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Command and Control (C2) Data Link White Paper

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FOREWORD

This report was prepared by RTCA Special Committee 228 (SC-228) and approved by the RTCA Program Management Committee (PMC) on (date)

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal advisory committee, and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;

- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders and several advisory circulars.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

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1 BACKGROUND

The Federal Aviation Administration (FAA) established the Unmanned Aircraft Systems Integration Office to integrate Unmanned Aircraft Systems (UAS) safely and efficiently into the National Airspace System (NAS). The UAS Integration Office is working closely with the UAS community to develop the performance and certification standards for the civil Command and Control (C2) Data Link. An initial phase of standards development will provide standards for the C2 Data Link using L-Band Terrestrial and C-Band Terrestrial data links. A second phase is envisaged to provide standards for the use of SATCOM in multiple bands as a C2 Data Link to support UAS.

To support the FAA mission above, RTCA Special Committee 228 Minimum Performance Standards for Unmanned Aircraft Systems (SC-228) was established by the RTCA Program Management Committee (PMC) on 20 May 2013 with Terms of Reference (TOR) given in RTCA Paper No. 109-13/PMC-1089. The remainder of this introductory section contains relevant text extracts directly from the TOR as background for this paper.

Terms of Reference Guidance

> The focus of the C2 data link will be to provide the command and control function as the primary use of the spectrum. During a period of transition to the FAA's digital voice switch network, a secondary capability will be included on the C2 Data Link for ATC voice communications relay. It is expected that this voice communications relay function will no longer be included in the C2 Data Link once the digital voice switch network is fielded in the NAS. See section 6.4 for further discussion. [1]
>
> The International Telecommunications Union (ITU) has identified multiple spectrum bands as candidates for use for this C2 Data Link. These include:
>
> - L-Band Terrestrial
> - C-Band Terrestrial
> - SATCOM in multiple bands
>
> In order to validate use of the spectrum and thereby to protect the frequencies under consideration for UAS use, there is an implied urgency to define, establish performance characteristics, and validate and verify the developed standards.
>
> As the Phase One C2 Data Link Minimum Operational Performance Standard (MOPS) will not contain requirements for Satellite Communication (SATCOM), UAS operations using the Phase One deliverables of SC-228 will involve having any use of satellite Data Link in those operations covered through bilateral agreements between the operator and the FAA. [2]

[1] This is a relay of controller/pilot voice communications for retransmission to and from the aircraft over standard VHF aeronautical channels.

[2] WG-2 believes that the highlighted section of the SC-228 TOR should read: "Phase One deliverables of SC-228 involving any use of satellite Data Link in those operations will be covered through bilateral agreements between the operator and the FAA." A request for an editorial change in the TOR will be requested.

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In developing the Phase One C2 Data Link MOPS, the C2 Data Link Working Group should discuss in detail in its White Paper deliverable which Data Link protocol levels will be defined in the MOPS. It is not anticipated that application-level message formats will be specified (as opposed to how message payloads are framed).

Complete C2 systems engineering tasks:

- Develop system architectures / performance allocations to C2 architectures, with particular focus on how differing Detect and Avoid (DAA) allocations may impact required C2 performance. What are the differing performance levels for different DAA architectures? Specification of the performance levels to support the DAA Architecture of the Phase One DAA MOPS will be the top priority here.
- Evaluate / determine point-to-point and network C2 architectures that must be supported.
- Evaluate potential for sharing waveform structure between L-band and C-band solutions to reduce certification.
- Evaluate potential / value of simultaneous operation of L-band and C-band to improve system performance.
- Evaluate potential / value of physical integration of L-band and C-band into a common radio for SWAP advantage. Or do we have L-band alone, and joint L-band / C-band variant? Small UAS may need L-band alone, larger UAS will need both and might want a single LRU.

Determine preferred MOPS structure:

- Determine if a single MOPS (with L-band and C-band unique characteristics in appendices) is preferable to the approach of two separate MOPS
- Determine the preferred approach for ground radio requirements – Included in airborne MOPS, a separate ground MOPS, or 2 ground MOPS (L-band and C-band), or in a form other than MOPS.

Complete MOPS:

- Determine / document the frequency allocation scheme that is adequate to support anticipated system capacity and performance.
- Determine / document physical layer waveform requirements
- Determine / document network waveform requirements.
- Determine / document upper level services that need to be co-located in the C2 LRU.
- Determine / document external interfaces.
- Write performance verification.

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2 SCOPE AND INTRODUCTION

In the general sense, C2 describes a broad array of systems, procedures and operations that connect a pilot with control surfaces or other actuation that cause the aircraft to maneuver per his intended trajectory. The MOPS being developed under current TOR will characterize minimum performance standards for one key element of that broader chain – the airborne data link radio component.

2.1 Avionics System Certification Background and the Role of RTCA

A Technical Standard Order (TSO) from the FAA is a minimum performance standard for specified materials, parts, and appliances used on civil aircraft. When authorized to manufacture a material, part, or appliance to a TSO standard, this is referred to as TSO authorization. Receiving a TSO authorization is both design and production approval. Receiving a TSO Authorization is not an approval to install and use the article in the aircraft. It means that the article meets the specific TSO and the applicant is authorized to manufacture it.

RTCA has been formally designated to provide recommendations to the FAA under the Federal Advisory Committee Act. RTCA recommendations are generated by an industry consensus process through the work of Special Committees. Output of these committees comes in a variety of document types. Two of these document types are frequently referred to by the FAA in TSOs and Advisory Circulars (ACs) and, thereby, provide a partial basis for the certification of equipment. These two document types are:

- **Minimum Aviation System Performance Standards (MASPS)** – MASPS specify characteristics that are useful to designers, installers, manufacturers, service providers and users of systems intended for operational use within a defined airspace. Where the systems are global in nature, international applications are taken into consideration. MASPS describe the system (subsystems / functions) and provide information needed to understand the rationale for system characteristics, operational goals, requirements and typical applications. Definitions and assumptions essential to proper understanding of MASPS are provided as well as minimum system test procedures to verify system performance compliance (e.g., end-to-end performance verification).

  Compliance with RTCA MASPS is recommended as one means of assuring that the system and each subsystem will perform its intended function(s) satisfactorily under conditions normally encountered in routine aeronautical operations for the environments intended. MASPS may be implemented in part or in total.

- **Minimum Operation Performance Standards (MOPS)** – MOPS provide standards for specific equipment(s) useful to designers, manufacturers, installers and users of the equipment. The word "equipment" used in MOPS includes all components and units necessary for the system to properly perform its intended function(s). MOPS provide the information needed to understand the rationale for equipment characteristics and requirements stated, describe typical equipment applications and operational goals, and establish the basis for required performance under the standard. Definitions and assumptions essential to proper understanding are provided as well as installed equipment tests and operational performance characteristics for equipment installations.

  Compliance with RTCA MOPS is recommended as one means of assuring the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operations. MOPS may be

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