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To	SAI Subcommittee	**Date**	June 3, 2015
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Subject

Strawman Circulation
ARINC Project Paper 7xx: *Aeronautical Mobile Airport Communication System (AeroMACS) Transceiver and Aircraft Installation Standards*

Summary

Honeywell and Selex prepared the attached strawman document as the starting point for ARINC Project Paper 7xx describing AeroMACS components.

The strawman is organized as follows:

1.0 Introduction
2.0 Interchangeability Standards
3.0 System Design Considerations
4.0 Functional Capability
5.0 Interfaces and Protocols
6.0 Maintenance and Test
7.0 AeroMACS Unit (AU)

The strawman proposes three possible form factors as follows:

- ARINC 600 size 2-MCU
- Remote flange mount unit
- Integrated unit (with existing avionics equipment)

Action

This strawman document will be reviewed by the SAI Subcommittee on June 17, 2015, in Frankfurt, Germany. Those unable to attend the meeting may send comments in advance of the meeting for review. Comments provided before July 10, 2015, will be considered for inclusion in Draft 1. All comments should be directed to Paul Prisaznuk.

cc

DLK, NIS

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STRAWMAN

FOR

ARINC PROJECT PAPER 7XX

AERONAUTICAL MOBILE AIRPORT COMMUNICATION SYSTEM (AEROMACS)

TRANSCEIVER AND AIRCRAFT INSTALLATION STANDARDS

This draft dated: June 3, 2015

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION AND DESCRIPTION

1.1 Purpose and Scope

This document describes the airline industry desires for an Aeronautical Mobile Airport Communication System (AeroMACS) radio and modem components intended for installation in all types of aircraft. It defines the physical form factors, fit dimensions, low level Built-In-Test (BIT), data loading and the electrical interface definition.

This document defines appropriate AeroMACS equipment architectures that arrange equipment in central and/or remote locations that enable the creation of airborne networks that are scalable, interchangeable, upgradeable and remotely manageable with minimum cost. Aircraft equipment configurations and aircraft wiring recommendations are also described to allow aircraft network growth through the addition or replacement of an AeroMACS Unit (AU). Hardware characteristics of standardized components are described without specifying equipment capacity or the operational functions of those components

The general characteristics of AU include standardized packaging, connectors, electrical power and signal interfaces that apply to general families of network components. Equipment suppliers are free to define the hardware features of components that are designed to meet this characteristic. In typical commercial networking fashion, the functionality of the airborne network will be defined separately by the applications installed and executed on the equipment. Software developers are encouraged to utilize the network services defined in [ARINC Standards TBD] to ensure application compatibility across the widest possible range of AeroMACS implementations.

The modular approach to AeroMACS will enable networks on aircraft to grow and change with minimal impact on other systems. Suppliers are encouraged to create competitive ARINC xxx AeroMACS components by developing new product versions that incorporate the latest processor, storage and network technologies, thus allowing airlines to make compatible hardware choices for the design, configuration and expansion of their airborne networks.

Example AeroMACS architectures are provided in Attachments 5 and 6 to this document.

1.2 Organization of this Document

This document provides standards necessary to achieve interoperability of AeroMACS components. It includes mechanical packaging standards and connector 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.

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

1.3 Relationship to Other Documents

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

ARINC Specification 600: *Air Transport Avionics Equipment Interfaces*

ARINC Report 607: *Design Guidance for Avionics Equipment*

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

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

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 763A: *Mark 2 Network Server System (NSS) Form and Fit Definition*

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: *Avionics Data Interface Service*

ICAO AeroMACS Technical Manual

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

IEEE 802.3: *Ethernet LAN*

RTCA DO-160E: *Environmental Conditions and Test Procedures for Airborne Equipment*

RTCA DO-178C/ED12C: *Software Considerations for Airborne Equipment*

RTCA DO-254/ED80*: Design Assurance Guidance for Airborne Electronic Hardware*

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

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

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.

1.0 INTRODUCTION AND DESCRIPTION

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 part of the Airport Surface Network (ASN). It supports those services available in the protected aeronautical C-band (5091 MHz to 5150 MHz).

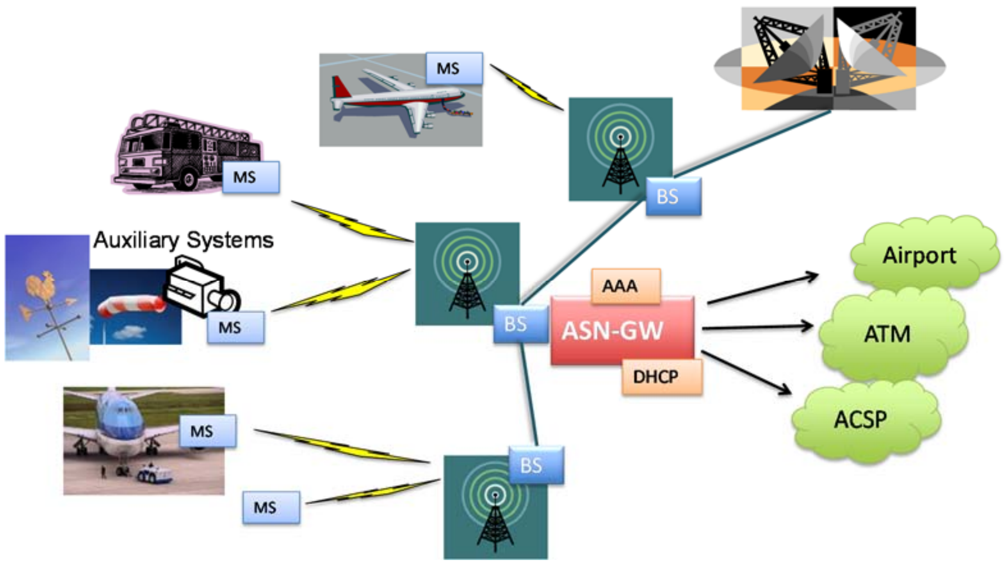


Figure 1-1 – AeroMACS Network Illustration

AeroMACS is designed specifically for IP data communication. Voice communication may be provided as a digital data communication service (e.g., voice over Internet Protocol (VoIP)). AeroMACS can be used to provide Air Traffic Management (ATM) services. AeroMACS can also be used to provide additional services, such as weather advisory and Airline Information Services (AIS). In addition, AeroMACS can enable and support System Wide Information Management (SWIM) type services in the airport surface environment. Therefore, AeroMACS could provide on-board communication support to both ACD and AISD applications.

The AeroMACS system encompasses the following network components/elements:

- AeroMACS Subscriber Stations
  - Mobile Stations
    - Avionic Mobile Station (AMS)
    - Vehicular Mobile Stations (VMS)
  - Fixed Stations
- AeroMACS Base Stations (BS)
- AeroMACS Access Service Network (ASN)

- AeroMACS Connectivity Service Network (ACSP)

This document will focus on the Avionic Mobile Station (AeroMACS Unit) Form, Fit and Function standards.

1.4.1 AeroMACS Unit Function Definition

The AeroMACS Unit (AU), as defined in the MASPS/MOPS, is expected to support the Aircraft Control Domain (ACD) and the Airline Information Systems Domain (AISD) per **ARINC Report 821:** *Aircraft Network Server System (NSS) Functional Definition.*

AeroMACS will enable access to software applications and network communication services residing in the ACD and AISD. As such, the AU will provide the Internet Protocol Convergence Sublayer (IP CS) service to the avionics applications.

The AU will provide the functionalities and services as shown in Figure 1-2. This is the baseline functionality for AU, as specified in MOPS/MASPS.

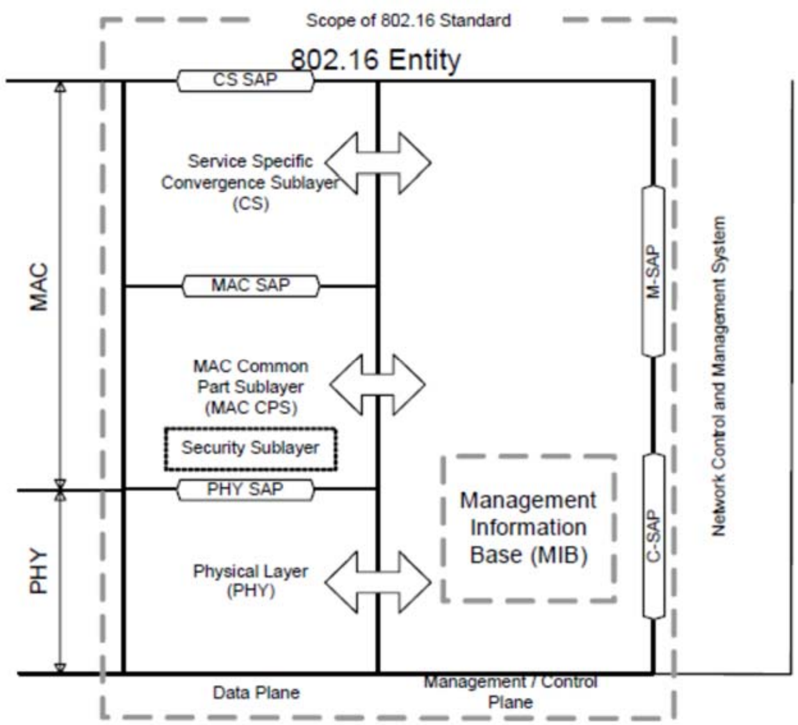


Figure 1-2 – Baseline AeroMACS Unit Functionality per MOPs/MASPS

1.4.1.1 AeroMACS Growth Concept

Many traditional aircraft systems are built to satisfy specific functions based on a customer specification or industry characteristic. The system supplier is responsible for defining all aspects of system behavior and thereafter maintaining that system to a fixed configuration. This approach works very well for autopilots, flight deck displays and other systems that are associated with the aircraft but is fundamentally opposite of the way that modern 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 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. Airborne clients may include Electronic Flight Bags (EFBs), Portable Electronic Devices (PEDs) and other clients.

1.4.2 Standardized Equipment Concept

This document specifies standardized ARINC 600 size 2-MCU equipment for AeroMACS components that are installed in traditional ARINC 600 mounting trays. A Remote AeroMACS Unit (RAU) not requiring forced air cooling may use the alternate form factor, further described in Section 1.4.3 of this document.

The standardized 2-MCU equipment concept seeks to define common features implemented in all components to enable a modular approach to aircraft network design. The network can be modified and expanded in the same way that ground-based networks are modified, while minimizing the impact to the aircraft type certification.

Standardized 2-MCU components share common form factor and power requirements and adhere to specific rules for rear connector configuration and connector keying. This approach enables the design of aircraft installations that can accept different equipment in standard ARINC 600 trays.

Standardized 2-MCU equipment components have a common set of network interfaces that can be used collectively to implement centralized or remote network management and maintenance services and share network communications services if aircraft networks are connected to Wide Area Networks (WAN).

The following sections describe typical standardized 2-MCU components. Suppliers may integrate these components and they may introduce new components that expand the available network features. This is necessary to ensure that the latest network technologies are made available to the airlines within the components.

Typical standardized 2-MCU equipment concept network components include:

- Computational Resource Unit (CRU)
- RF Combiner/Splitter (RFC)
- Optional Ethernet Switch Unit (ESU) and/or Ethernet Switch Router (ESR) which are define in ARINC Characteristic 765.

The minimum configuration is a CRU. If the aircraft network is more extensive, then one or more ESUs and/or ESRs may be added. An RFC may be included in the configuration depending on the antenna.

1.4.2.1 Computational Resource Unit (CRU)

The Computational Resource Unit (CRU) contains the Baseline AeroMACS functionality depicted in Figure 1-2 as defined in the MASPS and MOPS. The CRU may contain functions other than the minimum set defined herein and by reference.

1.4.2.2 RF Combiner/Splitter (RFC)

The RF Combiner/Splitter (RFC) provides wired RF signal separation and/or mixing between AeroMACS Unit (AU) and the associated antennae.

COMMENTARY

Note: [ARINC Standard TBD] defines a form factor for the RFC.

1.4.2.3 Ethernet Switch Unit (ESU)

The Ethernet Switch Unit (ESU) provides OSI Layer 2 switch services. The ESU distributes Ethernet to other network components connected on Base-T ports. Today Layer 2 switches routinely include some Layer 3 services to assist in managing network isolation such as Virtual LANs (VLAN).

1.4.2.4 Ethernet Switch Router (ESR)

[TBD]

1.4.3 Remote Form Factor Equipment

AeroMACS equipment not requiring forced air cooling may use the alternate form factor defined in this document. This equipment may be installed in remote locations and away from standard ARINC 600 style airborne equipment racks.

1.4.3.1 Remote AeroMACS Unit (RAU)

The Remote AeroMACS Unit (RAU) shall contain the baseline AeroMACS functionality described in Figure 1-2 as defined in the MASPS and MOPS. The RAU may contain functions other than the minimum set defined herein and by reference. The RAU is defined in Section 7.

1.4.3.2 Remote Ethernet Switch (RES)

The Remote Ethernet Switch (RES) provides OSI Layer 2 switch services and is used to distribute Ethernet to other network components connected on Base-T ports. Today Layer 2 switches routinely include some Layer 3 services to assist in managing network isolation such as Virtual LANs (VLAN). The RES may be housed in a remote form factor enclosure. See Attachment 9 for packaging and connector details.

1.4.4 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 IEEE 802.3) with no customization.

1.4.5 Interchangeability

AeroMACS system components are expected to be interchangeable among suppliers that meet this standard. For more information, see Section 2 of **ARINC Report 607:** *Design Guidance for Avionics Equipment.*

1.5 Regulatory Approval

This equipment could form part of an onboard information system conveying data intended for use by the flight crew and/or avionics systems. The equipment should meet all applicable ICAO, JAA, and FAA regulatory requirements. This document does not and cannot set forth the specific requirements that the equipment must meet to be assured of approval. This information must be obtained from the appropriate regulatory authority.

1.6 Integrity

The architectural design for the AU/RAU software is required to comply with RTCA DO-178C level E, or D depending on the system architecture and criticality of applications and services supported by the AeroMACS system. Portions of the hardware may be required to comply with the requirements of RTCA DO-254.

1.7 Reliability

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 AU/RAU. It is not the purpose of this Characteristic to define specific requirements for MTBF. A special emphasis should be given to total system quality, including built in testing, ramp testing, and shop testing to increase the Mean Time Between Unscheduled Removals (MTBUR). MTBUR has a profound effect on airline operations, despite a high 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.

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

1.8 Testability and Maintainability

The total system quality should include adequate ability for the operator to test and maintain the AU effectively. The AU 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 AU 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.

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 desired for AU components.

Three different form factors are possible for the AU:

- A stand-alone AU in an ARINC 600 2-MCU form factor located in the equipment bay. This form factor may also include additional components such as a, Ethernet Switch, Ethernet Router, etc.
- A Remote AU (RAU), flange-mount unit that can be coupled with the AeroMACS antenna. See Section 7 for details.
- An integrated AU (IAU) can be part of other avionics equipment such as an ARINC 763A TWLU, an ARINC 758 CMU, or an ARINC 781 SDU.

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

2.2 Form Factor, Connectors, and Index Pin Coding

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

The AU should be provided with a low insertion force, size 2 shell ARINC 600 service connector. This connector, which should accommodate service interconnections in its middle plug (MP) and top plug (TP) inserts respectively and power interconnections in its bottom plug (BP) insert should be located on the center grid of the CMU Mark.

This standard for AU components assigns standardized ARINC 600 connectors, signal definitions, and indexed keying pins to enable sharing of common form factor and power requirements. It defines specific rules for rear connector configuration and connector keying. This approach enables the design of aircraft installations that can accept different AU components in commonly wired trays. The 2-MCU form factor defined in ARINC 600 is specified for AU components located in traditional equipment racks.

This document specifies the form factor, connectors and index pin codes for AU components referenced in Table 2-1. The RAU form factor is defined in Section 7 of this document.

2.0 INTERCHANGEABILITY STANDARDS

Table 2-1 – Component Form Factors, Connector and Index Pin Polarization

Component	Form Factor	Connector	Index Pin Polarization
AU (AeroMACS Unit)	2-MCU	ARINC 600 Size 2	See Section 2.4.2

2.3 Power

AU components should be powered by either 115 Vac, 360 to 800 Hz power, or +28 Vdc 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.*

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. 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

If battery devices are used in the equipment designs, manufacturers should consider a design that allows battery removal and replacement without removal of the LRU 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 AU Connectors

The standard connectors for the AU components are referenced in Table 2-1 and set forth in the following subsections.

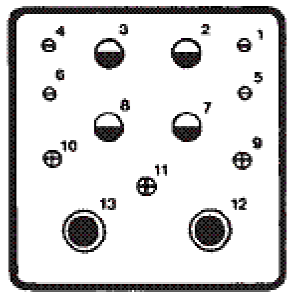
2.4.1 ARINC 600 Rear Connector

All AU components packaged in the 2-MCU form factor should utilize a common ARINC 600 Size 2 rear connector with three inserts, bottom, middle and top. The three inserts are described in the following sections.

2.4.1.1 Bottom Insert

The bottom insert shall be the same for all components, limited to power, ground and RF interconnection. The insert shown is an Arrangement 04 per Attachment 19 to ARINC Specification 600. Pin assignments are shown in Table 2-3.

Table 2-3 – Bottom Insert Pin Assignments

Contact	Signal Name
	
1	115 Vac, 360 to 800 Hz Hot
2	+28 Vdc
3	+28 Vdc Ground
4	Reserved (Radio On/Off Discrete Input)
5	Reserved (Radio Transmitter On/Off Discrete Input)
6	Reserved (Unit Reset Discrete Input)
7	115 Vac, 360 to 800Hz Neutral
8	Aircraft Chassis Ground
9	LRU Status Discrete Output
10	N/C
11	Signal Ground
12	(RF 1 Coaxial Size 5)
13	Optional (RF 2 Coaxial Size 5)

The power source may be either 28 Vdc or 115 Vac. Some units may be designed for only type of power. It’s not required to support both. One or the other should be wired to the LRU tray but <u>not</u> both. Pins BP2 and BP3 are for 28 Vdc power. Pins BP1 and BP7 are for 115 Vac power. Chassis ground is pin BP 8 and signal ground is BP11

Bottom insert pins BP12 and BP13 contain coaxial connectors associated with radio frequency signals. If a component does not require both RF coaxial connections then pin BP13 on the LRU may remain unpopulated.

Bottom insert pins BP4 and BP5 are reserved for common radio discrete inputs. See Section 5.1.

Bottom insert pin BP6 is reserved for Unit Reset discrete input. See Section 5.1.

The inclusion of Radio On/Off, Transmitter On/Off and Unit Reset discrete inputs in the Bottom Insert is expected to eliminate the need for a 150-pin Top Insert in most radio components, thus reducing component cost and expanding aircraft installation tray compatibility. See Section 5.1.1.

Bottom Inset pin BP9, LRU Status discrete output is defined in Section 5.1.2.

2.4.1.1.1 AU Antenna

The input impedance at AU RF connector should be a nominal 50 ohms with a maximum voltage standing wave ratio (VSWR) of 2.0 over the AeroMACS frequency range.

Manufacturers may choose to implement two RF pins in Bottom Plug pins BP12 and BP13 for connection of two antennas in support of diversity algorithms embedded as part of the COTS RF electronics. 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 BP12.

The AU should provide at least one RF pin (BP12) for connection of coax cable fed to an antenna externally mounted on the aircraft. This document does not specify the type of AU antenna to be used due to the evolution of this technology and the availability of acceptable designs.

2.4.1.2 Middle Insert

The middle insert should be populated with either Gigabit Ethernet or 100Base-T Ethernet or RF connector inserts as described in the subsections herein.

2.4.1.2.1 Middle Insert – Gigabit Ethernet

Quadrax connectors should be used for all Ethernet connections. A single four pin Quadrax connector can support 100Base-T Ethernet. Two Quadrax connectors (8 pins total) are required to support each 1000Base-T interconnect. The middle insert layout can support a maximum of eleven Quadrax Size 8 inserts. Ethernet Quadrax connectors in the Middle Insert are assigned in pairs to enable support of 1000Base-T as shown in Figure 2-1. The insert shown is an Arrangement 11Q11 per Attachment 19 to ARINC Specification 600. Quadrax pair assignments are shown in Figure 2-4.

COMMENTARY

Preliminary studies indicate that the recommended dual Quadrax configuration may also support 10GBase-T in cable lengths that are significantly less than 100 meters.

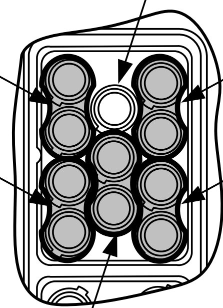


Figure 2-1 – Middle Insert Gigabit Quadrax Pair Assignments

Quadrax ports should be allocated as vertically adjacent pairs to minimize paired cable length differences and to provide a visual orientation for installing technicians.

Every Ethernet port should support auto-negotiation of 100 or 100/1000 Mbps. Auto-negotiation of ports that have either one or two Quadrax ports assigned requires that one of the two Quadrax ports must have the same pin assignments for either 100 Base-T or 1000 Base-T. The top Quadrax port of a pair will be considered primary for auto-negotiation. Quadrax pin assignments for 100 Base-T are shown in Figure 2-2. Pin assignments for 1000 Base-T are shown in Figure 2-3. Note, both figures are shown looking at the rear of the LRU.

COMMENTARY

For “auto-negotiation” enabled devices, interoperability problems can exist when two 1000Base-T capable devices are interconnected with only two pairs of wires (100Base-T configuration) and their respective auto-negotiation feature is enabled.

Both devices may repeatedly attempt to advertise themselves as 1000Base-T capable and fail to establish a link.

For this reason, AU providers should consider the merits of providing a capability to disable auto-negotiation. This is intended to be manufacturer specific. For more information, refer to ARINC Specification 664 Part 2.

2.0 INTERCHANGEABILITY STANDARDS

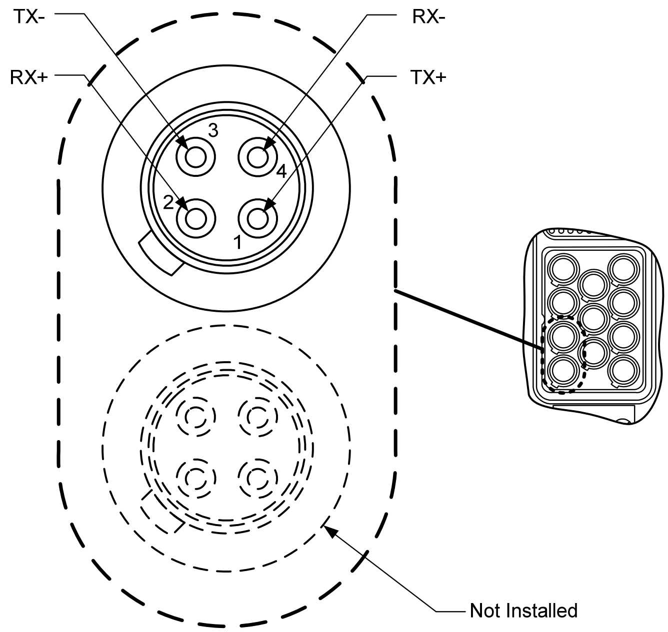


Figure 2-2 – Quadrax Pair Pin Configuration for 100 Base-T

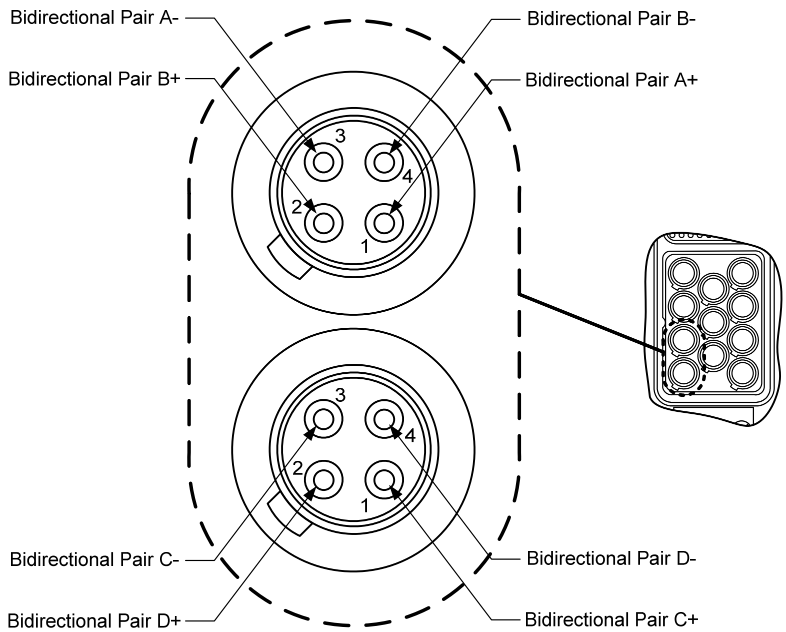
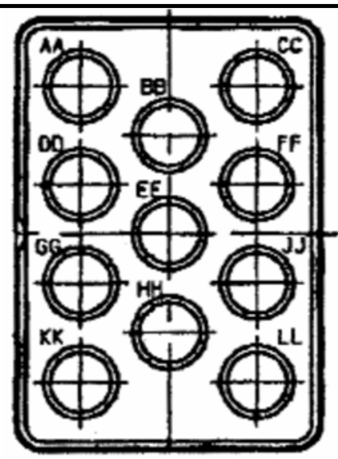


Figure 2-3 – Quadrax Pin Configuration for 1000 Base-T

The population of Quadrax connectors in the Middle insert is populated depending on component definition. However, all components with a Quadrax Middle insert should maintain the Quadrax layout defined in Figure 2-3 and Table 2-4 (are both needed?) for family commonality. Port #1 is the primary Ethernet connector on each component. Additional Ethernet ports should be allocated to components sequentially thereafter to ensure maximum tray commonality.

Table 2-4 – Middle Insert Gigabit Quadrax Pin Assignments

Quadrax Contact	Signal Name
	
AA	100/1000-Base-T #4 Auto-select
BB	100-Base-T #5
CC	100/1000-Base-T #6 Auto-select
DD	1000-Base-T #4 Secondary
EE	100/1000-Base-T #2 Auto-select
FF	1000-Base-T #6 Secondary
GG	100/1000-Base-T #1 Auto-select
HH	1000-Base-T #2 Secondary
JJ	100/1000-Base-T #3 Auto-select
KK	1000-Base-T #1 Secondary
LL	1000-Base-T #3 Secondary

Since the standard ARINC 600 Quadrax insert has eleven Quadrax connectors, the middle insert can support a maximum of five 1000Base-T Quadrax pairs. The remaining, unpaired Quadrax connector is assigned as a 100Base-T port.

Middle insert layouts for typical components are shown in Figure 2-4.

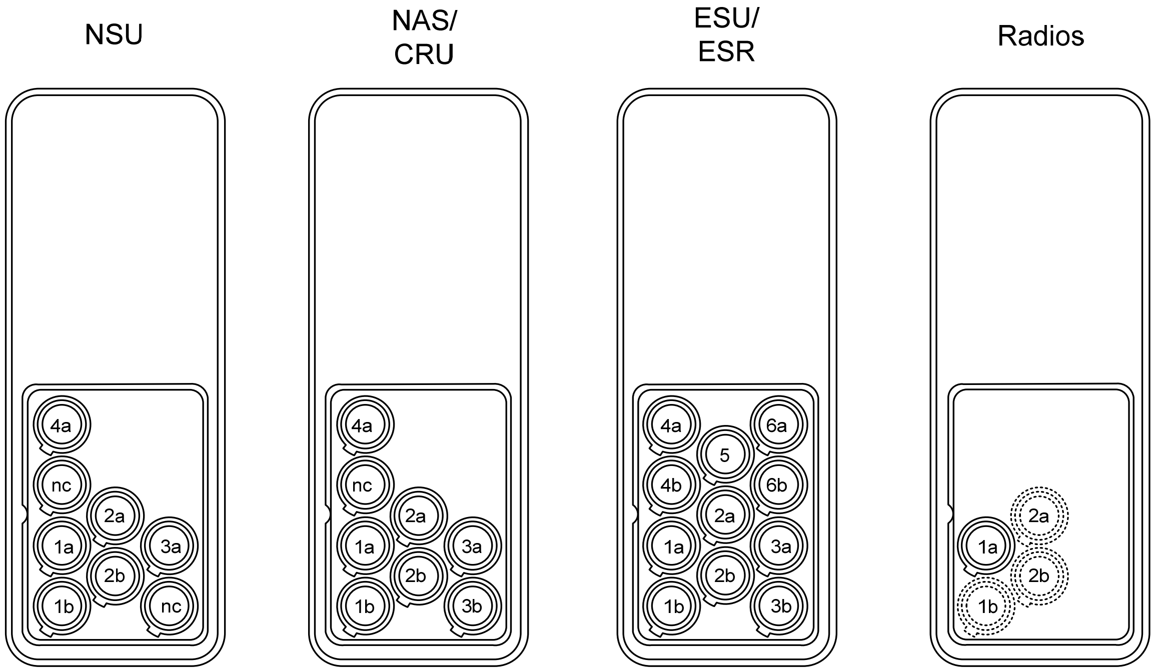


Figure 2-4 – Middle Insert Gigabit Example Quadrax Layouts

The minimum middle insert configuration for an AU component should be populated as Radios as shown in Figure 2-4.

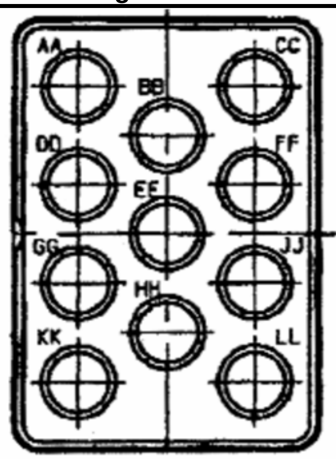
2.4.1.2.2 Middle Insert – 100Base-T Ethernet

If only 100Base-T Ethernet is implemented in the AU, 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-T Ethernet. Eleven 100Base-T interfaces can be supported in the middle insert.

Every 100Base-T Ethernet port should support auto-negotiation. Pin assignments for 100Base-T are shown in Table 2-5a. The insert shown in Table 2-5a is an Arrangement 11Q11 per Attachment 19 to ARINC Specification 600.

Middle insert Quadrax connectors may not be fully populated depending on component definition, however, all components should maintain the Quadrax layout defined in Table 2-5a for family commonality. Port #1 is the primary Ethernet connector on each component. Additional Ethernet ports should be allocated to components sequential thereafter to ensure maximum tray commonality.

Table 2-5a – Middle Insert 100 Quadrax Pin Assignments

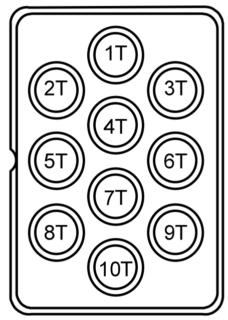
Quad Contact	Signal Name
	
AA	100-Base-T #10
BB	100-Base-T #8
CC	100-Base-T #11
DD	100-Base-T #7
EE	100-Base-T #5
FF	100-Base-T #9
GG	100-Base-T #4
HH	100-Base-T #2
JJ	100-Base-T #6
KK	100-Base-T #1
LL	100-Base-T #3

2.4.1.2.3 Middle Insert – RF: delete?

The middle insert for RF should be populated with coaxial connectors that are used to collect or distribute RF between the common antenna and various AU radio components.

The middle insert for RF may contain up to ten Size 8 coaxial connectors. Coaxial connectors should be assigned to components sequentially in the order shown in Table 2-5b. Any unused coaxial connector locations in the component insert should remain unpopulated. The insert shown in Table 2-5b is an Arrangement 12 per ARINC Specification 600.

Table 2-5b – Middle Insert RF Pin Assignments

RF Contact	Signal Name
	
1T	RF 9
2T	RF 8
3T	RF 10
4T	RF 6
5T	RF 5
6T	RF 7
7T	RF 3
8T	RF 2
9T	RF4
10T	RF 1

2.4.1.3 Top Insert

The presence and type of top insert will vary depending on the component family. Four types of top inserts are defined. Additional configurations may be defined as additional components are developed. The top insert types shown in Figure 2-5 are:

- Blank
- 150 pin (22 gauge)

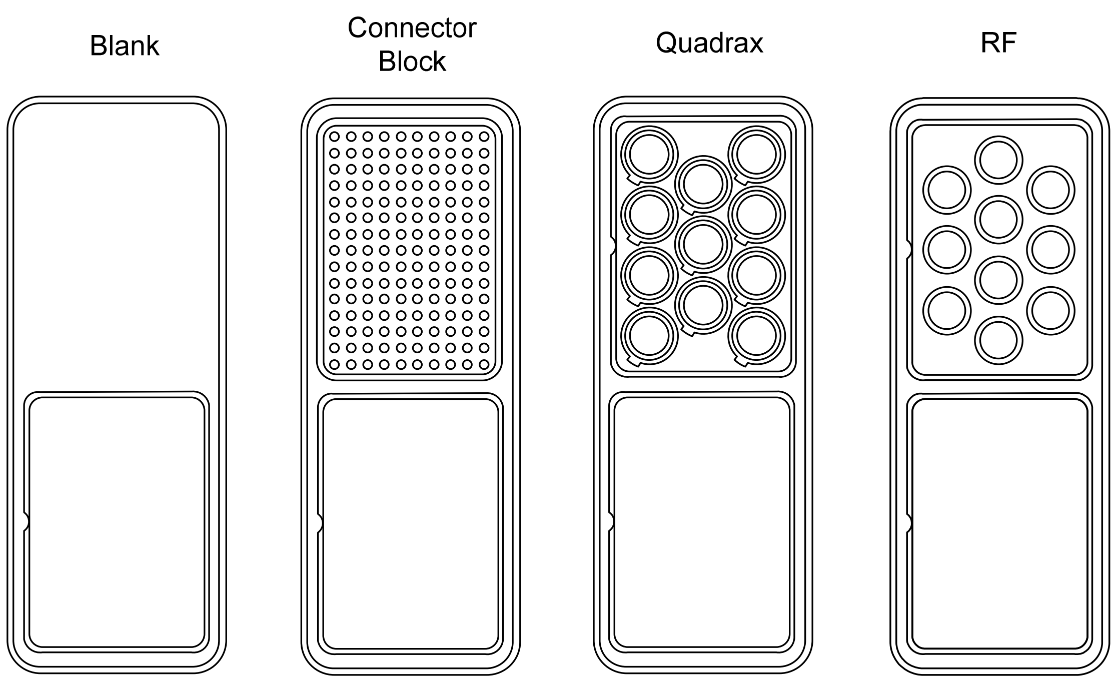


Figure 2-5 – Top Insert Alternate Configurations

Figure 2-6 – TBD

2.4.1.3.1 Top Insert –Blank

The top insert should remain Blank unless specifically required to support system interconnection. It is expected that a component with a blank top insert can be plugged into the widest possible number of tray configurations without physical or electrical conflict.

The AeroMACS Unit should have a blank top insert. Most radio components should also have a blank top insert, though some Wireless Network Transceivers could be equipped with 150-pin top inserts to accommodate connection to aircraft interfaces for unique radio control functions.

2.4.2 2-MCU Index Pin Polarization

One goal of this document is to establish the standards by which aviation-grade network components can be designed to achieve the same flexibility as the commercial network components while maintaining design standards, component standards and rigorous configuration control required by the aviation industry. Standardizing a family of 2-MCU components with three keyways helps to make this vision a reality.

Table 2-8 defines the example AU key combinations that are used to identify rear connector configurations for ARINC XXX components. See Attachment 8 for the derivation of these key combinations.

ARINC Characteristic 763A creates a seventh polarization setting (refer to ARINC 600 Attachment 18). This seventh position (“blank” or “0” or 'no post installed') is defined for the LRU side only. It does not apply to the aircraft side (rack side). In this scenario, the aircraft-side connector could continue to have posts installed in all three polarization post positions (left, center, right), thereby not being in conflict with existing standards.

Table 2-8 – AU Connector Key Positions

Component	Left Key	Center Key	Right Key
ESU (6 or more Gb ports)	2	1	0
ESR (6 or more Gb ports)	2	1	0
AU	0	1	1
RFC	3	2	1

Plug connector index posts and receptacle connector keyways are defined in ARINC Specification 600. Six possible positions are numbered 1-6 as shown in Figure 2-7.

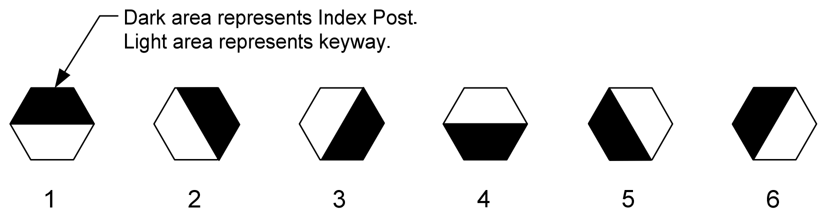


Figure 2-7 – ARINC 600 Receptacle Connector Key Polarization Positions

For the purpose of this document, the position of index posts and connector keyways are treated with unique purpose. Index posts and keyways retain their traditional definition as detailed in ARINC Specification 600. For the purpose of this document, a seventh value is assigned by defining the lack of a definitive connector keyway as position 0. Thus, seven connector keyway positions are shown in Figure 2-8, looking at the rear of the unit.

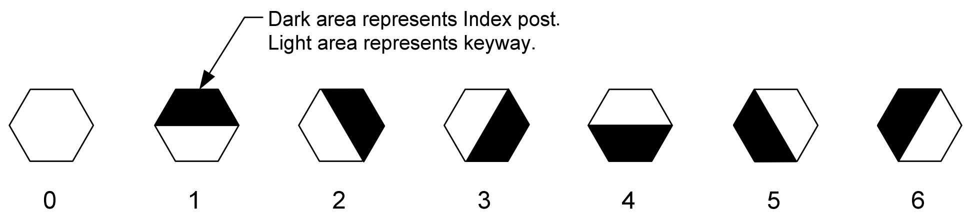


Figure 2-8 – ARINC XXX Receptacle Connector Key Polarization Positions

The polarization positions for connector keyways on an AU are shown in Figure 2-9 as an example. The left keyway in position 0 indicates that the unit has a blank top insert. The center keyway in position 1 indicates a Quadrax middle insert. The right keyway in position 1 indicates that the bottom insert includes RF connections to the RFC.

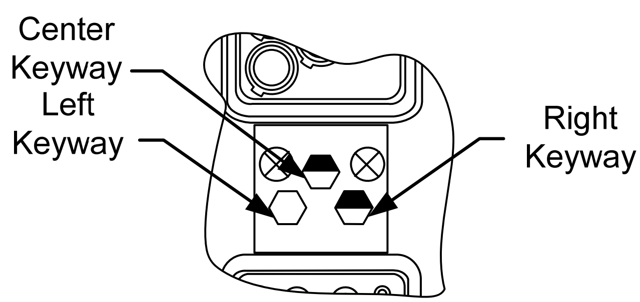


Figure 2-9 – Connector Key Example (AU)

2.5 Remote Form Factor

A Remote AeroMACs Unit (RAU) may be desired for some types of aircraft installation. This form factor may also be used to package the Ethernet Switch Unit (ESU) with AeroMACS equipment not requiring forced air cooling. See Section 7.3.2.

2.6 Integrated AeroMACS Unit (AIU)

In some cases it may be desirable to integrate the AeroMACS functionality into an existing avionics unit in which case all the functions described by this document should be integrated into the candidate LRU. The appropriate ARINC Characteristic for the candidate unit (if applicable) is expected to reference this document for guidance on the AeroMACS function requirements.

2.7 Environmental Conditions

The hardware components of the AU should conform to the requirements of the latest applicable version of **RTCA DO-160E/EUROCAE ED-14:** *Environmental Conditions and Test Procedures for Airborne Equipment*. Attachment 4 to this characteristic tabulates the relevant environmental categories in DO-160E/ED-14.

2.8 Cooling

This section provides guidance for cooling AU equipment.

2.8.1 2-MCU Form Factor Cooling

Where cooling is required, AU components packaged in the 2-MCU form factor are expected to use forced air cooling per ARINC Specification 600. AU components should be capable of accepting cooling airflow from either bottom-to-top or top-to-bottom for maximum installation choices by the systems integrator. A metered plenum must be used within each unit to restrict the amount of cooling air for the specific AU component. The AU should be designed to accept, and airframe manufacturers should configure the installation to provide forced air cooling as defined in ARINC Specification 600. The standard installation should provide an air flow rate of 13.6 kg/hr of 40°C air and the unit should not dissipate more than an average of 50 watts of energy. The coolant air pressure drop through the equipment should be 5±3 mm at standard conditions of 1013.25 millibars. A loss of cooling should not cause total loss of functionality.

2.8.2 Remote Form Factor Cooling

See Section 7.3.4.

2.9 Weight

AU component weights are defined in ARINC Specification 600 for their respective form factors. Remote equipment should be designed to weigh less than 10 pounds (4.5 kg).

2.10Grounding and Bonding

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

2.11ARINC 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.

2.11.1 Standard “Open”

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

COMMENTARY

In many 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.

2.11.2 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.

2.11.3 Standard “Applied Voltage” Output

The standard “applied voltage” is defined as having a nominal value of + 27.5 Vdc. This voltage should be considered to be “applied” when the actual voltage under the specified load conditions exceeds 18.5 volts (+ 36 Vdc maximum) and should be considered to be “not applied” when the equivalent impedance to the voltage source exceeds 100,000 ohms.

2.11.4 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 2.11.1 and 2.11.2 of this Characteristic. 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 Characteristic, 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 logic sources for the Discrete Inputs to the AU components 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 AU, in each case, expected to provide the dc signal to be switched. Typically, this is done through a pull-up resistor. 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 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 to the components 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 equipment and airframe suppliers 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 excessive current spikes.

2.11.5 Standard Discrete Output

A standard Discrete output should exhibit two states, “open” and “ground” as defined in Sections 2.11.1 and 2.11.2. In the “open” state, provision should be made to present an output resistance of at least 100,000 ohms. In the “ground” state provision should be made to sink at least 20 mA 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.

A Discrete output may need to source current. Discrete outputs which are to source current should utilize the standard “Applied Voltage” output defined in Section 2.11.3. These special cases are noted in the text describing each applicable discrete output function and in the notes to interwiring.

Although defined here, discrete outputs which provide a current output rather than a current sink are not “Standard Discrete Outputs”.

2.11.6 Standard Program Pin Input

Program pins may be assigned to the AU component 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 2.11.1 of this Characteristic. The other state is a connection (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.

2.11.7 Ethernet Ports

Ethernet ports should comply with ARINC Specification 664 Part 2. They should be auto down-selectable from the highest rates. For example, 1000Base-T should be selectable between 1000Base-T, and 100Base-T.

COMMENTARY

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

3.0 SYSTEM DESIGN CONSIDERATIONS

3.1 AeroMACS Avionic System Architecture

As stated in Section 1.4, the use of AeroMACS on-board is relevant to both the Aircraft Control Domain (ACD) and the Airline Information Services Domain (AISD) to support ATM and AOC applications.

Assuming current and future ACD and AISD communication architectures various scenarios are described hereafter, each one representing a possible AU implementation.

3.1.1 Scenario 1-A – Near-term Installation of AeroMACS Unit in AIS Domain

Scenario 1-A assumes that with a near term perspective, an AeroMACS Unit (AU) (Mobile Station) could be initially introduced as an additional communication media of the AIS domain, attached to an "Open IP" router, as a complement or alternative technology to the gatelink technologies (WIFI/GSM/GPRS/EDGE/UMTS/LTE/ WIMAX, etc.), Following this scenario, the AeroMACS Unit (AU) could be implemented as a standalone equipment similar to current TWLU equipment, or could be integrated (added) within the current gatelink communication equipment.

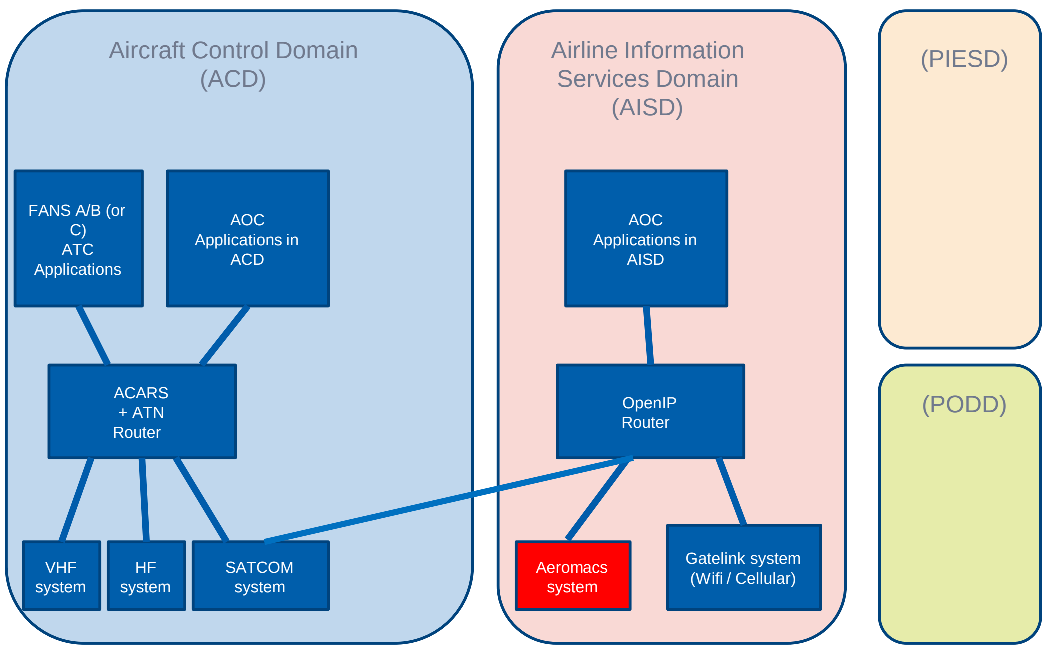


Figure 3-1: AeroMACS Unit (AU) integration on Aircraft – Scenario 1-A

3.1.2 Scenario 1-B – Near-medium Term Installation of AeroMACS Unit in AC Domain

Scenario 1-B assumes, in the short-medium term, the availability of an AeroMACS Unit (AU) connected to the AIS domain, but hosted in the AC domain in preparation of the longer term scenario 3A/B described farther below. In terms of initial capabilities and supported services this AeroMACS Unit (AU) is the same as the one shown in Scenario 1-A. The difference with Scenario 1-A is that a Scenario 1-B AeroMACS Unit (AU) would be designed and possibly pre-installed to be directly interfaced with the ACD airborne network and with peripheral ACD avionics systems. In particular, a Scenario 1-B AeroMACS Unit (AU) could be designed with the physical Inputs/Outputs modules (e.g. ARINC 429, ARINC 664, etc. 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 with an ATN/IPS router envisioned to be installed in the ACD at a longer term.

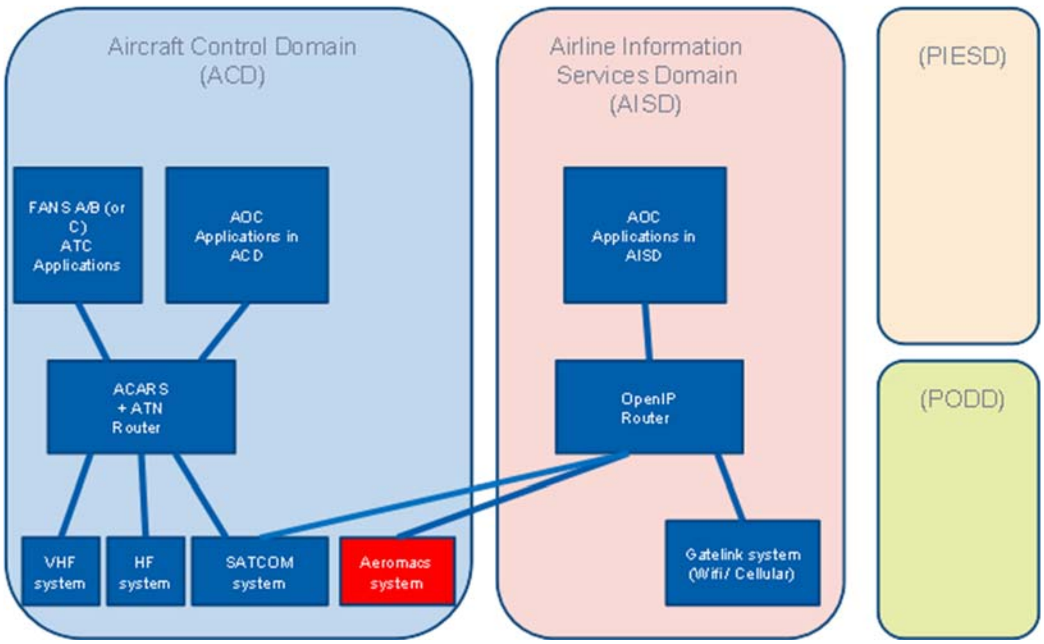


Figure 3-2: AeroMACS Unit (AU) integration on Aircraft – Scenario 1-B

3.1.3 Scenario 2-A – Medium-term Installation of AeroMACS Unit in AC Domain

Scenario 2-A assumes that with a Medium Term perspective, the AeroMACS Unit (AU) could be initially developed and certified as a more global equipment, providing in the same unit the following capabilities: 1) the AU (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 System Security assures secure Air to Ground and Ground to Air communications, implementing authentication (PKMv2), data encryption (AES) and integrity check. On top of this AeroMACS security framework the AeroMACS unit 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 AC domain from the outside IP world, can be also added.

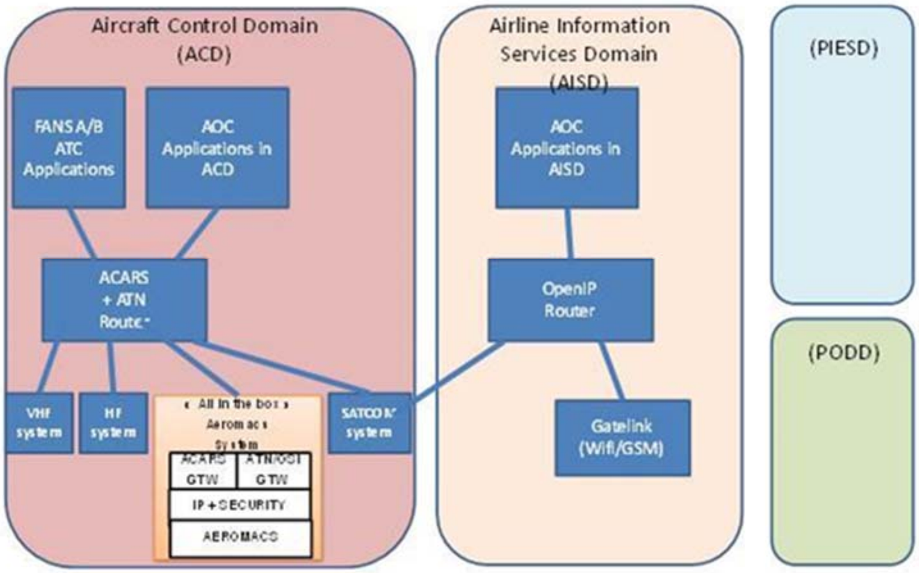


Figure 3-3: AeroMACS Unit (AU) integration on Aircraft – Scenario 2-A

3.1.4 Scenario 2-B – Medium-term Installation of AeroMACS Unit in AC and AIS Domains

In the medium term, the AeroMACS unit onboard could simultaneously be connected to the AC domain and the AIS domain, thanks to its capability to provide segregation among AC and AIS users. This approach is very similar to solutions currently envisaged for easing introduction of/transition to new IP-based satellite communication services in the AC domain (Iridium and Inmarsat-SBB).

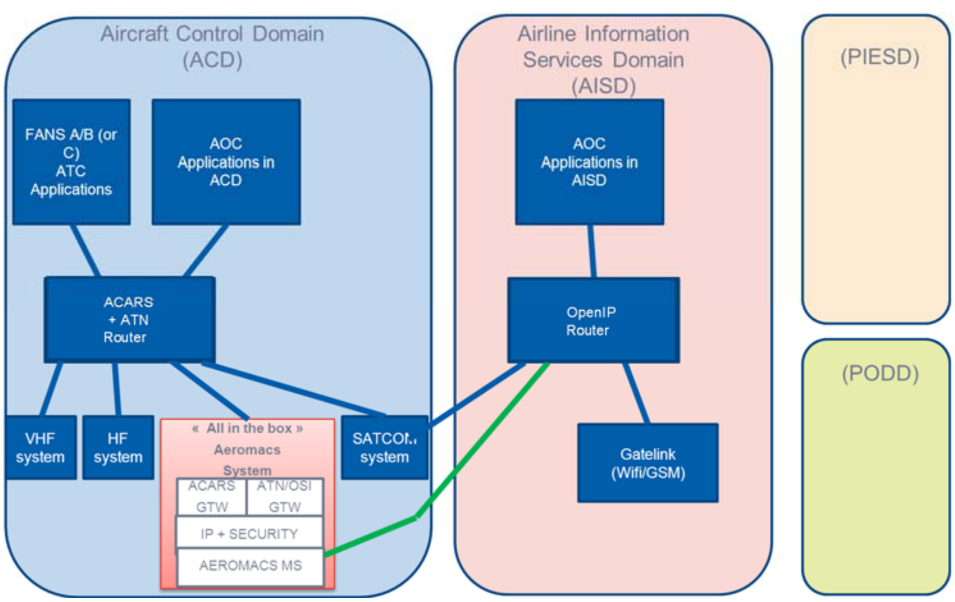


Figure 3-4 – AeroMACS Unit (AU) integration on Aircraft – Scenario 2-B

3.0 SYSTEM DESIGN CONSIDERATIONS

AeroMACS, as a native-IP system, could be connected directly to the AIS domain OpenIP Router. Instead, the connectivity with the ACD COTS ACARS+ATN Router depicted in Figure 3-4 should be provided by an appropriate SubNetwork Dependent Convergence Function Layer. A similar solution has been already tested and validated under the SANDRA Project, allowing interoperability between AUs and COTS ATN/OSI Routers (See Figure 3-5).

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

- Data authentication, ciphering and Integrity check functions, to improve privacy and integrity of data.
- A firewall function to segregate the AC domain from the AIS domain, avoiding the Open IP world to access to the AC domain

It has to be noted that the needed Security Requirements should be provided by this scenario increase the complexity of the AeroMACS Unit (AU), providing however the advantage of having a single AeroMACS Unit (AU) connecting both ACD and AISD users.

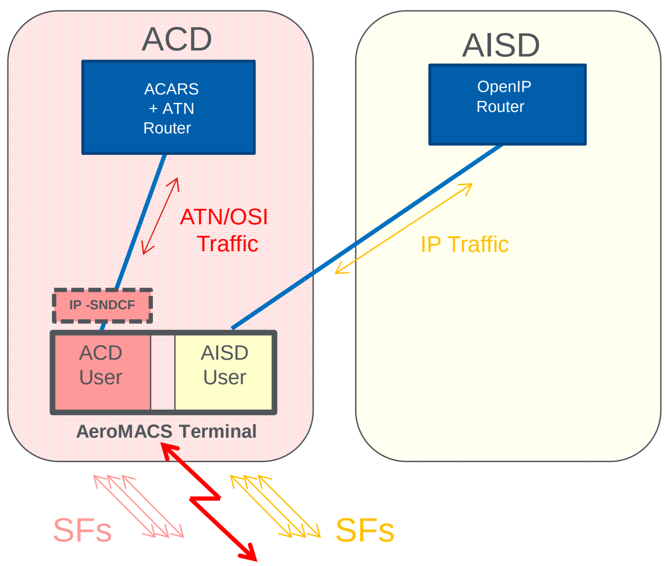


Figure 3-4 – Scenario 2-B: connection between AeroMACS Unit and ACD/AISD

3.1.5 Scenario 3-A – Long-term Installation of the AeroMACS Unit in AC Domain

Scenario 3-A assumes that in the long-term, when the aircraft is equipped with ATN/IPS router in the AC domain, the AeroMACS Unit (AU) will be a radio-communication system of the AC domain, attached to the ATN/IPS router.

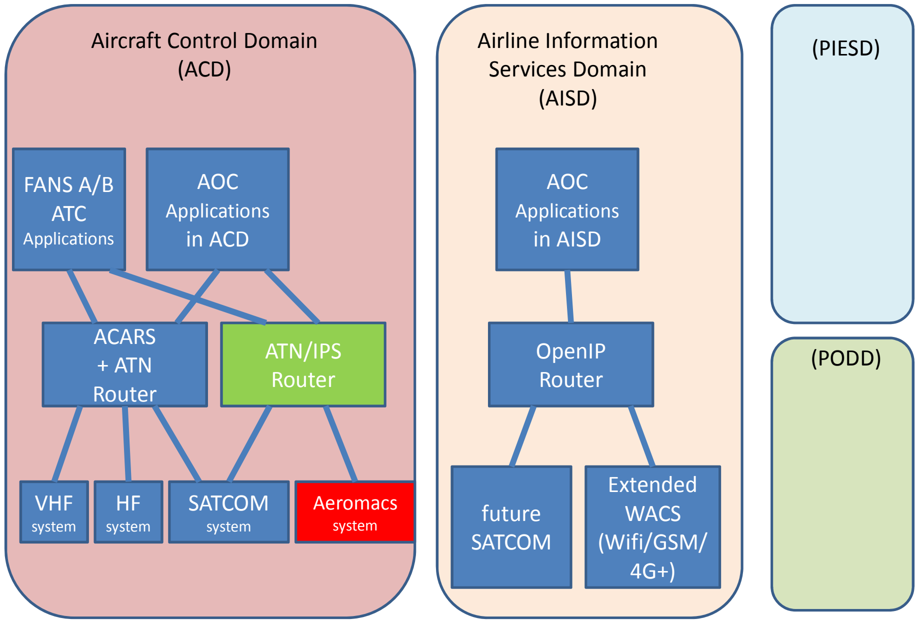


Figure 3-5: AeroMACS Unit (AU) integration on Aircraft – Scenario 3-A

3.1.6 Scenario 3-B – Long-term Installation of AeroMACS Unit in AC and AIS Domains

Scenario 3-B assumes that in a longer term, when Aircraft will be equipped with ATN/IPS router in the ACD domain, the AeroMACS Unit (AU) will be developed as a certified (level D) radio-communication system of the ACD domain, 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 AeroMACS Unit (AU) and by IP level security capabilities (as explained in the scenario 2-B) implemented between the ATN/IPS (referred to also as AeroIP) and OpenIP routers (outside the AeroMACS Unit (AU) onboard system) (See Figure 3-7 and Figure 3-7).

3.0 SYSTEM DESIGN CONSIDERATIONS

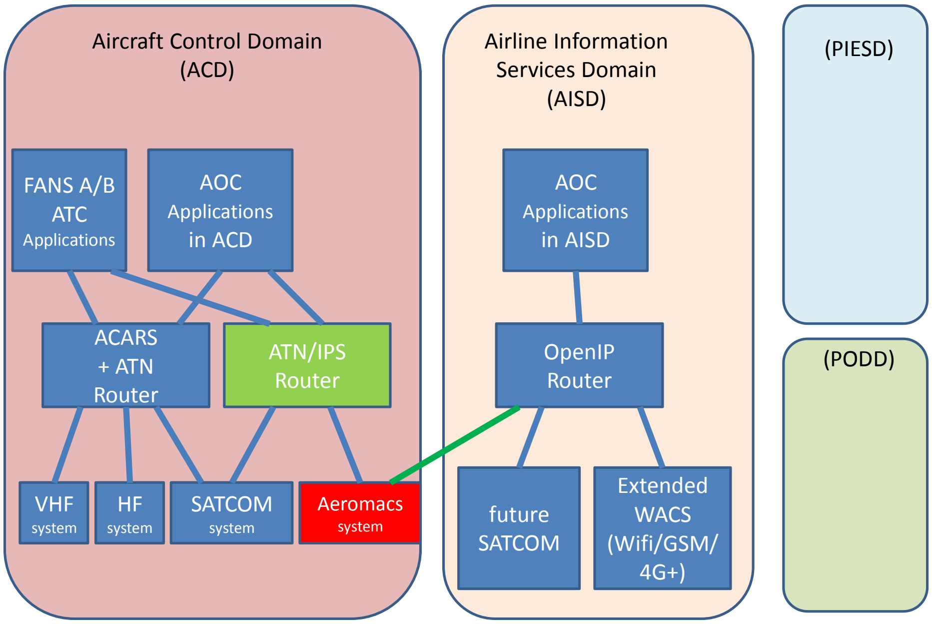


Figure 3-6 – AeroMACS Unit Integration on Aircraft – Scenario 3-B

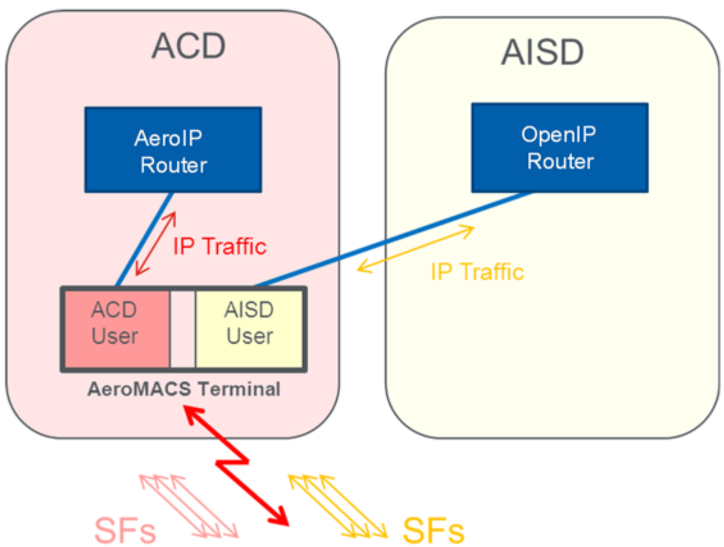


Figure 3-7: Scenario 3-B: Connection between AeroMACS Unit and ACD/AISD

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.

A number of possible combinations of the above scenarios could also be envisaged. For instance, the possibility to implement both Scenarios 1-A and 3-A, in the Long Term should not be precluded. This scenario could allow using 2 separated AU devices onboard, using a single antenna thanks to an appropriate branching system. This solution would grant a physical segregation between the AC domain and the AIS domain. See Figure 3-8.

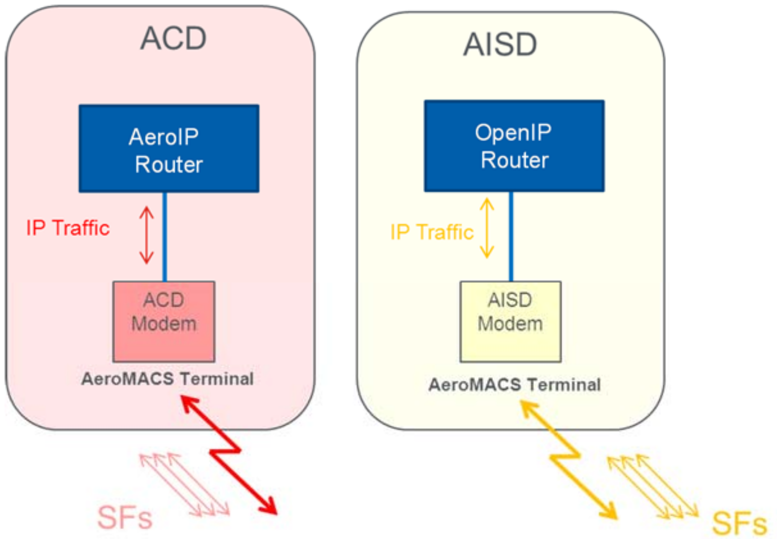


Figure 3-8: Physical Segregation between ACD and AISD, with separate AeroMACS Unit

3.2 System Flexibility

The AU should be built around industry standards and open systems architecture that may be frequently and easily upgraded at a reasonable cost. The AU implementations should use industry standard (and popular) COTS components capable of hosting popular operating environments like a Windows or Linux product.

3.3 Certification and Partitioning Considerations

The AU will contain software that provides functions that are expected to evolve over time. The AU should be capable of reporting its software configuration to the Network Management Service. Any software component that is loaded into an AU 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 AU, qualification tests should be performed to validate the operational characteristics of its intended functions. In addition to supplier testing as described in RTCA/DO-160 and DO-178, the supplier should conduct various qualification tests developed by OEMs and service providers as part of the activities to obtain airworthiness approval.

3.4 AU Operational Software and Data Loading

The AU 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 AU without the need to remove the units from the aircraft, and to avoid disrupting normal aircraft operations.

The AU software and data may be loaded using the most economic means available. AU software uploads are not specifically required to meet ARINC

615/615A media provisions. The current media include, but are not limited to CD-ROM, DVD, file transfer over wired LAN, file transfer over wireless LAN.

4.0 FUNCTIONAL CAPABILITY

4.1 Functional Description

This section describes component hardware interchangeability and maintenance aspects of the AeroMACS system, including the AeroMACS Unit (AU). RTCA DO-346 MOPS describes additional AU functional capabilities.

4.2 Hardware Maintenance

A common core of maintenance and network service features should be provided in the AU to enable that equipment to securely communicate and be centrally or remotely monitored, managed and troubleshot using the network services defined in [ARINC Standard TBD].

All AU components with active circuitry should incorporate a Built-In Test (BIT) function that includes one or more end-to-end test sequences. The AU 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 xxx 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 AU should host its own local Management Information Base (MIB), accessible by SNMPv2 or later, as described in [ARINC Standard TBD]. As a minimum, the local MIB should include BIT procedures and access to maintenance logs.

MIBs of AU should typically include the following types of information:

- Hardware Status
- Configuration Status
- Application and Process Status
- Resource Status
- Functional Status
- Other TBD

5.0 INTERFACES AND PROTOCOLS

5.1 Discretes

5.1.1 Discrete Inputs

5.1.1.1 Radio On/Off Discrete Input

Pin BP4 is the Radio On/Off discrete input. When this discrete input is grounded then the radio transmitter and receiver are both commanded off (inactive, no transmissions and no received data). When this discrete input is open circuit then the radio transmitter and receiver are both active and will communicate with approved AeroMACS Base Station when within range. The signal that drives this AU input should ONLY be open circuit when the aircraft is on the ground.

5.1.1.2 Transmitter On/Off Discrete Input

Pin BP5 is the Transmitter On/Off discrete input. When this discrete input is grounded then the radio transmitter is commanded off. If the Radio On/Off discrete is grounded (radio off) then the state of the Transmitter On/Off discrete does not matter since the radio is inactive. When this discrete input is open circuit then the radio transmitter is active and will communicate with approved AeroMACS Base Station when within range. The signal that drives this AU input should ONLY be open circuit when the aircraft is on the ground.

5.1.1.3 Unit Reset Discrete Input

Pin BP6 is the Unit Rest discrete input. When grounded then the AeroMACS Unit operation is inhibited and it enters the reset state. When released (open circuit) then operation begins with a full initialization of memory.

5.1.2 Discrete Outputs

5.1.2.1 Unit Status Discrete Output

Pin BP9 is the Unit Status discrete output. When the discrete is grounded that indicates the AeroMACS Unit status is not normal (aka failed). When the discrete output is open circuit that indicates the AeroMACS Unit status is normal.

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

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

6.0 MAINTENANCE AND TEST

6.1 Built-In Test Provisions

6.1.1 General Discussion

A primary focus for the specification of the AU design is the integrity, maintainability, availability and ease of installation for the AU 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 AU 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 AU using Commercial Off-The-Shelf (COTS) systems to help reduce maintenance and engineering labor and costs.

The AU BIT design, and associated Built-In Test-Equipment (BITE) implemented in an LRU 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 AU 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 AU should provide self-contained fault detection and reporting capabilities as a part of the BIT design. The AU 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 an LRU. Alternatively or in addition, the AU may contain an extensive set of BIT screens that can be displayed on a MCDU or other display device (e.g., Laptop, MAT, etc.).

6.1.3 Ramp Return to Service Testing

When an AU 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 AU elements when the fault was actually in another part of the system.

As an end-to-end test, the procedure needs to verify integrity of the LRUs, as well as interface with other systems and applicable antenna connections. All elements of the AU should support return to service testing in a line maintenance environment. AU 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 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 REMOTE AEROMACS UNIT (RAU)

7.1 Introduction and Description

In addition to the basic requirements of the AeroMACS Unit (AU) defined by this document, this section defines additional characteristics unique to the Remote AeroMACS Unit (RAU).

This section defines form and fit dimensions, and electrical interface definition of an RAU, which may be housed in a dedicated unit or integrated with existing equipment on the airplane.

COMMENTARY

Note that Section 2 of this document provides the physical form and fit dimension, and electrical interface definition of the 2-MCU unit.

7.2 Functional Overview

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

7.2.1 RAU Overview

Like the AU defined in Section 1.4.1 of this document, the RAU is used to form an AeroMACS connection between the aircraft and a ground-based network, at an airport.

The RAU supports Air Traffic Services such as CPDLC, FIS, D-Taxi, ADS-B on the airport surface, etc., and AOC functionality such as ACARS messaging, Graphical Weather to EFB, surface movement guidance and situational awareness, FOQA downloads, NAV dB and charts updates, software uploads, AAtS etc. that support safety and regularity of flight.

The RAU functions as a flexible, broadband data communication medium on the airport surface, complementing other air/ground data communications such as VDLM2, SATCOM, LDACS (for ACD Applications), and GSM/UMTS/3G/4G (for AISD Applications) etc.

The RAU connects to an aircraft antenna, which is capable of transmitting and receiving the RF signals in the licensed 5000 MHz to 5150 MHz AeroMACS spectrum, which is globally allocated by ITU-R and ICAO. Antennas are further defined in Attachments 5 and 6. This characteristic does not preclude the implementation of an RAU that supports a multiple antenna arrangement (diversity) provided that all other standards are met.

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

See RTCA DO-346, AeroMACS MOPS for an expanded RAU functional description.

7.3 Interchangeability Standards

7.3.1 Objectives

This section describes the specific form factor, mounting provision, interwiring, input and output interfaces, and power supply characteristics for the RAU.

7.3.2 RAU Form Factor

This section defines the form factor and mounting footprint for a Remote AeroMACs Unit (RAU) intended for aircraft installation. This form factor may be used to package the Ethernet Switch Unit (ESU) with AeroMACS equipment not requiring forced air cooling.

The maximum dimensions for the RAU is shown in Figure 7-1. The dimensions are 174 mm (6.85 inches width) by 292 mm (11.5 inches length) and 102 mm (4 inches height), including the flange mounts. Connectors may protrude outside of the defined form-factor envelope at the approximate locations shown in Figure 7-1. Connector J1 contains the power and control signals similar to the Bottom Plug insert for the LRU. Connector J2 is a standard TNC type connector for connecting to the antenna. A second, optional connector (J3) of type TNC may be provided for connecting to the antenna also. Both main (J2) and optional (J3) RF connectors should be clearly identified.

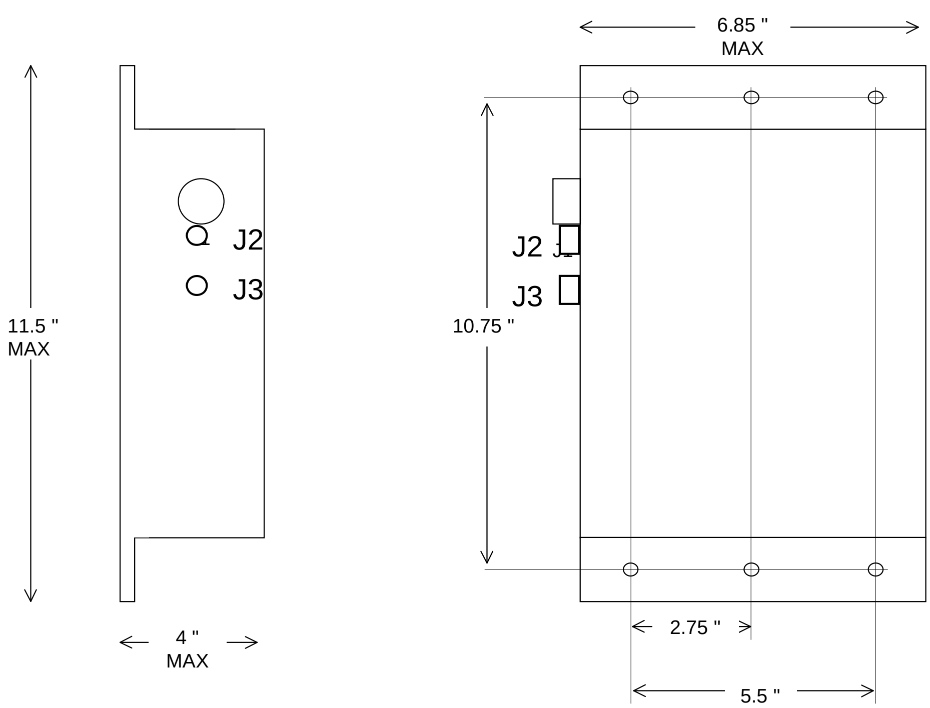


Figure 7-1 – Remote Equipment Envelope Outline

7.3.3 Power

The RAU should be designed to use either aircraft 115 Vac, 360 to 800 Hz, variable frequency or 28 Vdc power. The RAU should be designed to operate normally through power interruptions of up to 200 milliseconds. For more information, see Section 2.3 commentary.

7.3.4 Cooling

The RAU should be designed to operate without active cooling.

7.3.5 Weight

The RAU should weigh less than 10 lbs. (4.5kgs)

7.3.6 Grounding and Bonding

The reader should refer to Section 3.2.4 of ARINC Specification 600 and Appendix 2 of ARINC Specification 404A on the subject of equipment grounding and bonding.

7.3.7 Connectors

The RAU primary connector (J1) is a 41-pin primary signal/power interface connector, part number M83723/72R2041N or equivalent. The pin definitions are specified in Attachment 3 to this document. The connector should be installed as shown in Figure 7-1. The receptacle side (LRU) connector arrangement is shown in Figure 7-2. The mating connector part number is M83723/77R2041N. These connectors were originally specified in ARINC 763.

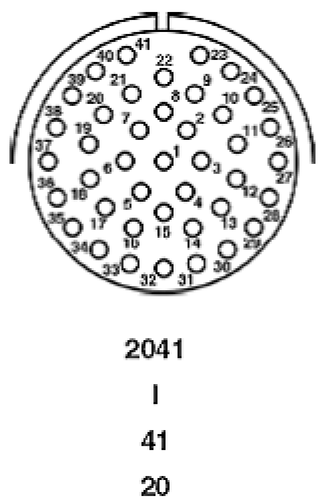


Figure 7-2 – RAU Connector J1

The RAU should use a standard TNC type connector for RF antenna interface(s). Both main (J2) and optional (J3) RF connectors of the RAU should be clearly identified. All RAU connectors may protrude outside of the defined form-factor envelope at the approximate locations shown in Figure 7-1.

7.4 Interfaces and Protocols

7.4.1 Discrete Inputs

The RAU should provide three standard open/ground input discretes to provide remotely switchable on/off control of the device. For example, for an RAU, this may be from Weight-On-Wheels (WOW) Air/Ground Strut Switch or from another LRU such as a Network Server Unit (NSU).

The RAU radio or transmitter should be commanded to the “active” state only when both related on/off control discrete inputs are in the open circuit state.

Operation of the RAU is only applicable while the aircraft is on the ground. The on/off control logic should be implemented within the RAU to supply (or not supply) power to the internal electronics.

7.4.1.1 RAU J1 pin 3 Radio On/Off discrete input

RAU J1 pin 3 has the same definition as LRU Pin BP4, Radio On/Off discrete input. When this discrete input is grounded then the radio transmitter and receiver are both commanded off (inactive, no transmissions and no received data). When this discrete input is open circuit then the radio transmitter and receiver are both active and will communicate with approved AeroMACS Base Station when within range. The signal that drives this RAU input should ONLY be open circuit when the aircraft is on the ground.

7.4.1.2 RAU J1 pin 8, Transmitter On/Off discrete input

RAU J1 pin has the same definition as LRU Pin BP5, Transmitter On/Off discrete input. When this discrete input is grounded then the radio transmitter is commanded off. If the Radio On/Off discrete is grounded (radio off) then the state of the Transmitter On/Off discrete does not matter since the radio is inactive. When this discrete input is open circuit then the radio transmitter is active and will communicate with approved AeroMACS Base Station when within range. The signal that drives this RAU input should ONLY be open circuit when the aircraft is on the ground.

7.4.1.3 RAU J1 pin 13, Unit Reset discrete input

RAU J1 pin 13 has the same definition as LRU Pin BP6, Unit Rest discrete input. When grounded then the AeroMACS Unit operation is inhibited and it enters the reset state. When released (open circuit) then operation begins with a full initialization of memory.

7.4.2 Discrete Outputs

7.4.2.1 RAU J1 pin 15, Unit Status discrete Output

See Section 5.1.2.1.

7.4.3 ARINC 429 Interfaces

No ARINC 429 interfaces should be required.

7.4.4 Ethernet Interfaces

The RAU should be designed to operate with any equipment that supports ARINC 664 Part 2 compliant 100/1000 Base-T Ethernet.

7.4.5 Antennas

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

The input impedance at RF connector should be a nominal 50 ohms with a maximum voltage standing wave ratio (VSWR) of 2.0 over the frequency range.

Manufacturers may choose to implement two RF TNC coax connectors (J2 and J3 in Figure 7-1) for connection of two antennas in support of diversity algorithms embedded as part of the COTS RF electronics. 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 WHAT IS AU TYPE A?

ATTACHMENT 2 WHAT IS AU TYPE B?

ATTACHMENT 3 CONNECTOR PIN DESIGNATIONS – REMOTE AU

This Attachment TBD

ATTACHMENT 3
CONNECTOR PIN DESIGNATIONS – REMOTE AU

CONNECTOR PIN DESIGNATIONS – REMOTE AU

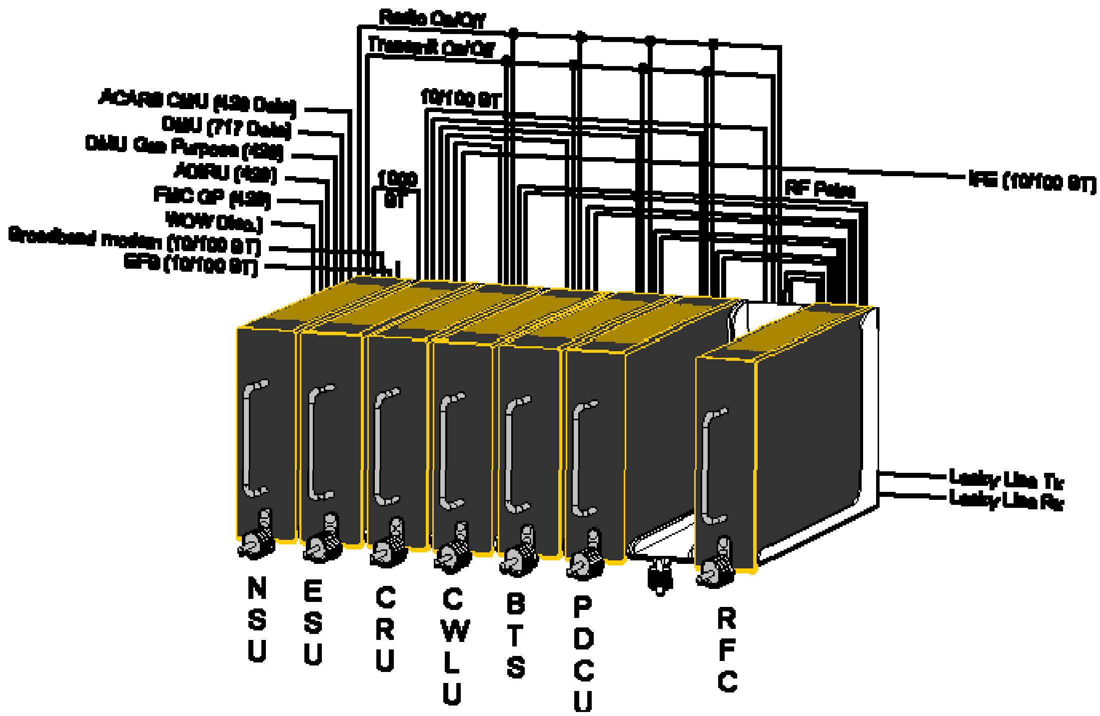
ATTACHMENT 3B		
Connector	**Pin**	**Signal**
J1-B	1	spare
	2	spare
	3	Radio On/Off Discrete Input
	4	ATE
	5	mfg defined
	6	mfg defined
	7	mfg defined
	8	Transmitter On/Off Discrete Input
	9	mfg defined
	10	mfg defined
	11	mfg defined
	12	mfg defined
	13	Unit Reset Discrete Input
	14	mfg defined
	15	LRU 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
J1-A Location	1	Ethernet1 (Primary) AU Port
	2	spare
	3	Ethernet2 (Secondary) AU Port
J1-A Pins	1	TX+ PRI_10_100_TX_A/SEC_10_100_TX_A
	2	RX+ PRI_10_100_RX_A/SEC_10_100_RX_A
	3	TX- PRI_10_100_TX_B/SEC_10_100_TX_B
	4	RX- PRI_10_100_RX_B/SEC_10_100_RX_B

ATTACHMENT 4 RTCA ENVIRONMENTAL TEST CATEGORIES

RTCA DO-160E Section	TEST/EQUIPMENT	AU/ESU/ESR/WNT/ RFC	RAU/RES	AU 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 1: 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 T/1000BASE TX ETHERNET LAN

6.1 Interface Requirements

Ethernet interface requirements should comply with **ARINC Specification 664 Part 2:** *Aircraft Data Network* for 100/1000Base-T Ethernet. ARINC xxx 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 100/1000Base-T Ethernet operation.

6.4 Line Impedance

Line impedance requirements are per ARINC 664, Part 2, 100/1000Base-T Ethernet. 100 ohm cable should be used.

Refer to ARINC 664, Part 2, for cabling requirements for 100/1000Base-T applications.

ATTACHMENT 7 CONSIDERATIONS FOR REQUESTING INDEX PIN ASSIGNMENTS

7.1 Guidance for Index Pin Assignment

To prevent the inadvertent installation of an LRU in the wrong tray, an adaptation of ARINC 600 may be utilized. This defines the key combinations that should be used to identify rear connector configurations for ARINC xxx components packaged in the 2-MCU form factor. Specific assignment of index pins must be coordinated with the ARINC IA staff.

Key	Key Position	Indication	Comments
Left Keyway (top insert)	0	Blank	Default Blank examples: AU NAS, BTS
	1	150-pin Connector (NSU Type A)	Connector Block example: NSU
	2	Gigabit Quadrax	Quadrax examples: ESU, ESR
	3	RFC	
	4	150-pin Connector (NSU Type B)	Connector Block examples: NSU
	5	10/100 Quadrax	Quadrax examples: ESU, ESR
	6	Not used	
Center Keyway (middle insert)	0	Blank	
	1	Gigabit Quadrax	Default
	2	RFC	
	3	100 Quadrax	
	4 - 6	Not used	
Right Keyway (bottom insert)	1	RFC	
	2	RF enabled	RF examples: AU, TWLU, BTS
	3-6	Not used	

ATTACHMENT 8 REMOTE ETHERNET SWITCH (RES)

ATTACHMENT 9 ACRONYMS AND ABBREVIATIONS

ACMS	Aircraft Condition Monitoring System
ADN	Aircraft Data Network
AEEC	Airlines Electronic Engineering Committee
AOC	Airline Operational Control
AP	Access Points
API	Application Program Interface
ATE	Automatic Test Equipment
AWG	American Wire Gauge
AU	AeroMACS Unit
BIT	Built-In Test
BITE	Built-In Test Equipment
BTS	Base Transceiver Station
CAN	Controller Area Network
CCS	Cabin Communications System
CMU	Communications Management Unit
CMM	Component Maintenance Manual
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
CRC	Cyclic Redundancy Checking
CRU	Computational Resource Unit
DHCP	Dynamic Host Control Protocol
DITS	Digital Information Transfer System
DFDR	Digital Flight Data Recording
DMU	Data Management Unit
DNS	Domain Name Service
EFB	Electronic Flight Bag
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESR	Ethernet Switch Router
ESU	Ethernet Switch Unit
FOQA	Flight Operations Quality Assurance
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

ATTACHMENT 9
ACRONYMS AND ABBREVIATIONS

MIB	Management Information Base
MTBF	Mean Time Between Failure
MTBUR	Mean Time Between Unscheduled Removals
NAS	Network Attached Storage
NAT	Network Address Translation
NFF	No Fault Found
NSS	Network Server System
NSU	Network Server Unit
OMTS	On-Board Mobile Telephony System
OSI	Open System Interconnect
PED	Portable Electronic Device
P/N	Part Number
QoS	Quality of Service
RAM	Random Access Memory
RAU	Remote AeroMACS Unit
RES	Remote Ethernet Switch
RF	Radio Frequency
RFC	RF Combiner/Splitter
RX	Receive
SNMP	Simple Network Management Protocol
TWLU	Terminal Area Wireless LAN Unit
TX	Transmit
WAN	Wide Area Network
WNT	Wireless Network Transceiver
WOW	Weight-On-Wheels