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# **Unmanned Aircraft Systems**

## **Spectrum Topics**

### **FSMP WG/06 WRC-19 Workshop**

6-7 February 2018



## Topics

- **Spectrum issues and challenges, not on the specific agenda for WRC-19**
  - Potential frequency bands
    - ICAO Remotely Piloted Aircraft System Panel SARP amendment proposals
  - Use of the Fixed Satellite Service
    - ITU Resolution 155 (WRC-15)



# ICAO and WRC-15 Resolution 155

*invites the International Civil Aviation Organization*

to provide to the Director of the Radiocommunication Bureau, in time for WRC-19 and WRC-23, information on ICAO efforts regarding implementation of UAS CNPC links, including the information related to the development of SARPs for UAS CNPC links.

- **ICAO RPASP will have its first package of (technology neutral) C2 Link SARPs ready by WRC-19 and is planning to have its technology specific SARPs ready by WRC-23**
- **Proposed amendments to Annex 10 Volume 5 do include some WRC-15 Resolution 155 resolves**
  - Resolves 1, 5 and 13 are respectively covered in 5.1.1.3, 5.1.2 and 5.1.3 of the first package of C2 Link SARP amendment proposals



# RPASP WG2 Long-Term Schedule

2016	2017	2018	2019	2020
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**First Package of SARP Proposals**  
High Level – Technology Neutral

★ **Submit First Package of SARP Amendment Proposals**

Finalize SARP Amendment Proposals

Liaise and Concense with other Panels and RPAS WGs

Update Guidance Manual

Work with SASP and OPLDWG to develop details of Required Link Performance

Work with AVSECP to develop details of C2 Link Security Requirements

**Second Package of SARP Proposals**  
Technology Specific

★ **Submit Second Package of SARP Amendment Proposals**

Terrestrial RLOS

Point to Point Network

Satellite BRLOS

L Band  
C Band  
Ku and Ka Band

Airborne Networks

**EUROCAE, ISO, ITU-R and RTCA contributions**

**Schedules will depend on level of interest and support**



## ICAO RPAS Panel

- **The C2 Link Working Group of the RPAS Panel is developing RPAS/UAS related SARP amendment proposals that are anticipated to be added to Annex 10 over the next two years (WG06-WP03)**
- **Amongst approximately one hundred and fifty proposed additions to Annex 10 are a number related to specific frequency bands**



## 5.2 Terrestrial C2 Link Communications services

- 5.2.1 Terrestrial RPAS systems shall operate in bands allocated to the Aeronautical Mobile (Route) Service (AM(R)S). Frequency bands with such allocations include the 117.975 - 137, 960 - 1164 and 5030 - 5091 MHz frequency bands. The operation of the C2 Link within any of these bands shall be in accordance with Regional Air Navigation Agreements, so that the C2 Links do not constrain other aeronautical systems using these allocations.



## 5.1 Satellite based C2 Link Systems

- 5.1.1. Satellite based RPAS C2 Link systems shall operate in the following frequency bands:
  - 5.1.1.1 Frequency bands with an allocation to aeronautical safety services under the Aeronautical Mobile Satellite (Route) Service (AMS(R)S). Frequency bands that meet these criteria are: the 1 610 – 1 626.5MHz and the 5 030 - 5 091 MHz frequency bands;
  - 5.1.1.2 Frequency bands with an allocation to aeronautical safety services under the Mobile-Satellite Services (MSS) where AMS(R)S operations have priority access. Frequency bands that meet these criteria are: the 1 545 - 1 555MHz and the 1 646.5 - 1 656.5MHz frequency bands;



## 5.1 Satellite based C2 Link Systems

- 5.1.1.3. Frequency bands with an allocation to the Fixed Satellite Service (FSS) where the conditions in ITU-R Resolution 155 (WRC-15) are met. Frequency bands where this resolution applies are: the frequency bands 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) in Region 2, 12.2-12.5 GHz (space-to-Earth) in Region 3, 12.5-12.75 GHz (space-to-Earth) in Regions 1 and 3 and 19.7-20.2 GHz (space-to-Earth), 14-14.47 GHz (Earth-to-space) and 29.5-30.0 GHz (Earth-to-space) frequency bands operating with an ITU satellite earth station class of “UG”.
- *Note:* UG is an Earth station on board an unmanned aircraft communicating with a space station of a geostationary-satellite network in the fixed-satellite service for the control and non-payload communications of unmanned aircraft systems in non-segregated airspaces in the frequency bands listed under resolves 1 of Resolution 155 (WRC-15).

**Above ICAO SARPs text taken directly from Resolution 155 WRC-15**





## 5.1 Satellite based C2 Link Systems

- 5.1.2. RPA and RPS Earth stations shall operate within the notified and recorded technical parameters of the associated satellite network, including specific or typical earth stations as published by the ITU Radiocommunication Bureau.
- 5.1.3. RPA and RPS Earth stations operating in accordance with Section 5.1.1.3. shall use FSS assignments that have been successfully coordinated under Article 9 of the ITU Radio Regulations and recorded in the Master International Frequency Register (MIFR) with a favorable finding under Article 11, of the ITU Radio Regulations including Nos. 11.31, 11.32 or 11.32A where applicable, and except those assignments that have not successfully completed coordination procedures under No. 11.32 by applying Appendix 5 § 6.d.i of the ITU Radio regulations.

**Above ICAO SARPs text taken directly from Resolution 155 WRC-15**

## ITU-R Status Update

- **At WRC 2015 Resolution 155 was adopted**
- **This presentation considers all of the *resolves* in the Resolution and discuss ITU-R's status**
  - General Considerations
  - Coordination Considerations
  - Harmful Interference Considerations
  - Non-RPAS/UAS System Protection Considerations
  - RPAS/UAS System Considerations
  - ICAO Considerations



# At WRC 2015 Resolution 155 was adopted

## • General Considerations

*resolves*

1 that assignments to stations of geostationary FSS satellite networks operating in the frequency bands 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) in Region 2, 12.2-12.5 GHz (space-to-Earth) in Region 3, 12.5-12.75 GHz (space to-Earth) in Regions 1 and 3 and 19.7-20.2 GHz (space-to-Earth), and in the frequency bands 14-14.47 GHz (Earth-to-space) and 29.5-30.0 GHz (Earth-to-space), may be used for UAS CNPC links in non-segregated airspace\*, provided that the conditions specified in *resolves* below are met;

2 that earth stations in motion on board UA may communicate with the space station of a geostationary FSS satellite network operating in the frequency bands listed in *resolves* 1 above, provided that the class of the earth station in motion on board UA is matched with the class of the space station and that other conditions of this Resolution are met (see also *instructs the Director of the Radiocommunication Bureau* 3 below);

3 that the frequency bands specified in *resolves* 1 shall not be used for the UAS CNPC links before the adoption of the relevant international aeronautical standards and recommended practices (SARPs) consistent with Article 37 of the Convention on International Civil Aviation, taking into account *instructs the Director of the Radiocommunication Bureau* 4;

Ku and Ka FSS Bands

ITU-R Bureau has created the UG class

ICAO RPAS Panel is developing SARPs to be Effective by 2022



# At WRC 2015 Resolution 155 was adopted

## • Coordination Considerations

### *resolves*

4 that administrations responsible for an FSS network providing UA CNPC links shall apply the relevant provisions of Articles 9 (necessary provisions need to be identified or developed) and 11 for the relevant assignments, including, as appropriate, assignments to the corresponding space station, specific and typical earth station and earth station in motion on board UA, including the request for publication in BR IFIC of items referred to in *resolves* 2 and the course of actions identified in that *resolves* in order to obtain international rights and recognition as specified in Article 8;

9 that the use of assignments of a FSS satellite network for UAS CNPC links shall not constrain other FSS satellite networks during the application of the provisions of Articles 9 and 11;

10 that the introduction of UAS CNPC links shall not result in additional coordination constraints on terrestrial services under Articles 9 and 11;

RPAS/UAS  
Earth Stations  
(Air and  
Ground) are to  
be  
coordinated  
using the  
same process  
as other FSS  
networks and  
not be given  
any special  
status during  
coordination



# At WRC 2015 Resolution 155 was adopted

## • Harmful Interference Considerations

*resolves*

13 UAS CNPC links shall:

- ensure that the use of UAS CNPC links be in accordance with the international standards and recommended practices (SARPs) consistent with Article 37 of the Convention on International Civil Aviation;
- take the required measures, consistent with No. 4.10, to ensure freedom from harmful interference to earth stations on board UA operated in accordance with this Resolution;
- act immediately when their attention is drawn to any such harmful interference, as freedom from harmful interference to UAS CNPC links is imperative to ensure their safe operation, taking into account *resolves* 11;
- use assignments associated with the FSS networks for UAS CNPC links (see Figure 1 in Annex 1), including assignments to space stations, specific or typical earth stations and earth stations on board UA (see *resolves* 2), that have been successfully coordinated under Article 9 (including provisions identified in *resolves* 4) and recorded in the Master International Frequency Register (MIFR) with a favorable finding under Article 11, including Nos. 11.31, 11.32 or 11.32A where applicable, and except those assignments that have not successfully completed coordination procedures under No. 11.32 by applying Appendix 5 § 6.d.i;
- ensure that real-time interference monitoring, estimation and prediction of interference risks and planning solutions for potential interference scenarios are addressed by FSS operators and UAS operators with guidance from aviation authorities;

RPAS/UAS  
CNPC Links  
require  
careful  
monitoring  
and  
immediate  
action to be  
taken to  
minimize the  
potential for  
any safety  
effects due  
to harmful  
interference



# At WRC 2015 Resolution 155 was adopted

## • Non-RPAS/UAS System Protection Considerations

### *resolves*

8 that earth stations of UAS CNPC links of a particular FSS network shall not cause more interference to, or claim more protection from, stations of terrestrial services than specific or typical earth stations of that FSS network as indicated in *resolves* 5 that have been previously coordinated and/or notified under relevant provisions of Articles 9 and 11;

14 that, unless otherwise agreed between the administrations concerned, UA CNPC earth stations shall not cause harmful interference to terrestrial services of other administrations (see also Annex 2);

15 that, in order to implement *resolves* 14 above, power flux-density hard limits need to be developed for UAS CNPC links; one possible example of such provisional limits to protect the fixed service is provided in Annex 2; subject to agreement between the administrations concerned, that annex may be used for the implementation of this Resolution;

16 that the power flux-density hard limits provided in Annex 2 shall be reviewed and, if necessary, revised by the next conference;

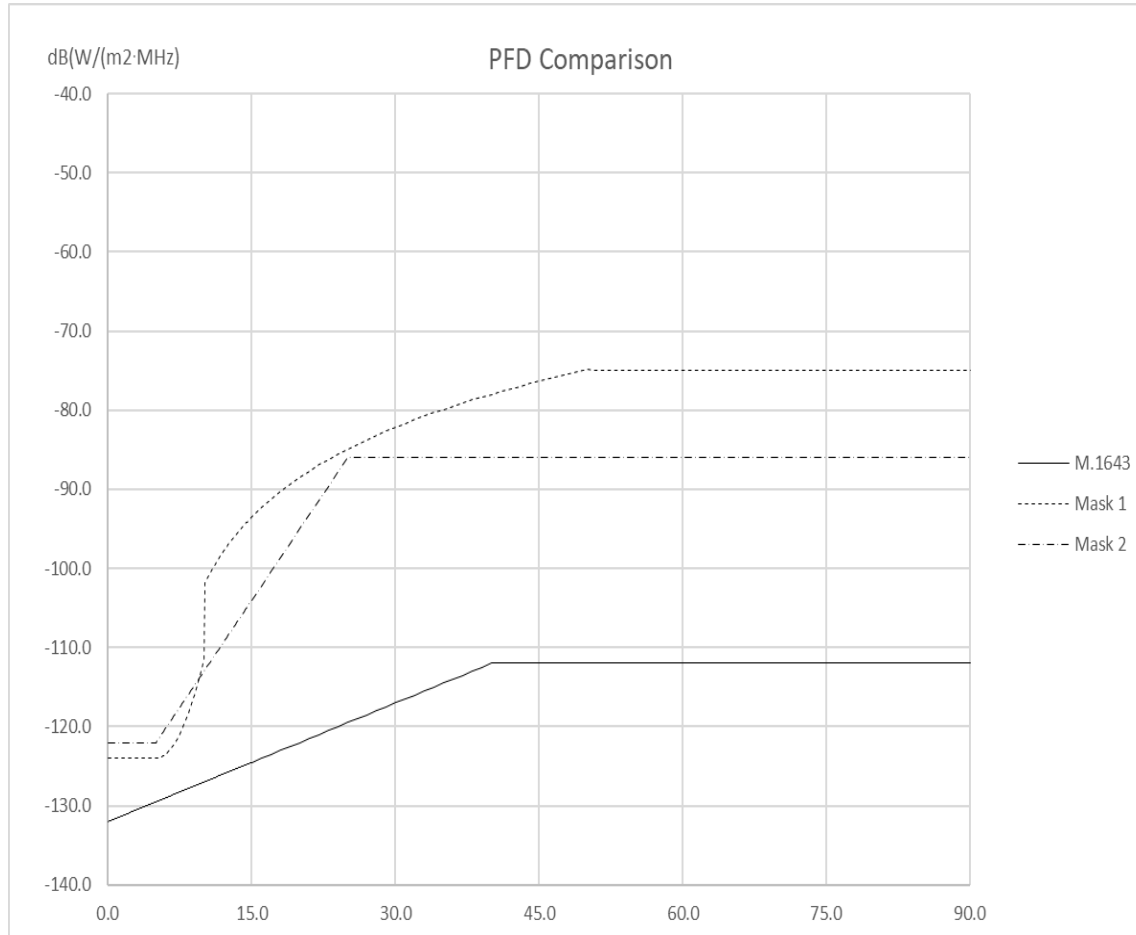
17 that, in order to protect the radio astronomy service in the frequency band 14.47-14.5 GHz, administrations operating UAS in accordance with this Resolution in the frequency band 14-14.47 GHz within line-of-sight of radio astronomy stations are urged to take all practicable steps to ensure that the emissions from the UA in the frequency band 14.47-14.5 GHz do not exceed the levels and percentage of data loss given in the most recent versions of Recommendations ITU-R RA.769 and ITU-R RA.1513;

Pfd masks are required to protect the terrestrial services, in particular the FS

Out of band emissions also need to be considered



# PFD Mask to Protect the Fixed Service



WP 5B is reviewing the ITU-R M.1643 based mask from Annex 2 of Resolution 155 (WRC-15). Alternate masks are being developed with the intent to review/revise the pfd mask during the next conference (WRC-19) as indicated in resolves 6

During its November 2017 meeting WP 5C provided WP 5B with the appropriate FS characteristics (5B/308) to be used in this pfd analysis

WP5B is expected to be ready with a pfd mask by WRC-19



# At WRC 2015 Resolution 155 was adopted

## • RPAS/UAS System Considerations

### *resolves*

5 that earth stations of UAS CNPC links shall operate within the notified and recorded technical parameters of the associated satellite network, including specific or typical earth stations of the geostationary FSS satellite network(s) as published by the Radiocommunication Bureau;

6 that earth stations of UAS CNPC links shall not cause more interference to, or claim more protection from, other satellite networks and systems than specific or typical earth stations as indicated in *resolves* 5 as published by the Bureau;

7 that, in order to apply *resolves* 6 above, administrations responsible for the FSS network to be used for UAS CNPC links shall provide the level of interference for the reference assignments of the network used for CNPC links upon request by an administration authorizing the use of UAS CNPC links within its territory;

WP 5B is  
developing CNPC  
Link  
characteristics to  
enable:

- 1) WP 5B to analyze compliance with the appropriate Radio Regulations
- 2) ICAO to perform its work on SARPs . Reference liaisons from RPASP/FSMP to WP 5B FSMP-WG/3-WP/04 and FSMP-WG/4 WP/12





# CNPC Link Characteristics

Guidelines extracted from Annex 28 of the November 2017 WP 5B meeting Chairman's Report 5B/411

- 3) Identify all satellite networks recorded in the MIFR in conformity with 3a) and 3b) below:
  - a) Having assignments that have been successfully coordinated under Article 9 of the Radio Regulations (RR).
  - b) Have been notified and recorded in the MIFR with favorable finding in conformity with respect to RR Nos. **11.31**, **11.32** or **11.32A** except those which are recorded under RR No. **11.32** by applying Appendix 5 § 6.d.

Request that the Radiocommunication Bureau certifies that those satellite networks identified comply with the appropriate resolves in Resolution **155 (WRC-15)**.
- 4) Identify the sensitive/critical satellite network parameters that are required in order to determine the generic envelope of satellite network characteristics from those satellite networks mentioned in 3) above to be used in step 6) below and develop a methodology/tools to extract these characteristics from the certified list of FSS satellite networks from 3).
- 5) Compile UAS CNPC earth stations characteristics and their parameter values from those submitted to WP 5B by its members in order to finalize characteristics for UAS CNPC in application of Resolution **155 (WRC-15)**.
- 6) Compare the characteristics and their parameter values in 4) with those in 5) to determine if the proposed characteristics of the UAS CNPC earth stations in 5) fit with the characteristics of the specific and/or typical earth stations for the satellite networks described in 4) to determine that UAS CNPC earth stations intended to communicate with satellite networks mentioned in 3) above are in compliance with Resolution **155 (WRC-15)**.

During its November 2017 meeting WP 5B developed Guidelines on how RPAS/UAS CNPC Link characteristics should be developed.

- 3+4) All of the appropriately coordinated Earth stations in the MIFR will be reviewed to develop maximum and minimum values of key parameters that could affect interference and link performance
- 5) CNPC Link characteristics will be proposed
- 6) The MIFR derived Earth station characteristics will be compared with the proposed CNPC Link characteristics to see if the CNPC Link characteristics comply



# At WRC 2015 Resolution 155 was adopted

## • ICAO Considerations

### *Resolves*

11 that earth stations on board UA shall be designed and operated so as to be able to accept the interference caused by terrestrial services operating in conformity with the Radio Regulations in the frequency bands listed in *resolves* 1 without complaints under Article 15;

12 that earth stations on board UA shall be designed and operated so as to be able to operate with interference caused by other satellite networks resulting from application of Articles 9 and 11;

18 to consider the progress obtained by ICAO in the process of preparation of SARPs for UAS CNPC links, to review this Resolution at WRC-23, taking into account the results of the implementation of Resolution 156 (WRC-15), and to take necessary actions as appropriate;

### *invites the International Civil Aviation Organization*

to provide to the Director of the Radiocommunication Bureau, in time for WRC-19 and WRC-23, information on ICAO efforts regarding implementation of UAS CNPC links, including the information related to the development of SARPs for UAS CNPC links.

ICAO needs to consider harmful interference in its SARPs for FSS related C2 Links

ICAO RPASP plans to complete its FSS related SARP amendments prior to 2023



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THANK YOU