



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

AERONAUTICAL MOBILE AIRPORT COMMUNICATIONS SYSTEM (AeroMACS) PROFILE

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EXECUTIVE SUMMARY

This Aeronautical Mobile Airport Communications System (AeroMACS) Profile document specifies the unique adaptations required to enable the current IEEE 802.16-2009 standard to specify technical requirements for wireless data communications to mobile stations on an airport surface. It was developed under collaboration between the European Organization for Civil Aviation Equipment EUROCAE Working Group-82 and the RTCA Special Committee 223 (SC-223).

The purpose and scope section concentrates on introducing the technology and describes the process for the AeroMACS profile development. It defines the bounds of the investigations, the required cooperation between RTCA, EUROCAE, and the WiMAX Forum™ and provides a clear scope prescribing guidelines for profile development. In this section various glossary terms used in the document are described.

The background section provides an overview of system characteristics including concept of operations and principal users of AeroMACS. A description of operational mobile and stationary applications illustrates the different requirements this technology is required to meet. A description of assumptions is provided along with verification procedures necessary to validate profile parameter selection.

The technical profile section describes technical parameter selection required to meet aviation communication requirements. Parameters are selected to meet mobile station requirements and considers operational uses for different environments along with different potential users. This profile requirements section concentrates on different spectrum areas focusing on efficient use of channel assignments and interoperability requirements prescribed by WiMAX Forum™.

CHAPTER 1

PURPOSE AND SCOPE

1.1 INTRODUCTION

This document specifies requirements for the unique adaptations to the current IEEE 802.16-2009 standard to provide wireless data communications to mobile platforms on an airport surface.

AeroMACS is based on the existing IEEE 802.16-2009 WiMAX standard. Within the WiMAX Forum™, an Aviation Working Group (AWG) has been incorporated to adapt AeroMACS requirements into the WiMAX profile documents. This ensures that all stakeholders comprising test equipment vendors, integrated circuit manufacturers, as well as the aviation industry are capable of supporting the AeroMACS development.

As system profiles gradually include more features -- resulting in increased performance -- more complex parts of the standard may be chosen by the aviation community to be incorporated into new and more-advanced AeroMACS profiles. If so, some of the parameters provided in this document may have to be updated."

This document has investigated the use of WiMAX Forum™ Mobile System Profile: Release 1.0 Version 0.9 (WMF-T23-001-R010v09) against avionics needs. No technical obstacles - which would make it impossible to operate this particular profile for aviation -- were found.

Further analysis of the AeroMACS features was performed in the context of the SESAR project P15.2.7 activities and the outcome of these activities has been injected in the finalization of the AeroMACS profile and related documents in RTCA and EUROCAE (e.g., the AeroMACS MOPS).

The joint RTCA and EUROCAE AeroMACS profile described in this document is based on the WIMAX document WiMAX Release 1 System Profile (WMF-T23-001 Release 010 v09).

1.2 AEROMACS DESIGN REFERENCE

- [1] Mobile WiMAX Release 1 System Profile (WMF-T23-001-R010v09)
http://members.wimaxforum.org/apps/org/workgroup/twg/document.php?document_id=53651
- [4] IEEE 802.16-2009

CHAPTER 2

BACKGROUND AND CONCEPT OF OPERATIONS

There is a recognized need in the aeronautical community for a wireless broad-band data communications capability to support future safety and regularity of flight services on the airport surface worldwide. These service areas include Air Traffic Service, Airline Operations Services and Airport Communications Services. Results from the joint Future Communications Study conducted by U.S. Federal Aviation Administration (FAA) and EUROCONTROL recommended the use of existing wireless communications technology based on the commercially available 802.16 2009 standard as the solution to support the future aviation requirements on the airport surface. This system, referred to as the Aeronautical Mobile Airport Communications System (AeroMACS) would operate in available protected aviation mobile communications spectrum with a core band from 5091MHz to 5150MHz. In addition to alleviating an already congested VHF communications band, AeroMACS would also provide a capability to support data intensive applications projected under the FAA's future Next Generation (NextGen) and the European Single European Sky ATM Research (SESAR) Program.

This AeroMACS Profile document specifies the unique adaptations required to enable the current IEEE 802.16-2009 standard to provide wireless data communications to users on an airport surface. It was developed under collaboration between the RTCA Special Committee 223 (SC-223) and EUROCAE WG-82. An AWG Subcommittee was created within the WiMAX Forum™ to support the AeroMACS Profile development. In an attempt to take full advantage of the existing standards and commercially available hardware, adaptations consist of only selected optional manufacturer settings already offered in the IEEE 802.16-2009 standard. This document will ensure that all stakeholders including test equipment vendors, integrated circuit manufacturers, as well as the aviation industry are capable of supporting the AeroMACS development.

2.1

AIRPORT SURFACE WIRELESS COMMUNICATION SYSTEM OVERVIEW

Future Communications Study, ICAO Aeronautical Communications Panel, Recommendation #1 was to develop a new system based on the IEEE 802.16e standard operating in the C-band and supporting the airport surface environment.

- Develop airport surface system based on IEEE 802.16e standard:
 - Identify the portions of the IEEE standard best suited for airport surface wireless communications, identify and develop any missing functionality and propose an aviation specific standard to appropriate standardization bodies;
 - Evaluate and validate the performance of the aviation specific standard to support wireless mobile communications networks operating in the relevant airport surface environments through trials and test bed development;
 - Propose a channelization methodology for allocation of safety and regularity of flight services in the band to accommodate a range of airport classes, configurations and operational requirements;
 - Complete business analysis in relation to the Future Communications Infrastructure components and implementation from the perspective of the ground infrastructure and the airlines.

- The WRC-07 approved adding an Aeronautical Mobile (R) Service (AM(R)S) allocation for 5091-5150 MHz to the International Table of Frequency Allocations:
 - Removed prior limitation in so-called MLS Extension Band for “support of navigation/surveillance functions.”
 - AM(R)S designation for safety and regularity of flight applications.
 - Ensure compatibility with other occupants in the band: non-GSO satellite feeder links and aeronautical telemetry.
 - Protected allocation enables ICAO to develop international standards for airport mobile (i.e., wheels in contact) surface wireless communications networks that include fixed assets.
 - Ideal for airport surface wireless network with short range (~10 km or less sector coverage) and high data throughput.

2.2

OPERATIONAL APPLICATIONS

The community of potential AeroMACS users in an airport environment varies with the size of the airport facility. Airport Authority, Airlines and Civil Aviation Authority are principal airport tenants that deliver services and have a need to transport application information over a wireless network. User applications for transport over AeroMACS have been classified in 5 different functional domain categories. The functional domains are:

- Air Traffic Management/Air Traffic Control
- Aeronautical Information Services and Meteorological Data (AIS/MET)
- Aircraft Owner / Operator
- Airport Authority
- Airport Infrastructure

Applications identified and categorized in these 5 domains may have different performance characteristics, security needs, and quality of service requirements. The type of information content for each application ranges from live video streaming to low throughput system monitoring data exchanges.

Several applications belonging to different functional domains have been identified for consideration. Following is a sample of potential applications that can be transported over AeroMACS. Digital Notice to Airmen (D-NOTAM), the next generation NOTAM, are created and transmitted by government agencies to alert pilots of hazards in the NAS. D-NOTAM has been identified as a strong candidate application for transport over AeroMACS. Pre-departure clearance (PDC) and digital Automatic Terminal Information System (D-ATIS) are applications that are currently transported using ACARS. Both PDC and D-ATIS have been noted as candidates for implementation over AeroMACS. Future applications such as 4D Trajectory Data Link (4DTRAD) leverage advanced avionics to manage the end-to-end aircraft trajectory. 4DTRAD for surface movement application is under consideration for transport over the AeroMACS network.

Mobile stations support both mobile and stationary applications on the airport surface. The following sections describe some potential examples of each. Operation in the RF Physical domain will be identical for all mobile stations.

2.2.1 Mobile Applications Examples

- ATC Communications with any aircraft (anywhere on the airport surface).
 - ATC communications with any vehicle in the airport movement area (runway and taxiways, but not ramp area where airlines control)
 - Tower Data Link System (TDLS) for flight clearances
 - Loading FMS via CMU with 4D trajectories and modifications
- AOC, Advisory, and non-ATS voice/data between airlines and pilot
 - Collaborative decision making and 4D trajectory negotiations
 - EFB data, GPS and AIS updates, hazards advisories; NOTAMS
 - Surface management, gate and ramp control
 - Graphical weather corresponding to 4D trajectory
- Mobile SWIM and airport surface users
 - Publish and subscribe; receive/"listen" only
 - Fire, safety, snow removal, de-icing (in movement area)
 - Airport operations security; security video from cockpit and cabin
 - Gate link applications such as navigation database updates.

2.2.2 Stationary Mobile Applications Examples

Mobile stations also might support airport infrastructure services depending on the regulations in place. Examples for applications are:

- Navigational Aid Monitoring and Maintenance
- Voice Remote radio
- Airport Surveillance

CHAPTER 3

TECHNICAL PROFILES

3.1 SCOPE AND REFERENCES

The recommendations of the Future Communications Study for the airport surface were to utilize Wireless Broadband technology based upon the IEEE 802.16-2009 (WiMAX) standard or equivalent. The key drivers for this decision are:

- Utilize maximum “Commercial Off of The Shelf” (COTS) technology to keep the costs low.
- Minimum additional hardware development required to implement the standard.

The basic idea is to take commercial 802.16 technology, and move it into the 5000 to 5150 MHz aeronautical band.

The technical contents of this document detail a design flow that is based on the WiMAX profile reference described in section 1.2, followed by the unique detailed requirements that are agreed upon by the international EUROCAE WG-82 and RTCA SC-223 plenary committee. The next phase of the document outlines a subset of WiMAX Forum™ features taken from the WiMAX profile document that enable interoperable AeroMACS. Examples include a new band class to enable WiMAX operation in the aeronautical band. Finally, a table and justification list is included to ensure international operability of the WiMAX standard. Generally, these are manufacturer option settings that are listed in the WiMAX profile which need to be coordinated among the various international airport communities

The following sections provide a description of the key features of the AeroMACS profile. A complete list of the features of the WIMAX system that are selected for the AeroMACS profile is provided in Section 3.9.

3.2 ASSUMPTIONS

- AeroMACS total (system) radiated power will be limited to stay within the interference thresholds established by the ITU-R for shared spectrum users. System settings may be adjusted to accommodate increased usage as needed, while maintaining compliance with the established interference thresholds (2% noise temperature increase at the Low Earth Orbit satellite receiver).
- US/Europe agree to use a common network model (Wimax Forum Network Reference Model - Architecture) to define higher level protocols and network functions in development of end-to-end system specifications.
- The AeroMACS will utilize the IP-based end-to-end WiMAX network architecture to develop the end-to-end system.
- AeroMACS will support roaming between Network Service Providers.
- AeroMACS will be implemented in compliance with required security policies.
- AeroMACS will support high availability services.
- All future AeroMACS avionics and infrastructure components will be required to be backwards compatible with previously installed AeroMACS equipment.
- AeroMACS profiles will be maintained under configuration control and will not be changed without undergoing proper review and approvals by all concerned parties.
- AeroMACS will be designed to efficiently utilize allocated spectrum and take full advantage of the technical capabilities of the IEEE 802.16-2009.
- The regulators will authorize the use of AeroMACS resources to ensure equitable access and cost-effective services to all users.
- Users of the AeroMACS include panel mounted avionics, hand held VoIP radios, Electronic Flight Bags, and airport support vehicles. All non-TSO / ETSO hardware used in the AeroMACS service are expected to have passed WiMAX Forum certification testing for the AeroMACS profile

- In the United States, the Federal Aviation Administration, Federal Communications Commission, and National Telecommunications and Information Administration will collaborate to formulate the regulatory framework for the AeroMACS service. A similar process will take place for Europe.

3.3 RADIO PROFILE REQUIREMENTS

Specific settings are required to implement the AeroMACS standard. The potential band of operations will be from 5000 MHz to 5150 MHz, AeroMACS unique profile settings or modifications include network synchronization settings and the transmitter output spectral content or mask. This mask is defined to protect communications in the adjacent band from AeroMACS interference. Current ITU allocations allow for (AM(R)S) operations in bands including the 5091 to 5150 MHz band.

3.4 SPECTRUM MASK REQUIREMENT

The Spectrum Mask requirement is taken from Title 47 CFR part 90.210. The AeroMACS spectrum mask requirement is based upon emission mask “M” for all power levels authorized for the AeroMACS service. The technical requirements of the spectrum mask will be under discussion in ICAO WG-F, ICAO NSP SSG and ICAO EANPG-FMG (Europe). Additionally, the technical requirements will need to be incorporated within Title 47 CFR Part 87 or equivalent ICAO guidance which will supersede the mask definitions stated below. The recommended text is below:

The power spectral density of the emissions must be attenuated below the output power of the transmitter as follows:

- (1) On any frequency removed from the assigned frequency between 0–45% of the authorized bandwidth (BW): 0 dB.
- (2) On any frequency removed from the assigned frequency between 45–50% of the authorized bandwidth: $568 \log (\% \text{ of } (BW)/45)$ dB.
- (3) On any frequency removed from the assigned frequency between 50–55% of the authorized bandwidth: $26 + 145 \log (\% \text{ of } (BW)/50)$ dB.
- (4) On any frequency removed from the assigned frequency between 55– 100% of the authorized bandwidth: $32 + 31 \log (\% \text{ of } (BW)/55)$ dB.
- (5) On any frequency removed from the assigned frequency between 100–150% of the authorized bandwidth: $40 + 57 \log (\% \text{ of } (BW)/100)$ dB.
- (6) On any frequency removed from the assigned frequency between above 150% of the authorized bandwidth: 50 dB or $55 + 10 \log (P)$ dB, whichever is the lesser attenuation.
- (7) The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz. The power spectral density is the power measured within the resolution bandwidth of the measurement device divided by the resolution bandwidth of the measurement device. Emission levels are also based on the use of measurement instrumentation employing a resolution bandwidth of at least one percent of the occupied bandwidth.

3.5 CHANNEL BANDWIDTHS AND CORRESPONDING FFT SIZES

Refer to the table 5 of the Mobile WiMAX system Profile [1] or equivalent.

The AeroMACS profile shall support only the 5 MHz bandwidth, with the corresponding FFT sizes of 512 points.

3.6 AEROMACS CENTER FREQUENCY ASSIGNMENTS

Considering current and potential future allocations, the AeroMACS equipment shall be able to operate in the band from 5000 MHz to 5150 MHz in channels of 5 MHz bandwidth.

NOTE 1: *In the above band, there are 29 potential AeroMACS channels with the nominal center frequencies at $5005+n \cdot 5$ MHz with $n=0$ to 28. The last center frequency of 5145 MHz is selected as the reference frequency. All AeroMACS channels are referenced downward from the reference frequency in 5 MHz steps.*

NOTE 2: *The nominal center frequencies identified in Note 1 are the preferred center frequencies for AeroMACS operations. However, the base stations shall have the capability to deviate from the preferred center frequencies to satisfy potential national spectrum authority implementation issues (i.e. to allow AeroMACS operations while avoiding receiving or causing interference to other systems operating in the band such as MLS and AMT). Therefore the mobile equipment shall be able to operate at center frequencies offset from the preferred frequencies, with that offset having a 250 KHz step size.*

3.7 DOPPLER VELOCITY

AeroMACS is operational with any Doppler velocity up to 50 nautical miles per hour.

3.8 MODULATION TYPES

All modulation types required by the WiMAX profile shall be required for AeroMACS. The 64 QAM Modulation Type is optional in the AeroMACS up-link.

3.9 PROFILE INTEROPERABILITY

The WiMAX MSP has a series of tables that set operational parameters for the mobile (MS) and base station (BS) equipment. The following tables provide a quick reference to the items for use in AeroMACS addressed from the base of WiMAX Profile rev 1.0. As such, the table references, as well as the meaning of items, are the same as specified in the corresponding items in the WiMAX Profile.

- PHY profile: refers to functionality in Physical Layer.
- MAC profile: refers to functionality in Medium Access Control Layer.
- Security: refers to functionality in Security Sub layer.
- Radio profile: indicates permitted radio frequency configuration.
- Power class profile: indicates permitted transmitted power configurations.