AGENDA ITEM 1.5

*1.5 to consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices **30**, **30A** and **30B** for the control and non-payload communications of unmanned aircraft systems (UAS) in non-segregated airspaces, in accordance with Resolution **153 (WRC-12)**;*

Resolution **153 (WRC-12)**: *To consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices **30**, **30A** and **30B** for the control and non-payload communications of unmanned aircraft systems in non-segregated airspaces*

3/1.5/1 Executive summary

Report ITU-R M.2171 identified the spectrum requirements for unmanned aircraft (UA) command and non-payload communication (CNPC) that would be needed to support flight through non-segregated airspace. Those requirements identified the need for both line of sight (LOS) and beyond line of sight (BLOS) spectrum. While the LOS requirements were addressed at the last World Radiocommunication Conference held in 2012 the BLOS requirements were only partially addressed.

Agenda item 1.5 was therefore established to investigate whether fixed-satellite service (FSS) networks, not subject to Appendix **30**, **30A** and **30B** could be used to provide additional capacity for UA CNPC links.

Two methods to address the agenda item are proposed. One method (Method A) is proposed that is intended through a footnote and associated resolution to identify the conditions under which systems operating in the FSS could provide UA CNPC links.

A no change method (Method B) is also proposed on the basis of concerns about the ability of FSS to provide a safety service. There are technical, operational and regulatory obstacles for the use of FSS for UAS CNPC links. Moreover, existing allocations for AMS(R)S as well as AMSS and MSS, under certain conditions could satisfy the requirements for UAS CNPC in the frequency bands of these services.

3/1.5/2 Background

In the context of this agenda item, an unmanned aircraft system (UAS) consist of a geostationary satellite operated in FSS frequency bands, an UA with an earth station on board to interconnect the communication link between this UA and associated remote earth station, called “unmanned aircraft control station” (UACS). UA are aircraft that do not carry a human pilot but that are piloted remotely, i.e. through a reliable communication link from outside the aircraft. UAS operations up to now have been limited to segregated airspace using FSS links under RR No. **4.4**. However, it is planned to expand UAS deployment outside of segregated airspace.

There are a variety of existing and envisioned applications of UAS in the fields of economy, public safety and science. Further details on UAS applications in non-segregated airspace can be found in Report ITU-R M.2171. The operation of UA outside segregated airspace requires addressing the same issues as manned aircraft, namely safe and efficient integration into the air traffic control system.

3/1.5/3 Summary of technical and operational studies, including a list of relevant ITU-R Recommendations

3/1.5/3.1 Summary of technical and operational studies

Based on the Report ITU-R M.2171, the maximum amount of spectrum required for UAS CNPC links is 56 MHz for the satellite component assuming regional beams with suitable antenna discrimination. However this estimation could rise to 169 MHz when using small aperture antenna with limited discrimination in lower frequency bands.

Studies carried out in response to Resolution **153 (WRC-12)** have considered the bidirectional links between an unmanned aircraft earth station and associated FSS space station (Earth-to-space and space-to-Earth) as well as the FSS space station and the UACS (E-to-s and s-to-E). They have been developed in cooperation with ICAO.

At the same time ICAO has been working on the aeronautical operational, institutional and technical requirements. Due to the different time frames ICAO has not been able to provide the technical performance characteristics in terms of availability, reliability and continuity against which FSS links and or systems can be judged. However what ICAO have provided are seven conditions that would have to be met as listed below noting that any solution would also have to take into account ICAO's strategic objective that aeronautical systems should operate in spectrum allocated to an appropriate aeronautical safety service.

The conditions identified by ICAO are:

1 "That the technical and regulatory actions should be limited to the case of UAS using satellites, as studied, and not set a precedent that puts other aeronautical safety services at risk.

2 That all frequency bands which carry aeronautical safety communications need to be clearly identified in the Radio Regulations.

3 That the assignments and use of the relevant frequency bands have to be consistent with Article **4.10** of the Radio Regulations which recognizes that safety services require special measures to ensure their freedom from harmful interference.

4 Knowledge that any assignment operating in those frequency bands:

a) is in conformity with technical criteria of the Radio Regulations;

b) has been successfully co-ordinated, including cases where co-ordination was not completed but the ITU examination of probability of harmful interference resulted in a favourable finding, or any caveats placed on that assignment have been addressed and resolved such that the assignment is able to satisfy the requirements to provide BLOS communications for UAS; and has been recorded in the International Master Frequency Register.

5 That interference to systems is reported in a transparent manner and addressed in the appropriate time-scale.

6 That realistic worst case condition with inclusion of a safety margin can be applied during compatibility studies.

7 That any operational considerations for UAS will be handled in ICAO and not in the ITU".

Preliminary draft new Report ITU-R M.[UAS-FSS] details the studies that have been carried to identify the performance capability of FSS networks as well as the radio regulatory issues that would have to be addressed for an FSS link to be capable of supporting a UA CNPC link.

3/1.5/3.2 Relevant ITU-R recommendations and reports

ITU-R Recommendations, relevant for studies under WRC-15 agenda item 1.5, as appropriate, are: ITU-R F.758-5, ITU-R F.1494, ITU-R F.1495, ITU-R F.1565, ITU-R M.1180, ITU-R M.1233, ITU-R M.1372, ITU-R M.1643, ITU-R M.1644, ITU-R M.1730, ITU-R M.2008, ITU-R SF.1650, ITU-R S.524-9, ITU-R SF.1006, ITU-R S.1432.

ITU-R Reports, relevant for the studies under WRC-15 agenda item 1.5 are:

– ITU-R M.2171, ITU-R M.2233.

New ITU-R Reports developed for this topic are:

– PDN Report ITU-R M.[UAS-FSS].

3/1.5/4 Analysis of the results of studies

CPM15-2 received several contributions from the membership with a view to include relevant material in this section. However, after lengthy discussions and extensive exchange of views it was not possible to include any agreed text in this section. It was therefore concluded that various views regarding the “analysis of results of studies” be included in this section with the understanding that these views were neither discussed nor agreed by the CPM as they reflect the opinion of the proponents of each view.

View 1

There are four different types of links between the unmanned aircraft earth station and the fixed-satellite service space station:

Link 1 UACS earth station to FSS space station.

Link 2 FSS space station to UA ES.

Link 3 UA ES to FSS space station.

Link 4 FSS space station to UACS earth station.

For links 1 and 4, a serious ambiguity of the regulatory status of the radio link between the unmanned aircraft control stations and the fixed-satellite service space station (links 1 and 4) exists if the earth station is not at fixed point due to the fact that the use of mobile earth stations in the FSS is not compatible with the FSS definition.

The type of earth station used (UA) in links 2 and 3 of unmanned aircraft earth stations are of a mobile nature (aeronautical mobile earth station) and thus cannot communicate with a fixed-satellite space station due to the fact that its future operation in that link is not compatible with the definition of the FSS and its associated earth station as contained in Article **1** of the Radio Regulations. Should WRC-15 authorize such use by adopting new footnotes, it would be in full contradiction with its earlier decision taken at WRC-12 under agenda item 1.2 not to modify any definitions as currently contained in Article **1** of the Radio Regulations. Any reconsideration of the matter at WRC-15 would entirely modify the scope of the space services definition in the RR and would create a series of complex regulatory environments which could hamper the operation of the space services as well as terrestrial services.

The conducted studies are based on the assumption that UA CNPC links will have the same technical characteristics as the FSS traditional systems operating in the same frequency bands.

However, the use of FSS earth stations on board the aircraft for the UAS CNPC links (on-board station of UA CNPC links) significantly changes the conditions of compatibility with existing services in comparison with the current use of special and typical FSS earth stations in the Earth's surface:

– **With respect to compatibility with terrestrial services**

Using the on-board station of UA CNPC links in FSS bands leads to the fact that the protection and coordination distances between these stations and stations of terrestrial services may increase several times compared to the current values. This increase depends on the flight altitude of the unmanned aircraft. This substantially changes the conditions of compatibility and current coordination conditions of the FSS earth stations with stations of terrestrial services.

In the ITU-R, there have been no studies that determine the technical and regulatory conditions of on-board station of UA CNPC links operation, ensuring that existing coordination conditions of the FSS earth stations with terrestrial radio services will be met.

WD towards PDNR ITU-R M.[UAS-FSS] studies the potential compatibility of on-board station of UA CNPC links with stations in the fixed service in the bands 14.0-14.5 GHz and 27.5-29.5 GHz, but the above-mentioned aspects are not present in these studies and have not been investigated.

– **With respect to compatibility with satellite services (including compatibility between different FSS networks)**

The WD towards PDNR ITU-R M.[UAS-FSS] presents the interference studies between GSO FSS satellite networks operating in the frequency bands 14/11 GHz and 30/20 GHz when one of the networks use the on-board station of UA CNPC link. However, there were no studies conducted by ITU-R on the topic of how the conditions of compatibility (coordination conditions) between existing GSO FSS satellite networks will change when using the on-board station of UA CNPC links instead of a coordinated typical (fixed) earth station located on the Earth's surface. There was no evidence that these conditions will be preserved. Operating conditions of on-board stations of UA CNPC links (for example, such as a change of location, instability hold the antenna, including the instability caused by the aircraft fluctuation, antenna pattern, etc.) significantly differ from operating conditions for existing earth stations of the FSS networks, fixed on the Earth's surface. Therefore, additional ITU-R studies needed to determine the technical and regulatory conditions for use of the on-board station of UA CNPC link that would ensure that the coordination conditions with other existing and future satellite networks will be met.

The FSS is not recognized by ITU as a safety service. It should be noted that most satellite networks are today seen to be brought into use without completion of all the required coordination with other satellite networks; that is these networks do not have favourable findings in the MIFR with respect to RR No. **11.32**. Consequently, the networks are recorded under RR No. **11.41**, i.e. with outstanding coordination requirements, operating on a non-interference, non-protected basis in respect of those networks with which coordination is not completed. This means that both the operational limitations (in terms of protecting other networks) and interference scenario (in terms of being protected against interference from other networks) are not fully determined. The BR has made an examination of this situation as of 20 July 2012, showing that more than 50 per cent, are recorded by use of RR No. **11.41**. A large majority of all new networks that are entered into the MIFR today are making use of RR No. **11.41**. The question is how an assignment which is recorded with non-protection or one against which another network has used RR No. **11.41** could be used to provide the radio link for unmanned aircraft system to ensure the safe operation of UAS CNPC links, pursuant to RR No. **4.10** and in compliance with the seven requirements outlined by ICAO?

Today there are over 300 FSS satellites in the geostationary-satellite orbit, operating in frequency bands regulated by and filed under Articles **9** and **11** of the Radio Regulations, almost one satellite per degree along the geostationary arc. Interference between FSS networks happens on a regular

basis, often several times per week in various transponders and frequency bands[22]. This may be the result of inappropriate use of transponders (hijacking and illegal use); malfunctioning equipment; mispointed antennas; end users exceeding power limits (e.g. when encountering operational problems) and launch, testing and bringing into use of satellites without the required coordination. Even if the satellite network providing the UAS CNPC has completed all coordination and complies with all limits, this is no guarantee for avoiding interference due to accidental interference or uncoordinated operation of neighbouring satellite networks. Cases of interference are normally sorted out between the satellite operators or countries involved and are very rarely reported to ITU. The ITU databases therefore will provide little information about the actual interference situation.

FSS has a nature of operation by commercial satellite operators. Satellite operators are normally not the end user of the services, but will lease capacity to service providers who in turn will sell services to the end users. Normally, these end users will then procure, establish and operate the earth stations accessing the satellite under a licence which normally will be granted by an administration different from that granting the licence for the satellite network. Furthermore, transmitting and receiving earth stations are often operating in a country without individual licensing or coordination under a class type of licence (e.g. VSAT type of networks). Compliance with coordinated limits has to rely on limitations passed on to the end user from the notifying administration of the satellite network The ability to pass on and enforce these, not only for the satellite network providing the CNPC links, but even more so for adjacent satellite networks, therefore is important in assessing the ability to control the interference into CNPC links.

Moreover since protection criteria for UAS CNPC links have not yet been identified it is therefore not possible to complete the compatibility studies of these links with existing services. Presented in the WD towards PDNR ITU-R M.[UAS-FSS] results of parametric studies of interference does not allow to conclude about the possibility of protection and fulfilment of technical requirements for UAS CNPC links at the existing levels of interference. Moreover, parametric studies submitted do not cover all radio services, and relate only to the interference from the fixed service.

Thus, the results of the studies presented in WD towards PDNR ITU-R M.[UAS-FSS], are not sufficient. They did not permit to determine the technical and regulatory conditions of use UAS CNPC links in the bands frequency bands allocated to the FSS not subject to Appendices **30**, **30A** and **30B** of the RR.

View 2

As mandated by Resolution **153 (WRC-12)**, the outcomes of technical studies should provide answers to the following requirements for:

– protection of incumbent applications/services;

– protection from incumbent applications/services;

– safety considerations, as mandated by aviation authorities and ICAO.

The table below reviews these requirements/answers in WDPDN Reports and comments associated:

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[22] At the ITU International Satellite communication workshop: “The ITU – challenges in the 21st century: Preventing harmful interference to satellite systems”, one international satellite operator reported that in 2012, a total of 329 826 minutes of interference had been recorded in the transponders of their fleet of satellites. Another regional satellite operator informed that in the same year, they had recorded 290 cases of interference.

Req: Protection of incumbent services from UAS CNPC links (i.e. from FSS earth station emissions on-board Unmanned Aircraft) / Ans: Preliminary results are provided but need further considerations.

Comments: The outcomes of technical studies should be exploited in order to derive regulatory or operational conditions for UAS CNPC links to ensure protection of other services having an allocation in the bands and that UAS CNPC links will be operated only under the scenarios covered by the studies.

Req: No impact on other FSS applications from UAS CNPC links / Ans: No results are available.

Comments: Concern expressed by certain FSS operators regarding the future protection that UAS CNPC links may seek from existing FSS applications. Similar concerns were at the origin of No. **5.527** in part of Ka band. Provisions to prevent interference from UAV emission, on other satellite networks need to be addressed.

Req: Protection of UAS CNPC links from incumbent services (i.e. protection of FSS earth station receiver on-board Unmanned Aircraft) / Ans: No protection criteria is available as FSS would be used under mobility conditions, and would face time-variant interference.
Preliminary evaluation of interference levels received by the UA under specific scenarios is provided but need further consideration.

Comments: ICAO has not defined performance specifications for UAS CNPC that are required for the derivation of the appropriate protection criteria. Without established protection criteria, ITU will not be in position to guarantee that UAS can operate under FSS with the appropriate performance level. Therefore, it is difficult to define guidelines on how protection could be implemented in practice.

ICAO condition #2 "That all frequency bands which carry aeronautical safety communications need to be clearly identified in the Radio Regulations"/ Ans: Identification via a new footnote referring to new Resolution [FSS-UA-CNPC] (WRC-15).

Comments: This condition is interpreted by some parties, as the need for UAS CNPC links to operate in spectrum allocated to an appropriate aeronautical safety service. Direct identification in Article **5** of certain FSS frequency bands for UAS CNPC use should be avoided because it may unduly give the impression that UAS CNPC links should preferably use this allocation, instead of other suitable allocations such as AMS(R)S, AMSS or MSS.

ICAO condition #3 "That the assignments and use of the relevant frequency bands have to be consistent with Article 4.10 of the Radio Regulations which recognizes that safety services require special measures to ensure their freedom from harmful interference."/ Ans: No explanation on how this condition could be implemented.

Comments: Application of Article **4.10** requires further considerations.

Req: ICAO condition #4 "Knowledge that any assignment operating in those frequency bands:

1) **is in conformity with technical criteria of the Radio Regulations;**
2) **has been successfully co-ordinated, including cases where co-ordination was not completed but the ITU examination of probability of harmful interference resulted in a favourable finding, or any caveats placed on that assignment have been addressed and resolved such that the assignment is able to satisfy the requirements to provide BLOS communications for UAS; and**
3) **has been recorded in the International Master Frequency Register."**

Ans: It is considered in Annex 8 of WDPDN report that administrations will ensure that assignments used for UAS CNPC links have been successfully registered in the MIFR, and have so obtained the necessary protected status (under the provisions of RR Nos. 11.32, 11.32A, 11.42 or 11.42A).

Comments: A successful registration in the MIFR (favourable findings under No. **11.32**) does not mean that the assignment is free from harmful interference, since it is possible to obtain such a finding by accepting the interference created by prior satellite networks. References to No. **11.42** or No. **11.42A** indicate that, in cases of harmful interference, no protection is given.

ICAO condition #5: "That interference to systems is reported in a transparent manner and addressed in the appropriate time-scale"/ Ans: No explanation on how this condition could be implemented.

Comments: Article **15** of the Radio Regulations contains procedures for the reporting of harmful interference. However, these procedures don't provide the capability to address the interference case to UAS CNPC links in the appropriate time-scale.

ICAO condition #6: "That realistic worst case condition with inclusion of a safety margin can be applied during compatibility studies."/ Ans: Studies consider some worst case conditions without safety margin.

Comments: The question of the safety margin has not been addressed.

View 3

The comprehensive technical, regulatory and operational aspects of the studies undertaken by ITU-R when developing the ITU-R Report M.[UAS-FSS] were prepared in compliance with the invites ITU-R of Resolution **153 (WRC-12)**. Its current status is captured in the editor's note "Based on the work during the November 2014 WP 5B is of the opinion that with the help of appropriate contribution this Report might be upgraded to a DNR during the July 2015 meeting of WP 5B" (see Annex 18 of Doc. 5B/761).

These studies have provided information on the CNPC radio-link performance under various UAS operating conditions. These results along with other information will be used by ICAO in the future as it develops the required communication performance and eventual standards and recommended practices (SARPs) for UAS CNPC. Other studies within the ITU-R also address the compatibility between this application of the FSS and other services that may be authorized by administrations. All of these studies, as well as the CNPC performance requirements, can then be used by ICAO to determine the particular UAS CNPC applications and scenarios that may be used safely in the different types of airspace within, and by, each administration. ICAO has indicated that UAS CNPC SARPs are in the early stage of development.

ITU has been addressing the possible regulatory actions to support the use of FSS for UAS CNPC links at WRC-15 to extend the benefits of UAS globally and to provide ICAO information critical to the development of SARPs for command and control of UAS.

A summary of the results of those studies which have been coordinated with ICAO are provided. As several issues are addressed in the Resolution, it comprises a large variety of studies on technical, operational, and regulatory issues that form the basis for implementation and operation of CNPC links through FSS satellite networks. Although FSS can be used for UAS CNPC links, the results of the studies recommend regulatory actions to meet the agenda item.

The main considerations are summarized below:

General findings

- The studies have assumed that earth stations operating on UA have the same technical and operational parameters as typical FSS earth stations.
- Similarly, assumptions on the validity of the interference environment for typical FSS links, and associated protection criteria have been assumed to carry out compatibility studies for interference generated into the UAS FSS.
- The studies also took into account nine typical flight scenarios for UA, as per guidelines received from ICAO.
- The studies were carried out in the 14/11 and 30/20 GHz bands allocated to the FSS but not subject to RR Appendices **30**, **30A**, **30B**.

Technical considerations

The analyses of the technical feasibility of CNPC links, when used in flight scenarios identified by ICAO, have been performed based on the technical characteristics of UAS CNPC systems.

- Characteristics of UA systems using geostationary satellite networks operating in the FSS have been assumed as contained in PDN Recommendation ITU-R S.[UAS-FSS] (see Annex 1 of Document 4A/468).
- Studies on link budgets, including 25 per cent increase of noise temperature, for a variety of flight scenarios and UA antenna sizes show link margins of up to 33.1 dB under clear-sky conditions.

- Impact of degradations to link availabilities were derived from environmental conditions, such as rain, gas, clouds, etc.
- Studies were performed assuming operation of UAS CNPC links with geostationary satellites.
- A number of mitigation measures have been examined that maintain, or enhance, service quality under severe propagation and interference conditions.

Regulatory considerations

- Studies show that for the given flight scenarios the protection criteria of incumbent services can be met.
- Studies analysed the regulatory requirements as contained in the ICAO conditions.
- The studies carried out do not suggest the need for new types or definitions for earth stations in RR Article **1**.
- There is a sufficient number of fully coordinated FSS assignments which have the potential to be used for UAS CNPC link applications.
- Intra service compatibility of FSS accommodating UAS CNPC links with respect to other FSS satellites (carrying regular FSS traffic) seems to be feasible without any restriction to the FSS regular operations.

Operational considerations

- Studies, using the UAS characteristics show that flight scenarios with flight level above 3 000 ft over land seem to be feasible under the given assumptions.
- Minimum elevation angles for CNPC links to geostationary satellite show that these links can only be used for UA flights between latitudes of ±70°.
- It is expected that operational characteristics, such as the required communication performance, will be further developed by ICAO, including certification, validation, and airworthiness of the UAS.
- Studies show that the UA might receive interference from FS links (in the bands 10.7-12.75 GHz and 17.3-20.3 GHz) under certain flight scenarios. UA system design and flight operations should take such potential interference into account.

Other relevant issues in connection with the studies

- The ICAO conditions in section 3/1.5/3.1 have been revised as follows:

  1) "That the technical and regulatory actions should be limited to the case of UAS using satellites, as studied, and not set a precedent that puts other aeronautical safety services at risk.

  2) That all frequency bands which carry aeronautical safety communications need to be clearly identified in the Radio Regulations.

  3) That the assignments and use of the relevant frequency bands have to be consistent with Article **4.10** of the Radio Regulations which recognizes that safety services require special measures to ensure their freedom from harmful interference.

  Consideration of these conditions are largely covered in the current studies and material available in the WDDNR [UAS-FSS].

- On the issue of interference, a number of arguments are made regarding the impact of interference episodes which radiocommunication systems can suffer. The issue of interferences, either operational or intentional, are applicable to any kind of

radiocommunication systems. It is assumed that the use of FSS frequency bands by UAS CNPC links would be made in full respect and in accordance with the provisions of the RR and therefore, ensuring proper operations of UAS CNPC links.

- Work is ongoing in WP 5B regarding protection to other existing services as well as consideration of the earth stations on board aircraft.

3/1.5/5 Methods to satisfy the agenda item

3/1.5/5.1 Method A: Use of the fixed-satellite service

To enable the use of the FSS for UAS CNPC applications operated in accordance with ICAO standards and procedures, through a footnote and associated Resolution. The intention being that compliance with the Resolution would ensure that all required technical, operational, and regulatory conditions are met. This Method will permit FSS links supporting UAS CNPC to operate without adverse effects to existing and future FSS networks.

The footnote would only be applied to frequency bands allocated to the FSS not subject to RR Appendix **30**, **30A** or **30B** in the frequency ranges 10.95-14.5 GHz, 17.8-20.2 GHz and 27.5-30 GHz, as appropriate, for which studies have been conducted.

Advantages:

– A worldwide large capacity provided by existing and planned satellite systems would be accessible for UA CNPC applications in non-segregated airspace.

– The growing demand for UA applications worldwide as described in Report ITU-R M.2171 could be served immediately.

– The variety of satellite networks available offers opportunities to use different frequency bands and satellite networks to enhance the overall reliability.

– The provisions of this method minimize the impact on the regulatory, technical and operational framework in which the FSS networks currently operate, while ensuring compliance with RR No. **4.10**.

– This method does not require re-coordination and re-notification of existing frequency assignments under provision of RR Articles **9** and **11**.

– Studies provided a clear definition of the interference environment vis-à-vis incumbent services which allows administrations to determine whether frequency bands allocated to the FSS which can be used for the provision of UAS CNPC links.

– Studies provided a comprehensive list of mitigation techniques available for UAS CNPC links which can be used to overcome any foreseen and unforeseen changes in the interference environment.

– Protection from interference is guaranteed for FSS assignments which are coordinated under RR No. **11.32** or RR No. **11.42**. Interference cases for unforeseen or unpredicted cases, particularly for FSS assignments notified under RR No. **11.41**, can be efficiently tackled through appropriate mitigation techniques.

– Since the assignment is recorded in the MIFR, it creates no additional burden to or from other FSS networks.

Disadvantages:

– This method is not in accordance with the definition of FSS.

– Operation of the earth station on board an aircraft when communicating with FSS satellites requires assumption that such earth station will operate within the FSS

associated parameters and will not cause more interference and will not claim more protection than a typical FSS earth station located on the surface of the Earth.

– Potential interference into frequency assignments examined under RR No. **11.32A** or recorded under RR No. **11.41** caused by frequency assignments recorded under RR No. **11.41** will require UAS CNPC links to implement appropriate interference mitigation techniques. Use of the assignment recorded under RR No. **11.41** would put serious uncertainty about the occurrence of interference from the networks which have not completed coordination procedures. Until such time when this interference is removed under RR No. **11.42** the operation of UAS will be fully at risk.

– The operation of UA which is an aeronautical mobile earth station to communicate with FSS has regulatory obstacles yet to be resolved.

– UAS CNPC links need to implement appropriate interference mitigation techniques which requires that all FSS networks that will potentially be used for this purpose need to implement these mitigation techniques. Such course of action would add technical, operational and cost burden to all FSS to be operated for UAS CNPC.

– The service performance and availability required for UAS CNPC has not yet been established. Such availability is fundamental element before making any decision with regard to the acceptance of this Method.

– The interference environment for UA which is considered an aeronautical mobile earth station vis-à-vis the other incumbent services have not yet been studied as such environment is different from those related to FSS earth station.

– Occurrence of interference from those FSS links used for this purpose is a matter to be carefully considered due to the fact that such interference resulting from technical and operational conditions would adversely affect the safe operation of UAS CNPC links.

– Conditions of operation of UAS CNPC which should be clearly mentioned in the resolution are currently missing which contribute to the inconsistency with the objectives of the footnote and the operation of UAS CNPC.

– If it is understood that these earth stations operate within the envelope of the FSS in case that interference is received from other networks due to the modifications of characteristics of CNPC earth stations would create an uncertain environment which puts the operation of UAS in danger.

– No agreement reached on the studies provided and claimed that the interference environment vis-à-vis incumbent services which allows administrations to determine whether frequency bands allocated to the FSS can be used for the provision of UAS CNPC links.

– There is no certainty about the potential interference which may be caused either as a result of operational and technical or non-coordinated interference that could be caused to UAS CNPC.

– Implementation of this Method would lead to the necessity of application of RR No. **4.10** provision to all identified frequency bands.

– The impact of cumulative interference from FSS, even those which have coordinated assignment (RR No. **11.31**, RR No. **11.32**) on the FSS network or transponder intended to be used for UAS CNPC have not been studied. Such cumulative interference could have adverse impact on the safety requirements as provided in Resolution 153.

– No agreement was reached in ITU-R on any of the mitigation technique. Studies provided a comprehensive list of mitigation techniques available for UAS CNPC links

which can be used to overcome any foreseen and unforeseen changes in the interference environment. The reason was given in the relevant disadvantage mentioned above.

– There is no guarantee of protection from interference for FSS assignments which are coordinated under RR No. **11.32** or RR No. **11.42**.

– Burden to or from other FSS networks to UAS CNPC application using the assignment recorded in the MIFR depends on the status and condition under which the UAS CNPC is recorded.

3/1.5/5.2 Method B: No change to the Radio Regulations (NOC)

Reasons for No Change:

There are considerable technical, operational and regulatory obstacles for the use of FSS for UAS CNPC links. Moreover, existing allocations for AMS(R)S as well as AMSS and MSS, under certain conditions could satisfy the requirements for UAS CNPC in the frequency bands of these services.

Advantages:

– Retention of equal-in-rights conditions for operation of FSS systems.

– Incumbent terrestrial services and FSS space stations will not suffer from potential harmful interference caused by the mobile use of FSS.

– No operational impact on incumbent services due to the need of protection of CNPC links operated in FSS in particular on existing FSS applications.

– Application of RR No. **4.10** for the frequency bands under consideration, protection of safety services required for safe operation of UAS in non-segregated airspace.

– No additional regulatory consideration regarding protection against interference or more interference created by UAS CNPC links, requiring these new services to respect the current FSS interference sharing conditions and protection criteria.

Disadvantages:

– The agenda item is not satisfied.

– Does not provide the opportunity to use FSS for UA CNPC links between the earth station on board an UA and an FSS space station in non-segregated airspace.

– Limits the number of frequency band available for UAS CNPC and hence the opportunity for deploying redundant systems.

– No explicit recognition in the Radio Regulations of the UAS CNPC links operation.

– UAS CNPC links in non-segregated airspace may operate in the frequency bands allocated to FSS only on national level without international recognition and without international harmonization of spectrum, and based on application of RR No. **4.4**.

NOTE − An additional method proposing allocations to AMS(R)S in the relevant frequency bands was also proposed. However based on legal advice that the scope of the agenda item did not include the possibility to consider additional allocations, this method was considered to be outside the scope of the agenda item and is therefore not included in this section of the CPM text.

3/1.5/6 Regulatory and procedural considerations

Within the regulatory and procedural considerations for Method A there are two options provided as possible examples of a draft resolution. These two options were neither discussed nor agreed at CPM15-2.

3/1.5/6.1 Method A: Use of the fixed satellite service

Example update to Table of Allocations

ARTICLE 5

Frequency allocations

Section IV – Table of Frequency Allocations
(See No. **2.1**)

MOD

14-15.4 GHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
14-14.25	FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B 5.484A 5.506 5.506B ADD 5.A15 RADIONAVIGATION 5.504 Mobile-satellite (Earth-to-space) 5.504B 5.504C 5.506A Space research 5.504A 5.505	

NOTE − The footnote in the example above could be applied to those frequency bands allocated to the FSS and not subject to RR Appendix **30**, **30A** or **30B** for which studies have been conducted in the frequency ranges 10.95-14.5 GHz, 17.8-20.2 GHz and 27.5-30 GHz.

ADD

5.A15 Resolution **[FSS-UA-CNPC] (WRC-15)** shall apply. (WRC-15)

Draft Resolution Option #1

ADD

DRAFT RESOLUTION [FSS-UA-CNPC] (WRC-15)

Regulatory provision related to earth stations on board unmanned aircraft which operate with geostationary satellites in the fixed-satellite service for the control and non-payload communications of unmanned aircraft systems

The World Radiocommunication Conference (Geneva, 2015),

considering

a) that worldwide use of unmanned aircraft systems (UAS), which include unmanned aircraft (UA) and unmanned aircraft control stations (UACS), is expected to increase significantly in the near future;

b) that UA need to operate seamlessly with piloted aircraft in non-segregated airspace;

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

d) that there is a demand for the control of UAS CNPC links via satellite communication networks for communications beyond the radio horizon while operating in non-segregated airspace, as shown in Annex 1;

e) that there is a need to provide internationally harmonized use of spectrum for UAS CNPC links;

f) that the use of fixed-satellite service (FSS) frequency assignments by UAS CNPC links should take into account their Article **11** notification status,

considering further

a) that there is a need to limit the number of communication equipment on board a UA;

b) that there is some urgency to conclude on the feasibility of the use of the FSS frequency bands to support short- and medium-term implementation of UAS CNPC links because a dedicated satellite system for this application is not likely to be implemented in this time-frame;

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., that can be used to ensure safe operation of UAS in all airspace;

d) that UAS CNPC relate to the safe operation of UAS and have certain technical, operational and regulatory requirements;

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

noting

a) that Report ITU-R M.2171 provides information on the vast number of applications for UAS needing access to non-segregated airspaces;

b) that although Recommendation **724 (WRC-07)** notes that FSS is not a designated safety service, FSS can be used, under certain conditions, on a permanent or temporary basis for safeguarding human life or property in accordance with RR No. **1.59**,

recognizing

a) that the UAS CNPC links shall be operated in accordance with international standards and recommended practices and procedures established by the Convention on International Civil Aviation;

b) that, in this context, ITU develops the conditions for operation of CNPC links, and then International Civil Aviation Organization (ICAO) would be in a position to develop further operational conditions to ensure safe UAS operation,

resolves

1 that FSS networks in this frequency band may be used for the control and non-payload communication of unmanned aircraft systems;

2 that earth stations on board UA can communicate with a space station operating in the fixed-satellite service, including while the UA is in motion;

3 that the use of such links and their associated performance requirements shall be in accordance with the international standards and recommended practices (SARPs) and procedures established by ICAO, consistent with Article 37 of the Convention on International Civil Aviation;

4 that a fixed-satellite service earth station on an unmanned aircraft shall be considered as an earth station operating in the fixed-satellite service;

5 that the FSS space stations operating in frequency bands supporting these CNPC links shall conform to the applicable technical provisions of the Radio Regulations;

6 that the use of UAS CNPC links is for safe operation and regularity of flight and requires absolute international protection;

7 that the freedom from harmful interference to UAS CNPC links is imperative to ensure safe operation, and administrations shall act immediately when their attention is drawn to any such harmful interference;

8 that the FSS operator will ensure that the assignments associated with the FSS networks to be used for UAS CNPC links (see Fig. 1 in Annex 1) have obtained the necessary protected status under the provisions of Nos. **11.32**, **11.32A**, **11.42** or **11.42A**, including the examinations made by the BR, and have been successfully registered in the MIFR;

9 that real-time interference monitoring and predicting interference risks, and planning solutions for potential interference scenarios shall be addressed in the specific agreements between FSS operators and UAS operators with guidance from aviation authorities;

10 that the protection of the fixed service shall be ensured by implementing measures shown in Annex 2,

encourages concerned administrations

to cooperate with administrations which license UA CNPC while seeking agreement under the above-mentioned provisions,

instructs the Secretary-General

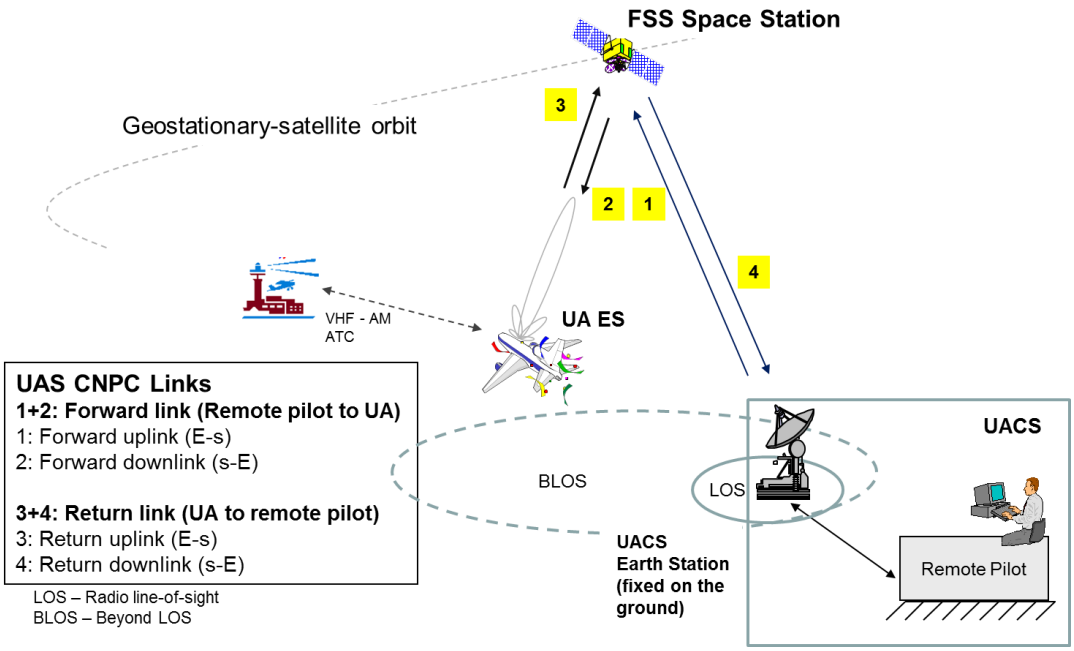
to bring this Resolution to the attention of the Secretary-General of the ICAO.

ANNEX 1 TO RESOLUTION [FSS-UA-CNPC] (WRC-15)

UA CNPC links

FIGURE 1

Elements of UAS architecture using the FSS



ANNEX 2 TO RESOLUTION [FSS-UA-CNPC] (WRC-15)

Protection of the fixed service and of other fixed-satellite service networks from UA CNPC emissions

1 Introduction

The fixed service is allocated by footnotes in several countries with a co-primary status to the FSS. Conditions of UA using CNPC shall be such that the fixed service is protected from any harmful interference as defined below.

2 Compatibility with the fixed service

NOTE − Protection measures to be added such as:

- Off-axis e.i.r.p. mask.
- Pfd mask to protect FS based on results agreed in July 2015 meeting.
- FS environment interference profile to be addressed in development of ICAO SARPs.

3 Protection of other fixed-satellite service networks

NOTE − Protection measures to be added such as:

- Off-axis e.i.r.p. mask.

4 Protection of radio astronomy and other incumbent services as appropriate

NOTE − Protection measures to be added.

Draft Resolution Option #2

ADD

DRAFT RESOLUTION [FSS-UA-CNPC] (WRC-15)

Provision related to earth stations on board unmanned aircraft which operate with geostationary satellites in the fixed-satellite service for the control and non-payload communications of unmanned aircraft systems in non-segregated airspaces

The World Radiocommunication Conference (Geneva, 2015),

considering

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

b) that unmanned aircraft (UA) need to operate with piloted aircraft in non-segregated airspace;

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 there is a demand for the control of unmanned aircraft systems (UAS) via reliable and interference-free satellite communication networks to relay control and non-payload communications (CNPC) beyond the horizon while operating in non-segregated airspace, as shown in Annex 2;

e) that it is desirable to provide internationally harmonized use of spectrum for UA CNPC application;

f) that the use of fixed-satellite service (FSS) frequency assignments by UAS CNPC links should be considered for the above-mentioned application, taking into account the status of the subject assignments as recorded in the MIFR,

considering further

a) that, as dedicated satellite system(s) for UAS are planned to be implemented, it is necessary to take into account these satellite networks to accommodate the growth of the use of UAS;

b) that various methods should be available and used to achieve service and performance reliability requirements that can be used to ensure safe operations of UAS in non-segregated airspace;

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

d) that the requirements in *considering further c)* are to be specified for UAS use of the satellite networks,

noting

a) that Report ITU-R M.2171 provides some information for unmanned aircraft which need access to non-segregated airspaces;

b) that Recommendation **724 (WRC-07)** notes that FSS is not a safety service,

recognizing

a) that appropriate technical, operational and regulatory provisions should be established in order that UAS CNPC links operate with sufficient safely;

b) that the International Civil Aviation Organization (ICAO) is responsible for the establishment of the standards for UAS CNPC;

c) that more than 50 per cent of the FSS assignments have not completed the required coordination as stipulated in the RR;

d) that the assignments referred to in *recognizing c)* above are recorded in the MIFR with an unfavourable finding under RR No. **11.41**, with the strict condition that they shall not cause harmful interference to nor claim protection from the assignments which were the basis of such unfavourable finding;

e) that even if the assignments used for UAS CNPC have fully coordinated, there is no guarantee that any future FSS would not cause harmful interference to such coordinated assignments;

f) that the very high service and performance availability required for the safe operation of UAS CNPC used for the control and command of unpiloted/unmanned aircraft does not tolerate any interference, even for fractions of minutes;

g) that the interference environment governing the operation of earth stations on board aircraft having an aeronautical mobile earth station has not yet been studied by ITU-R,

resolves

1 that UA control and non-payload communication shall operate under the appropriate technical, regulatory and operational provisions;

2 that, under the current provisions of the Radio Regulations, earth stations on unmanned aircraft which is an aeronautical mobile earth station cannot communicate with a space station operating in the fixed-satellite service;

3 that the operation of an earth station on an unmanned aircraft, if authorized to communicate with stations of the fixed-satellite service, does not meet the sharing and interference environment and regulatory provisions applicable to FSS, thus could create more interference than the notified FSS assignments under the UAS CNPC links would operate, and would require more

protection than the associated notified FSS assignment in order to ensure the safety aspects of the subject application;

4 that the satellite networks operating in frequency bands supporting these CNPC links shall conform to the applicable technical, operational and regulatory provisions of the Radio Regulations, in particular having a status of interference-free operation to ensure the safety aspects of the subject application;

5 that the above-mentioned conditions and criteria shall be met before an administration intending to operate such systems license UA CNPC requirements mentioned above,

instructs the Secretary-General

to bring this Resolution to the attention of the ICAO.

ANNEX 1 TO RESOLUTION [FSS-UA-CNPC] (WRC-15)

Regulatory and operational provisions for UA CNPC links operating through satellite systems operated in the FSS frequency bands

1 It is anticipated that ICAO will develop associated standards and recommended practices (SARPs), taking into account the above.

2 Conformity with the Radio Regulations shall be ensured by application of Articles **1**, **8**, **9**, **11** and **13** of the Radio Regulations. In the course of this action, frequency assignments with the relevant technical and regulatory provisions contained in the RR, thus any UAS CNPC link shall only be authorized to operate under the strict conditions that full protection and interference-free operation be provided by the registered FSS frequency assignments with favourable finding with respect to RR Nos. **11.31** and **11.32**.

3 FSS frequencies used for UAS will use frequency assignments that are “successfully coordinated”. Satellite operators and administrations are required to carry out coordination of their FSS frequency assignments in accordance with the provisions contained in Article **9** of the Radio Regulations. The application of such provisions ensures that FSS frequency assignments can operate free from harmful interference caused by and to other systems. The efficiency of those rules is proven by the fact that FSS frequency assignments have been successfully operated for many years.

4 When the coordination process is completed, the BR will be notified (according to the provisions of Article **11**) by the administration proposing the new system and the frequency assignments will be recorded in the MIFR. If a frequency assignment is recorded in the MIFR under No. **11.41**, such an assignment is still entitled to protect and be protected against frequency assignments of other networks with which coordination has been successfully completed. The FSS operator then has to make sure that the outstanding coordination issues are examined to determine if UAS CNPC operations can take place within the ICAO SARPs requirements. This would be done for example by determining whether the affected network with which coordination has not been achieved is actually in operation and, if so, what the operational parameters are (e.g. orbital location and filed power levels) to ensure that any resultant impact would be acceptable.

5 Predicting interference risks, planning solutions for potential interference scenarios, adopting measures to solve the interference issues, and reporting on the interference cases are elements which are well known to FSS operators and which should be included in the specific

agreements between FSS operators and UAS operators with guidance from aviation authorities (some of which could be included in SARPs).

6 Innovative ways to detect and prosecute the interference cases are being developed nowadays at international level in order to gain further experience and contribute to harmonized and transparent reporting mechanisms of interference cases.

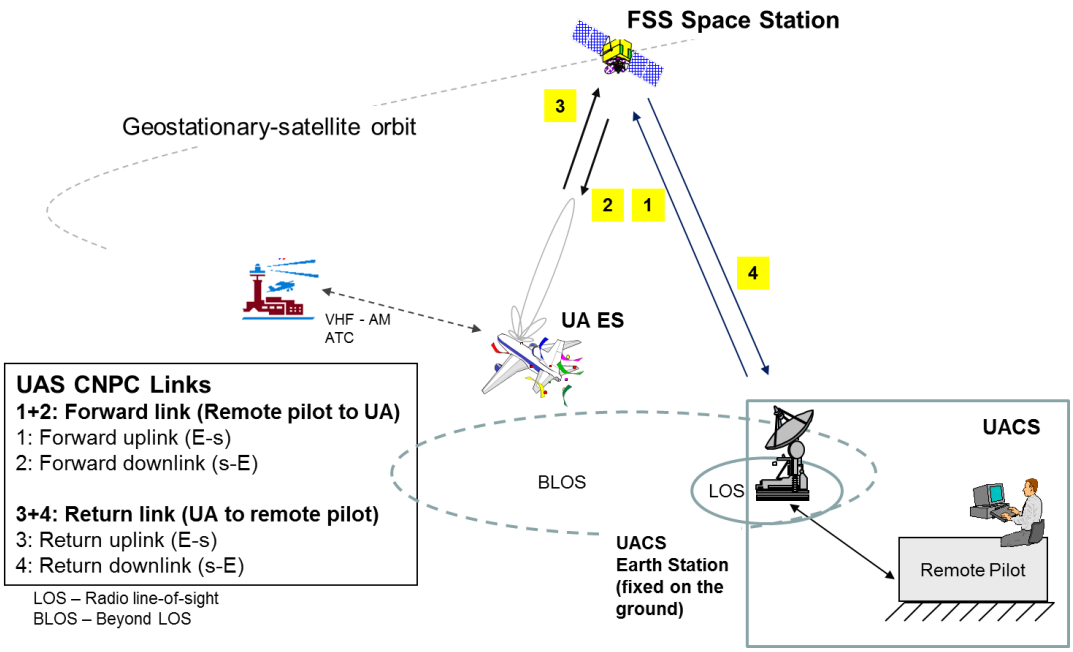
7 ITU and ICAO will carry out their mutual responsibilities in a cooperative manner. It is important that the respective roles of ICAO and ITU be fully understood to ensure appropriate separation of the regulatory needs to be addressed in the Radio Regulations and the operational issues to be addressed by ICAO processes. In this context, ITU will develop the typical conditions for operation of CNPC links, and then ICAO will develop further operational conditions to ensure safe operation.

ANNEX 2 TO RESOLUTION [FSS-UA-CNPC] (WRC-15)

UA CNPC links

FIGURE 1

Typical BLoS CNPC links in an unmanned aircraft system



3/1.5/6.2 Method B: No change to the Radio Regulations

No need to make any changes to the Radio Regulations.