CAAC

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China Civil Aviation Technical Standard Order

This China Civil Aviation Technical Standard Order (CTSO) is issued according to Part 37 of the China Civil Aviation Regulations (CCAR-37). Each CTSO is a criterion which the concerned aeronautical materials, parts or appliances used on civil aircraft must comply with when it is presented for airworthiness certification.

5G Aeronautical Mobile Airport Communication System（5G AeroMACS）Airborne Mobile Station（AMS）Equipment

1. **Purpose.**

This China Civil Aviation Technical Standard Order (CTSO) is for manufacturers applying for 5G Aeronautical Mobile Airport Communication System (5G AeroMACS) Airborne Mobile Station (AMS) Equipment CTSO authorization (CTSOA). This CTSO specifies the minimum performance standards (MPS) that 5G AeroMACS AMS equipment must meet for approval and identification with the applicable CTSO marking.

2. **Applicability.**

This CTSO affects new applications submitted after its effective date. Major design changes to article approved under this CTSO will require a new authorization in accordance with section 21.353 of CCAR-21.

3. **Requirements.**

5G AeroMACS AMS equipment manufactured on or after the effective date of this CTSO and intended to be identified using this CTSO marking must meet the minimum performance standards set forth in Appendices 1 of this CTSO.

a. Functionality.

This TSO’s standards apply to 5G AeroMACS AMS equipment intended to provide data communication in airport surface operations. 5G AeroMACS AMS equipment may provide access in the airport environment to one or more of the following services: Air Traffic Services (ATS), Aeronautical Operational Communication (AOC) including aeronautical information services and meteorological (AIS/MET) information, Airline Administrative Communication (AAC), and Airport Authority communication, as well as Aircraft Access to System Wide Information Management (SWIM) services. 5G AeroMACS AMS equipment consisting of Radio Unit（RU）and antenna，is intended for use while on the airport surface only. Passenger Information and Entertainment Service and passenger-owned devices are not included in this CTSO.

5G AeroMACS is considered supplemental to communication equipment required by the operating rules. 5G AeroMACS is based on 5G

AeroMACS communication protocol, and is only intended for operation on the airport surface.

b. Failure Condition Classifications.

The failure condition specified in paragraphs 3.b.(1) through 3.b.(3) of this CTSO is based on data communications in airport surface operations, its installation impact on own aircraft system, or impact to other aircraft operating in its vicinity.

(1) Failure of AeroMACS AMS equipment described in paragraph 3.a of this CTSO that enables unauthorized or inadvertent access to the aircraft control domain (ACD) from outside the ACD is a major failure condition (or, alternatively, a major security threat, as defined in RTCA DO-326A/EUROCAE ED-202A, Airworthiness Security Process Specification, issued in August/June 2014 respectively). The ACD is described in RTCA DO356A/EUROCAE ED-203A, Airworthiness Security Methods and Considerations, issued June 2018, Appendix I, Section I.1.1, Domains under ARINC 811 and 664 Part 5.

(2) Failure of the function defined in paragraph 3.a of this CTSO, other than failures described in paragraph 3.b.(1), is a minor failure condition. This failure condition classification is based on the network protocol and/or application system layers above the AeroMACS AMS equipment being able to detect and annunciate errors that would result in misleading or missing ATS messages.

(3) Loss of the function as defined in paragraph 3.a of this TSO,

except for loss of security partitioning that meets the threshold described in paragraph 3.b.(1), is a minor failure condition.

(4) Design the system to at least the design or security assurance level, as applicable, equal to the above failure condition or security threat classifications.

c. Functional Qualification.

Demonstrate the required functional performance under the test conditions specified in RTCA DO-346A / EUROCAE ED-223A section 2.4.1. Applicants must propose a method to demonstrate interoperability with an authorized 5G AeroMACS data.

d. Environmental Qualification.

Demonstrate the required performance under the test conditions specified in RTCA DO-346A / EUROCAE ED-223A section 2.3.1 using standard environmental conditions and test procedures appropriate for airborne equipment. You may use a different standard environmental condition and test procedure than RTCA DO-160G / EUROCAE ED-14G, provided the standard is appropriate for the 5G AeroMACS AMS equipment.

Note: The use of RTCA DO-160D/EUROCAE ED-14D, Environmental Conditions and Test Procedures for Airborne Equipment (with Changes 1 and 2 only, without Change 3

incorporated) or earlier versions is generally not considered appropriate and will require substantiation via the deviation process as discussed in paragraph 3.h of this CTSO.

e. Software Qualification.

If the article includes software, develop the software according to RTCA, Inc. document RTCA DO-178C/EUROCAE ED-12C, Software Considerations in Airborne Systems and Equipment Certification, issued in December 2011/January 2012 respectively, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph 3.b of this CTSO. You may also develop the software according to RTCA DO-178B / EUROCAE ED-12B, issued in December 1992, if you communicate and confirm with the authority. The authority has the right to require the applicant to meet other additional requirements while meeting RTCA DO178B/EUROCAE ED-12B.

f. Electronic Hardware Qualification.

If the article includes airborne electronic hardware, and the failure condition of paragraph 3.b.(1) of this TSO applies, then develop the component according to RTCA DO-254 / EUROCAE ED-80, Design Assurance Guidance for Airborne Electronic Hardware, issued in April 2000, to at least the development assurance level consistent with the failure condition classification defined in paragraph 3.b.(1) of this CTSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

g. Aircraft Information Security and Protection Qualification.

Design and develop 5G AeroMACS AMS equipment in accordance with, as applicable, guidance and methods of RTCA DO326A / EUROCAE ED-202A, Airworthiness Security Process Specification, issued August 2014 and June 2014 respectively, and RTCA DO-356A/EUROCAE ED-203A, Airworthiness Security Methods and Considerations, issued in June 2018.

(1) You must provide information security and protection to safety communications services in the ACD and Aircraft Information Services Domain (AISD) in accordance with this CTSO.

(2) If 5G AeroMACS AMS equipment interfaces with ACD, and/or AISD, and/or Aeronautical Passenger Communication / Passenger Information and Entertainment Services Domain (APC/PIES) communications; then you must develop the system to provide partitioning for system protection for 5G AeroMACS AMS equipment intended to support such shared communications.

h. Deviations.

We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this CTSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under the provision of 21.368(a) in CCAR-21.

4. Marking.

a. Mark at least one major component permanently and legibly with all the information in 21.423(b) of CCAR-21. The marking must include the serial number.

b. Mark the following permanently and legibly, with at least the manufacturer’s name, subassembly part number, CTSO number, class and subclass identification.

(1) Each component that is easily removable (without hand tools).and,

(2) Each subassembly of the article that manufacturer determined may be interchangeable.

c. If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

d. You may use electronic part marking to identify software or airborne electronic hardware components by embedding the identification within the hardware component itself (using software) rather than marking it on the equipment nameplate. If electronic marking is used, it must be readily accessible without the use of special tools or equipment.

5. **Application Data Requirements.**

The applicant must furnish the responsible certification personnel with the related data to support design and production approval. The application data include a statement of conformance as specified in section 21.353(a)(1) in CCAR-21 and one copy each of the following technical data.

a. Manuals containing the following:

(1) Operating instructions and article limitations sufficient to describe the equipment's operational service capability.

(2) Detailed description of any deviations.

(3) Installation procedures and limitations sufficient to ensure that the equipment, when installed according to the installation procedures, still meets this CTSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must also include a note with the following statement:

"This article meets the minimum performance and quality control standards required by a CTSO. Installation of this article

requires separate approval."

(i) For equipment intended to support communication service in ACD, and/or AISD, and/or APC/PIES communications, if the required security between ACD, AISD and APC/PIES communications specified in paragraphs 3.a and 3.g of this CTSO is provided by the overall installation (either partially or wholly), you must specifically include installation procedures and limitations for provision of the security.

(4) For each unique configuration of software and airborne electronic hardware, reference the following:

(i) Software part number including revision and software level.

(ii) Airborne electronic hardware part number including revision and design assurance level.

(iii) Functional description.

(5) A summary of the test conditions used for environmental qualifications for each component of the article. For example, a form as described in RTCA DO-160G / EUROCAE ED-14G, Environmental Conditions and Test Procedures for Airborne Equipment, Appendix A.

(6) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the 5G AeroMACS AMS

equipment. For equipment intended to support shared ACD/AISD and APC/PIES communications, this must specifically include a description of how the required security partitioning between ACD/AISD and APC/PIES communications is provided.

(7) By-part-number list of replaceable components that makes up the 5G AeroMACS AMS equipment. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the 5G AeroMACS AMS equipment continues to meet the CTSO approved design. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. If the article requires considerations for information security and protection to meet paragraphs 3.a, 3.b.(1), and 3.g of this CTSO: a plan for security aspects of certification (PSecAC), and other supporting documentation, as applicable.

f. A drawing depicting how the article will be marked with the information required by paragraph 4 of this CTSO.

g. Identify functionality or performance contained in the article not evaluated under paragraph 3 of this CTSO (defined as non-CTSO functions). Non-CTSO functions can be accepted in parallel with the CTSOA. For those non-CTSO functions to be accepted, you must declare these functions and include the following information with your CTSO application:

(1) Description of the non-CTSO function(s), such as performance specifications, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-CTSO function(s) do not interfere with the article's compliance with the requirements of paragraph 3.

(2) Installation procedures and limitations sufficient to ensure that the non-CTSO function(s) meets the declared functions and performance specification(s) described in paragraph 5.g.(1).

(3) Instructions for continued performance applicable to the non-CTSO function(s) described in paragraph 5.g.(1).

(4) Interface requirements and applicable installation test procedures to ensure compliance with the non-CTSO function(s)

performance data defined in paragraph 5.g.(1).

(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting CTSO article is not affected by the non-CTSO function(s).

(6) Test plans and analysis, as appropriate, to verify that the function and performance of the non-CTSO function(s) is as described in paragraph 5.g.(1).

h. The quality system description required by section 21.358 of CCAR-21, including functional test specifications. The quality system should ensure that it will detect any change to the approved design that could adversely affect compliance with the CTSO MPS, and reject the article accordingly.

i. Material and process specifications list.

j. List of all drawings and processes (including revision level) that define the article’s design.

k. Manufacturer’s CTSO qualification report showing results of testing accomplished according to paragraph 3.c of this CTSO.

6. **Manufacturer Data Requirements.**

Besides the data given directly to the authorities, have the following technical data available for review by the authorities:

a. Functional qualification specification used to identify each piece of equipment for compliance with the requirements of this CTSO.

b. Article calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. Material and process specifications.

f. The results of the environmental qualification tests conducted according to paragraph 3.d of this CTSO.

g. If the article includes software, the appropriate documentation defined in the version of RTCA DO-178/EUROCAE ED-12 as specified in paragraph 3.e of this CTSO, including all data supporting the applicable objectives in Annex A, Process Objectives and Outputs by Software Level.

h. If the article includes airborne electronic hardware, and the failure condition of 3.b.(1) of this CTSO applies, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA DO-254/EUROCAE ED-80, Appendix A, Table A-1.

i. If the article contains non-CTSO function(s), the applicant must also make available items 6.a through 6.h as they pertain to the non-CTSO function(s).

7. **Furnished Data Requirements.**

a. If furnishing one or more articles manufactured under this CTSO to one entity (such as an operator or repair station), provide one copy or online access to the data in paragraphs 5.a and 5.b of this CTSO. Add any data needed for the proper installation, certification, use, or for continued compliance with the CTSO of the airborne equipment.

b. If the article contains declared non-CTSO function(s), include one copy of the data in paragraphs 5.f.(1) through 5.f.(4).

c. If the article contains software or complex custom airborne electronic hardware, include one copy of the Open Problem Report (OPR) summary to type certification, supplemental type certification, or amended type certification design approval holders.

8. **Availability of Referenced Documents.**

Order RTCA documents from:

Radio Technical Commission for Aeronautics, Inc.

1150 18th Street NW, Suite 910, Washington D.C. 20036

You may also order them online from the RTCA Internet website at: www.rtca.org.

Order EUROCAE documents from the EUROCAE Internet website at: www.eurocae.net.

Appendix 1 Minimum Performance Standards for 5G AeroMACS AMS Equipment

This appendix contains the minimum performance standards for 5G AeroMACS AMS equipment.

1 **Minimum Performance Requirements of RU**

1.1 General Requirements

1.1.1 Interfaces

Interfaces of RU shall meet the following requirements:

(1) It shall support at least 4 ARINC 429 inputs and 2 ARINC 429 outputs.

(2) It shall support at least 2 full duplex 1000Base-TX Ethernet ports.

(3) It shall support at least 3 discrete digital inputs and 3 discrete digital outputs.

(4) It shall support at least 1 port with antenna.

1.1.2 Power

The power source can be either 115 Vac or 28 Vdc power.

1.1.3 Installation

Installation of the airborne equipment must provide for inspection and replacement so as not to impair the airworthiness.

1.2 Functional Requirements of RU

1.2.1 5G AeroMACS Communication

It shall possess the processing function for the 5G AeroMACS communication protocol (compatible with the 3GPP Release 15 version), conduct data and control signaling communications with the 5G AeroMACS ground stations, and provide wireless communication transmission links.

1.2.2 Multiple-Input Multiple-Output (MIMO)

It shall support the MIMO function. The 5G AeroMACS downlink should support the working mode of dual-transmit channels and dual-receive channels.

1.2.3 Frequency Allocation

Radios shall operate in the 5091-5150 MHz band. The carrier bandwidth can be configured to 20MHz, 30MHz, 40MHz, and 50MHz

1.2.4 Transmit and Receive Channels

The RU shall support Time Division Duplexing (TDD) working mode, and should support at least 2 transmit and 2 receive channels.

1.2.5 Working Mode

The RU shall support at least 2 modes: normal working mode and maintenance test mode

1.2.6 "On/Off" Control of RU

Operation of the RU radio frequency transmitter is only allowed while the aircraft is on the ground. The "on/off" control logic should be implemented within the RU to supply (or not supply) power to the radio frequency transmitter based on the aircraft status (airborne or not airborne) as indicated by the discrete inputs.

The RU should provide two standard open/ground discrete inputs to allow remote switchable on/off control of the device, such as from the weight-on-wheels (WOW) air/ground strut switch or from other avionics or flight deck switch. The RU radio frequency transmitter should be powered up only when both "on/off" control discrete inputs are in the grounded state thus indicating that the aircraft is on the ground. When either discrete input is open then the RU radio frequency transmitter should be powered down. Other functions within the RU, such as Built-in testing or health monitoring/reporting, may remain powered up during flight as long as all RF transmissions are inhibited.

1.2.7 Software Version Management

The RU shall have the ability to manage software versions, and support version updating and rolling back.

The RU shall have the means to electronically load andupdate its operational software programs and data bases. The RU should interrupt data communication with ACD and AISD while loading data.

1.2.8 Working Status Indication

The RU should support the function of real-time indication of working status.

1.2.9 Self-Test

The RU shall support a self-test function to display and report fault information and self-test information. Power-on self-test, periodic self-test and manual self-test shall be realized.

1.3 Performance Requirements of RU

1.3.1 Adjacency Selection(ACS) of RU Receiver

For adjacent channel interference signals with a maximum of -25dBm, the ACS of the RU receiver shall not be less than 33dB.

1.3.2 Maximum Input Signal of RU Receiver

The maximum no-damage level received by the RU receiver antenna port is -21dBm

1.3.3 Reference Sensitivity of RU Receiver

RU receiver reference sensitivity shall be less than or equal to -88dBm under the condition of 50MHz bandwidth, 30kHz subcarrier, and bit error rate less than 5%.

1.3.4 Transmit Power Dynamic Range of RU Transmitter

The output power of the RU transmitter shall not exceed 30dBm. The minimum output power requirements for RU transmitters are shown in Table 1.

TABLE 1 Minimum Output Power Requirements for the RU Transmitter

Channel Bandwidth (MHz)	**Minimum Output Power (dBm)**	**Measurement Bandwidth (MHz)**
20	-40	19.095
30	-38.2	28.815
40	-37	38.895
50	-36	48.615

1.3.5 Error Vector Amplitude（EVM）of RU Transmitter

The maximum error vector amplitude of RU transmitter under different modulation modes is shown in Table 2.

TABLE 2 Error Vector Amplitude Requirements

Modulation	**EVM**
QPSK	17.5%
16QAM	12.5%
64QAM	8%

1.3.6 Switch Time Templates of RU

The switch time template of the RU transmitter shall not exceed 10us.

1.3.7 Spurious Emission of RU Transmitters

The requirements for spurious emissions of RU transmitter are shown in Table 3.

TABLE 3 Transmitter Spurious Emission Requirements

Frequency Range (Hz)	**Measurement Bandwidth (Hz)**	**Maximum Level (dBm)**
9kHz≤f<150kHz	1kHz	-36 dBm
150kHz≤f<30MHz	10kHz	-36 dBm
30MHz≤f<1GHz	1MHz	-36dBm
1GHz≤f<12.75GHz	1MHz	-30dBm
12.75GHz≤f<25.75GHz	1MHz	-30dBm

1.3.8 Access Distance

The maximum access distance of RU shall not be less than 1.7 km.

1.3.9 Movement Speed

The RU shall maintain normal communication under the moving speed of the 300km/h.

1.3.10 Peak Data Rate

The uplink peak rate shall not be less than 60 Mbps, and the downlink peak rate should not be less than 115 Mbps under the condition of 50 MHz channel bandwidth.

1.3.11 Handover Delay

The Xn handover control plane delay should not be higher than 120 ms in the scenario where normal communication is maintained during the handover between 5G AeroMACS cells and there are no error-free packets at the near point.

2 **Performance Requirements for Airborne Antennas**

2.1 Antenna Gain

The antenna gain shall not be greater than 6dBi.

2.2 Effective Isotropic Radiated Power (EIRP)

The EIRP of 5G AeroMACS AMS equipment shall not exceed 30 dBm, and meet the requirements of RTCA DO-346A *"Minimum Operational Performance Standard for Aeronautical Mobile Airport Communication System (AeroMACS)"*, issued in June 2022, Article 3.2.3.

2.3 Receive Sensitivity

The receiver sensitivity shall be less than or equal to -87 dBm, under the condition of 50MHZ channel bandwidth and 30KHz subcarrier.

2.4 Voltage Standing Wave Ratio(VSWR)

The VSWR shall be less than or equal to 2:1 over 5091-5150 MHz..

Appendix 2 5G AeroMACS AMS Equipment Test Procedures

1 General Introduction

The correspondence between the test procedure and the technical requirements of 5G AeroMACS AMS equipment is shown in Table 4. The 5G AeroMACS ground station used in the test shall be authorized, but the test requirements of the ground station are not included in this document.

TABLE 4 Test Level Reference

Required Sections	Subject	Test Chapter
1.2.1	5G Communication	2.2.1
1.2.2	MIMO	2.2.2
1.2.3	Frequency Allocation	2.2.3
1.2.4	Transmit and Receive Channels	2.2.4
1.2.5	Working Mode	2.2.5
1.2.6	“On/Off” Control of RU	2.2.6
1.2.7	Software Version Management	2.2.7
1.2.8	Working Status Indication	2.2.8
1.2.9	Self-Test	2.2.9
1.3.1	ACS of RU Receiver	2.3.1
1.3.2	Maximum Input Signal of RU Receiver	2.3.2
1.3.3	Reference Sensitivity of RU Receiver	2.3.3
1.3.4	Transmit Power Dynamic Range of RU Transmitter	2.3.4
1.3.5	EVM of RU Transmitter	2.3.5
1.3.6	Switch Time Templates of RU	2.3.6

1.3.7	Spurious Emission of RU Transmitters	2.3.7
1.3.8	Access Distance	2.3.8
1.3.9	Movement Speed	2.3.9
1.3.10	Peak Data Rate	2.3.10
1.3.11	Handover Delay	2.3.11
2.2.1	Antenna Gain	3.2.1
2.2.2	EIRP	3.2.2
2.2.3	Receive Sensitivity	3.2.3
2.2.4	VSWR	3.2.4

The following requirements shall be met before the test is carried out:

(1) The device under test has been completed the unit test and the software version has been stabilized.

(2) The power-on initialization and self-check of the device under test have been completed.

(3) The test instruments have been fully preheated, working properly, connected to the protective ground wire, and are within the metrological validity period.

(4) The test personnel have taken radiation protection and anti-static measures.

(5) The line loss and space loss have been calculated and

compensated.

2 Test Methods for RU

2.1 Test Setup

Principle block diagram of the RU test and the principle block diagram of the handover delay test are shown in Figure 1 and Figure 2 respectively.

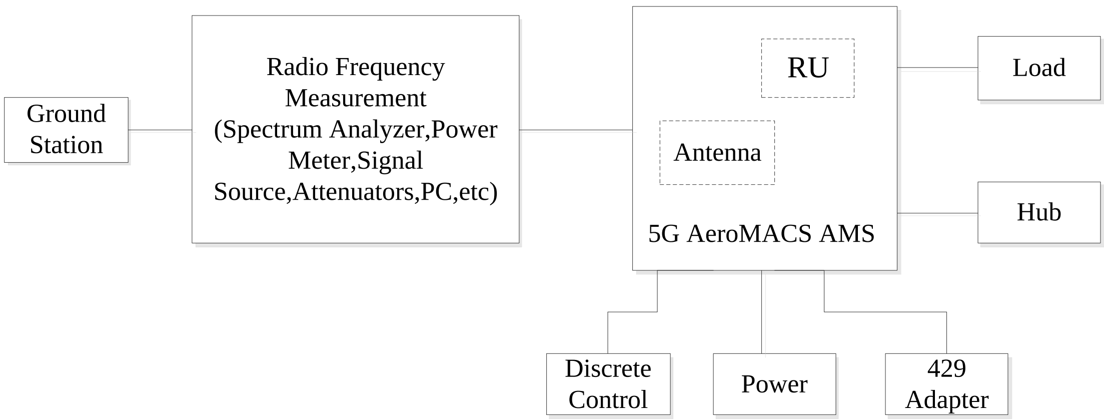

Figure1 Test Setup for RU

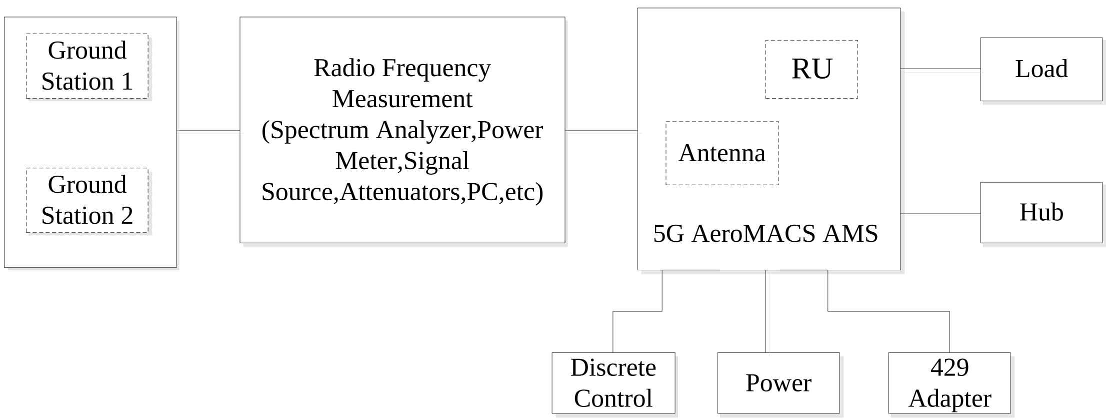

Figure2 Test Setup for Handover

2.2 Function Test

2.2.1 5G AeroMACS Communication

Test Condition

Figure 1 shows the test setup for testing the communication.

Test Procedure

(1) Operate the channel simulator, load the channel model with the aircraft at a distance of "0 meters in height and 0 meters horizontally" from the base station, and configure the Doppler frequency offset corresponding to 0km/h and 300 km/h as well as the input/output power adapted to each port.

(2) Operate the software to load the aviation parameter simulation data corresponding to "0 meters in height".

(3) Connect the Remote Unit (RU). Confirm that the RU is within the near coverage area of the base station (0 km horizontally).

(4) The RU conducts the ping packet service.

(5) Trigger the uplink and downlink User Datagram Protocol (UDP) tests.

(6) Repeat the above operations and go through the situation where the RU is within the far coverage area of the base station (1.7 km horizontally)

Acceptable Criterion

RU are connected normally.

The ping packet delay meets the requirement that the average delay is lower than 120 ms.

The uplink and downlink traffic meets the requirement that under the condition of a 50 MHz carrier bandwidth, the peak uplink rate in the near coverage area is not less than 60 Mbps and the peak downlink rate in the near coverage area is not less than 115 Mbps.

2.2.2 MIMO

Test Condition

Figure 1 shows the test setup for testing the MIMO.

Test Procedure

(1) Operate the channel simulator, load the near-field channel model (the distance between the aircraft and the base station is "0 meters in height and 0 meters horizontally"), and configure the Doppler frequency offset corresponding to 0km/h and 300 km/h as well as the input/output power adapted to each port.

(2) Load the aviation parameter simulation data corresponding to "0 meters in height and 0 meters horizontally" through the software.

(3) After the RU is connected, trigger the uplink and downlink UDP tests.

Acceptance Criteria

The RU is connected normally. The uplink and downlink rate meets the requirement that under the condition of a 50 MHz carrier bandwidth, the peak uplink rate is not less than 60 Mbps and the peak downlink rate is not less than 115 Mbps. Meanwhile, the relevant logs indicate that the uplink scheduling is dual-stream and the downlink scheduling is dual-stream.

2.2.3 Frequency Allocation

Test Condition

Figure 1 shows the test setup for testing the frequency band.

Test Procedure

(1) Configure the uplink central frequency point, carrier bandwidth, antenna transmission parameters, and send out test signals.

(2) Set up the measurement system and read the carrier power values through the measurement system.

(3) Traverse the high, medium and low frequency points to be tested, and repeat steps 1 to 2 for measurement.

(4) Traverse all supported channel bandwidths and repeat steps 1 to 3 for measurement.

(5) Traverse the transmission channels and repeat steps 1 to 4 for measurement.

(6) Configure the downlink central frequency point, carrier bandwidth, and antenna reception parameters.

(7) Configure the measurement system to send downlink useful signals.

(8) Reduce the power of the useful signals and check the throughput until the throughput is not less than 95% of the maximum throughput, and record the power of the useful signals.

(9) Traverse the high, medium and low frequency points to be tested, and repeat steps 6 to 8 for measurement.

(10) Traverse all supported channel bandwidths and repeat steps 6 to 9 for measurement.

(11) Traverse the reception channels and repeat steps 6 to 10 for measurement.

Acceptance Criteria

For all channels within 5091 - 5150 MHz: The Error Vector Magnitude (EVM) of rated power transmission shall meet the requirements in Table 2, and the received reference sensitivity of all ports at frequency points shall be ≤ -88 dBm under the conditions of a 50 MHz bandwidth and 30 kHz subcarriers.

2.2.4 Transmit and Receive Channels

Test Condition

Figure 1 shows the test setup for testing the transmit and receive channels.

Test Procedure

(1) Configure the uplink central frequency point, channel bandwidth, antenna transmission parameters, and send out test signals.

(2) Set up the measurement system and read the carrier power values through the measurement system.

(3) Traverse the high, medium and low frequency points to be tested, and repeat steps 1 to 2 for measurement.

(4) Traverse all the supported channel bandwidths and repeat steps 1 to 3 for measurement.

(5) Traverse the transmission channels and repeat steps 1 to 4 for measurement.

(6) Configure the downlink central frequency point, channel bandwidth, antenna reception parameters.

(7) Configure the measurement system to send downlink useful signals.

(8) Reduce the power of the useful signals and check the throughput until the throughput is not less than 95% of the maximum throughput, and record the power of the useful signals.

(9) Traverse the high, medium and low frequency points to be tested, and repeat steps 6 to 8 for measurement.

(10) Traverse all the supported channel bandwidths and repeat steps 6 to 9 for measurement.

(11) Traverse the reception channels and repeat steps 6 to 10 for measurement.

Acceptance Criteria

The Error Vector Magnitude (EVM) of the rated power transmission for the two transmitting channels shall meet the requirements in Table 2. The received reference sensitivity of the two receiving channels shall be no more than -88 dBm under the conditions of a 50 MHz bandwidth and 30 kHz subcarriers.

2.2.5 Working Mode

Test Condition

Figure 1 shows the test setup for testing the working mode.

Test Procedure

(1) Configure relevant switches and parameters according to the test conditions.

(2) Connect the RU and observe the RU mode.

(3) When the RU is connected to the maintenance tool for maintenance/testing, observe the RU mode.

Acceptance Criteria

When the RU is connected, it can enter the normal working mode.

When the RU is connected to the maintenance tool for maintenance/testing, it can enter the maintenance and testing mode.

2.2.6 "On/Off" Control

Test Condition

Figure 1 shows the test setup for testing the "on/off" control.

Test Procedure

(1) Set the transmission control signal in the radio frequency off state, and then input two high-level discrete signals through the discrete control switch interface. Observe whether the RU RF transmitter are turned on.

(2) Set the transmission control signal in the radio frequency on state, input one low-level discrete signal and then two low-level discrete signals in sequence through the discrete control switch interface, and observe whether all the RU RF transmitter are turned off.

(3) Set the transmission control signal in the radio frequency off state and observe whether the RU RF transmitter are turned off.

(4) Set the transmission control signal in the radio frequency off state, and input one high-level discrete signal through the discrete control switch interface. Observe whether the RU RF transmitter are turned on.

Acceptance Criteria

After step 1 is executed, the RU RF transmitter is turned on, and

After step 2 is executed, the RU RF transmitter is turned off, and

After step 3 is executed, the RU RF transmitter is turned off, and

After step 4 is executed, the RU RF transmitter is turned off.

2.2.7 Software Version Management

Test Condition

Figure 1 shows the test setup for testing the software version management.

Test Procedure

(1) Use the data loading tool via the wired local area network to load the software of Version A.

(2) After the loading is successful, restart the RU and query the software version.

(3) Use the data loading tool via the wired local area network to load the software of Version B.

(4) After the loading fails, restart the RU and query the software version.

(5) Use the data loading tool via the wired local area network to load the software of Version C.

(6) After the loading is successful, restart the RU and query the

software version.

Acceptance Criteria

In step 2, the queried software version is Version A; and

In step 4, the queried software version is Version A; and

In step 6, the queried software version is Version C.

2.2.8 Working Status Indication

Test Condition

Figure 1 shows the test setup for testing the working status indication.

Test Procedure

(1) Observe the on and off states of the status indicator lights.

(2) Perform different operations and observe whether the status indicator lights are consistent with the plan.

Acceptance Criteria

When the power supply is working normally, the power indicator light stays on.

When the initialization is completed, the operation indicator light stays on.

When the equipment is working normally, the operation indicator light stays on.

2.2.9 Self-Test

Test Condition

Figure 1 shows the test setup for testing the working status indication.

Test Procedure

(1) Read the self-check file and check the results.

(2) While the device is in operation, trigger a manual self-check, read the self-check file and check the results.

(3) During the continuous operation of the device, trigger abnormalities in the RU interface, and check the alarms. Restore the abnormalities in the RU interface, and check the alarms again.

Acceptance Criteria

The self-check results can be checked, and alarms can be reported and restored.

2.3 Performance Test

2.3.1 ACS of RU Receiver

Test Condition

Figure 1 shows the test setup for testing the ACS of RU receiver.

Test Procedure

(1) Select the intermediate frequency point within the downlink frequency range as the frequency point to be tested.

(2) Configure the central frequency point, channel bandwidth, and parameters of the receiving antenna.

(3) Configure the signal source to send the downlink useful signal of the fixed reference measurement channel, and set the power of the downlink useful signal to -56.5 dBm.

(4) Configure the signal source to send the adjacent channel interference signal according to the power given in Table 5, set the power of the interference signal to -25 dBm, adjust the frequency of the interference signal until the throughput is not lower than 95% of the maximum throughput of the reference measurement channel, and record the ACS of this frequency point.

(5) Traverse all the supported channel bandwidths and repeat steps 1 to 4 for measurement.

(6) Traverse the receiving channels and repeat steps 1 to 5 for measurement.

Acceptance Criteria

The ACS of the RU receiver is not lower than 33 dB.

TABLE 5 ACS of RU Receiver

Receiver Parameters	**Unit**	**Channel Bandwidth**		
		20MHz	40MHz	50MHz
Useful Signal Power	dBm	-56.5		
Interfering Signal Power	dBm	-25		
Interference Signal Bandwidth	MHz	20	40	50
Frequency Offset Range of Interfering Signal	MHz	20/-20	40/-40	50/-50

2.3.2 Maximum Input Signal of RU Receiver

Test Condition

Figure 1 shows the test setup for testing the ACS of RU receiver.

Test Procedure

(1) Select the intermediate frequency point within the downlink frequency range as the frequency point to be tested.

(2) Configure the central frequency point, channel bandwidth and parameters of the receiving antenna.

(3) Configure the signal source to send the downlink useful signal of the fixed reference measurement channel.

(4) Reduce the power of the useful signal and conduct a burn-in test for 2 hours with the power output at -21 dBm.

(5) Stop the input of the large signal and check whether the sensitivity is normal.

(6) Traverse all the supported channel bandwidths and repeat steps 1 to 5 for measurement.

(7) Traverse the receiving channels and repeat steps 1 to 6 for measurement.

Acceptance Criteria

After conducting a burn-in test on all channels with a useful signal power of -21 dBm for 2 hours, the sensitivity result is normal.

2.3.3 Reference Sensitivity of RU Receiver

Test Condition

Figure 1 shows the test setup for testing the reference sensitivity of RU receiver.

Test Procedure

(1) Configure the downlink central frequency point, channel bandwidth, and parameters of the receiving antenna.

(2) Configure the measurement system to send the downlink useful signal of the fixed reference measurement channel.

(3) Adjust the power of the useful signal until the throughput is not lower than 95% of the maximum throughput, and record the power of the useful signal.

(4) Traverse the high, medium and low frequency points to be tested,

and repeat steps 1 to 3 for measurement.

(5) Traverse all the supported channel bandwidths and repeat steps 1 to 4 for measurement.

(6) Traverse the receiving channels and repeat steps 1 to 5 for measurement.

Acceptance Criteria

The sensitivity of all ports at frequency points are no more than -88 dBm.

2.3.4 Transmit Power Dynamic Range of RU Transmitter

Test Condition

Figure 1 shows the test setup for testing the transmit power dynamic range of RU transmitter.

Test Procedure

(1) Configure the uplink central frequency point, channel bandwidth, and parameters of the transmitting antenna.

(2) Adjust the power of the Remote RU to the rated output power and send test data.

(3) Measure the output power of the RU transmission cycle through the spectrum analyzer.

(4) Traverse the high, medium and low frequency points to be tested, and repeat steps 1 to 3 for measurement.

(5) Traverse all the supported channel bandwidths and repeat steps 1 to 4 for measurement.

(6) Traverse the transmission channels and repeat steps 1 to 5 for measurement.

(7) Configure the uplink central frequency point, channel bandwidth, and parameters of the transmitting antenna.

(8) Adjust the transmitting power to the minimum transmitting power and send test data.

(9) Measure the output power of the RU transmission cycle through the spectrum analyzer.

(10) Traverse the high, medium and low frequency points to be tested, and repeat steps 7 to 9 for measurement.

(11) Traverse all the supported channel bandwidths and repeat steps 7 to 10 for measurement.

(12) Traverse the transmission channels and repeat steps 7 to 11 for measurement.

Acceptance Criteria

The output power of the RU transmitter shall not exceed 30 dBm;

the minimum output power of the RU transmitter shall meet the requirements listed in Table 1.

2.3.5 EVM of RU Transmitter

Test Condition

Figure 1 shows the test setup for testing the EVM of RU transmitter.

Test Procedure

(1) Configure the uplink central frequency point, channel bandwidth, and antenna transmission parameters.

(2) Send test data with customized modulation modes and adjust the power of the RU to the rated output power.

(3) Measure the error vector magnitude of the RU transmission cycle through the spectrum analyzer.

(4) Traverse the high, medium and low frequency points to be tested, and repeat steps 1 to 3 for measurement.

(5) Traverse all the supported channel bandwidths and repeat steps 1 to 4 for measurement.

(6) Traverse the transmission channels and repeat steps 1 to 5 for measurement.

Acceptance Criteria

The EVM of the RU transmitter shall not exceed the limits listed in Table 2.

2.3.6 Switch Time Templates of RU

Test Condition

Figure 1 shows the test setup for testing the switch time templates.

Test Procedure

(1) Configure the uplink central frequency point, channel bandwidth, and antenna transmission parameters.

(2) Adjust the power of the RU to the rated output power and send test data with specified modulation modes.

(3) Measure the switching time template of the RU transmitter through the spectrum analyzer.

(4) Traverse the high, medium and low frequency points to be tested, and repeat steps 1 to 3 for measurement.

(5) Traverse all the supported channel bandwidths and repeat steps 1 to 4 for measurement.

(6) Traverse the transmission channels and repeat steps 1 to 5 for measurement.

Acceptance Criteria

The switching time template of the RU transmitter shall not exceed 10 μs.

2.3.7 Spurious Emission of RU Transmitter

Test Condition

Figure 1 shows the test setup for testing the spurious emission of RU transmitter.

Test Procedure

(1) Configure the uplink central frequency point, channel bandwidth, and antenna transmission parameters, and send out test signals with full Resource Block (RB).

(2) Set up measurement system such as power meters and spectrum analyzers to test the spurious values of each frequency band.

(3) Traverse the high, medium and low frequency points and repeat steps 1 to 2 for measurement.

(4) Traverse all the supported channel bandwidths and repeat steps 1 to 3 for measurement.

(5) Traverse the transmission channels and repeat steps 1 to 4 for measurement.

Acceptance Criteria

The spurious emissions of the RU transmitter meets the requirements in Table 3.

2.3.8 Access Distance

Test Condition

Figure 1 shows the test setup for testing the access distance.

Test Procedure

(1) Operate the channel simulator, and load the channel model with the distance between the aircraft and the base station being "0 km in altitude and 1.7 km horizontally". Configure the Doppler frequency offset corresponding to 300 km/h as well as the input/output power adapted to each port.

(2) Load the aviation parameter simulation data corresponding to "0 km in altitude and 1.7 km horizontally" through software.

(3) Observe the access status of the RU.

Acceptance Criteria

The RU accesses normally.

2.3.9 Movement Speed

Test Condition

Figure 1 shows the test setup for testing the movement speed.

Test Procedure

(1) Operate the channel simulator, load the near-field channel model (with the distance between the aircraft and the base station being "0 km in altitude and 1 km horizontally"), and configure the Doppler frequency offset corresponding to 300 km/h as well as the input/output power adapted to each port.

(2) Load the aviation simulation data corresponding to "0 km in altitude and 1 km horizontally" through software.

(3) After the RU is accessed, trigger the uplink and downlink UDP tests.

Acceptance Criteria

The RU accesses normally, and the performance of the uplink and downlink UDP tests complies with the current channel conditions. The observed downlink frequency offset value conforms to the Doppler frequency offset corresponding to 300 km/h.

2.3.10 Peak Data Rate

Test Condition

Figure 1 shows the test setup for testing the peak data rate.

Test Procedure

(1) Operate the channel simulator, and load the near-field channel model (with the distance between the aircraft and the base station being

"0 km in altitude and 0 km horizontally"). Configure the Doppler frequency offsets corresponding to 0 km/h and 300 km/h as well as the input/output power adapted to each port.

(2) Load the aviation parameter simulation data corresponding to "0 km in altitude and 0 km horizontally" through software.

(3) After the RU is accessed, trigger the uplink and downlink UDP tests.

Acceptance Criteria

The RU accesses normally. Under the condition of a 50 MHz carrier bandwidth, the peak uplink rate is no less than 60 Mbps, and the peak downlink rate is no less than 115 Mbps.

2.3.11 Handover Delay

Test Condition

Figure 2 shows the test setup for testing the handover delay.

Test Procedure

(1) Configure the parameters of the ground stations. Configure the Xn link between Ground Station 1 and Ground Station 2. The access attenuation of Ground Station 1 and Ground Station 2 is the same.

(2) The RU accesses Ground Station 1.

(3) Adjust the signal attenuation to make the RU perform a handover,

switching from Ground Station 1 to Ground Station 2.

(4) Repeat step 2 to make the number of handovers of the RU reach more than 10 times.

Acceptance Criteria

The access is successful and the number of handovers is greater than or equal to 10 times with no handover failures. And the average handover delay of the control plane does not exceed 120 ms.

3 Test Methods for Airborne Antenna

3.1 Test Setup

The principle block diagrams of the airborne antenna performance test are shown in Figure 3 and Figure 4.

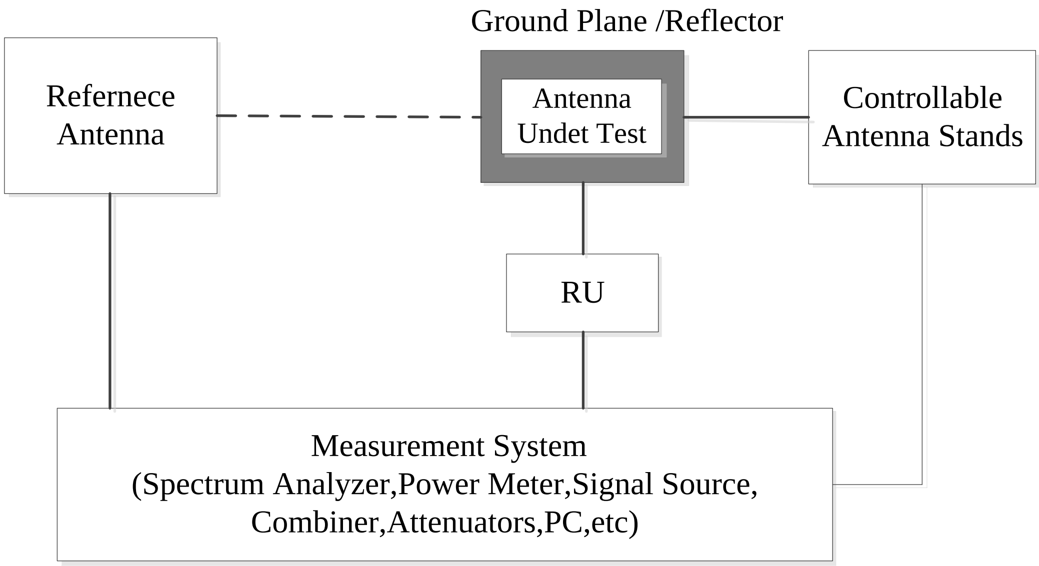

Figure 3 Test Setup for Antenna

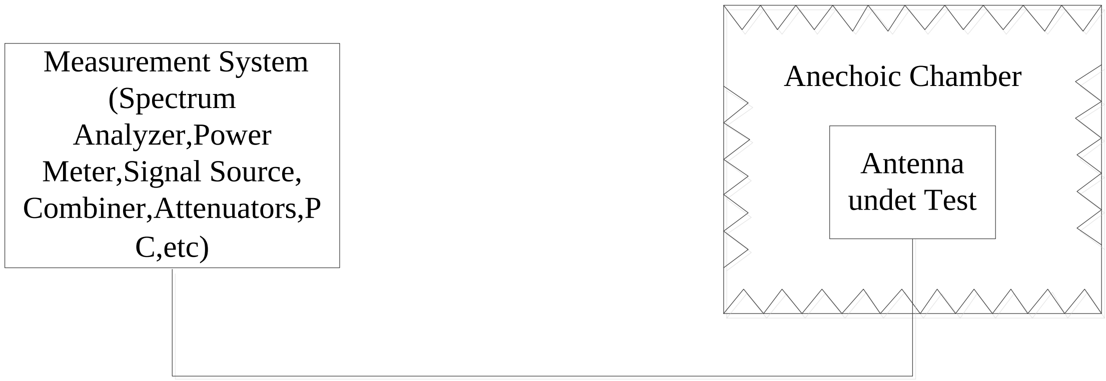

Figure 4 Test Setup for VSWR

3.2 Performance Test

3.2.1 Antenna Gain

Test Condition

Figure 3 shows the test setup for testing the antenna gain.

Test Procedure

(1) Configure the uplink center frequency points and the operating bandwidth and antenna transmission parameters of the RU, and then send out the test signal.

(2) Set up the spectrum analyzer and read the carrier power value.

(3) Step the antenna by 30° in the azimuth plane and by 5° in the elevation plane, and then read the power value on the spectrum analyzer.

(4) Calculate the antenna gain.

(5) Traverse the high, medium and low frequency points to be tested, and repeat steps 1 to 4 for measurement.

Acceptance Criteria

The antenna gain is not greater than 6 dBi.

3.2.2 Effective Isotropic Radiated Power (EIRP)

Test Condition

Figure 3 shows the test setup for testing the EIRP of AMS equipment.

Test Procedure

(1) Configure the uplink center frequency points and the operating bandwidth and antenna transmission parameters of the RU, and then send out the test signal.

(2) Set up the spectrum analyzer and read the carrier power value.

(3) Traverse the high, medium and low frequency points, and repeat steps 1-2 respectively.

Acceptance Criteria

The EIRP of 5G AeroMACS AMS equipment is not exceed 30 dBm, and meets the requirements of RTCA DO-346A, Article 3.2.3.

3.2.3 Receive Sensitivity

Test Condition

Figure 3 shows the test setup for testing the receive sensitivity of antenna.

Test Procedure

(1) Configure parameters such as the downlink center frequency points, operating bandwidth and antenna reception parameters of the RU.

(2) Select a low frequency point within the downlink frequency range as the carrier frequency to be tested.

(3) Select the low carrier frequency point to be tested and configure the vector signal source to send the downlink useful signal of the fixed reference measurement channel.

(4) Adjust the power of the useful signal until the throughput is not lower than 95% of the maximum throughput, and record the power of the useful signal.

(5) Select the medium and high carrier frequency points to be tested respectively and repeat steps 3-4 for measurement.

Acceptance Criteria

The receiving sensitivity of antenna is not greater than -87 dBm under the conditions of a 50 MHz bandwidth and 30 kHz subcarriers.

3.2.4 VSWR

Test Condition

(1) Figure 4 shows the test setup for testing the VSWR of antenna.

(2) Install the airborne antenna in a free space or anechoic chamber that is relatively free of reflections and is quite far away from the measuring equipment and personnel. The judgment condition for the qualification of the test site is that when the airborne antenna (including the supporting structure) is moved at least half a wavelength in four horizontal directions separated by 90° and is moved half a wavelength upwards and downwards respectively, the change in the voltage standing wave ratio is less than 10%.

Test Procedure

(1) Match the interfaces between the testing ends of the test instruments and the airborne antenna ends.

(2) Connect the measurement system to the airborne antenna and conduct voltage standing wave ratio measurements within the operating frequency range. The measured voltage standing wave ratio reading is the voltage standing wave ratio at the airborne antenna port.

(3) Traverse the high, medium and low frequency points, and repeat steps 1-2 respectively.

Acceptance Criteria

The voltage standing wave ratio is no more than 2:1 over 5091-5150 MHz.

Appendix 3 ACRONYMS

Acronym	Meaning
5G	5th Generation Mobile Communication Technology
ARINC	Aeronautical Radio INCorporated
RTCA	Radio Technical Commission for Aeronautics
EUROCAE	European Organization for Civil Aviation Electronics
AeroMACS	Aeronautical Mobile Airport Communication System
RU	Radio Unit
dB	decibel
dBm	decibels relative to 1 mW
dBi	Decibel isotropic
EIRP	Effective Isotropic Radiated Power
EVM	Error Vector Magnitudes
ACS	Adjacent Channel Selectivity
ATS	Air Traffic Services
SWIM	System Wide Information Management
AIS	Aeronautical Information Services
MET	Meteorology
AAC	Airline Administrative Communication
AOC	Aeronautical Operational Communication
AMS	Airborne Mobile Station
ACD	Aircraft Control Domain
AISD	Aircraft Information Services Domain
APC	Aeronautical Passenger Communication
PIES	Passenger Information and Entertainment Services
Mbps	Megabits per second

Acronym	Meaning
MIMO	Multiple Input Multiple Output
MCS	Modulation and Coding Scheme
ms	Millisecond
PC	Personal Computer
PING	Packet Internet Grope
PHAC	Plan for Hardware Aspects of Certification
PSAC	Plan for Software Aspects of Certification
PSecAC	Plan for Security Aspects of Certification
PUSCH	Physical Uplink Shared Channel
QPSK	Quadrature Phase Shift Keying
QAM	Quadrature Amplitude Modulation
RB	Resource Block
TDD	Time Division Duplex
UDP	User Datagram Protocol
3GPP	3rd Generation Partnership Project
AeroMACS downlink	The transmission direction from the base station (BS) to the Airborne Mobile Station (AMS)
AeroMACS uplink	The transmission direction from the Airborne Mobile Station (AMS) to the base station (BS)
VSWR	Voltage Standing Wave Ratio
Xn	Xn interface

Appendix 4 TERMS

TDD	A duplex scheme where uplink and downlink transmissions occur at different times but may share the same frequency
AeroMACS downlink	The transmission direction from the AeroMACS ground station to the AeroMACS Airborne Mobile Station (AMS)
AeroMACS uplink	The transmission direction from the AeroMACS Airborne Mobile Station (AMS) to the AeroMACS ground station

(The English version is for reference only. In case of any discrepancy or ambiguity of meaning between this English translation and the Chinese version, the latter shall prevail.)