

Department of Transportation **Federal Aviation Administration** Aircraft Certification Service Washington, DC TSO-C213a

Effective Date: {*mm/dd/yy*}

Technical Standard Order

Subject: Unmanned Aircraft Systems Control and Non-Payload Communications Terrestrial Link System

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards your Unmanned Aircraft Systems (UAS) terrestrial Control and Non-Payload Communications (CNPC) Link System designed for operation in C Band, 5030-5091 megahertz (MHz), must meet for approval and identification with the applicable TSO marking.

The CNPC Link System covered by this TSO helps to standardize the of use of C Band spectrum in order to minimize the radio frequency (RF) interference, i.e. RF compatibility, and ensure that spectrum resources are used effectively to provide equitable access.

As shown in Figure 1, the CNPC Link System comprises Airborne Radio System (ARS) and Ground Radio System (GRS) radios and their corresponding antennas, directly linked to each other within radio line of sight (RLOS). This TSO covers the airborne and ground radios and their corresponding antenna components of the ARS and GRS.



Figure 1. CNPC Link System Components

The CNPC Link System covered by this TSO is a subset of the end-to-end C2 Link System shown in Figure 2 below. (Refer to RTCA/DO-377A, *Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace*, dated September 16, 2021, for full details on end-to-end C2 Link Systems.)

The CNPC Link System provides functions of the Physical Layer of a typical datalink communication system. The higher layer protocols of this C2 Link System are outside the scope of this TSO and are certified as part of installation approval in accordance with specific operational requirements of the UAS and its C2 Link System.

This TSO covers only CNPC Link Systems using a Terrestrial GRS paired directly with a Terrestrial ARS designed to pair with the specific GRS.



Figure 2. C2 Link System, Context, Scope and Boundaries (Ref: RTCA DO-377A, Figure 3-2)

2. APPLICABILITY. This TSO affects new applications submitted after its effective date. This TSO cancels TSO-C213, dated March 9, 2018.

3. REQUIREMENTS. New models of UAS CNPC Link Systems identified and manufactured on or after the effective date of this TSO must meet the applicable requirements in Section 2 of RTCA Document RTCA/DO-362A, *Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)*, dated December 17, 2020, with the additional requirements listed in appendix A of this TSO. UAS CNPC Link System equipment classes are identified in Table 1 of this TSO. The equipment must meet the

Applicable Requirements in RTCA/DO-362A, Table 2-1, for the Equipment Class Identifier corresponding to the equipment class in Table 1 for which you are seeking TSO authorization. RTCA/DO-362A describes the features and characteristics needed by the CNPC Link System airborne and ground equipment to achieve a terrestrial point-to-point or point-to-multipoint communication functionality via direct radio line-of-sight operation to support UAS operating in the National Airspace System (NAS).

Table 1 identifies the UAS CNPC Link System equipment classes. Class G is a GRS, and Class A is an ARS. Each equipment class is further subdivided into several individual articles with corresponding functionalities.

System Capabilities				Equipment Class Identifier
Ground Radio System -G	Low Gain Antenna -L	Gaussian Minimum Shift Keying (GMSK) -X	Single Uplink Subframe -S	GLXS
			Multiple Uplink Subframe -M	GLXM
		Quadrature Phase Shift Keying (QPSK)	Single Uplink Subframe -S	
	Medium Gain Antenna -M	-Y GMSK -X	Single Uplink Subframe -S	GLYS GMXS
			Multiple Uplink Subframe -M	GMXM
		QPSK -Y	Single Uplink Subframe -S	GMYS
	High Gain Antenna -H	GMSK -X	Single Uplink Subframe -S	GHXS
			Multiple Uplink Subframe -M	GHXM
		QPSK -Y	Single Uplink Subframe -S	GHYS
Airborne Radio System -A		GMSK -X	Single Uplink Subframe -S	AXS
			Multiple Uplink Subframe -M	AXM
		QPSK -Y	Single Uplink Subframe -S	AYS

Table 1 – UAS CNPC Link System Equipment Classes (Ref: RTCA/DO-362A, Table 2-1)

Note: Equipment classes with single subframe for uplink and downlink radio ("-S") are "point-to-point", and equipment classes with multiple subframe for uplink and downlink radio ("-M") are "point-to-multipoint" link systems. A point-to-point link system supports a single GRS communicating with a single ARS. A point-to-multipoint link system supports a GRS that can communicate with multiple ARS.

Note: RTCA/DO-362A does not address interoperability between radios. ARS and GRS radios designed and produced under this TSO must be designed and produced as specifically interoperable ARS/GRS radio combinations, and are not considered interoperable with other radios not designed to the same interoperability standard. Therefore, this TSO may not be used to design and produce incomplete TSO systems that provide CNPC ARS or GRS function only.

a. Functionality.

(1) This TSO's standards apply to a CNPC Link System intended to provide information exchanges between the Pilot Station and the unmanned aircraft (UA) to allow the pilot to safely control, monitor, and manage the UA. This primary intended function includes capabilities and services associated with the CNPC Link System radio physical layers and some interfaces associated with the CNPC Link System radio data link layers.

(2) The CNPC Link System also provides information exchanges between the Pilot Station and the UA to support one or more of the following functions as required by the expected operations of UAS in which they are intended to be installed: Air Traffic Control (ATC) voice and data relay, Detect-and-Avoid (DAA), weather radar, video, CNPC Link System management, frequency assignment, and CNPC Link System monitoring and alerting.

b. Failure Condition Classifications. There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classification for which the equipment is designed.

c. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in RTCA/DO-362A, corresponding section 2.4 appropriate for the CNPC Link equipment class.

d. Environmental Qualification. Demonstrate the required performance under the test conditions specified in RTCA/DO-362A, corresponding section 2.3 using standard environmental conditions and test procedures appropriate for the equipment class. You may use a different standard environmental condition and test procedure than RTCA/DO-362A, section 2.3, provided the standard is appropriate for the CNPC Link Systems.

Note: The use of RTCA/DO-160D (with Changes 1 and 2 only, and 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 TSO.

e. Software Qualification. If the CNPC Link System includes software, develop the software in accordance with RTCA, Inc. document RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the declared failure condition classification(s) defined in paragraph **3.b** of this TSO. If the CNPC Link System GRS includes software, you may also develop the GRS software according to RTCA, Inc. document RTCA/DO-278A, *Software Integrity Assurance Considerations for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems*, dated December 13, 2011.

f. Electronic Hardware Qualification. If the airborne and ground systems include complex custom airborne/ground electronic hardware that is intended to meet failure condition classification of Major or higher, develop the component in accordance with RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, dated April 19, 2000, to at least the design assurance level consistent with the declared failure condition classification defined in paragraph **3.b** of this TSO. For custom airborne/ground electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

Note: Use RTCA/DO-254 for electronic hardware qualification of the airborne and ground systems.

g. Security Requirements. Demonstrate that the required security protection specified in RTCA/DO-362A, paragraph 2.1.10 is met.

Note 1: Design and develop ARS and GRS in accordance with, as applicable, guidance and methods of RTCA DO-326A *Airworthiness Security Process Specification*, dated August 6, 2014, and RTCA DO-356A, *Airworthiness Security Methods and Considerations*, dated June 21, 2018.

Note 2: If the ARS or GRS include higher layer functions to support the end-to-end C2 Link System Data Transfer, Security, and Routing (DTSR) function as defined in RTCA/DO-377A, demonstrate that the required security protection specified in RTCA/DO-362A, paragraph 2.1.11 is met.

h. Deviations.

(1) We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your system maintains an equivalent level of safety. Apply for a deviation pursuant to Title 14 of the Code of Federal Regulations (14 CFR) 21.618.

(2) The FAA will not grant deviations to exceed the maximum transmit power, exceed the maximum emission bandwidths, exceed the out-of-band emission and susceptibility limits (see Tables 2-5 and 2-6 of paragraphs 2.2.1.8.2.2 and 2.2.1.8.3 of RTCA/DO-362A, respectively), deviate from the adjacent and non-adjacent channel rejection requirements, deviate from the time-division duplex (TDD) frame structure, increase the antenna gain, change the channelization, or increase the system losses.

4. MARKING.

a. Mark at least one major component of the GRS and ARS permanently and legibly with all the information in 14 CFR 45.15(b). Mark each system with the CNPC Link System equipment class with the Equipment Class Identifier from Table 1 above.

(1) Since there is no standard minimum failure condition classification for this TSO, applicants can design and manufacture equipment to any hardware and software design assurance level (DAL). Mark the DAL to which the equipment is designed on the ARS and GRS.

Example: Mark a Ground Radio System with Low Gain Antenna, GMSK, and Single Uplink Subframe Class as "GLXS – DAL X". (DAL-X can be from A to D in accordance with RTCA/DO-178C and RTCA/DO-254. UAS top level design and operational criteria will govern the selection of required equipment DAL)

b. If the systems include software and/or airborne and ground electronic hardware, then the systems part numbering scheme must identify the software and airborne/ground electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne/ground electronic hardware.

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

5. APPLICATION DATA REQUIREMENTS. You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph 5.g) through their civil aviation authority.

a. Manuals containing the following:

(1) Operating instructions and system limitations sufficient to describe the system's operational capability, specifically including the following:

(a) Identify the UAS Concept of Operations (CONOPS) with which the UAS CNPC Link System is compatible.

Note: Examples of CONOPS are described in Appendix A, *Concept of Operations*, of RTCA/DO-377A, *Minimum Aviation System Performance Standards (MASPS) for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace*, dated September 16, 2021.

(b) Information on how to determine the UA minimum and maximum recommended operating altitude (relative to the GRS antenna elevation) for the installed system and the intended operational environment, considering distance from the GRS, clutter, manmade structures, and other obstacles.

(c) The maximum operating range between the CNPC ARS and the CNPC GRS for the CNPC Link System.

(d) Information on the Federal Communications Commission (FCC) license and authorization requirements for the GRS siting and operation. Include a specification that operations must stay within the specified geographic confines authorized to the operator, and a note indicating that for an ARS operating in conjunction with any GRS, the GRS and the ARS must receive FCC Certification in addition to FAA TSOA approval.

(e) For point-to-point systems (GRS Equipment Classes GLXS, GLYS, GMXS, GMYS, GHXS, and GHYS, and ARS Equipment Classes AXS and AYS): An operating limitation stating that:

"The CNPC Link Systems meeting the minimum operational performance standards of this TSO are limited to providing a terrestrial point-to-point communication functionality (one GRS communicating with one ARS) and radio line-of-sight operation to support UAS operating in the NAS."

(f) For point-to-multipoint systems (GRS Equipment Classes GLXM, GMXM, and GHXM, and ARS Equipment Class AXM): An operating limitation stating that: "The CNPC Link Systems meeting the minimum operational performance standards of this TSO are limited to providing a terrestrial point-to-multipoint communication functionality (one GRS communicating with up to *[specify maximum number of ARS the GRS can support]* ARS) and radio line-of-sight operation to support UAS operating in the NAS."

Note: All references to GRS location, or to distance from the GRS, are to the location of (or distance from) the GRS antenna.

(2) Detailed description of any deviations.

(3) Installation procedures and system limitations sufficient to ensure that the CNPC Link System, when installed according to the installation or operational procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

"These CNPC Link Systems meet the minimum performance and quality control standards required by TSO–C213a. Installation of these CNPC Link Systems requires separate approval." Include the following data in the installation manual:

(a) The highest CNPC uplink and downlink data rates, CNPC ARS and GRS minimum transmitter RF output power, minimum receiver sensitivity, minimum antenna gain, and maximum antenna RF connector and cable loss.

(b) Guidance on providing or determining required isolation between CNPC Link System ARS and co-located AeroMACS Airborne Mobile Station (AMS) equipment.

Note: This isolation could be provided by using appropriate filtering of both the AeroMACS and the CNPC transceivers.

(c) Guidance for CNPC Link System GRS siting co-located with AeroMACS equipment at airports to ensure that interference from AeroMACS mobile and fixed stations does not impact the intended UA operations.

(d) Any unique aspects of the CNPC ARS and GRS antenna(s), including antenna pattern performance characteristics, aircraft antenna free space patterns, and instructions to determine how antenna radiation patterns are modified by airframe obstruction at their installed locations.

(e) For the C Band CNPC Link System installation, state the limitations of the installed system performance as specified in RTCA/DO-362A, §3.2.

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

(a) Software part number, including revision and design assurance level;

(b) Airborne/ground electronic hardware part number, including revision and design assurance level; and

- (c) Functional description. The documentation must clearly identify that the system has been designed for the following safety considerations

 - i Hardware Part Number "_____" meets Failure Probability "____".
 ii Software Part Number "____" meets Design Assurance Level "____".
 - iii *[if applicable]* Electronic Hardware Part Number " " meets Design Assurance Level " ".

(5) A summary of the security protection for the UAS CNPC Link Systems.

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

(7) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the UAS CNPC Link System.

(8) By-part-number list of replaceable components that makes up the UAS CNPC Link System. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the UAS CNPC Link System continues to meet the TSO approved design. Include recommended inspection intervals and service life, as appropriate.

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

d. If the systems include simple or complex custom airborne/ground 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. A drawing depicting how the system will be marked with the information required by paragraph 4 of this TSO.

f. Identify functionality or performance contained in the system not evaluated under paragraph **3** of this TSO (that is, non-TSO functions). Non-TSO functions can be accepted in parallel with the TSOA. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph **3**. Show that in the event of a Lost CNPC Link, the non-TSO function(s) not associated with Lost Link condition or procedures are automatically disabled.

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

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

(4) Interface requirements and applicable installation test procedures to ensure compliance with the non-TSO function(s) performance data defined in paragraph **5.f.(1)**.

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

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

g. The quality manual required by 14 CFR 21.608, including functional test specifications. The quality system must ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS and reject the article accordingly. Applicants who currently hold TSOAs must submit revisions to the existing quality manual as necessary (not required for LODA applicants).

h. A description of your organization as required by 14 CFR 21.605.

i. Material and process specifications list.

j. A list of all drawings and processes (including revision level) that define the article's design.

k. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3.c** of this TSO.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

Note: The following data for a LODA applicant may be made available for review through its CAA. Refer to the applicable bilateral agreement for specific details regarding access to this data.

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

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 TSO.

g. If the systems include software, the appropriate documentation defined in RTCA/DO- 178C (or RTCA/DO-278A for the CNPC Link System GRS) for the selected DAL as specified in paragraph **3.e** of this TSO, including all data supporting the applicable objectives in RTCA/DO-178C Annex A, *Process Objectives and Outputs by Software Level*.

h. If the article includes complex custom airborne electronic hardware developed to RTCA/DO-254 DAL C or higher in accordance with paragraph **3.f** of this TSO, the appropriate hardware life-cycle data in combination with design assurance level, as defined in

RTCA/DO-254, Appendix A, Table A-1. For simple custom airborne electronic hardware, the following data are required: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

i. If the system contains non-TSO function(s), you must also make available items **6.a** through **6.h** as they pertain to the non-TSO function(s). Additionally, you must make available data showing that, in the event of a Lost CNPC Link, the non-TSO function(s) not associated with Lost Link condition or procedures are automatically disabled.

7. FURNISHED DATA REQUIREMENTS.

a. When furnishing one or more articles manufactured under this TSO 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 TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with this TSO, of the CNPC Link System.

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

c. If the article contains software, include one copy of the OPR summary.

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington, DC 20036. Telephone: (202) 833-9339; fax: (202) 833-9434. You can also order copies online at <u>www.rtca.org</u>.

b. Order copies of parts 21 and 45 from the Superintendent of Documents, Government Publishing Office, PO Box 979050, St. Louis, MO 63197-9000. Telephone: (202) 512-1800, fax: (202) 512-2104. You can also order copies online at <u>https://bookstore.gpo.gov</u>, or find them online at the following Internet websites:

(1) The FAA Dynamic Regulatory System (DRS) website at https://drs.faa.gov.

(2) The U.S. Government's online Electronic Code of Federal Regulations website, <u>https://www.ecfr.gov</u> (select Title 14 - Aeronautics and Space).

c. You can find a current list of TSOs and advisory circulars on the FAA <u>DRS at https://drs.faa.gov</u>. You will also find the TSO Index of Articles at the same site.

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APPENDIX A. ADDITIONAL REQUIREMENTS

This appendix specifies the following additional requirements to the minimum operational performance standards of RTCA/DO-362A, as specified by paragraph **3** of this TSO.

1. CNPC Link Channelization.

In order to facilitate the management of the 5030-5091 MHz band a channel plan has been developed that divides the band into 10 MHz slices. Each of these 10 MHz slices includes C2 Link non-video channels of various band widths up to 205 kHz and channels for the downlink-only video transmission sent from the UA to the Pilot Station to support takeoff/landing and emergency operations (See **Figure A-1**). The assigned non-video channel bandwidth is determined by the data throughput requirements for a specific flight (for example, command and control (C2) only, C2 with ATC voice relay, C2 with detect and avoid (DAA), C2 with weather radar data). The video requirements **shall** be supported on the following channels:

- a) Two Takeoff and Landing Channels (Channel A, Channel B), each having a width of 250 kHz at the upper and lower edge of each 10 MHz slice of the band.
- b) One In-Flight Emergency Channel (Channel C) having a width of 500 kHz located immediately adjacent to the lower 250 kHz Takeoff and Landing Channel in each 10 MHz slice of the band.



Figure A-1. C2 Link Channelization (10 MHz Frequency Slice – Example 5040-5050 MHz shown)