FIRST MEETING OF THE COMMUNICATIONS PANEL (CP)

Montreal, Canada, 1 – 5 December, 2014

Agenda Item XX: Approval of the SARPs??

PROPOSALS TO AMEND ANNEX 10 VOLUME III CONCERNING AEROMACS

(Presented by Chairperson of the ACP WG/S)

SUMMARY
This working paper contains the recommendation from WG/S regarding the AeroMACS SARPs. WG/S completed development and validation of the AEROMACS SARPs and recommends that Chapter 7, Volume III of ICAO ANNEX-10 be amended to include the AeroMACS SARPs. Proposed changes to Chapter 7 are presented in Appendix C. In addition, Appendix-A of this WP contains a Cost Benefit analysis for AeroMACS, Appendix B contains an impact assessment of AeroMACS and Appendix-D contains the validation report.

ACTION
The CP is invited to:

a) review, modify, as necessary, and agree on the cost/impact statement contained in Appendix A; the impact assessment contained in Appendix B; and validation report contained in Appendix D

b) review, modify, as necessary, and agree on the proposals for amendment dated 1 December 2014, to Annex 10 Volume III in Appendix C; and

c) agree to finalize the AeroMACS proposal for amendment by 5 December 2014 for submission to the Secretary of the CP.
1. INTRODUCTION

1.1 With respect to future digital voice and data communications systems, the 11th Air Navigation Conference (ANConf/11, 2003) noted that research and development work on air-ground communications would be continued to enable international civil aviation to meet future communication requirements in a spectrum-efficient manner and enable gradual implementation of the ATM operational concept. Based on this recognition, ANConf/11 recommended that ICAO;

- In view of the anticipated saturation of VHF band for voice communication, consider transition to spectrally more efficient ICAO systems, and/or make increased use of data communications (Refer to Doc 9828 Recommendation 7/3 e);

- assess the needs for additional aeronautical spectrum to meet requirements for increased communications capacity and new applications, and assist States in securing appropriate additional allocations by the ITU (Refer to Doc 9828 Recommendation 7/4);

- continue to monitor emerging communication systems technologies but undertake standardization work only when the systems meet all the conditions (refer Doc 9828 Recommendation 7/5).

Based on those recommendations by ANConf/11, ACP WG/WHL/3 in 2010 decided to establish a new working group (i.e. WG/S: Surface Air-Ground Datalink Communication System) for dealing with a specific task to develop SARPs and guidance material for Airport Surface Communication.

1.2 Subsequently, at ACP WG/WHL/4 in 2011, the Group agreed with the initiation of ACP WG/S to commence work on the airport surface communication standards based on IEEE 802.16e specifications to utilize the newly allocated AM(R)S spectrum. Specifically, ACP recommended that WG/S:

- To identify the portions of the IEEE standard that would be best suited for airport surface communications, identify and develop any missing functionality and propose an aviation specific standard to ACP;

- To evaluate and validate the performance of the aviation specific standard to support wireless mobile communication networks operating in the relevant airport surface environments through trials and testbed development;

1.3 WG/S has completed its work on the standards and recommended practices addressing the above recommendations.

This paper provides PfA to Annex 10, Volume III and action by the CP/1 is included in Section 3.

2. DISCUSSION

2.1 At the 6th meeting of ACP WG/S, the group gave careful consideration to the timing of the ICAO approval process along with the needs of the aviation community for provisions on AeroMACS. From the outset, WG/S has recognised the need for a detailed technical manual providing guidance on the implementation and operation of AeroMACS systems, which meet the requirements of the SARPS. Given the two year timeframe for SARPS approvals, it was deemed necessary to obtain
approval at the ###th session of the Air Navigation Commission. In order to do this the main focus of WG-S was the development of the attached SARPS amendment. Once achieved, the focus will shift to the development of a Technical Manual. The objective is to complete the manual so that its publication coincides with the applicability date of the SARPS in November 2016.

2.2 The Technical Manual will be a detailed document covering many practical and institutional issues. WG-S is quite confident of achieving the necessary publication date, as much of the necessary material has been compiled during the development of the SARPS.

2.3

2.4 In addition, a cost/benefit statement is contained in Appendix A, and the impact assessment is contained in Appendix B. The proposals for amendments to Annex 10 (refer to Table 1) is contained in Appendix C of this paper. Furthermore, ACP WG/S created validation report to support new amendment proposal which is contained in Appendix D.

### TABLE 1. PROPOSED AMENDMENTS TO ANNEX

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description of proposed amendment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex 10</td>
<td>Amend Chapter 7 of Volume III by deleting the currently existing placeholder Chapter 7 on Subnetwork Interconnection and inserting the proposed AeroMACS standards provided in Appendix-C of this WP.</td>
</tr>
</tbody>
</table>

3. **ACTION BY THE CP**

3.1 The CP is invited to:

a) review, modify, as necessary, and agree on the cost/impact statement contained in Appendix A; the impact assessment contained in Appendix B; and validation report contained in Appendix D

b) review, modify, as necessary, and agree on the proposals for amendment dated 1 December 2014, to Annex 10 Volume III in Appendix C; and

c) agree to finalize the AeroMACS proposal for amendment by 5 December 2014 for submission to the Secretary of the CP.
APPENDIX A

COST AND BENEFIT STATEMENT FOR AEROMACS

Due to the continuing growth of aviation, it is recognized that demands on airspace capacity will increase and if this trend will continue, saturation of the VHF band for voice communication might be inevitable. To deal with this issue, ANConf/11 recommended that:

- In view of the anticipated saturation of VHF band for voice communication, consider transition to spectrally more efficient ICAO systems, and/or make increased use of data communications (Recommendation 7/3 e));

- assess the needs for additional aeronautical spectrum to meet requirements for increased communications capacity and new applications, and assist States in securing appropriate additional allocations by the ITU(Recommendation 7/4);

- continue to monitor emerging communication systems technologies but undertake standardization work only when the systems meet all the conditions (Recommendation 7/5).

To deal with those recommendations, ACP has dedicated to draft SARPs amendment proposal related to AeroMACS. The ACP believe that the AeroMACS is the system which benefits derived from their services will offset the implementation and operating costs.

AeroMACS is the wireless communication network systems which will provide aircraft and ground infrastructures with the broadband connectivity to support aircraft operations at airport and wide range of applications. For instance, expected applications include the next generation NOTAM, Pre-departure clearance (PDC), Digital Automatic Terminal Information System (D-ATIS) and future applications such as 4D Trajectory Data Link (4DTRAD). Furthermore, AeroMACS will support graphical, moving map taxi guidance on the airport surface, enable upload of graphical weather maps to the cockpit and enhance situational awareness of controllers, which in turn, will improve conflict resolution. In addition, other potential benefit from implementing AeroMACS will include:

- higher throughput in ground communications
- improving scalability and interoperability worldwide;
- increasing security and protecting privacy;
- reducing costs over proprietary solutions;
- reducing airport congestion and delays; and
- reducing congestion on A/G VHF datalink

As written in Impact Assessment, AeroMACS will require new ground infrastructure, which can be owned and operated by the States or procured as service. In addition, industry operators will require additional avionics equipment for AeroMACS.
However as described in Impact Assessment, since significant safety, security and environmental benefits are expected derived from AeroMACS which will be an enabler for ATM, AOC & airport services, those implementation and operating costs can be offset.
APPENDIX B

IMPACT ASSESSMENT (used FLTOPSP Ver 1.1)
1. What is the problem that this proposal is designed to solve?

Please include reference to Job card / ASBU / work program item, as applicable

ICAO Global Air Navigation Plan (GANP) identifies a need for broadband communication system on airport surface to support future air traffic management (ATM) services. The proposed AeroMACS Standards and Recommended Practices (SARPs) fulfils that stated need by utilizing 5091 MHz to 5150 MHz spectrum allocated by WRC-07 for AM®S services. [Work Program Number??]

2. What documents need to be amended or created in order to address the Job Card problem statement

<table>
<thead>
<tr>
<th>None</th>
<th>Annex</th>
<th>PANS</th>
<th>Doc/Circ</th>
<th>Other (please explain)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. What is the impact of this proposal on a **State** and **Industry**?

<table>
<thead>
<tr>
<th>Safety impact: Implementing this proposal will have a positive safety impact.</th>
<th>Criteria</th>
<th>Increased safety</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rationale:**
State: The proposed AeroMACS will support graphical, moving map taxi guidance on the airport surface, enable upload of graphical weather maps to the cockpit and enhance situational awareness of controllers, which in turn, will improve conflict resolution.

Industry: AeroMACS will enable better situational awareness and hazard avoidance for the pilots. It will also provide better, graphical weather to cockpit.

<table>
<thead>
<tr>
<th>Security impact: Implementing this proposal will enhance security.</th>
<th>Criteria</th>
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<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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<td></td>
<td></td>
</tr>
<tr>
<td>Impact on Industry</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rationale:**
State: AeroMACS utilizes state-of-the-art, PKI-based, cryptographic functions for peer entity authentication. This will virtually eliminate spoofing & masquerading.

Industry: AeroMACS utilizes PKI-based encryption to protect operational and business data from unauthorized access.

<table>
<thead>
<tr>
<th>Financial impact: Implementation of this proposal represents a negligible financial cost.</th>
<th>Criteria</th>
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<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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</thead>
<tbody>
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<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rationale:**
State: AeroMACS will require new ground infrastructure, which can be owned and operated by the States or procured as service. If procured as service, the operating costs will be offset by savings derived from efficiency gains.

Industry: Operators will require additional avionics equipment for AeroMACS; however, AeroMACS will be an enabler for ATM, AOC & airport services. Benefits derived from these services will offset the implementation and operating costs.

<table>
<thead>
<tr>
<th>Environmental impact: Implementing this proposal will have a positive environmental impact (reduction in atmospheric or surface pollutants, noise, etc.).</th>
<th>Criteria</th>
<th>Reduced Emissions/ Noise</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
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<tr>
<td>Impact on Industry</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rationale:**
State: By reducing hold over, taxi, and weather related delays through utilization of better information available over AeroMACS, noise and carbon pollutions will be reduced.

Industry: Reduced fuel consumption will reduce the carbon footprint for aircraft operations.
B-3

Efficiency impact:
Implementing this proposal will have a positive impact on the efficiency of the air transportation system.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Increased efficiency</th>
<th>Decreased efficiency</th>
</tr>
</thead>
<tbody>
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<td>Impact on State</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Impact on Industry</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

**Rationale:**
State: AeroMACS is a key enabler for ATM. It will offload most of the strategic ATM and FIS communications from VDL Mode2, thereby preserving limited VDL/M2 spectrum for tactical communications. Also, it will improve the capacity and efficiency of the airport and airspace.

Industry: AeroMACS will enable airport automation, improve situational awareness of pilots and controllers and permit better flight planning, which will reduce operating costs by reducing delays, holding times, fuel burn and carbon emissions.

4. Do the overall benefits of this proposal justify the costs and/or adverse effects of implementing the proposal?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not sure</th>
<th>Not applicable</th>
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<tr>
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</tr>
<tr>
<td>Industry</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comment:**
State: Efficiency improvements listed under item (3) above will result in cost savings that would be significantly higher than the cost of infrastructure build out and operating costs.

Industry: Saving resulting from reduced fuel consumption, delays and weather avoidance through the use of better information available over AeroMACS will outweigh the cost of avionics equipage.

5. How long would it take for States and Industry to implement this proposal?

<table>
<thead>
<tr>
<th></th>
<th>Already implemented</th>
<th>0-1 yrs</th>
<th>1-2 yrs</th>
<th>2-5 yrs</th>
<th>5-10 yrs</th>
<th>more than 10 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td></td>
<td></td>
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<tr>
<td>Industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

**Comment:** AeroMACS deployment will require new ground infrastructure and avionics equipage. COTS products are available from the ground infrastructure; certified avionics development & equipage will take 36 to 60 months.

**USER NOTES**

**TABLE 1:** Table 1 is meant to capture, in general terms, a need or an opportunity for change. The Title and the Problem Statement should be extracted from a Job card, if available. Its size should be limited to a few statements and its scope should remain focused on the issue at hand.

**TABLE 2:** Fields in Table 2 identify all types of guidance material (Annex, PANS, Doc or Circular) that may have to be amended. The “Other” field should be used to identify other documents that may fall within the scope of the work associated with the proposed change(s), such as a new manual or an amendment to an existing one.

**TABLE 3:** The various statements in Table 3 seek to evaluate the impact of the proposed change on the State and Industry, in terms of safety, security, financial costs, efficiency, and the environment. It is possible that the impact assessment applicable to the State is a different than the one applicable to the Industry.

Safety, security, efficiency, as well as financial and environmental impacts may be negligible or substantial, or not applicable. Separate Rationale statements for State and Industry should substantiate in general terms the assessment of these specific items. Items deemed not applicable should be annotated N/A and shall not account towards the overall impact assessment of the proposed change.

With respect to financial costs for the State, it refers to the cost to develop, implement, maintain, and consider oversight issues associated with the proposed change. For the Industry, it refers to the cost of implementing the change where compliance is required by the State, which may translate in costs for equipage, human resources, training, documentation, aircraft modifications or upgrades, operations and airworthiness for example.
Whereas some changes have limited implications, other changes may be far-reaching in terms of resource commitment and long-term implications. The Rationale field should not attempt to quantify the proposed change(s), but identify the overall scope (narrow change with no inter-dependencies; broad changes with numerous inter-dependencies) and timeline (a one-time change, or an evolving change with short-, medium- and/or long-term implications).

TABLES 4 AND 5: The Comment field for tables 4 and 5 explain the substantive reason behind the choice of answer. These tables may combine comments and statements that apply to both State and Industry, or consider these separately.
NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

1. The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

   a) Text to be deleted is shown with a line through it. text to be deleted

   b) New text to be inserted is highlighted with grey shading. new text to be inserted

   c) Text to be deleted is shown with a line through it followed by the replacement text which is highlighted with grey shading. new text to replace existing text

2. The source of the proposed amendment is the Communication Panel (CP).
### INITIAL PROPOSAL 1

#### CHAPTER 7. **Subnetwork Interconnection - Airport Surface Datalink System (AeroMACS)**  I-7-1

- **7.1 Definitions** .................................................. I-7-1
- **7.2 Introduction** ................................................... I-7-1
- **7.3 General** ....................................................... I-7-2
- **7.4 Radio Frequency (RF) Radio Characteristics** ................................................... I-7-2
- **7.5 Performance Characteristics** ................................................... I-7-3
- **7.6 System Interfaces** ................................................ I-7-4
- **7.7 Application Requirements** ........................................ I-7-5

(to be developed)
Chapter 7  SUBNETWORK INTERCONNECTION AIRPORT SURFACE DATALINK SYSTEM (AEROMACS)

[to be developed]

7.1 DEFINITIONS

Aerodrome. A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

AeroMACS Downlink (DL). The transmission direction from the base station (BS) to the mobile station (MS).

AeroMACS Uplink (UL). The transmission direction from the mobile station (MS) to the base station (BS).

AeroMACS Handover. The process in which a mobile station (MS) migrates from the air-interface provided by one base station (BS) to the air-interface provided by another BS. A break-before-make AeroMACS Handover is where service with the target BS starts after a disconnection of service with the previous serving BS.

Adaptive modulation. A system’s ability to communicate with another system using multiple burst profiles and a system’s ability to subsequently communicate with multiple systems using different burst profiles.

Base station (BS). A generalized equipment set providing connectivity, management, and control of the mobile station (MS).

Bit error rate (BER). The number of bit errors in a sample divided by the total number of bits in the sample, generally averaged over many such samples.

Burst profile. Set of parameters that describe the uplink or downlink transmission properties associated with an interval usage code. Each profile contains parameters such as modulation type, forward error correction (FEC) type, preamble length, guard times, etc.

Convolutional Turbo Codes (CTC). Type of Forward Error Correction (FEC) code that uses a double binary Circular Recursive Systematic Convolutional code, feeding the data alternatively to serial or parallel concatenated convolutional codes with pseudo-random interleaving between the inner and outer code.

Data transit delay. In accordance with ISO 8348, the average value of the statistical distribution of data delays. This delay represents the subnetwork delay and does not include the connection establishment delay.

Domain. A set of end systems and intermediate systems that operate according to the same routing procedures and that is wholly contained within a single administrative domain.
**Forward Error Correction.** The process of adding redundant information to the transmitted signal in a manner which allows correction, at the receiver, of errors incurred in the transmission.

**Frequency assignment.** A logical assignment of centre frequency and channel bandwidth programmed to the base station (BS).

**Mobile station (MS).** A station in the mobile service intended to be used while in motion or during halts at unspecified points. An MS is always a subscriber station (SS).

**Partial usage sub-channelisation (PUSC).** A technique in which the orthogonal frequency division multiplexing (OFDM) symbol subcarriers are divided and permuted among a subset of sub-channels for transmission, providing partial frequency diversity.

**Residual error rate.** The ratio of incorrect, lost and duplicate subnetwork service data units (SNSDUs) to the total number of SNSDUs that were sent.

**Service data unit (SDU).** A unit of data transferred between adjacent layer entities, which is encapsulated within a protocol data unit (PDU) for transfer to a peer layer.

**Service flow.** A unidirectional flow of media access control layer (MAC) service data units (SDUs) on a connection that is providing a particular quality of service (QoS).

**Subscriber station (SS).** A generalized equipment set providing connectivity between subscriber equipment and a base station (BS).

**Subnetwork entry time.** The time from when the mobile station starts the scanning for BS transmission, until the network link establishes the connection, and the first network user “protocol data unit “ can be sent.

**Subnetwork service data unit (SNSDU).** An amount of subnetwork user data, the identity of which is preserved from one end of a subnetwork connection to the other.

**Time division duplex (TDD).** A duplex scheme where uplink and downlink transmissions occur at different times but may share the same frequency.
7.2. **INTRODUCTION**

7.2.1 Aeronautical mobile airport communications system. (AeroMACS) is a high capacity data link supporting mobile and fixed communications, related to the safety and regularity of flight, on the aerodrome surface.

*Note.*—AeroMACS is derived from the IEEE 802.16-2009 mobile standards. AeroMACS profile document (RTCA DO345 and EUROCAE ED 222) lists all features from these standards which are mandatory, not applicable or optional. AeroMACS profile differentiates between base station and mobile station functionality and contains -for each feature - a reference to the applicable standards parts.

7.3 **GENERAL**

7.3.1 AeroMACS shall conform to the requirements of this and the following chapters.

7.3.2 AeroMACS shall only transmit when on the surface of an aerodrome.

7.3.3 AeroMACS shall support aeronautical mobile (route) service (AM(R)S) communications.

7.3.4 AeroMACS shall process messages according to their associated priority.

7.3.5 AeroMACS shall support multiple levels of message priority.

7.3.6 AeroMACS shall support point to point communication.

7.3.7 AeroMACS shall support multicast and broadcast communication services.

7.3.8 AeroMACS shall support internet protocol (IP) packet data services.

7.3.9 AeroMACS shall provide mechanisms to transport ATN/IPS and ATN/OSI (over IP) based messaging.

7.3.10 **Recommendation.**—AeroMACS should support voice services.

*Note.* Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocols (Doc 9896) provide information on voice service over IP.

7.3.11 AeroMACS shall support multiple service flows simultaneously.

7.3.12 AeroMACS shall support adaptive modulation and coding.

7.3.13 AeroMACS shall support handover between different AeroMACS BSs during aircraft movement or on degradation of connection with current BS.
7.3.14 AeroMACS shall keep total accumulated interference levels with limits defined by the International Telecommunication Union - Radiocommunication Sector (ITU-R) as required by national/international rules on frequency assignment planning and implementation.

7.3.15 AeroMACS shall support a flexible implementation architecture to permit link and network layer functions to be located in different or same physical entities.
7.4 RADIO FREQUENCY (RF) CHARACTERISTICS

7.4.1 General Radio Characteristics

7.4.1.1 AeroMACS shall operate in time division duplex (TDD) mode.

7.4.1.2 AeroMACS shall operate with a 5 MHz channel bandwidth.

7.4.1.3 AeroMACS MS antenna polarization shall be vertical.

7.4.1.4 AeroMACS BS antenna polarization shall have a vertical component.

7.4.1.5 AeroMACS shall operate without guard bands between adjacent AeroMACS channels.

7.4.1.6 AeroMACS shall operate according to the orthogonal frequency division multiple access method.

7.4.1.7 AeroMACS shall support both segmented partial usage sub-channelisation (PUSC) and PUSC with all carriers as sub-carrier permutation methods.

7.4.2 Frequency Bands

7.4.2.1 AeroMACS equipment shall be able to operate in the band from 5030 MHz to 5150 MHz in channels of 5 MHz bandwidth.

Note 1.— Some States may, on the basis of national regulations, have additional allocations to support AeroMACS. Information on the technical characteristics and operational performance of AeroMACS is contained in the AeroMACS Minimum Operational Performance Specification (MOPS) (EUROCAE ED-223 / RTCA DO-346) and AeroMACS Minimum Aviation System Performance Standard (MASPS) (EUROCAE ED-227).

Note 2.— The last centre frequency of 5145 MHz is selected as the reference frequency. AeroMACS nominal centre frequencies are referenced downward from the reference frequency in 5 MHz steps.

7.4.2.2 The mobile equipment shall be able to operate at centre frequencies offset from the preferred frequencies, with an offset of 250 KHz step size.

Note.— The nominal centre frequencies are the preferred centre frequencies for AeroMACS operations. However, the base stations should have the capability to deviate from the preferred centre 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).
7.4.3 Radiated Power

7.4.3.1 The maximum mobile station effective isotropic radiated power (EIRP) shall not exceed 30 dBm.

7.4.3.2 The maximum base station EIRP in a sector shall not exceed 39.4 dBm.

7.4.3.3 Recommendation. — In order to meet ITU requirements, the total base station EIRP in a sector should be decreased from that peak, considering the antenna characteristics, at elevations above the horizon. Further information is provided in the guidance material;

Note 1.— EIRP defined as antenna gain in a specified elevation direction plus the average AeroMACS transmitter power. While the instantaneous peak power from a given transmitter may exceed that level when all of the subcarriers randomly align in phase, when the large number of transmitters assumed in the analysis is taken into account, average power is the appropriate metric.

Note 2.— If a sector contains multiple transmit antennas (e.g., multiple input multiple output (MIMO) antenna), the specified power limit is the sum of the powers from each antenna.

7.4.4 Minimum Receiver Sensitivity

7.4.4.1 AeroMACS receiver sensitivity shall comply with table 7-1 – AeroMACS Receiver Sensitivity values.

Note 1.— The computation of the sensitivity level for AeroMACS is described in XXX guidance material.

Note 2.— AeroMACS receiver would be 2 dB more sensitive than indicated if Convolutional Turbo Codes (CTC) is used.

Note 3 - The sensitivity level is defined as the power level measured at the receiver input when the bit error rate (BER) is equal to 1*10^-6 and all active sub-carriers are transmitted in the channel. In general the requisite input power depends on the number of active sub-carriers of the transmission.

Note 4.— The above values assume a receiver noise figure of 8 dB.

Note 5.— The sensitivity values in Table X-1 assume absence of any source of interference except for thermal and receiver noise.
Table 7-1 – AeroMACS Receiver Sensitivity values

<table>
<thead>
<tr>
<th>Modulation scheme using convolutional codes (CC) encoding scheme</th>
<th>Rep. Factor</th>
<th>MS Sensitivity</th>
<th>BS Sensitivity</th>
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</thead>
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<tr>
<td>64 QAM 3/4</td>
<td>1</td>
<td>-74.3 dBm</td>
<td>-74.5 dBm</td>
</tr>
<tr>
<td>64 QAM 2/3</td>
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</tr>
<tr>
<td>16 QAM 3/4</td>
<td>1</td>
<td>-80.3 dBm</td>
<td>-80.5 dBm</td>
</tr>
<tr>
<td>16 QAM 1/2</td>
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<td>-83.8 dBm</td>
<td>-84.0 dBm</td>
</tr>
<tr>
<td>QPSK 3/4</td>
<td>1</td>
<td>-86.3 dBm</td>
<td>-86.5 dBm</td>
</tr>
<tr>
<td>QPSK 1/2</td>
<td>1</td>
<td>-89.3 dBm</td>
<td>-89.5 dBm</td>
</tr>
<tr>
<td>QPSK 1/2 with repetition 2</td>
<td>2</td>
<td>-92.3 dBm</td>
<td>-92.5 dBm</td>
</tr>
</tbody>
</table>

**Note.** — 64 QAM transmission is optional for MS.

### 7.4.5 Spectral Mask And Emissions

7.4.5.1 The power spectral density of the emissions when all active sub carriers are transmitted in the channel shall be attenuated below the maximum power spectral density as follows:

a) On any frequency removed from the assigned frequency between 50–55% of the authorized bandwidth: \(26 + 145 \log (\% \text{ of BW/50})\) dB.

b) On any frequency removed from the assigned frequency between 55–100% of the authorized bandwidth: \(32 + 31 \log (\% \text{ of (BW)/55})\) dB.

c) On any frequency removed from the assigned frequency between 100–150% of the authorized bandwidth: \(40 +57 \log (\% \text{ of (BW)/100})\) dB.

d) On any frequency removed from the assigned frequency beyond 150% of the authorized bandwidth: 50 dB.

**Note.** — The power spectral density at a given frequency is the power within a bandwidth equal to 100 kHz centred at this frequency, divided by this measurement bandwidth. It is clarified that the measurement of the power spectral density should encompass the energy over at least one frame period.

7.4.5.2 AeroMACS shall implement power control.

7.4.5.3 AeroMACS minimum rejection for adjacent (+/−5MHz) channel – measured at BER=10^{-6} level for a victim signal power 3 dB higher than the receiver sensitivity - shall be 10 dB for 16 QAM 3/4.

7.4.5.4 AeroMACS minimum rejection for adjacent (+/−5MHz) channel measured at BER=10^{-6} level for a victim signal power 3 dB higher than the receiver sensitivity shall be 4 dB for 64 QAM 3/4.
7.4.5.5 AeroMACS minimum rejection for second adjacent (+/−10MHz) channel and beyond – measured at BER=10−6 level for a victim signal power 3 dB higher than the receiver sensitivity - shall be 29 dB for 16 QAM 3/4.

7.4.5.6 AeroMACS minimum rejection for second adjacent (+/−10MHz) channel and beyond – measured at BER=10−6 level for a victim signal power 3 dB higher than the receiver sensitivity - shall be 23 dB for 64 QAM 3/4.

Note.— for additional clarification, to the requirements stated in paragraph 7.4.5.3, 7.4.5.4, 7.4.5.5 and 7.4.5.6, refer to IEEE 802.16-2009 section 8.4.14.2.

7.4.6 Frequency Tolerance

7.4.6.1 AeroMACS BS reference frequency accuracy shall be better than +/- 2 x 10E-6.

7.4.6.2 AeroMACS MS reference frequency shall be locked to that of the BS centre frequency with an accuracy better than 2% of the subcarrier spacing.

7.4.6.3 AeroMACS MS shall track the frequency of the BS and shall defer any transmission if synchronisation is lost or exceeds the tolerances given above.
7.5 PERFORMANCE REQUIREMENTS

7.5.1 Aeromacs Communications Service Provider

7.5.1.1 The maximum unplanned service outage duration on a per aerodrome basis shall be 6 minutes.

7.5.1.2 The maximum accumulated unplanned service outage time on per aerodrome basis shall be 240 minutes/year.

7.5.1.3 The maximum number of unplanned service outages shall not exceed 40 per year per aerodrome.

7.5.1.4 Connection resilience. The probability that a transaction will be completed once started shall be at least .999 for AeroMACS over any one-hour interval.

Note 1. — Connection releases resulting from AeroMACS handover between base stations, log-off or circuit pre-emption are excluded from this specification.

Note 2. — The requirements given in 7.5.1 refer to the overall service provision, i.e.; when all aircraft operating at the aerodrome are affected.

7.5.2 Doppler Shift

7.5.2.1 AeroMACS shall operate with a Doppler shift induced by the movement of the MS up to a radial speed of 92.6km (50 nautical miles) per hour, relative to the BS.

7.5.3 Delay

7.5.3.1 Subnetwork entry time shall be less than 90 seconds.

7.5.3.2 Recommendation. — Subnetwork entry time should be less than 20 seconds.

7.5.3.3 The from-MS data transit delay (95th percentile) for the highest priority data service, shall be less than or equal to 1.4 seconds over a window of 1 hour or 600 SDUs, whichever is longer.

7.5.3.4 The to-MS data transit delay (95th percentile) for the highest priority data service, shall be less than or equal to 1.4 seconds over a window of 1 hour or 600 SDUs, whichever is longer.

7.5.4 Integrity

7.5.4.1 AeroMACS BS and MS shall support mechanisms to detect and correct corrupt SNSDUs.

7.5.4.2 AeroMACS BS and MS shall only process SNSDUs addressed to themselves.
7.5.4.3 **Recommendation**.— The residual error rate, to/from MS should be less than or equal to $5 \times 10^{-8}$ per SNSDU.

*Note.— There are no integrity requirements for SNSDU residual rate to the BS and MS as the requirement is entirely satisfied by the end-to-end systems in the aircraft and Air Traffic Service Provider.*

7.5.4.4 The maximum bit error rate shall not exceed 10-6 after CTC-FEC assuming a minimum received signal equal to the corresponding sensitivity level.

### 7.5.5 Security

7.5.5.1 AeroMACS shall provide a capability to protect the integrity of messages in transit.

*Note.— The capability includes cryptographic mechanisms to provide integrity of messages in transit.*

7.5.5.2 AeroMACS shall provide a capability to protect the availability of the system.

*Note.— The capability includes measures to ensure that the system and its capacity are available for authorized uses during unauthorized events.*

7.5.5.3 AeroMACS shall provide a capability to protect the confidentiality of messages in transit.

*Note.— The capability includes cryptographic mechanisms to provide encryption/decryption of messages.*

7.5.5.4 AeroMACS shall provide an authentication capability.

*Note.— The capability includes cryptographic mechanisms to provide peer entity authentication, mutual peer entity authentication, and data origin authentication.*

7.5.5.5 AeroMACS shall provide a capability to ensure the authenticity of messages in transit.

*Note.— The capability includes cryptographic mechanisms to provide authenticity of messages in transit.*

7.5.5.6 AeroMACS shall provide a capability to authorize the permitted actions of users of the system.

*Note.— The capability includes mechanisms to explicitly authorize the actions of authenticated users. Actions that are not explicitly authorized are denied.*

7.5.5.7 If AeroMACS provides interfaces to multiple domains, AeroMACS shall provide capability to prevent intrusion from lower integrity domain to higher integrity domain.
7.6 SYSTEM INTERFACES

7.6.1 AeroMACS shall provide data service interface to the system users.

7.6.2 AeroMACS shall support notification of the status of communications.

Note.—This requirement could support notification of the loss of communications (such as join and leave events).

7.7 APPLICATION REQUIREMENTS

7.7.1 AeroMACS shall support multiple classes of services to provide appropriate service levels to applications.

7.7.2 If there is a resource contention, AeroMACS shall pre-empt lower priority service(s) in favour of higher priority service(s).

<table>
<thead>
<tr>
<th>Origin:</th>
<th>Rationale:</th>
</tr>
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</table>
| CP      | Due to the continuing growth of aviation, it is recognized that demands on airspace capacity will increase and if this trend will continue, saturation of the VHF band for voice communication might be inevitable. Based on the recommendation at ANConf/11, CP has dedicated to draft SARPs for future communication systems for airport surface (airport surface communication system so called AeroMACS).

AeroMACS will support graphical, moving map taxi guidance on the airport surface, enable upload of graphical weather maps to the cockpit and enhance situational awareness of controllers, which in turn, will improve conflict resolution.

In addition, other potential benefit from implementing AeroMACS will include:
- higher throughput in ground communications
- improving scalability and interoperability worldwide;
- increasing security and protecting privacy;
- reducing costs over proprietary solutions;
- reducing airport congestion and delays; and
- reducing congestion on A/G VHF datalink

Although AeroMACS will require new ground infrastructure, which can be owned and operated by the States or procured as service and industry operators will require additional avionics equipment for AeroMACS, as mentioned above, since significant safety, security and environmental benefits are expected derived from AeroMACS, those implementation and operating costs can be offset. |
APPENDIX D

VALIDATION REPORT

Appendix D is included in the separate file (Refer to WPXX.1)

— END —