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**AERONAUTICAL COMMUNICATIONS PANEL (ACP)**

**Twenty Third meeting of ACP WG-F (Frequency)**

**Cairo, Egypt 21 – 27 September 2010**

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| **Agenda Item 3:** | Development of material for ITU-R meetings |

A short analysis of the draft regulatory text examples on WRC-12 Agenda Item 1.3, contained in ITU-R Document CPM11-2/1-E (13 August 2010),

Draft CPM REPORT

(Presented by the Secretary)

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| **SUMMARY** |
| This paper reproduces the methods proposed for the solution of WRC-12 Agenda Item 1.3, as contained in the Draft ITU-R CPM Report for WRC-12, which will be the working basis for considerations during the Conference Preparatory Meeting (CPM-11/2) to be held in Geneva, 14 – 25 February 2011. While some of these methods look promising, others do not satisfy the ICAO Position, appear to be in breach of the service definitions of the Radio Regulations and are not likely to satisfy safety requirements for operation of unmanned aircraft systems (UAS) in international civil airspace.  In short, methods A1, A4, A5, B1 and B2 appear in line with the ICAO Position and are likely to facilitate a solution to this agenda item, by enabling the development of International Standards and Recommended Practices (SARPs)[[1]](#footnote-1) which would in turn enable insertion of UAS into international segregated and non-segregated airspace. Methods A2 and A3 appear problematic. |

Attachment: Excerpts relevant to Agenda Item 1.3, from ITU-R document CPM11-2/1-E

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**Attachment**

**ITU-R document CPM11-2/1-E excerpts relevant to Agenda Item 1.3**

The CPM-11 Management Team identified the following issues:

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• For Chapter 1, Agenda item 1.3, the examples of regulatory text in Section 1/1.3/6.1, provided by one or more administrations, were not discussed at the WP 5B meeting at all.

• …

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| 1.3 | to consider spectrum requirements and possible regulatory actions, including allocations, in order to support the safe operation of unmanned aircraft systems (UAS), based on the results of ITU‑R studies, in accordance with Resolution **421 (WRC‑07)**; | 1 |

…

AGENDA ITEM 1.3

(**WP 5B** / **WP 4A**, **WP 4C**, (WP 7B), (WP 7C), (WP 7D))

*1.3 to consider spectrum requirements and possible regulatory actions, including allocations, in order to support the safe operation of unmanned aircraft systems (UAS), based on the results of ITU‑R studies, in accordance with Resolution****421 (WRC‑07)****;*

*Resolution* ***421 (WRC‑07)****: Consideration of appropriate regulatory provisions for the operation of unmanned aircraft systems*

# 1/1.3/1 Executive summary

A significant increase of the worldwide use of unmanned aircraft systems is expected in the future. The seamless operation of unmanned aircraft with piloted aircraft in non-segregated airspaces is becoming vital for the further development of unmanned aircraft applications that will fill many diverse requirements. Therefore, globally harmonized spectrum is required to satisfy this need. WRC-12 Agenda item 1.3 seeks to identify spectrum that can be used to meet this demand. The envisioned unmanned aircraft systems infrastructure will be composed of terrestrial and satellite components.

Report ITU-R M.2171 provides the analyses for determining the amount of spectrum required for the operation of a prospected number of unmanned aircraft systems sharing non-segregated airspace with manned air vehicles as required by Resolution **421 (WRC-07)** and in response to WRC‑12 Agenda item 1.3. The methodologies estimating the total spectrum requirements in this report address terrestrial and satellite requirements in a separate manner. Deployment of unmanned aircraft systems will require access to both terrestrial and satellite spectrum.

The maximum amount of spectrum required for unmanned aircraft systems are:

– 34 MHz for terrestrial component,

– 56 MHz for satellite component.

Eight methods have been proposed to satisfy this Agenda item. Compatibility and characteristics issues are raised in the corresponding methods.

Five methods are proposed for the Issue A - satellite component:

– Method A1 proposes the use of the current AMS(R)S allocations for both links (unmanned aircraft to satellite and unmanned aircraft control station (mobile and fixed) to satellite);

– Method A2 proposes the use of the current MSS, AMSS and AMS(R)S allocations for both links (unmanned aircraft to satellite and unmanned aircraft control station (mobile and fixed) to satellite) and FSS allocations (only for the fixed unmanned aircraft control station to satellite link) in accordance with the Radio Regulation;

– Method A3 proposes the use of the current FSS allocations by adding a new footnote pointing toward a WRC Resolution/Recommendation (except frequency bands covered by Appendices **30**, **30A** and **30B** to the Radio Regulations);

– Method A4 proposes to restrict the communication link between unmanned aircraft and satellite to AMS(R)S allocations, to confirm the use of AMS(R)S allocations for the radio communication link between unmanned aircraft control station and the satellite and to allow the use of the FSS allocations for this link (except frequency bands covered by Appendices **30**, **30A** and **30B** to the Radio Regulations);

– Method A5 proposes new AMS(R)S allocations.

Two methods are proposed for the Issue B - terrestrial component:

– Method B1 proposes new AM(R)S allocations;

– Method B2 proposes a WRC Resolution indicating that any terrestrial link between the unmanned aircraft and the unmanned aircraft control station should only use the AM(R)S allocation.

Method C, covering both Issues (A+B) - terrestrial and satellite components, proposes no change to the Table of Frequency Allocations (RR Article **5**) for frequency bands for which the studies have not been completed.

# 1/1.3/2 Background

Unmanned aircraft systems (UAS) consists of unmanned aircraft (UA) and associated unmanned aircraft control station (UACS). UA are powered, aerial vehicles that do not carry a human pilot, use aerodynamic forces to provide vehicle lift, and may fly autonomously or be piloted remotely. UAS operations have been limited to segregated airspace where separation from other air traffic can be assured. However, it is planned to expand UAS deployment outside of segregated airspace.

The development of the UAS is based on recent technological advances in aviation, electronics and metallurgy, making the economics of UAS operations more favourable, particularly for more repetitive, routine and long-haul duration applications. The current state of the art in UAS design and operation, is leading to the rapid development of UAS applications to fill many diverse requirements. UAS applications that have been demonstrated or planned are in such areas as agriculture, communications relays, aerial photography, mapping, emergency management, and scientific research, environmental management, and law enforcement. UAS also bring major benefits in reducing risk to human life in environments not easily accessible to manned aircraft, such as volcanoes, hurricanes and poisonous or electromagnetic zones. Thus, the safe operation of UA outside segregated airspace requires addressing the same issues as manned aircraft, namely integration into the air traffic control system.

# 1/1.3/3 Summary of technical and operational studies and relevant ITU‑R Recommendations

Existing relevant ITU-R Report: ITU-R M.2171.

New relevant ITU-R Reports: Reports ITU‑R M.[UAS-BANDS-EXIST-ALLOC], ITU‑R M.[UAS-BANDS-NEW-ALLOC], ITU-R M.[UAS-SENSE-AND-AVOID] and ITU-R M.[UAS‑PERF-AND-REQ].

## 1/1.3/3.1 Radiocommunication system spectrum studies

Radiocommunication links used by UAS can be segmented amongst the following categories, each of them having specific spectrum requirements including satellite and terrestrial ones:

### 1/1.3/3.1.1 Command and control

As a replacement of the control stick of a manned aircraft the remote pilot needs this link to command the aircraft during flight. This link will also provide the pilot with the aircraft information needed, such as speed, heading, position, etc. The required data rate is very much dependent on the capabilities of the UAS. The more the aircraft is able to control its flight autonomously the less data need to be transferred.

### 1/1.3/3.1.2 Relay of air traffic control

Safe operation of aircraft manned or unmanned depends on the communication with air traffic control (ATC). The rules of air traffic rely on the fact that the pilot reacts according to instructions received from ATC. If the pilot does not sit in the aircraft, this means for the existing ATC system that a voice channel has to be maintained to relay information from the radio in the aircraft to the pilot and back. This ATC relay communications also includes future ATC data link communications.

### 1/1.3/3.1.3 Relay of sense and avoid data

Sense and avoid corresponds to the piloting principle “see and avoid” used in all air space volumes where thepilot is responsible for ensuring separation from nearby aircraft, terrain and obstacles. Despite the fact that under instrument flight rules part of this responsibility is transferred to ATC, the pilot is required to observe the airspace in his vicinity. Modern aircraft are equipped with a number of sensors to support this requirement, such as: radar airborne collision avoidance system, automatic dependant system-broadcast and universal access transceiver (UAT). Under special conditions (taxi, take off and landing) it may be also required to provide the remote pilot with visual information. Therefore the relay of sense and avoid data is the transmission of this information from these sensors to the remote pilot is part of the control communications.

## 1/1.3/3.2 Sense and avoid system spectrum studies

The safe flight operation of UA necessitates advanced techniques to detect and track nearby aircraft, terrain, and obstacles to navigation through sensors. Studies related to the sense and avoid function of UAS are being completed.

## 1/1.3/3.3 Spectrum needs to support command and control, relay of ATC and relay of sense and avoid

Based on the requirement per UA, ITU-R studies have been completed to define the overall amount of spectrum needed to support the operation of unmanned aircraft seamlessly with piloted aircraft in non-segregated airspaces. For more detailed information see Report ITU-R M.2171.

## 1/1.3/3.4 Potential frequency bands for UAS operations and compatibility studies

ITU-R has considered the compatibility studies on certain existing allocations and under certain conditions, where required, sharing studies on new allocations and, performances and characteristics including ICAO’s international standards and recommended practices (SARPs) of control and non payload radiocommunications systems used for UA.

The compatibility studies are structured as follows:

– For terrestrial component

– in the existing AM(R)S allocation in the 960-1 164 MHz;

– in possible new AM(R)S allocations in the 5 000-5 030, 5 030-5 091 and 5 091-5 150 MHz and 15.4-15.63 GHz bands.

– For satellite component

– in the existing AMS(R)S allocation in the 5 030-5 091 MHz;

– in new AMS(R)S allocations in the 13.25-13.4 GHz, 15.4-15.7 GHz, 22.5‑22.55 GHz, 23.55-23.6 GHz bands.

# 1/1.3/4 Analysis of the results of studies

Studies initially focus on existing allocations. They take into consideration links using terrestrial and/or satellite systems.

## 1/1.3/4.1 Spectrum requirements to support command and control, relay of ATC and relay of sense and avoid

Market surveys and commercial and government forecasts were used to predict the number of UA available to operate in the 2030 time frame. This time frame was used as it represents the time when the UAS demand will be established and approaching maturity.

Deployment of UAS will require access to both terrestrial and satellite spectrum. The maximum UAS spectrum requirements as identified in Report ITU-R M.2171 are:

– 34 MHz for a terrestrial line-of-sight (LOS) system;

– 56 MHz for satellite beyond line-of-sight (BLOS) system.

## 1/1.3/4.2 Spectrum needs to support the UAS sense and avoid function

Based on a review of the spectrum needs of UAS sense and avoid and the existing ARNS allocations in Report ITU-R M.[UAS-SENSE-AND-AVOID] the existing ARNS allocations appear to be sufficient to support UAS sense and avoid operations.

## 1/1.3/4.3 Potential frequency bands for UAS operations and compatibility studies

### 1/1.3/4.3.1 Compatibility studies

#### 1/1.3/4.3.1.1 Satellite component

##### 1/1.3/4.3.1.1.1 Existing allocation (5 030-5 091 MHz band)

The studies performed (see Report ITU‑R M.[UAS-BANDS-EXIST-ALLOC]) show that it is possible to design an AMS(R)S system sharing the 5 030-5 091 MHz band with the microwave landing system (MLS) under certain conditions. See also RR No. **5.444**.

##### 1/1.3/4.3.1.1.2 Possible new allocations

[Compatibility studies are ongoing for new AMS(R)S allocations in the portions of the 13.25‑13.4 GHz, 15.4-15.7 GHz, 22.50-22.55 GHz, and 23.55-23.6 GHz bands.]

*CPM-11 Management Team:*

*At the time of the CPM-11 Management Team meeting, the results of the compatibility studies were not available; as a consequence the CPM11-2 meeting will have to amend this sentence as appropriate.*

#### 1/1.3/4.3.1.2 Terrestrial component

##### 1/1.3/4.3.1.2.1 Existing allocation (960-1 164 MHz band)

Portion(s) of the existing AM(R)S allocation in the band 960-1 164 MHz could be used to support some UAS terrestrial spectrum requirements subject to satisfactory completion of sharing studies and under certain conditions (see Report ITU‑R M.[UAS-BANDS-EXIST-ALLOC]). However, the band cannot be used to meet the entire 34 MHz terrestrial spectrum requirement for UAS operations due to the existing and planned system (distance measuring equipment, secondary surveillance radar, UAT, AM(R)S and ARNS systems).

##### 1/1.3/4.3.1.2.2 Possible new allocations

ITU-R ongoing studies indicate the possibility that a terrestrial UA control and non payload radio communications system under new AM(R)S allocation and MLS under ARNS allocation could operate in the band 5 030-5 091 MHz under certain conditions.

A compatibility study between the new proposed AM(R)S systems and systems operating under the existing AMS(R)S allocation needs to be undertaken in consultation with ICAO at the appropriate stage of the study. This study should take into account the results of the sharing study between AMS(R)S systems and MLS operating under an ARNS allocation and the results of the sharing study between the new proposed AM(R)S systems and MLS operating under an ARNS allocation. Consultation with ICAO also needs to be undertaken with respect to the sharing study between AM(R)S and ARNS (MLS) systems.

[Compatibility studies are ongoing for new AM(R)S allocation in portion(s) of the 5 000‑5 030 MHz or/and 5 091-5 150 MHz or/and 15.4-15.63 GHz bands.]

*CPM-11 Management Team:*

*At the time of the CPM-11 Management Team meeting, the results of the compatibility studies were not available; as a consequence the CPM11-2 meeting will have to amend this sentence as appropriate.*

### 1/1.3/4.3.2 Other considerations

#### 1/1.3/4.3.2.1 Issue A: Satellite component

Existing systems in the bands 1 545-1 555 MHz (space-to-Earth), 1 610-1 626.5 MHz (space-to-Earth and Earth-to-space), and 1 646.5-1 656.5 MHz (Earth-to-space) may be used to meet some of the UAS requirements. Each of these bands has its advantages and disadvantages and opinions vary as to which bands are appropriate and required. However, taking into account the existing extensive use of these bands and the limited spectrum available, they cannot accommodate the full projected future satellite spectrum requirements of UAS. To this effect, in order to fulfil the longer term requirements of UAS, other appropriate bands with larger bandwidth are necessary.

Usage of FSS

For the link between UA and the satellite:

**View 1** The use of FSS systems for the link between UA and satellite is not in line with the service/station definitions in the RR.

**View 2** UAS BLOS communications can be conducted using some existing FSS allocations through the use of a footnote referencing a WRC Resolution/Recommendation.

The WRC Resolution/Recommendation will be used to provide the appropriate system performance and regulatory procedures necessary to ensure the safe operation of UAS.

For the link between mobile UACS and the satellite:

**View 1** The use of FSS systems for the link between mobile UACS and satellite is not in line with the service/station definitions in the RR.

**View 2** UAS BLOS communications can be conducted using some existing FSS allocations through the use of a footnote referencing a WRC Resolution/Recommendation.

The WRC Resolution/Recommendation will be used to provide the appropriate system performance and regulatory procedures necessary to ensure the safe operation of UAS.

For the link between fixed UACS and the satellite:

**View 1** The use of FSS systems is not possible unless in FSS bands that have a specific footnote pointing toward a WRC Resolution/Recommendation which described the conditions of use FSS allocations (except frequency bands covered by Appendixes **30**, **30A** and **30B** to the Radio Regulations).

**View 2** The use of FSS systems between fixed UACS and satellite is in line with the service/station definitions in the RR.

Usage of MSS and AMSS for all control and non payload radiocommunication UAS links

**View 1** The use of systems belonging to MSS and AMSS is not in accordance with the definition of the services of the RR and principles of use of these services contain in the RR (see preamble in Section 1/1.3/5.1).

**View 2** The use of systems belonging to MSS and AMSS is in line with the service/station definitions in the RR.

#### 1/1.3/4.3.2.2 Issue B: Terrestrial component

The terrestrial communication between an unmanned aircraft and the UACS has to be considered as AM(R)S and should be operated in a frequency band allocated to this service.

# 1/1.3/5 Methods to satisfy the Agenda item

## 1/1.3/5.1 Methods to satisfy the UAS radiocommunication requirements

The methods below have been so far developed and any method or a combination of these methods may be used.

Preamble

RR Article **4** provides description of the assignments and the use of frequencies.

One of the fundamental principle enshrined in the Radio Regulations in the allocating of a given frequency band to a given radiocommunication service is that the allocation is merely made based on the definition of that service. Any departure from that very principle is in total contradiction and non-observance of the Radio Regulations, unless, a supplementary procedure and/or arrangement is included in the subject allocation through a footnote to the allocation or through a footnote and a WRC Resolution/Recommendation.

To this effect, previous WRC made some procedure under which frequency bands allocation to a given service could be used for different service under the specific conditions that stipulated either in a footnote to the Table of Frequency Allocation (RR Article **5**) or to the footnote and a WRC Resolution specifying the condition of use of that application

Absence of the above course of action would contravene the very principle of the administrative regulations which is amended to the basic instrument of the ITU and thus would be detrimental to the very objectives of the Radio Regulations.

Moreover, RR Article **1** contains definition of various services in a clear and distinct manner specifying the scope of the allocation and the conditions of use of the allocations contained in other parts of the Radio Regulations need to be consistent with these definitions (unless otherwise specified in the Radio Regulations).

Notwithstanding No. **191** of the ITU Constitution, RR Nos. **1.59** and **4.10** and taking into account the following points, the methods outlined below are proposed to satisfy the Agenda item:

1) All the allocations used in such a way that the systems envisaged for UAS control and non payload radiocommunications under Agenda item 1.3 have to be compliant with the SARPs.

2) Any new allocation must be compatible with existing allocations, supported by necessary studies to ensure the compatibility between these allocations.

3) Non AMS(R)S or AM(R)S allocations may be used if the safety of life is ensured, to support UA radiocommunications.

### 1/1.3/5.1.1 Issue A: Satellite component

#### 1/1.3/5.1.1.1 Method A1

Use of the current AMS(R)S allocationsfor both links (UA to satellite and UACS (mobile and fixed) to satellite) (see Report ITU‑R M.[UAS-BANDS-EXIST-ALLOC]). Thus, no change to the RR.

#### 1/1.3/5.1.1.2 Method A2

Use of the current MSS, AMSS and AMS(R)S allocations for both links (UA to satellite and UACS (mobile and fixed) to satellite) and the FSS (only for the fixed UACS to satellite link) allocations in accordance with the Radio Regulations (see Report ITU‑R M.[UAS-BANDS-EXIST-ALLOC] and Report ITU-R M.[UAS-PERF-AND-REQ]). Thus, no change to the RR.

#### 1/1.3/5.1.1.3 Method A3

Use of the current FSS allocations.

Modify RR Article **5** by adding a new footnote pointing towards a WRC Resolution/Recommendation allowing radio communications means between:

a) UA and satellite,

b) UACS (fixed or mobile) and satellite,

in portions of the existing 11/12/14 GHz and 20/30 GHz FSS allocations (except frequency bands covered by RR Appendices **30**, **30A** and **30B**).

#### 1/1.3/5.1.1.4 Method A4

Development of a WRC Resolution.

a) to restrict the communication link between UA and satellite to AMS(R)S,

b) confirm the use of AMS(R)S for the radio communication link between UACS and the satellite and to allow the use of the FSS for this link (except frequency bands covered by RR Appendices **30**, **30A** and **30B**).

#### 1/1.3/5.1.1.5 Method A5

New AMS(R)S allocations in the portions of the [13.25-13.4 GHz], [15.4-15.7 GHz], [22.50‑22.55 GHz], and [23.55-23.6 GHz] bands subject to satisfactory results of compatibility studies (see Report ITU‑R M.[UAS-BANDS-NEW-ALLOC]).

### 1/1.3/5.1.2 Issue B: Terrestrial component

#### 1/1.3/5.1.2.1 Method B1

New AM(R)S allocation in portion(s) of the [5 000-5 030 / 5 030-5 091 / 5 091-5 150] MHz or/and [15.4-15.63] GHz subject to satisfactory results of compatibility studies (see Report ITU‑R M.[UAS-BANDS-NEW-ALLOC]).

#### 1/1.3/5.1.2.2 Method B2

Development of a WRC Resolution indicating that any terrestrial link between the UA and the UACS should only use the AM(R)S allocation.

### 1/1.3/5.1.3 Both Issues A and B: Terrestrial and satellite components

#### 1/1.3/5.1.3.1 Method C

No change to the Table of Frequency Allocations (RR Article **5**) for frequency bands for which the studies have not been completed. This method is equally applied to the terrestrial and satellite component.

## 1/1.3/5.2 Methods to satisfy the UAS sense and avoid requirements

Studies in Report ITU-R M.[UAS-SENSE-AND-AVOID] indicate that the existing ARNS allocations can be used to support UAS sense and avoid operations so no change to the existing ARNS allocations is proposed.

## 1/1.3/5.3 Views

Due to the complexity of matter, it was agreed that the advantages and disadvantages of various methods be reflected under “views” from proponent and opponent of each method. Analysis of the results of studies also provides materials on the subject matter.

View 1 (Both Issues A and B)

Radiocommunication services which are not afforded the status of safety service, if used for UAS system would:

a) On a de-facto basis upgrade that service to a service providing a safety and regulatory of flight.

b) Such general upgrading would create serious inconsistencies and imbalance between the use of a portion or portions of a given frequency band associated with that service and other usage of the same band used for other application e.g. use of commercial FSS or MSS systems for UAS.

c) The procedures for coordination as stipulated in RR Article **9** and Appendix **5** are quite different for MSS and FSS e.g. for FSS, the concept of coordination arc is used in which, apart from satellite networks located within the coordination arc (which are identified as affected), no other technical examinations are carried out by the Bureau. Whereas for the case of AMS(R)S, at least the examinations of ΔT/T is performed. This provides some degree of actual coordination between the satellite networks in question.

d) Administrations effecting coordination in the case of non-safety service usually negotiate among themselves on a reciprocal and package deal basis, giving concession on acceptance of interference in a reciprocal manner whereas in the case of safety services such concession on acceptance of interference is almost minimal or no concession is given at all.

e) As a general rule, the allocation to a service or identification of an allocation for certain application is made once the results of successful compatibility studies between the new service/application and existing services have been carried out, taking into account the nature of service and the class of stations and the corresponding status of allocation of the concerned services.

f) The use of a given band(s) for a given service must be in strict conformity with the definition of the service as stipulated in the RR, unless accompanied by necessary and the appropriate procedure in form of a footnote to the allocation pointing towards a WRC Resolution specifying the condition of that use and any other regulatory measures to be observed in order to be in full conformity with the Radio Regulations

g) Use of MSS and AMSS for UAS.

– WRC-95 based on the conclusions reached at Voluntary Group of Experts initiated the application of the concept of generic allocation. To this effect, WRC-97 used that concept and made some generic allocation in the band 1.5/1.6 GHz for MSS involving AMS(R)S. Since then considerable difficulties were encountered by membership for several years resulting WRC-12 Agenda item 1.7 to find a solution for the resolution of difficulties. The proposal to use MSS and AMSS, that are non-safety services, for AMS(R)S, which is a safety service, would result in having generic definition for MSS covering different service definitions; AMS(R)S, AMS(OR)S and by extension MMSS, LMSS. It may unintentional result in a generic definition for MS covering AM(R)S, AM(OR)S and by extension MMS, LMS. This may further impact all other services. The issue then needs to be discussed and examined by a General WRC similar to that held in 1979 for more than 12 weeks involving the participation and attendance of all users of the entire radiocommunication community.

– Moreover aeronautical mobile–satellite networks/systems may comprise geostationary and non-geostationary-satellite networks/systems. Unlike the geostationary-satellite networks that are normally coordinated using the ΔT/T coordination criteria, there is no other criteria, apart from frequency overlap, for the identification of affected administration operating non-geostationary-satellite systems. This means that there are therefore a high probability that a MSS geostationary–satellite network even if successfully coordinated be interfered by a non-geostationary-satellite system for the reasons given above. Consequently, the MSS system having such an unsecure and uncertain coordination status could hardly be considered as a communication link to support UAS used for safety and regularity of flights according to the definition of AMS(R)S.

h) Use of FSS for UAS

– In addition to the explanation provided in paragraph c) above, it is to be noted that according to the statistics available, more than 60% of FSS assignments recorded in the Master International Frequency Register (MIFR) under RR No. **11.41** under ”non-interference, non-protection“ status which are further governed by RR No. **11.42** requiring that to take necessary action to either cease emission or reduce the interference (as results of non coordinated status). Consequently, the use of a such FSS assignment with a doubtful regulatory status could hardly satisfy the requirements of the UAS having the status of safety and regularity of flight according to the definition of AMS(R)S.

– In view of the above, there is severe uncertainty in using FSS and MSS for UAS having the status of safety and regularity of flight according to the definition of AMS(R)S.

– Moreover, should such application be authorized by WRC-12, it requires introduction of a new footnote allowing such use in certain specific frequency FSS bands pointing to a WRC Resolution describing the condition of use of that specific band(s). Such a WRC Resolution should have an Annex describing the regulatory course of action to be taken for the earth station of the FSS in those certain frequency bands to be used as feeder links between the UA control station and the satellite. The coordination procedures for each such specific earth station, together with its characteristics, should be subject to a publication of a special section by the BR publicly making available this information in order to ensure the required safety aspect of the subject radio link.

View 2 (Both Issues A and B)

Terrestrial Component (Issue B)

Method B1 can fulfil the spectrum requirements for the terrestrial component of UAS, subject to, as stated in the method, satisfactory results of compatibility studies.

Method B2 on its own will restrict the possible bands to be used for UAS to bands which are already heavily used for a number of aeronautical applications. These existing bands will therefore not provide sufficient spectrum to support the requirements of UAS for the terrestrial component.

Satellite Component (Issue A)

Current satellite systems providing safety and regularity of flight radiocommunications for aviation purposes satisfy existing ICAO SARPS which specify inter alia RF characteristics, priority and pre-emptive access requirements and performances requirements (including security). These systems operate under an AMS(R)S allocation or under an AMS(R)S allocation through generic MSS allocations which do not exclude aeronautical usage (therefore appropriately allocated to AMS(R)S as stipulated in Annex 10 to the Convention on International Civil Aviation) and FSS allocations in accordance with the RR.

Methods A1 and A2 can both fulfil the spectrum requirements of the satellite component for UAS. These methods lead to the same regulatory solution, which is a no change to the RR.

Method A3 implies modification of the sharing condition in the frequency band allocated to FSS and listed in the method. The required sharing studies should be completed and satisfactory results should be obtained.

The example regulatory implementation of this method does not establish priority in the RR for UAS control links over any other radiocommunication.

The spectrum requirement for mobile UACS, if any, will only be met in combination with other methods.

Dependent on the outcome of sharing studies Method A5 could fulfil the spectrum requirements for UAS. However results of studies indicate that there is no need for additional spectrum.

View 3 (Issue A)

Under Method A3, unmanned aircraft satellite communications can be conducted using some of the existing FSS allocations through the use of a WRC Resolution/Recommendation. The WRC Resolution/Recommendation will be used to provide appropriate RF performance and regulatory procedures necessary to ensure the safe operation of the UAS. Further, the relative priority between FSS networks is maintained.

Method A3 provides the advantage of near-term implementation by using existing infrastructure, while the disadvantage of the other methods is that they rely on the costly development and lengthy time to launch new satellite systems to meet the UAS spectrum needs. Additionally, other methods will be disadvantaged by the limited bandwidth of currently available spectrum for AMS(R)S systems.

A further advantage of Method A3 is that safe operation of UAS is assured through the above-mentioned WRC Resolution/Recommendation that will provide the specific details of how to ensure the RF performance and ITU regulatory procedures necessary to support safe operation of UAS. Such specifics would be included in contracts between the UAS operators and the FSS operators. Additionally, RF performance requirements are assured through bi-lateral coordinations triggered by RR Article **9** provisions between FSS satellite operators.

A disadvantage of Methods A1 and A2 is that they do not recognize the satellite coordinations triggered by the provisions of RR Article **9**. These coordinations lead to bi-lateral agreements between satellite operators that ensure the necessary RF performance is attained by FSS networks to support safe operation of UAS.

A disadvantage of Method A4 is that it would preclude AMS(R)S operation under AMSS and MSS allocations for all UAS satellite communications. By contrast, an advantage of Method A3 is that it goes beyond requirements normally included in ICAO SARPS for AMS(R)S operations.

View 4 (Both Issues A and B)

Disadvantages of Methods A1, А2, А3, А4, А5, В1, В2:

– For any frequency bands considered for UAS the ITU-R compatibility studies are not completed and the sharing conditions with services allocated in accordance with the RR are not defined (the conditions specified inResolution **421 (WRC-07)** “*invites ITU-R”* are not met). Moreover there are currently no UAS technical characteristics agreed within ITU-R and also methodologies with results of compatibility assessment.

– The usage of any frequency bands for UAS without finalizing the compatibility studies does not allow to provide safety operation of UAS and service stations affected by UAS.

– Current provisions of the Radio Regulations do not seem to be sufficient for the use of existing allocations for UAS.

– Existing technical and regulatory provisions of the RR may not be provided for sharing between radio services if UAS will be applied.

View 5 (Both Issues A and B)

Methods A1, A4, A5, B1 and B2 allow ICAO to develop SARPs which would facilitate automatic compliance to the requirements of Article 8 of the Convention on International Civil Aviation, thus allowing UAS to fly internationally without the need for bi-lateral co-ordination.

Methods A2 and A3: it is unlikely that these methods will facilitate international use of UAS in non-segregated airspace, as it will not satisfy ICAO safety requirements, and therefore not facilitate automatic compliance to Article 8 of the Convention on International Civil Aviation.

View 6 (Issue B)

Disadvantages of Method B1:

– Would increase the possibility of interference to incumbent MLS system in 5 030‑5 091MHz band.

– It would be difficult and even impractical to meet frequency separation and geographical separation requirements in sharing the 5 030-5 091 MHz band with MLS.

– Regulatory measures to protect existing co-primary services from AM(R)S and the services in the adjacent bands and technical/operational restrictions on AM(R)S have yet to be determined.

# 1/1.3/6 Regulatory and procedural considerations

## 1/1.3/6.1 Regulatory and procedural considerations for the UAS radiocommunication requirements

The following examples of regulatory text were provided by one or more administrations. However, they were not discussed at WP 5B meeting at all.

### 1/1.3/6.1.1 Issue A: Satellite component

#### 1/1.3/6.1.1.1 Method A1

No modifications to the RR and no new WRC Resolution/Recommendation.

#### 1/1.3/6.1.1.2 Method A2

No modifications to the RR and no new WRC Resolution/Recommendation.

#### 1/1.3/6.1.1.3 Method A3

ADD

**5.A103** Earth stations on board unmanned aircraft that operate as part of an unmanned aircraft system (UAS) may receive from geostationary-satellite systems on a primary basis in the fixed- satellite service (space-to-Earth) in accordance with Resolution/Recommendation [A1.3\_SAT\_UAS\_FSS] (WRC-12) in the following frequency bands: [aa-bb GHz, cc-dd GHz, ee-ff GHz,...]. The use of the above frequency bands by the aforementioned UAS stations is limited to UAS control link communications in the space-to-Earth direction. Moreover, the operation of UAS control links in any of the above specified frequency bands does not establish priority in the Radio Regulations over any station operating in a primary service allocated to these bands, including stations operating in the fixed-satellite service, nor does it establish priority in relation to other communication links within the fixed-satellite service.

ADD

**5.B103** Earth stations on board unmanned aircraft that operate as part of an Unmanned Aircraft System (UAS) may transmit to geostationary-satellite systems on a primary basis in the fixed- satellite service (Earth-to-space) in accordance with a Resolution/Recommendation [A1.3\_SAT\_UAS\_FSS] (WRC-12) in the following frequency bands: [aa-bb GHz, cc-dd GHz, ee-ff GHz,...]. The use of the above frequency bands by the aforementioned UAS stations is limited to UAS control link communications in the Earth-to-space direction. Moreover, the operation of UAS control links in any of the above specified frequency bands does not establish priority in the Radio Regulations over any station operating in a primary service allocated to these bands, including stations operating in the fixed‑satellite service, nor does it establish priority in relation to other communication links within the fixed-satellite service.

A possible example of a WRC Resolution/Recommendation

ADD

Resolution/Recommendation [A1.3\_SAT\_UAS\_FSS] (WRC-12)

Use of FSS frequency bands not subject to Appendices 30, 30A, 30B for the command and control communications of unmanned aircraft systems  
in non-segregated airspaces with geostationary-satellites  
operating in the fixed-satellite service

The World Radiocommunication Conference (Geneva, 2012),

considering

*a)* that worldwide use of unmanned aircraft systems (UAS) is expected to increase in the future;

*b)* that unmanned aircraft need to operate seamlessly with piloted aircraft in non-segregated airspace and that there is a need to provide spectrum for that purpose;

*c)* that the operation of UAS in non-segregated airspace requires reliable communication links, in particular to relay the air traffic control communications and for the remote pilot to control the flight;

*d)* that the operation of UAS in non-segregated airspace on a worldwide basis requires the development by the civil aviation community (e.g. ICAO) of international aeronautical standards and recommended practices (SARPs) for the airworthiness certification of supporting terrestrial and satellite systems;

*e)* that satellite radiocommunications are an essential part of UAS operations, in particular to relay transmissions beyond the horizon and include links between the unmanned aircraft (UA) and the satellite, and links between the control station (CS) and the satellite;

*f)* that satellite systems operating in the fixed-satellite service (FSS) bands have the capability to provide the communication links mentioned in *considering* *e)*;

*g)* that Annex 10 to the Convention on International Civil Aviation contains SARPs for aeronautical radionavigation and radiocommunication systems used by international civil aviation,

further considering

*a)* that there is a need to limit the number of communication equipments onboard an UA;

*b)* that, as a dedicated satellite system for UAS is not likely, it is necessary to take into account the existing and future satellite systems to accommodate the growth of the use of UAS;

*c)* that there are various technical methods that may be used to increase the reliability of digital communication links, e.g. modulation, coding, redundancy, etc.;

*d)* that for the UAS communications for the control of UA, relay of air traffic control (ATC) voice communications, and sense and avoid, relate to safe operation of UAS and have certain technical, operational, and regulatory requirements;

*e)* that the requirements in *further considering d)* can be specified for UAS use of FSS networks,

resolves/recommends

1that for the communications for control of the unmanned aircraft (UA), ATC voice communications, and sense and avoid, between an UA and the control station via geostationary-satellite, frequency band(s) allocated worldwide on a primary basis to FSS (except those covered by Appendices **30**, **30A** and **30B**) may be used, provided that these FSS satellite systems meet the technical requirements contained in Annex 1 of this Resolution/Recommendation;

2 that the information in Annex 1 of this Resolution/Recommendation may be updated as appropriate through consultation with ICAO,

requests the Secretary-General

to bring this Resolution/Recommendation to the attention of ICAO in order to study the development of appropriate SARPs.

Annex 1 to

Resolution/Recommendation [A1.3\_SAT\_UAS\_FSS] (WRC-12)

Technical characteristics of fixed-satellite service systems to support  
control communication links of unmanned aircraft systems

# 1 Introduction

[Describe what is contained in this Annex.]

# 2 Technical requirements

a) Frequency band.

b) Minimum and maximum antenna sizes and corresponding gains of the transmit and receive earth station and of the airborne station antenna.

c) Transmit and receive antenna off-axis gain patterns of the earth station and of the airborne station.

d) Pointing accuracy of the control station antenna and the airborne station antenna.

e) Geographic coverage area where the UAS requirements will have to be met.

f) Maximum and minimum e.i.r.p. and e.i.r.p. density of the earth station and of the airborne station.

g) Minimum G/T of the receiving earth station and the airborne station.

h) The rain conditions (i.e. rain rates) in which the link must operate.

i) Minimum required availability for the total (up and down) link (both outbound and inbound). Alternatively, the minimum required availability in the uplink and the minimum required availability in the downlink.

j) Carrier characteristics:

– Information rate

– Occupied bandwidth

– Allocated bandwidth

– Modulation type

– Forward error correction rate

– Minimum required C/(N+I).

# 3 Link budget

[TBD]

# 4 Link integrity

[TBD]

# 5 Safety assurances

[TBD]

# 6 Other

[TBD]

#### 1/1.3/6.1.1.4 Method A4

A possible example of a WRC Resolution

ADD

Resolution [B1.3] (WRC-12)

Provisions of spectrum for command and control, sense and avoid data  
as well as air traffic control relay for unmanned aircraft systems

The World Radiocommunication Conference (Geneva, 2012),

considering

*a)* that unmanned aircraft (UA) operate in an integrated manner with manned aircraft;

*b)* that the command and control of such systems by a ground pilot is analogous to that exercised by a pilot of a manned aircraft;

*c)* that the provision of sense and avoid data to the ground pilot is analogous to the sensor data provided to a pilot of a manned aircraft;

*d)* that the relay of air traffic control information provides the means of completing the communications link between air traffic control and the UA pilot;

*e)* that the actions of a pilot are regarded as being part of the safety of life system;

*f)* that the provision of command and control and sense and avoid links between a UA and the ground pilot can be regarded as safety of life;

*g)* that when operating a UA beyond line-of-sight from the pilot communications may be provided via a satellite link or via an aircraft (terrestrial) relay,

recognizing

*a)* that the definition of aeronautical mobile-satellite (R) service includes the link between the UA and the satellite and can cover the link between the UA pilot and the satellite;

*b)* that the fixed-satellite service can also be to provide the feeder link between the UA pilot and the satellite;

*c)* that civil aeronautical radio systems, used for safety and regularity of flight, are internationally standardized through ICAO in spectrum allocated to recognized safety of life services,

resolves

1 that terrestrial radio systems used for the provision of command and control, sense and avoid data as well as air traffic control relay between a ground pilot and a civil unmanned aircraft system (UAS) shall operate in spectrum allocated to the aeronautical mobile (R) service;

2 that satellite radio systems used for the provision of command and control, sense and avoid data as well as air traffic control relay between a ground pilot and a civil UAS shall operate in spectrum allocated to the aeronautical mobile-satellite (R) service, except for those links identified in *resolves* 3;

3 that the fixed-satellite service may be used to provide the feeder link between the civil UA control station and the satellite for the aeronautical mobile-satellite (R) service;

4 that where the fixed-satellite service is used to provide a link as described in *resolves* 3 the aeronautical mobile-satellite (R) service system provider must ensure that the link meets the ICAO SARPs performance requirements.

#### 1/1.3/6.1.1.5 Method A5

Needs to be developed.

### 1/1.3/6.1.2 Issue B: Terrestrial component

#### 1/1.3/6.1.2.1 Method B1

NOC

5.444

MOD

4 800-5 570 MHz

|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Region 1 | Region 2 | Region 3 |
| ... | | |
| 5 030-5 091 AERONAUTICAL RADIONAVIGATION  5.367 5.444 ADD 5.C103 | | |
| ... | | |

ADD

**5.C103** *Additional allocation:*  The band 5 030-5 091 MHz is also allocated to the aeronautical mobile (R) service on a primary basis for use by internationally standardized aeronautical systems.

*Regulatory examples for other bands referred in Section 1/1.3/5.1.2.1 need to be developed when studies are similarly carried out.*

#### 1/1.3/6.1.2.2 Method B2

See Method A4.

### 1/1.3/6.1.3 Both Issues A and B: Terrestrial and satellite components

#### 1/1.3/6.1.3.1 Method C

No change to the Table of Frequency Allocations (RR Article **5**) for frequency bands for which the studies have not been completed. This method is equally applied to the terrestrial and satellite component.

## 1/1.3/6.2 Regulatory and procedural considerations for the UAS sense and avoid requirements

No regulatory and procedural considerations are required to address the UAS sense and avoid portion of Resolution **421 (WRC-07)**.

1. SARPs is a term defined in Article 37 of the Convention on International Civil Aviation (ICAO Convention) and describes the regulatory material contained in Annexes 1 through 18 to the Convention.  The ICAO Convention is the vehicle which facilitates a uniform regulatory framework for international Civil Aviation similar to what the ITU Radio Regulations do for frequency spectrum.  Further more, the framework provided by the ICAO Convention and its SARPs also facilitates flight across international borders by civil aircraft without express pre-authorization for each flight, while not doing so for State aircraft (including military, customs, police).  Technical SARPs may be minimalistic and performance based, while containing references to supplemental material, such as ICAO Manuals or Industry Standards, for example material published by AEEC, EUROCAE, IEC, IEEE, RTCA...  However such references, normally made through *Notes*, do not elevate this material to SARPs level.  [↑](#footnote-ref-1)