in many different ways. For example, BIT status may only be reported via a pass/fail annunciator on the front panels of the ARU. The ARU may also display its status on a CDU/MCDU or other display device (e.g., Laptop, MAT, etc.).

6.1.3 Ramp Return to Service Testing

When an ARU is installed on an air transport aircraft, some form of end-to-end testing should be available to:

- Provide an operational verification of the system functions prior to return to service.
- Reduce unnecessary removals of ARU elements when the fault was actually in another part of the system.

As an end-to-end test, the test procedure must verify the integrity of the ARU, as well as interface with other systems and applicable antenna connections. All elements of the ARU should support return to service testing in a line maintenance environment. ARU ramp test should also have provisions for in hangar testing.

The return to service test results should indicate the probable cause of failure in order to minimize needless replacement of healthy equipment.

Additional system return-to-service guidance is provided in ARINC Report 821.

COMMENTARY

Emphasis on end-to-end system testing should lead to an increase in the Mean Time Between Unscheduled Removals (MTBUR), especially for removals not related to LRU faults.

7.0 ANTENNA

The ARU should provide at least one RF connector (J2) for connection to an antenna externally mounted on the aircraft using coax cable. This document does not specify the type of ARU antenna to be used due to the evolution of this technology and the availability of acceptable designs.

This document defines a standard footprint for the antenna in order to facilitate provisioning an aircraft for AeroMACS. See Attachment 7 for standard antenna mounting provisions.

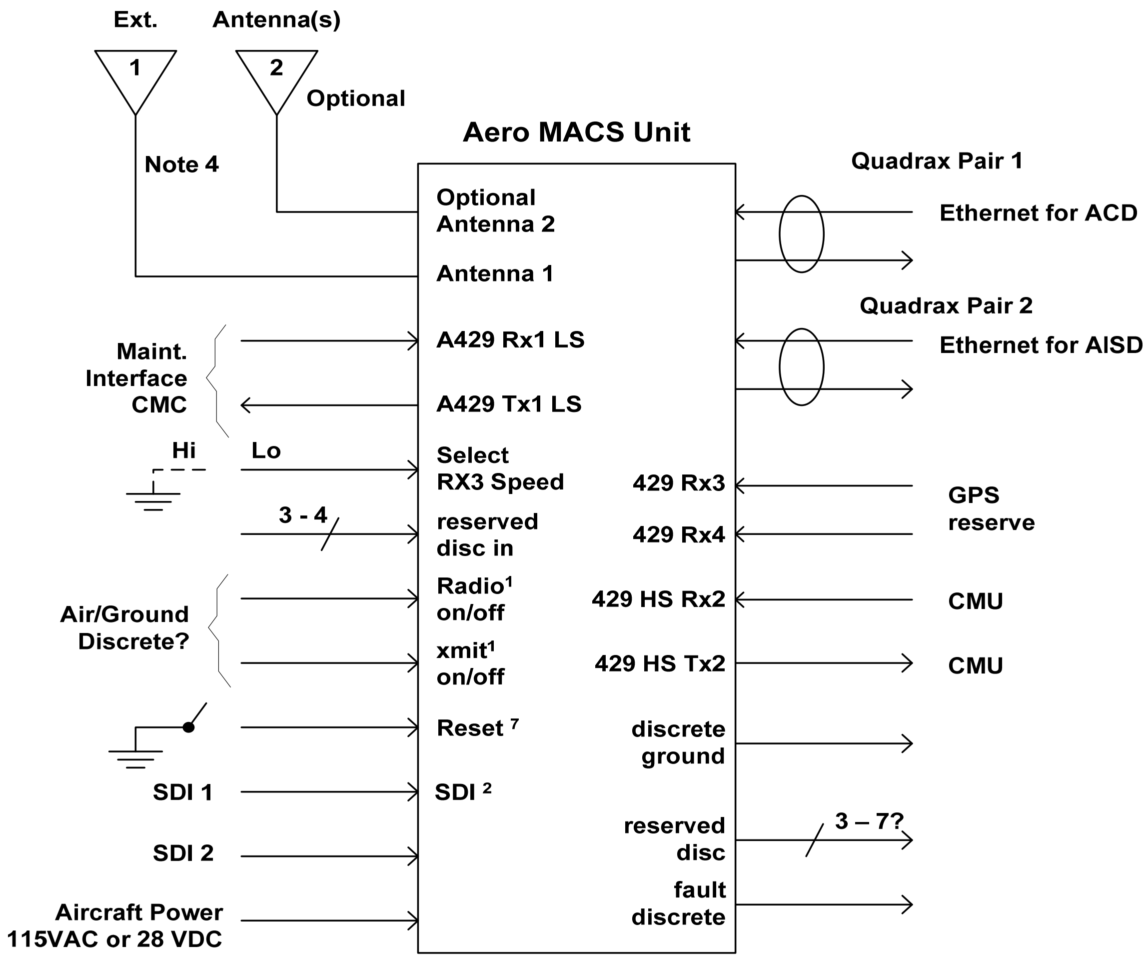
This document also defines some antenna properties in order to facilitate system connectivity and interoperability.

- Impedance: with the antenna installed and connected to the antenna cable, the impedance should 50 ohms over the frequency range 5000 to 5150 MHz
- VSWR: with the antenna installed and connected to the antenna cable, the VSWR should be less than or equal to 2:1 over the frequency range 5000 to 5150 MHz per RTCA DO-346 Section 3.2.1.1.
- Standard ARU antenna connector: TNC female
- The AeroMACS antenna should have a radiation pattern that is omni-directional in the horizontal plane.
- The AeroMACS antenna vertical radiation pattern should be nominally equivalent to that of a quarter-wave monopole on a ground plane.
- The antenna should be predominantly vertical polarization over 5000 to 5150 MHz. Response to horizontally polarized signal should be at least 10dB below the response to vertically polarized signals emanating from the same direction per RTCA DO-346 Section 3.2.2.
- Protected against lightning

Redundant: Manufacturers may choose to implement two RF TNC coax connectors (J2 and J3 in Figure 2.2.2-1) for connection of two antennas in support of diversity algorithms (MIMO). Implementations that support two-antenna diversity should function without modification (other than a possible configuration setting change) with only a single antenna connection using connector J2.

ATTACHMENT 1
ARU AVIONICS BLOCK DIAGRAM

ATTACHMENT 1 ARU AVIONICS BLOCK DIAGRAM



Notes:
1. Redundant? Consolidate into one discrete input? Radio or Xmit on/off?
2. SDI program pins for multiple AU installation? Figure 3-8
3. Program pin to select GPS A429 Rx2 speed
4. Preamp?
5. ADL Interface? Ethernet
6. CMU interface? A429 to match A758? Ethernet? or both?

SDI 2	SDI 1	Unit Location
open	open	1
open	gnd	2
gnd	open	3
gnd	gnd	4

AeroMACS blk dia.vsd

ATTACHMENT 2 2 MCU REAR CONNECTOR INSERT LAYOUT

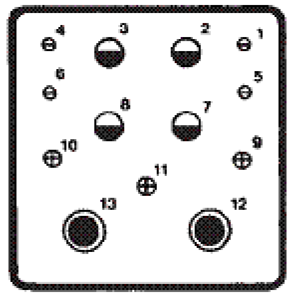
Table 2-1 – Top Plug (TP) Insert

ATTACHMENT 2
2 MCU REAR CONNECTOR INSERT LAYOUT

Table 2-2 – Middle Plug (MP) Insert

ATTACHMENT 2
2 MCU REAR CONNECTOR INSERT LAYOUT

Table 2-3 – Bottom Plug (BP) Insert

Contact	Signal Name
	
1	115 Vac, 360 to 800Hz Hot
2	+28 Vdc
3	+28 Vdc Ground
4	No connection
5	No connection
6	No connection
7	115 Vac, 360 to 800Hz Neutral
8	Aircraft Chassis Ground
9	No connection
10	No connection
11	No connection
12	RF 1 Coaxial Size 5 for primary antenna
13	Optional RF 2 Coaxial Size 5 for MIMO antenna

ATTACHMENT 3 CONNECTOR PIN DESIGNATIONS – FLANGE MOUNT ARU

Connector	Pin	Signal
J1	1	spare
	2	spare
	3	Radio On/Off Discrete Input
	4	ATE
	5	mfg defined
	6	mfg defined
	7	mfg defined
	8	Transmitter On/Off Discrete Input
	9	mfg defined
	10	mfg defined
	11	mfg defined
	12	mfg defined
	13	Unit Reset Discrete Input
	14	mfg defined
	15	ARU status
	16	mfg defined
	17	ATE
	18	mfg defined
	19	mfg defined
	20	ATE
	21	+28 Vdc RTN
	22	+28 Vdc
	23	Chassis GND
	24	ATE
	25	GND
	26	ATE
	27	GND
	28	ATE
	29	GND
	30	ATE
	31	
	32	
	33	
	34	
	35	
	35	
	37	
	38	
	39	
	40	
	41	
TBD	1	Ethernet1 (Primary) ARU Port
	2	spare
	3	Ethernet2 (Secondary) ARU Port
TBD	1	TX+ PRI_100_TX_A/SEC_100_TX_A
	2	RX+ PRI_100_RX_A/SEC_100_RX_A
	3	TX- PRI_100_TX_B/SEC_100_TX_B
	4	RX- PRI_100_RX_B/SEC_100_RX_B

ATTACHMENT 4 RTCA ENVIRONMENTAL TEST CATEGORIES

RTCA DO-160E Section	TEST/EQUIPMENT	2 MCU	Flange Mount	Antenna
		Cat/Remarks	Cat/Remarks	Cat/Remarks
4.0	Temperature & Altitude	A1	A1	D2
4.5.4	Loss of Cooling	V	X	X
5.0	Temperature Variation	C	B	A
6.0	Humidity	A	A	C
7.0	Shock	B	B	A
8.0	Vibration (Random)	SB	SC	SC
9.0	Explosion Proofness	X	X	E
10.0	Water Proofness	X	X	S
11.0	Fluids Susceptibility	X	X	F
12.0	Sand and Dust	X	X	D
13.0	Fungus Resistance	X	X	F
14.0	Salt Spray	X	X	S
15.0	Magnetic Effect	A	C	X
16.0	Power Variation	E Z	E Z	X
17.0	Voltage Spike	B	B	X
18.0	AF Conducted Susceptibility	E/Z	E/Z	X
19.0	Induced Signal Susceptibility	A	Z	X
20.0	RF Susceptibility	T	V	X
21.0	Emission of RF Energy	M	M	X
22.0	Lightning Induced Transient Susceptibility	A1/E1	A1/E1	X
23.0	Lightning Direct Effects	X	X	2A
24.0	Icing	X	X	A
25.0	Electrostatic Discharge (ESD)	A	A	X

Note: These environmental categories specified in this table are generic and are intended to pertain to a wide-variety of equipment installations. Specific airframe types may have more stringent requirements.

ATTACHMENT 5 EXAMPLE SYSTEM ARCHITECTURE – AIRCRAFT NETWORK

ATTACHMENT 6 CONSIDERATIONS FOR 100BASE-TX ETHERNET LAN

6.1 Interface Requirements

Ethernet interface requirements should comply with **ARINC Specification 664 Part 2:** *Aircraft Data Network* for 100Base-TX Ethernet. ARINC 766 components specify the use of Quadrax contacts.

6.2 Noise Immunity

Noise immunity test requirements are per RTCA DO-160.

6.3 Line Termination

No line termination is required for 100Base-TX Ethernet operation.

6.4 Line Impedance

Line impedance requirements are per ARINC Specification 664, Part 2, 100Base-TX Ethernet. 100 ohm cable should be used.

Refer to ARINC Specification 664, Part 2, for cabling requirements for 100Base-TX applications.

ATTACHMENT 7 ANTENNA MOUNTING FOOTPRINT

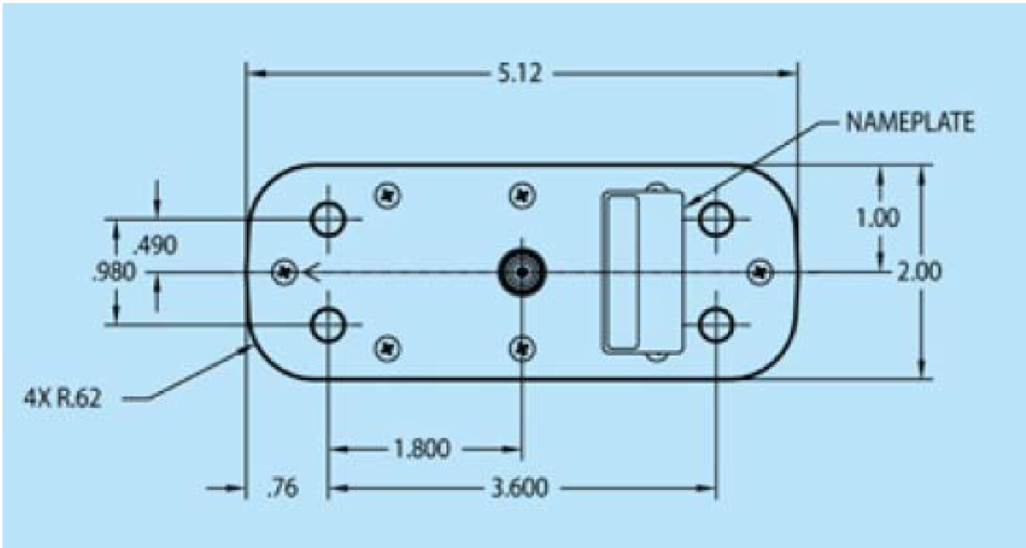


Figure 7-1 Aeromacs Single Antenna with One TNC Female Connector and Standard L-Band Four Hole Foot Print

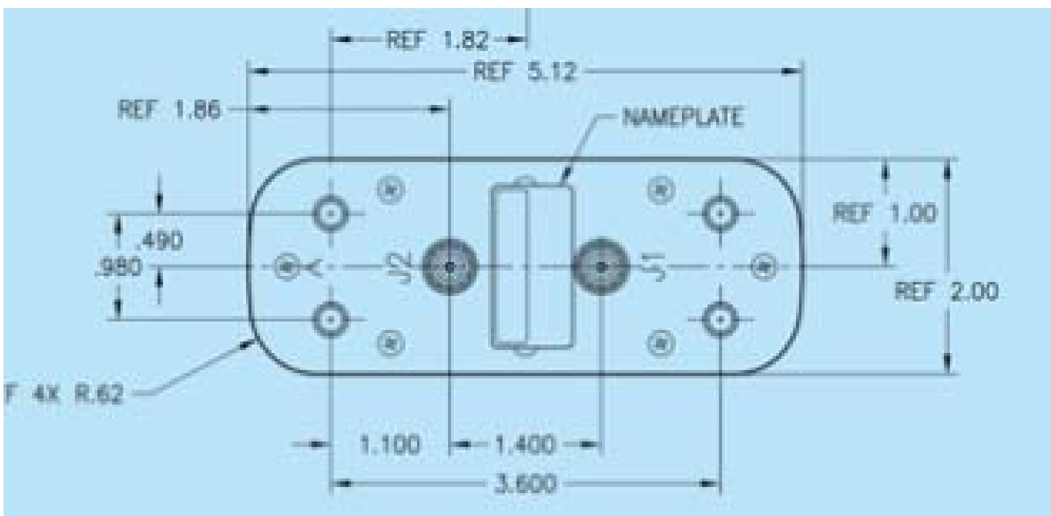


Figure 7-2 Aeromacs MIMO Antenna with Two TNC Female Connector and Standard L-Band Four Hole Foot Print

ATTACHMENT 8 TBD

ATTACHMENT 9 ACRONYMS AND ABBREVIATIONS

ACD	Aircraft Control Domain
ACMS	Aircraft Condition Monitoring System
ADN	Aircraft Data Network
AEEC	Airlines Electronic Engineering Committee
AISD	Airline Information Services Domain
AOC	Airline Operational Control
API	Application Program Interface
ARU	AeroMACS Radio Unit
ATE	Automatic Test Equipment
AWG	American Wire Gauge
BIT	Built-In Test
BITE	Built-In Test Equipment
BS	AeroMACS Base Station
CAA	Civil Aviation Authority
CMU	Communications Management Unit
CMM	Component Maintenance Manual
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
CRC	Cyclic Redundancy Checking
DITS	Digital Information Transfer System
EFB	Electronic Flight Bag
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESR	Ethernet Switch Router
ESU	Ethernet Switch Unit
FOQA	Flight Operations Quality Assurance
FWC	Failure Warning Computer
GB	Gigabytes
IFE	In-Flight Entertainment
I/O	Input/Output
IP	Internet Protocols
LAN	Local Area Network
LRU	Line Replaceable Unit
Mbps	Megabits per second
MCU	Modular Concept Unit
MIB	Management Information Base
MIMO	Multiple Input Multiple Output
MTBF	Mean Time Between Failure
MTBUR	Mean Time Between Unscheduled Removals

ATTACHMENT 9
ACRONYMS AND ABBREVIATIONS

NAS	Network Attached Storage
NFF	No Fault Found
NSS	Network Server System
NSU	Network Server Unit
OSI	Open System Interconnect
PED	Portable Electronic Device
PIES	Passenger Information and Entertainment System
P/N	Part Number
QoS	Quality of Service
RES	Remote Ethernet Switch
RF	Radio Frequency
RX	Receive
SBB	Swift Broad band
SNMP	Simple Network Management Protocol
TWLU	Terminal Area Wireless LAN Unit
TX	Transmit
WOW	Weight-On-Wheels

APPENDIX A AEROMACS AVIONICS SYSTEM ARCHITECTURE

As stated in Section 1.4, AeroMACS may be utilized in both ACD and AISD domains on the aircraft for the purpose of supporting ATM and AOC applications.

Various scenarios are described in this appendix using various ACD and AISD communication architectures, each one representing a possible ARU implementation.

A-1Scenario 1-A – Initial Installation of the ARU in the AISD

Scenario 1-A shows that the ARU could be installed as an additional communication medium in the AISD, attached to the existing AISD "Open-IP" router, as a complement or alternative technology to the various Gatelink technologies (Wi-Fi/ GSM/GPRS/EDGE/UMTS/LTE/WiMAX).

In this scenario, the ARU could be implemented as stand-alone equipment similar to current TWLU equipment, or could be integrated within Gatelink equipment.

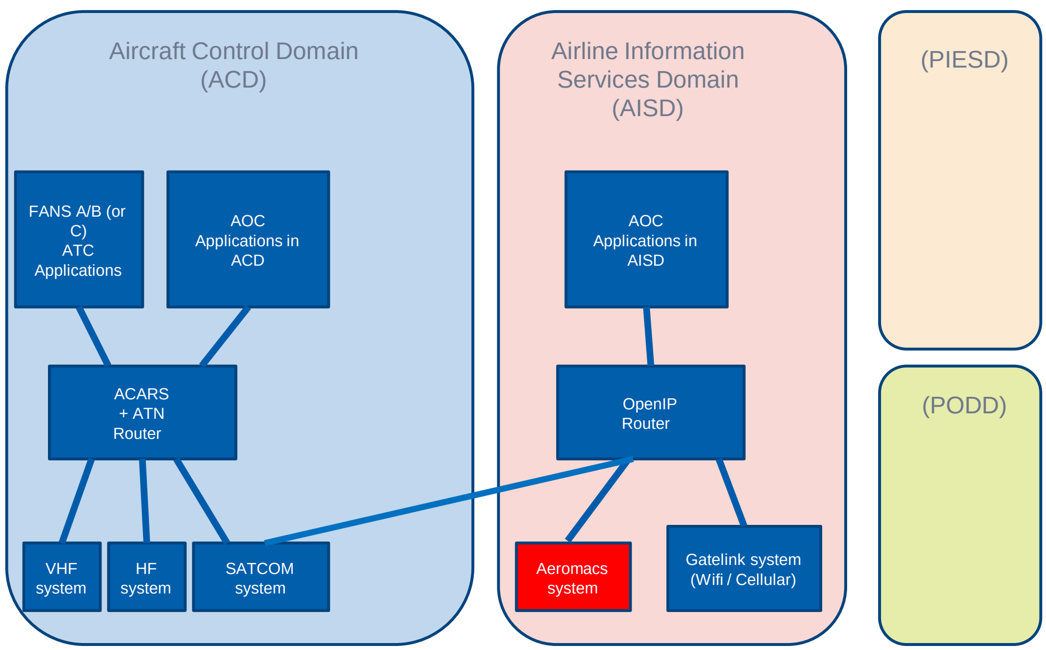


Figure A-1 – AeroMACS Radio Unit (ARU) integration on Aircraft – Scenario 1-A

A-2Scenario 1-B – Initial Installation of the ARU in the ACD

Scenario 1-B shows the ARU connected to the AISD, but designed and pre-installed to be hosted in the ACD in preparation of the longer-term scenario 3A/B described below. In terms of initial capabilities and supported services, this ARU is the same as the one shown in Scenario 1-A. The difference with Scenario 1-A is that a Scenario 1-B ARU would be designed and possibly installed to directly interface with the ACD and the associated ACD avionics systems. In particular, a Scenario 1-B ARU could be designed with the physical Inputs/outputs modules (e.g., ARINC 429, ARINC 664) necessary to interface with the ACD systems generally involved in the monitoring, control, and maintenance of ACD radio communication systems (e.g., to support possible interfaces with an ACD Radio

Management Panel (RMP) or Multi-Purpose Display Unit (MCDU), with the Failure Warning Computer (FWC), with the Aircraft Centralized Maintenance System (CMS), and Data Loading and Configuration System, etc. The equipment would also be designed with provisions to support an interface to an ATN/IPS router expected to be installed in the ACD in the long-term.

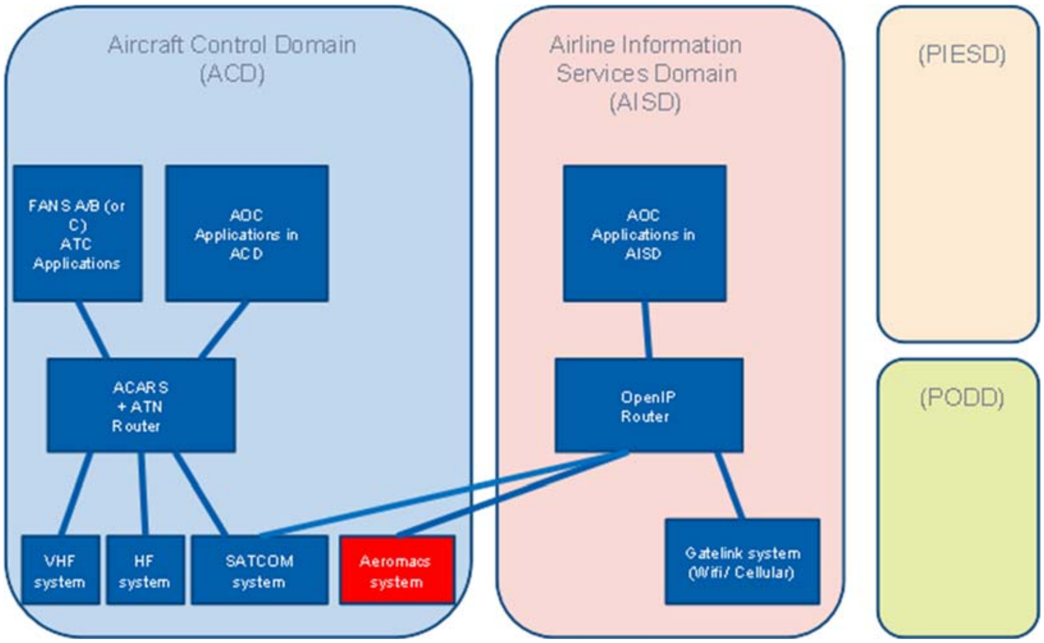


Figure A-2 – AeroMACS Radio Unit (ARU) Integration on Aircraft – Scenario 1-B

A-3Scenario 2-A – Installation of the ARU in the ACD

Scenario 2-A shows that the ARU could be developed and certified providing the following capabilities: 1) the ARU (Mobile Station) functions, 2) an initial IP router function, 3) a (optional) security function at IP Level, 4) a function allowing the encapsulation of ACARS messages over IP (and AeroMACS) and 5) a function allowing the encapsulation of ATN/OSI messages over IP (and AeroMACS).

AeroMACS must assure a secure air-to-ground and ground-to-air communications, implementing authentication (PKMv2), data encryption (AES) and integrity check. On top of the AeroMACS security framework the ARU can optionally implement a security capability at IP level (e.g., IPSEC) to improve privacy and integrity of communications. An (optional) Firewall capability, to improve segregation of the ACD from the Open-IP world, can be also added.

APPENDIX A
AEROMACS AVIONICS SYSTEM ARCHITECTURE

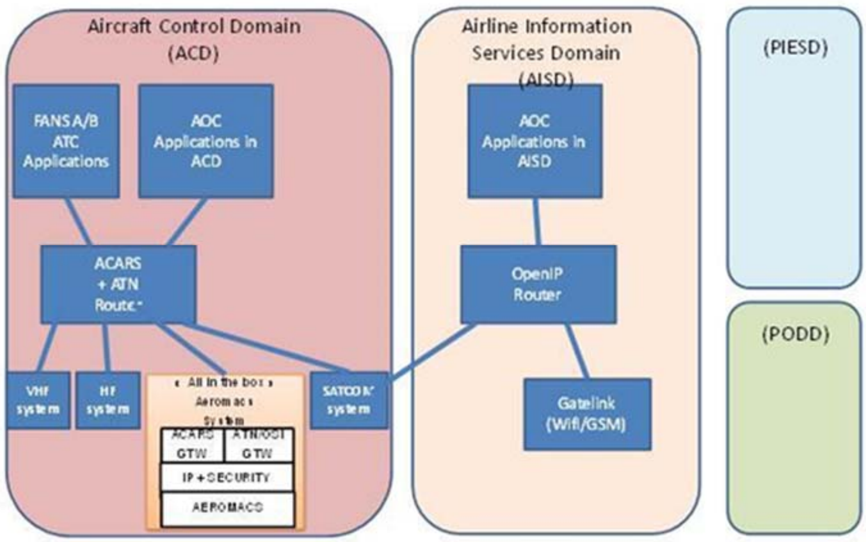


Figure A-3 – AeroMACS Radio Unit (ARU) Integration on Aircraft – Scenario 2-A

A-4Scenario 2-B – Installation of the ARU in both the ACD and AISD

The ARU could simultaneously be connected to the ACD and AISD domains, and at the same time provide the needed segregation among ACD and AISD users. This approach is very similar to solutions that introduce IP-based satellite communication services in the ACD (e.g., Iridium and Inmarsat SBB).

Because AeroMACS is a native-IP system, it could be connected directly to the AISD Open-IP router. Connectivity with the ACD ACARS/ATN router depicted in Figure A-4 could be provided by an appropriate Subnetwork Dependent Convergence Function (SDCF) layer.

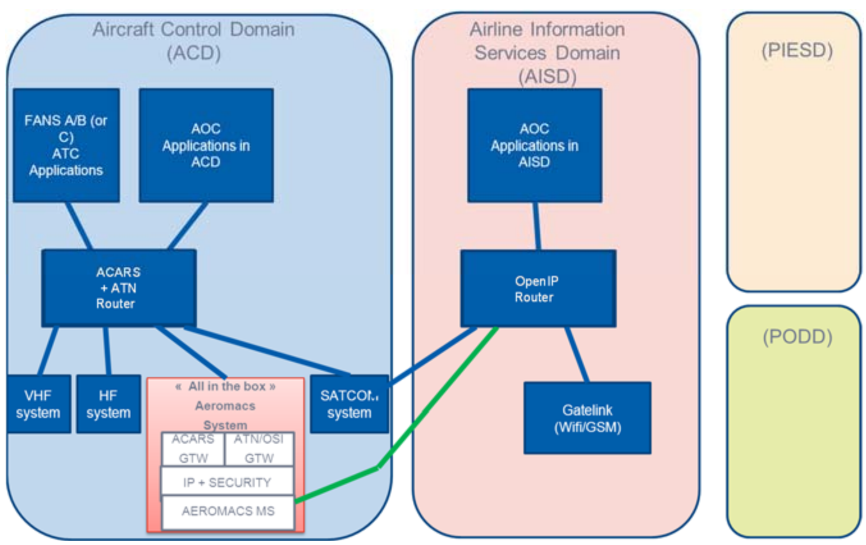


Figure A-4 – AeroMACS Radio Unit (ARU) Integration on Aircraft – Scenario 2-B

APPENDIX A
AEROMACS AVIONICS SYSTEM ARCHITECTURE

A similar architecture has been tested and validated under the SANDRA project, allowing interoperability between ARUs and ATN/OSI routers as shown in Figure A-5.

A security capability, on top AeroMACS security framework, should be implemented at the IP level. ARU security capabilities should encompass:

- Data Authentication, Cyphering and Integrity check functions, to improve privacy and integrity of data.
- A Firewall function to segregate the ACD from the AISD, preventing Open-IP access to the ACD.

It has to be noted that the needed Security Requirements to be guaranteed by this Scenario increase the complexity of the ARU, providing however the advantage of having a single ARU connecting both ACD and AISD Users.

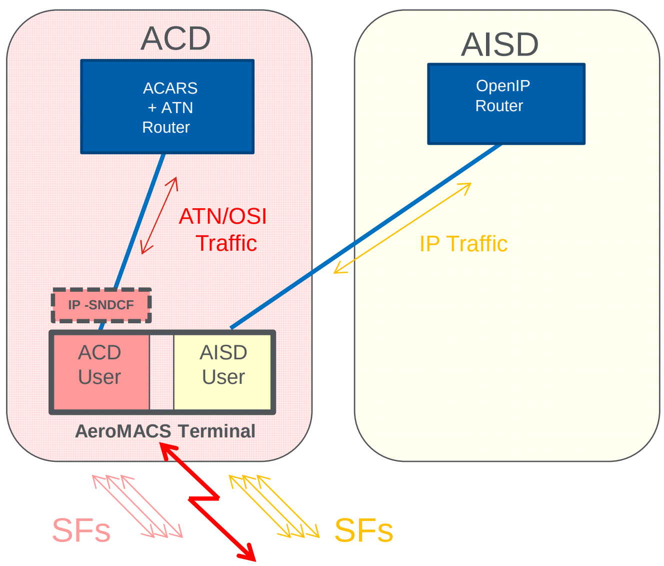


Figure A-5 – Scenario 2-B: Connection between AeroMACS Radio Unit (ARU) and ACD/AISD

A-5Scenario 3-A – Installation of the ARU in the ACD

Scenario 3-A shows that aircraft may be equipped with ATN/IPS router in the ACD. In this scenario, the ARU will become an integral part of the radio-communication system in ACD, attached to the ATN/IPS router.

APPENDIX A
AEROMACS AVIONICS SYSTEM ARCHITECTURE

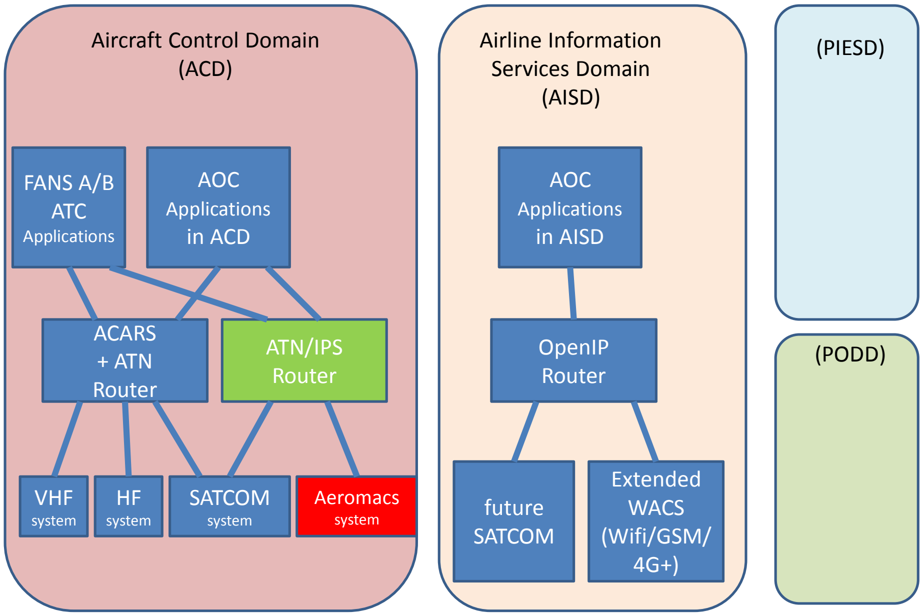


Figure A-6 – AeroMACS Radio Unit (ARU) Integration on Aircraft – Scenario 3-A

A-6Scenario 3-B – Installation of the ARU in ACD and AISD

Scenario 3-B shows that in a longer term, the aircraft will be equipped with an ATN/IPS router in the ACD, the ARU will be developed as a certified (Level D) radio-communication system of the ACD, attached to both the ATN/IPS router and the AISD “Open-IP” router. The needed segregation between ACD and AISD users will be granted by the ARU and by IP level security capabilities (as explained in the scenario 2-B) implemented between the ATN/IPS (referred to also as Aero-IP) and Open-IP routers (outside the ARU onboard system).

APPENDIX A
AEROMACS AVIONICS SYSTEM ARCHITECTURE

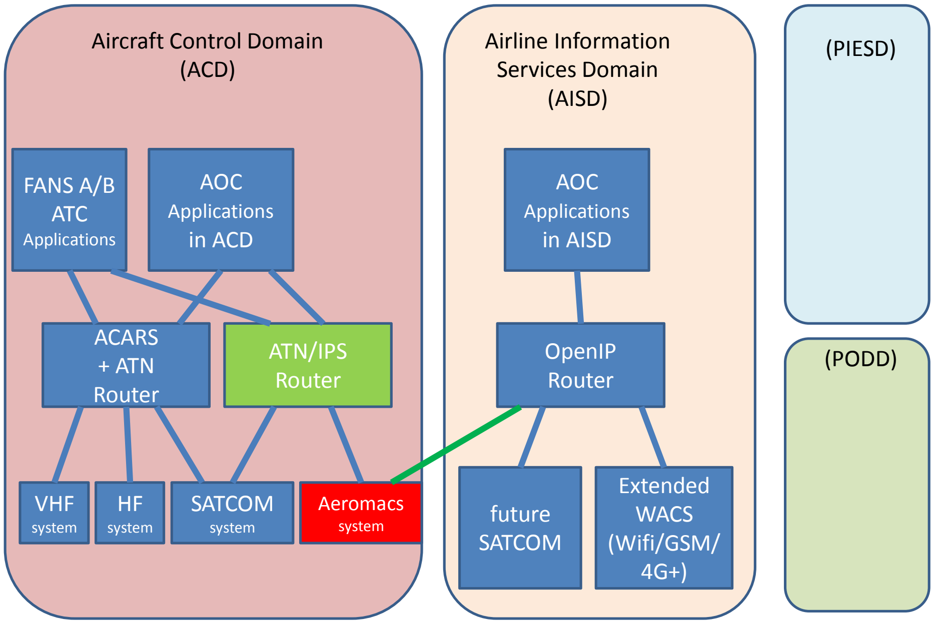


Figure A-7 – AeroMACS Radio Unit (ARU) Integration on Aircraft – Scenario 3-B

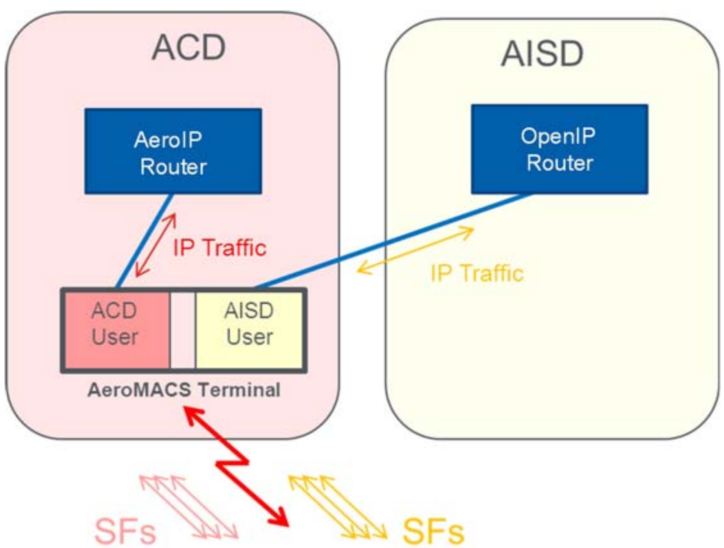


Figure A-8 – Scenario 3-B: Connection between ARU and ACD/AISD

The above scenarios define different strategies for implementing an AeroMACS System on aircraft, which may lead to the definition of different airborne AeroMACS System architectures.

It is worth underlying that possible combinations of the above Scenarios could also be envisaged. For instance, the possibility to implement both Scenarios 1-A

APPENDIX A
AEROMACS AVIONICS SYSTEM ARCHITECTURE

and 3-A, in the Long Term should not be precluded. This scenario could allow using 2 separated ARU devices onboard, using a single antenna thanks to an appropriate branching system. This solution would enable physical segregation between the ACD and the AISD. See Figure A-9.

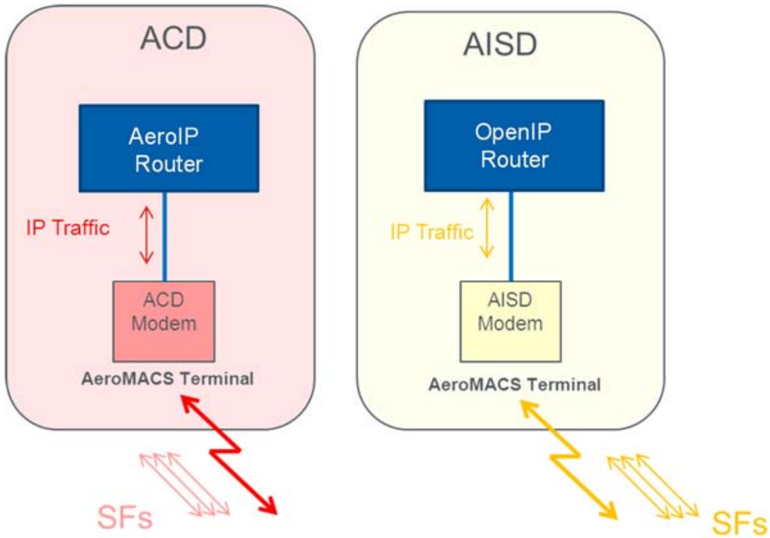


Figure A-9 – Physical Segregation between ACD and AISD, with Separated ARU