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| U.S. Radiocommunications Sector  Fact Sheet | |
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| **Document Title:** WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[TER\_AG\_CNPC\_CHAR] - **Characteristics of terrestrial, air-ground, unmanned aircraft system control and non-payload communications links operating in the AM(R)S allocation under No. 5.443C** | |
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| **Purpose/Objective:** The purpose of this contribution is to update the characteristics of terrestrial air-ground UAS CNPC links to enable any future sharing studies to use the correct values of the parameters of the characteristics of these systems. | |
| **Abstract:** This contribution will provide values of a range of RF parameters associated with the CNPC links that operate in the AM(R)S allocation under No. 5.443C. The performance of these links has a direct relationship to the safe operation of these unmanned aircraft. Consequently, it is important to ensure their operation is correctly considered in any sharing and interference analysis that may be carried out in the future. | |

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| **Radiocommunication Study Groups** |  |
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| WORKING DOCUMENT TOWARDS A PReliminary draft new RECOMMENDATION Itu-r m.[ter\_ag\_cnpc\_char] | |
| **Characteristics and Protection Criteria of Terrestrial Air-Ground, Unmanned Aircraft System Control and Non-Payload Communications Links operating in the AM(R)S allocation under No. 5.443C** | |

Introduction

At WRC-2012 it was agreed, under No. 5.443C, that the frequency band 5 030-5 091MHz could be used by the aeronautical mobile (R) service limited to internationally standardized aeronautical systems. Industry, international standards development organizations and ICAO have been working since then to develop the technology and standards necessary to use that allocation. Consequently, it is now possible to provide characteristics and protection criteria for such systems for use in any future sharing studies within ITU-R.

Proposal

The United States of America proposes to assist in answering the above need by providing characteristics for such Control and Non-Payload Communications (CNPC) links operating in the AM(R)S allocation under No. 5443C and used in air-ground applications between Unmanned Aircraft (UA) and their Control Station (CS) where the Remote Pilot (RP) is located.

**Attachment**: 1

attachment

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Characteristics and Protection Criteria of Terrestrial Air-Ground, Unmanned Aircraft System Control and Non-Payload Communications Links   
operating in the AM(R)S allocation under No. 5.443C

# 1 Introduction and Scope

The Characteristics of Unmanned Aircraft Systems (UAS) and spectrum requirements must support their safe operation in non-segregated airspace.[[1]](#footnote-1)There is a strong and growing demand for the use of UAS (also known as Remote Pilot Aircraft (RPA) by ICAO) in civil applications. These UAS flights will share airspace with passenger carrying aircraft so their operation needs to be managed to safely allow the introduction of this new paradigm in aviation.

The Control and Non-Payload Communications (CNPC) Link System consists of the CNPC Ground Radio System (GRS) Link (fixed, or mobile) and the CNPC Airborne Radio System (ARS) Link. Each link consists of the transceiver radio, the antenna(s), and the associated cabling.

**Figure. CNPCLink System Components**



CNPC LINK SYSTEM

CNPC GROUND RADIO SYSTEM

CNPC AIRBORNE RADIO SYSTEM

In non-segregated airspace a link between air traffic control and the Unmanned Aircraft Control Station (UACS) via the UA, called Air Traffic Control (ATC) relay, will be required to relay ATC and air-to-air communications received and transmitted by the UA.

For communicating with ATC, the UA uses the same equipment as a manned aircraft. This report only considers the downlink bringing the ATC information from the UA to the UACS and the uplink from the UACS to the UA allowing the UACS to communicate with ATC.

As these communications are critical for a safe management of the controlled airspaces, especially in terminal approach areas with high density of aircraft, future ICAO standards are obviously mandatory for these kinds of communications.

Command and control is the typical link between the UACS and the UA. The following two ways of communications are:

* *The uplink*:To send telecommands to the aircraft for flight and navigation equipment control.
* *The downlink*: To send telemetry (e.g. flight status) from the UA to the UACS. It is anticipated that in some flight conditions or in specific airspaces it could be necessary to downlink video streams.

In areas under the responsibility of the aeronautical authorities, the command and control communications will have to be compliant with ICAO standards. Nevertheless, in the periods where the UA will follow a full autonomous flight, the up and down links could have very low data rates.

A UA designed to fly in controlled airspace must be able to operate in both high and low density airspace. The air traffic control system would not necessarily be able to restrict UA to low density airspace only. Therefore, it is recommended that larger UA be equipped with a terrestrial link capability wherever possible and a UA may use a GEO satellite link in low density sectors and also probably in high density sectors where the total number of UA in that sector is low.

The impact of latency on UAS command and control systems is a prime factor when considering the safety of operations. Latency will be of the utmost importance when establishing a safety case for the operation of UA, particularly in non-segregated airspace. Current air traffic management relies heavily on voice communications although information via data links is being progressively implemented.

The potential types of information exchanges over the C2 Link System are:

The UA Control - To support the remote pilot's activity to aviate the UA, power plant status information from the aircraft back to the remote pilot is essential on a frequent basis relative to the dynamics of the UA.

The Avionics - Avionics systems send information (e.g. Flight Guidance System, Flight Management System (FMS), ATC Communication, DAA, Weather Radar, Status Reporting System) over the C2 Link System from the UA to the CS.

The Payload **-** Payload communications are not allowed to be carried in the C2 Link System. In some cases the C2 Link System and payload communications information may be carried over a common link.

To enable this interference analysis to be undertaken the characteristics and protection criteria for these Terrestrial, Air-Ground CNPC links operating in the AM(R)S allocation under No. 5.443C are required. This report contains those characteristics and protection criteria based on systems that are being developed for international standardization by ICAO and which will be included within Annex 10, Volume VI, of their Standards and Recommended Practices.

* 1. **Definitions**

***Unmanned Aircraft (UA)*:** Designates all types of aircraft remotely controlled.

***Unmanned Aircraft Control Station (UACS)*:** Facilities from which a UA is controlled remotely.

***Control and non-payload communications (CNPC)*:** The radio links, used to exchange information

between the UA and UACS, that ensure safe, reliable, and effective UA flight operation. The

functions of CNPC can be related to different types of information such as: telecommand messages,

non-payload telemetry data, support for navigation aids, air traffic control voice relay, air traffic

services data relay, target track data, airborne weather radar downlink data, non-payload video

downlink data.

***Sense and avoid (S&A)*:** S&A corresponds to the piloting principle “see and avoid” used in all air

space volumes where the pilot is responsible for ensuring separation from nearby aircraft, terrain

and obstacles.

***Unmanned Aircraft System (UAS)*:** Consists of the following subsystems:

* Unmanned aircraft (UA) subsystem (i.e. the aircraft itself);
* Unmanned aircraft control station (UACS) subsystem;
* Air traffic control (ATC) communications subsystem (not necessarily relayed through the UA);
* Sense and avoid (S&A) subsystem;
* Payload subsystem (e.g. video camera …).

***Handover operations*:** is the transfer:

* of a direct (LoS) RF communication from one dedicated UACS to another (LoS) dedicated UACS;
* of a direct (LoS) to an indirect (BLoS) RF communication link or vice versa.

***CNPC Link System:*** The combination of airborne and ground UAS radios and antennas that support the data and information exchanges between the UA and the Pilot Station for the purposes of managing and controlling the flight and operation of the UA.

**CNPC Link Airborne Radio System (ARS):** The system that resides on the UA to transmit and receive control and communication data to and from the CNPC Link Ground Radio System. The ARS consists of the CNPC Link System Airborne Radio, one or more airborne antennas, and all associated cabling.

**CNPC Link System Airborne Radio:** The CNPC radio that is part of the CNPC Link Airborne Radio System (ARS).

**CNPC Link Ground Radio System (GRS):** The system that resides on the ground to transmit and receive control and communication data to and from the CNPC Link Airborne Radio System. The GRS consists of the CNPC Link System Ground Radio, one or more antennas, and all associated cabling.

**CNPC Link System Ground Radio:** The CNPC radio that is part of the CNPC Link Ground Radio System (GRS).

**Pilot Station:** The equipment used to maintain control, communicate, guide, or otherwise manage an unmanned aircraft (UA).

**Radio line-of-Sight (LoS):** is defined as the direct radio line of sight radiocommunication between the UA and UACS.

# 2 Characteristics of Terrestrial Air-Ground CNPC links

**2.1 UA and CS Link Characteristics**

TABLE 1

Transmission and Reception Characteristics

|  | Units | CNPC Link System Airborne Radios | CNPC Link System Ground Radios |
| --- | --- | --- | --- |
| Frequency of Operation | MHz | 5 030 to 5 091 | 5 030 to 5 091 |
| Baseband Signal |  | Data | Data |
| User Data Rates | kbps | 7.04 to 34.8 | 7.04 to 34.8 |
| Duplexing |  | Time Division | Time Division |
| Transmit/Receive Duration  Up from CS  Down form UA | msec | 23 Up plus 1.3 Guard  23 Down plus 2.7 Guard | 23 Up plus 1.3 Guard  23 Down plus 2.7 Guard |
| Modulation |  | GMSK or QPSK | GMSK or QPSK |
| Symbol Rates | ksps | 34.5 to 138 including TDD, error correction/detection, guard times and synchronization overhead | 34.5 to 138 including TDD, error correction/detection, guard times and synchronization overhead |
| Occupied Bandwidth, C | kHz | Variable per application with a Maximum of 250 | Variable per application with a Maximum of 250 |
| Antenna Gain | dBi | 3 | 22.5 |
| Cable Loss | dB | 2 | 3 |
| Antenna Pattern |  | Constant Azimuth  Constant Elevation | Constant Azimuth  Tailored in Elevation  See Table 1 |
| Antenna Polarization |  | Vertical with aircraft flying straight and level | Vertical |
| Maximum Antenna Height | m | 22 860 (MSL)  Typical 8 000 | 2 to 50  Typical 10 |
| Service Range | km | 550  Typical 200 | 550  Typical 200 |
| Transmitter Conducted Power | dBm | 40 | 40 |
| Transmitter In Band Emission Limits | dBc/kHz | -96 at 2MHz offset  See Table 2 | -96 at 2MHz offset  See Table 2 |
| Receiver Noise Figure | dB | 6 | 6 |
| Receiver In Band Rejection – except the operating channel | dB | 44 | 44 |
| Protection Criteria I/N \* | dB | −10 | −10 |
| \* Compatibility/sharing analyses could consider an aeronautical safety margin as recommended by ICAO. Values from 0 to 6 dB have been discussed. | | | |

TABLE 2

Control Station Elevation Antenna Pattern  
Pattern is constant in azimuth

|  |  |
| --- | --- |
| Elevation Degrees | Gain dBi |
| 0.5 | 20.0 |
| 1 | 20.5 |
| 2 | 21.5 |
| 4 | 22.5 |
| 8 | 20.5 |
| 16 | 14.0 |
| 32 | 6.5 |
| 64 | 3.0 |
| >64 | 3.0 |

TABLE 3

Transmitter In Band Emission Limits

|  |  |
| --- | --- |
| Offset from Carrier Frequency | dBc/kHz |
| Channel Width ÷ 2 | −54 |
| 1.5 x Channel Width | −74 |
| 500 kHz | −90 |
| 2 000 kHz | −96 |

TABLE 4

Transmitter Out Of Band Emission Limits

|  |  |
| --- | --- |
| Maximum CNPC Link System Power Spectral Density | |
| CNPC Link System Airborne Radios | CNPC Link System Ground Radios |
| TBD | TBD |

***Editor’s Note:****It is envisioned that the proposed Recommendation ITU-R M.[TER\_AG\_CNPC\_CHAR] will eventually include the out of band emission characteristics of AM(R)S transmissions into adjacent bands including those below 5 030 MHz that would be necessary for sharing studies to resolve the provisional nature of the -75 dBW/MHz protection value in* ***No. 5.443C****.*

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1. Report ITU-R M.2171 – Characteristics of unmanned aircraft systems and spectrum requirements to support their safe operation in non-segregated airspace, December 2009. [↑](#footnote-ref-1)