UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
INTERDEPARTMENT RADIO ADVISORY COMMITTEE
Washington, D.C. 20230

SEP 17 2014

Ms. Mindel De La Torre
Chief of the International Bureau
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Dear Ms. De La Torre:

The National Telecommunications and Information Administration (NTIA) on behalf of the Executive Branch agencies, approves the release of the draft Executive Branch proposals for WRC-15 agenda items 1.3 (public protection and disaster relief), 1.5 (UAS Satellite), and 9 (earth stations in motion). For agenda item 1.3, NTIA proposes a modification to Resolution 646. For agenda item 1.5, NTIA proposes allowing the use of control and non-payload communication links in the fixed-satellite service. For agenda item 9, NTIA proposes providing more spectrum in both the uplink and downlink to support growing global broadband communication requirement.

NTIA considered the federal agencies' input toward the development of U.S. proposals for WRC-15. NTIA forwards this package for your consideration and review by your WRC-15 Advisory Committee. Mr. Charles Glass is the primary contact from my staff.

Sincerely,

Karl B. Nebbia
Associate Administrator
Office of Spectrum Management

UNITED STATES OF AMERICA

DRAFT PROPOSALS FOR THE WORK OF THE CONFERENCE

Agenda Item 1.3: *to review and revise Resolution **646 (Rev. WRC-12)** for broadband public protection and disaster relief (PPDR), in accordance with Resolution **648 (WRC-12)***

Background Information: Resolution **646 (WRC-12)**, initially adopted at WRC-03, encouraged administrations to utilize a set of regionally harmonized spectrum bands identified for public protection and disaster relief (PPDR) in each region. Resolution **646** listed the following set of bands, covering all three ITU regions:

- In Region 1: 380-470 MHz as the frequency range within which the band 380-385/ 390-395 MHz is a preferred core harmonized band within certain countries;
- In Region 2: 746-806 MHz, 806-869 MHz, 4 940-4 990 MHz;
- In Region 3: 406.1-430 MHz, 440-470 MHz, 806-824/851-869 MHz, 4 940-4 990 MHz and 5 850-5 925 MHz;

Recognizing that it would be timely to review Resolution **646 (Rev. WRC-12),** Resolution **648 (WRC-12)** invited ITU-R to study technical and operational issues related to broadband PPDR applications and scenarios. It also resolved to invite WRC-15 to take any action that would be appropriate to revise Resolution **646**. Resolution **648** did not call specifically for identification of additional, regionally harmonized spectrum bands for PPDR, and it did not contemplate identifying a globally harmonized spectrum range.

During a May 2014 meeting, ITU-R Working Party 5A completed draft text for the CPM Report to WRC-15 that describes, among others, a Method A for review and revision of Resolution **646**. Method A proposes that "no change will be made to Resolution **646 (Rev.WRC-12)**, other than editorial amendments to Footnote 1 of Resolution **646 (Rev.WRC-12)** and the text surrounding it, and updated references to ITU-R Reports." ITU-R studies would address any further requirements for spectrum not already identified in Resolution **646**.

The United States proposes to resolve AI 1.3 through Method A for review and revision of Resolution **646**.

Proposal:

MOD USA/1.3/1

RESOLUTION 646 (REV.WRC-~~12~~-15)

Public protection and disaster relief

The World Radiocommunication Conference (Geneva, ~~2012~~2015),

considering

…

g) that new technologies for wideband and broadband public protection and disaster relief applications are being developed in various standards organizations~~[1]~~;

~~[1] For example, a joint standardization programme between the European Telecommunications Standards Institute (ETSI) and the Telecommunications Industry Association (TIA), known as Project MESA (Mobility for Emergency and Safety Applications) has commenced for broadband public protection and disaster relief. Also, the Working~~

…

m) that the Tampere Convention on the Provision of Telecommunications Resources for Disaster Mitigation and Relief Operations (Tampere, 1998), an international treaty deposited with the United Nations Secretary-General and related United Nations General Assembly Resolutions

and Reports are also relevant in this regard[1],

…

recognizing

g) that currently some bands or parts thereof have been designated for existing public protection and disaster relief operations~~, as documented in Report ITU-R M.2033~~; [3]

…

noting

c) that public protection and disaster relief agencies and organizations have ~~an initial~~a set of requirements, including but not limited to interoperability, secure and reliable communications, sufficient capacity to respond to emergencies, priority access in the use of non-dedicated systems, fast response times, ability to handle multiple group calls and the ability to cover large areas as described in Report ITU-R M.~~2033~~[PPDR];

Reason: Method A completes the required review of Resolution 646, resulting in revisions to the document that will ensure its ongoing relevance and accuracy. Resolution 646 will continue to be a resource for meeting current and future requirements for PPDR applications, and the appropriate ITU-R study groups can undertake studies to address any further requirements for PPDR.

~~Group on Emergency Telecommunications (WGET), convened by the United Nations Office for Humanitarian Affairs (OCHA), is an open forum to facilitate the use of telecommunications in the service of humanitarian assistance comprising United Nations entities, major non-governmental organizations, the International Committee of the Red Cross (ICRC), ITU and experts from the private sector and academia. Another~~A platform for coordination and to foster harmonized global Telecommunication for Disaster Relief (TDR) standards is the TDR Partnership Coordination Panel, which has ~~just~~ been established under the coordination of ITU with participation of international telecommunication service providers, related government departments, standards development organizations, and disaster relief organizations.

[3] 3-30, 68-88, 138-144, 148-174, 380-400 MHz (including CEPT designation of 380-385/ 390-395 MHz), 400-430, 440-470, 764-776, 794-806 and 806-869 MHz (including CITEL designation of 821-824/866-869 MHz).

UNITED STATES OF AMERICA

DRAFT PROPOSALS FOR THE WORK OF THE CONFERENCE

Agenda Item 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)***

Background Information: Report ITU-R M.2171 identified the spectrum requirements for unmanned aircraft system (UAS) command and non-payload communication (CNPC) links 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 (WRC) held in 2012 the BLOS requirements were only partially addressed. As a result a new agenda item for the 2015 WRC (Agenda Item 1.5) was established to investigate whether fixed satellite networks, not subject to Appendix 30, 30A and 30B could be used to provide additional capacity for UAS CNPC links. This agenda item ~~is to~~ supports the addition of technical and regulatory provisions to enable use of portions of bands allocated to the fixed satellite service (FSS) for ~~unmanned aircraft system (~~UAS~~)~~ ~~control and non-payload communications (~~CNPC~~)~~ links in non-segregated airspace, ~~if~~ provided studies demonstrate compatibility with incumbent services and that the requirements of aviation authorities are satisfied ~~without supporting the addition of an aeronautical mobile satellite (route) service (AMS(R)S) allocation to the FSS bands used for this purpose~~.

In the context of this agenda item, a UAS consists of an ~~unmanned aircraft (~~UA~~)~~ with an Earth station on-board to interconnect the UA and the associated Earth station of the unmann~~er~~ed aircraft control station (UACS) ~~with its own Earth station~~ through a satellite operating in the FSS. UA are aircraft that do not carry a human pilot but that are piloted remotely, i.e. through a reliable communication link ~~(CNPC) from outside the aircraft~~. UAS operations up to now have been limited to segregated airspace. However, it is planned to expand UAS deployment outside of segregated airspace.

The development of UAS is based on recent technological advances in aviation, electronics and structural materials, making the economics of UAS operations more favorable, 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. There are a large 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 UAS outside segregated airspace requires addressing the same issues as manned aircraft, namely safe and efficient integration into the air traffic control system.

~~A huge number of~~ More than 100 geostationary satellite communication networks operate ~~on~~ in frequency bands allocated to the FSS in the bands 10.7-12.75, 13.75-14.5, 17.3-20.2, and 27.5-30.0 GHz. Report ITU-R M.2171 identifies a large variety of prospects for UAS ~~remotely piloted (Unmanned) aircraft~~ that would need to fly long-distances (worldwide) through airspaces controlled by civil air traffic control (ATC). Immediate access to this globally existing capacity would provide great advantages for UAS fleet operators fostering new applications, enabling faster developments of new markets, while providing planning stability for significant investments. Studies under this agenda item investigated the link feasibilities and sharing conditions for using UAS CNPC links over typical frequency spectrum allocated in several FSS allocations~~under which such applications could be authorized~~.

Report ITU-R M.2233 contains examples of technical characteristics for UA CNPC including FSS systems operating in portions of the frequency ranges 10.95-14.5 GHz and 17.3-30.0 GHz. These examples indicated that it may be possible to operate UAS CNPC links in these bands while meeting the desired link performance. It is recognized that a further Report may be available by the time of WRC-15.

The proposal found below sets forth the basis for accomplishing the ~~this~~ objective of using frequency bands allocated to the FSS for safe operation of UAS CNPC links. It includes text for a footnote to the appropriate FSS bands which points to a Resolution that spells out the conditions of use for supporting safe and efficient operation of UAS.

Proposal:

ADD USA/1.5/1

ARTICLE 5

Frequency allocations

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

10-11.7 GHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>10.7-11.7
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.441 5.484A
5.XXX
(Earth-to-space) 5.484
MOBILE except aeronautical mobile</td><td colspan="2">10.7-11.7
FIXED
FIXED-SATELLITE (space-to-Earth) 5.441 5.484A 5.XXX
MOBILE except aeronautical mobile</td></tr>
</table>

11.7-14 GHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr>
<td rowspan="3">11.7-12.5
FIXED
MOBILE except aeronautical mobile
BROADCASTING
BROADCASTING-SATELLITE
5.492

5.487 5.487A</td>
<td>11.7-12.1
FIXED 5.486
FIXED-SATELLITE (space-to-Earth) 5.484A 5.488 5.XXX
Mobile except aeronautical mobile
5.485</td>
<td rowspan="2">11.7-12.2
FIXED
MOBILE except aeronautical mobile
BROADCASTING
BROADCASTING-SATELLITE
5.492

5.487 5.487A</td>
</tr>
<tr>
<td>12.1-12.2
FIXED-SATELLITE (space-to-Earth) 5.484A 5.488 5.XXX
5.485 5.489</td>
</tr>
<tr>
<td rowspan="2">12.2-12.7
FIXED
MOBILE except aeronautical mobile
BROADCASTING
BROADCASTING-SATELLITE
5.492

5.487A 5.488 5.490</td>
<td>12.2-12.5
FIXED
FIXED-SATELLITE (space-to-Earth)5.XXX
MOBILE except aeronautical mobile
BROADCASTING

5.484A 5.487</td>
</tr>
<tr>
<td rowspan="2">12.5-12.75
FIXED-SATELLITE (space-to-Earth) 5.484A 5.XXX (Earth-to-space)

5.494 5.495 5.496</td>
<td rowspan="2">12.5-12.75
FIXED
FIXED-SATELLITE (space-to-Earth) 5.484A 5.XXX
MOBILE except aeronautical mobile
BROADCASTING-SATELLITE 5.493</td>
</tr>
<tr>
<td>12.7-12.75
FIXED
FIXED-SATELLITE (Earth-to-space)
MOBILE except aeronautical mobile</td>
</tr>
<tr>
<td>13.75-14</td>
<td colspan="2">FIXED-SATELLITE (Earth-to-space) 5.484A 5.XXX
RADIOLOCATION
Earth exploration-satellite
Standard frequency and time signal-satellite (Earth-to-space)
Space research
5.499 5.500 5.501 5.502 5.503</td>
</tr>
</table>

14-14.5 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 5.XXX RADIONAVIGATION 5.504 Mobile-satellite (Earth-to-space) 5.504B 5.504C 5.506A Space research 5.504A 5.505	
14.25-14.3	FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B 5.484A 5.506 5.506B 5.XXX RADIONAVIGATION 5.504 Mobile-satellite (Earth-to-space) 5.504B 5.506A 5.508A Space research 5.504A 5.505 5.508	
14.3-14.4 FIXED FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B 5.484A 5.506 5.506B 5.XXX MOBILE except aeronautical mobile Mobile-satellite (Earth-to-space) 5.504B 5.506A 5.509A Radionavigation-satellite 5.504A	**14.3-14.4** FIXED-SATELLITE (Earth-to-space) 5.457A 5.484A 5.506 5.506B 5.XXX Mobile-satellite (Earth-to-space) 5.506A Radionavigation-satellite 5.504A	**14.3-14.4** FIXED FIXED-SATELLITE (Earth-to-space) 5.457A 5.484A 5.506 5.506B 5.XXX MOBILE except aeronautical mobile Mobile-satellite (Earth-to-space) 5.504B 5.506A 5.509A Radionavigation-satellite 5.504A
14.4-14.47	FIXED FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B 5.484A 5.506 5.506B 5.XXX MOBILE except aeronautical mobile Mobile-satellite (Earth-to-space) 5.504B 5.506A 5.509A Space research (space-to-Earth) 5.504A	
14.47-14.5	FIXED FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B 5.484A 5.506 5.506B 5.XXX MOBILE except aeronautical mobile Mobile-satellite (Earth-to-space) 5.504B 5.506A 5.509A Radio astronomy 5.149 5.504A	

17.3-18.4 GHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr>
<td>17.3-17.7
FIXED-SATELLITE
(Earth-to-space) 5.516
(space-to-Earth) 5.516A
5.516B 5.XXX
Radiolocation
5.514</td>
<td>17.3-17.7
FIXED-SATELLITE
(Earth-to-space) 5.516
BROADCASTING-
SATELLITE
Radiolocation
5.514 5.515</td>
<td>17.3-17.7
FIXED-SATELLITE
(Earth-to-space) 5.516
Radiolocation
5.514</td>
</tr>
<tr>
<td rowspan="2">17.7-18.1
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.484A
(Earth-to-space) 5.516
MOBILE</td>
<td>17.7-17.8
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.517
(Earth-to-space) 5.516
BROADCASTING-
SATELLITE
Mobile
5.515</td>
<td rowspan="2">17.7-18.1
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.484A
(Earth-to-space) 5.516
MOBILE</td>
</tr>
<tr>
<td>17.8-18.1
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.484A
(Earth-to-space) 5.516
MOBILE
5.519</td>
</tr>
<tr>
<td>18.1-18.4</td>
<td colspan="2">FIXED
FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.XXX
(Earth-to-space) 5.520
MOBILE
5.519 5.521</td>
</tr>
</table>

18.4-20.2 GHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
18.4-18.6	FIXED FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.XXX MOBILE	
18.6-18.8 EARTH EXPLORATION-SATELLITE (passive) FIXED FIXED-SATELLITE (space-to-Earth) 5.522B 5.XXX MOBILE except aeronautical mobile Space research (passive) 5.522A 5.522C	**18.6-18.8** EARTH EXPLORATION-SATELLITE (passive) FIXED FIXED-SATELLITE (space-to-Earth) 5.516B 5.522B 5.XXX MOBILE except aeronautical mobile SPACE RESEARCH (passive) 5.522A	**18.6-18.8** EARTH EXPLORATION-SATELLITE (passive) FIXED FIXED-SATELLITE (space-to-Earth) 5.522B 5.XXX MOBILE except aeronautical mobile Space research (passive) 5.522A
…		
19.7-20.1 FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.XXX Mobile-satellite (space-to-Earth) 5.524	**19.7-20.1** FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.XXX MOBILE-SATELLITE (space-to-Earth) 5.524 5.525 5.526 5.527 5.528 5.529	**19.7-20.1** FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.XXX Mobile-satellite (space-to-Earth) 5.524
20.1-20.2	FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B 5.XXX MOBILE-SATELLITE (space-to-Earth) 5.524 5.525 5.526 5.527 5.528	

27.5-29.9 GHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>27.5-28.5</td><td colspan="2">FIXED5.537A
FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 5.XXX
MOBILE
5.538 5.540</td></tr>
<tr><td>28.5-28.6~~29.1~~</td><td colspan="2">FIXED
FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.523A 5.539 5.XXX
MOBILE
Earth exploration-satellite (Earth-to-space) 5.541
5.540</td></tr>
<tr><td>28.6-29.1</td><td colspan="2">FIXED
FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.523A 5.539
MOBILE
Earth exploration-satellite (Earth-to-space) 5.541
5.540</td></tr>
<tr><td colspan="3">...</td></tr>
<tr><td>29.5-29.9
FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 5.XXX
Earth exploration-satellite (Earth-to-space) 5.541
Mobile-satellite (Earth-to-space)
5.540 5.542</td><td>29.5-29.9
FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 5.XXX
MOBILE-SATELLITE (Earth-to-space)
Earth exploration-satellite (Earth-to-space) 5.541
5.525 5.526 5.527 5.529 5.540 5.542</td><td>29.5-29.9
FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 5.XXX
Earth exploration-satellite (Earth-to-space) 5.541
Mobile-satellite (Earth-to-space)
5.540 5.542</td></tr>
</table>

29.9-30 GHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
29.9-30	FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 5.XXX MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.543 5.525 5.526 5.527 5.538 5.540 5.542	

Reasons: To provide a footnote allowing the use of UAS CNPC links in the fixed-satellite service not subject to Appendices 30, 30A and 30B.

ADD USA/1.5/2

5.XXX ~~This~~ The FSS in this frequency band may also be used for the control and non-payload communication ~~(CNPC)~~ of unmanned aircraft systems.~~,~~ ~~s~~Such use shall be in accordance with Resolution **[FSS-UA-CNPC] (WRC-15)**.

ADD USA/1.5/3

~~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 ~~(CNPC)~~ of unmanned aircraft systems in non-segregated airspaces

The World Radiocommunication Conference (Geneva, 2015),

considering

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

b) that ~~unmanned aircraft (~~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 unmanned aircraft systems (~~UAS~~)~~ CNPC links via satellite communication networks ~~to relay control and non-payload~~ for communications ~~(CNPC)~~ beyond the radio horizon while operating in non-segregated airspace as shown in Annex 1~~2~~;

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

f) that ~~appropriate~~ the use of fixed satellite service (FSS) frequency assignments by UAS CNPC links should take into account their Article 11 notification status ~~of a FSS network is a pre-requisite for the use of FSS space system (channel) for UA CNPC links~~;

considering further

a) that there is a need to limit the ~~number~~ amount of communication equipment~~s~~ onboard a UA;

b) that, as a dedicated satellite system for UAS CNPC links is not likely to be implemented in the short or medium term, it is necessary to take into account the existing and future satellite systems to accommodate the growth in ~~of the use of~~ UAS operations;

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~~s~~ of UAS in all ~~non-segregated~~ air space;

d) hat ~~for~~ UAS CNPC ~~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;

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

notingrecognizing

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

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

recognizing

a) that appropriate technical and operational provisions can be implemented in the ITU-R to enhance the robustness of the UAS CNPC links;

be) that the UAS CNPC links shall be operated , in accordance with international standards and recommended practices and procedures established the Convention in accordance with the Convention on International Civil Aviation, the operation of UAS in non-segregated airspace has to meet standards and recommended practices;

c) that the International Telecommunications Union (ITU) and the International Civil Aviation Organization (ICAO) will carry out their mutual responsibilities in a cooperative manner;

d) that the respective roles of ICAO and the ITU must be fully understood to ensure appropriate separation of provisions to be addressed in the Radio Regulations and regulatory and operational matters that need to be addressed by ICAO;

e) that 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 UAS operation,

resolves

1 that earth stations on-board UA can communicate with a space station operating in the fixed satellite service, including while the UA is in motionthat UA control and non-payload communication shall operate under the regulatory and operational provisions contained in Annex 1;

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

3. that a fixed satellite service earth station on an unmanned aircraft shall be considered defined as an earth station operating in the fixed satellite service;

4. that the FSS space stations operating in frequency bands supporting these CNPC links shall conform to the applicable technical provisions of the radio regulations;

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

6 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;

7 that the FSS operator will ensure that the assignments associated with the FSS networks to be used for UAS CNPC links (see figure 1 in Annex 1) have obtained the necessary protected status under

the provisions of No. 11.32, 11.32A, 11.42, or 11.42A including the examinations made by the BR and have been successfully registered in the MIFR;

8 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 Aaviation Aauthorities,

encourages concerned administrations

1 to cooperate with administrations which license UAS CNPC while seeking agreement under the abovementioned provisions,

instructs the Secretary-General

to bring this Resolution to the attention of the Secretary-General of the International Civil Aviation Organization (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 is ensured by application of Articles **9** and **11**. In the course of this action, the BR always checks the consistency of any frequency assignment with the relevant technical and regulatory provisions contained in the RR, thus meeting the requirement in the ICAO conditions Any UAS CNPC link will operate under the protection provided by the registered FSS frequency assignments.

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 RR 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 RR 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 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 The ITU and ICAO will carry out their mutual responsibilities in a cooperative manner. It is important that the respective roles of ICAO and the ITU be fully understood to ensure appropriate separation of regulatory needs to be addressed in the RR and 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~~ 1 TO RESOLUTION [FSS-UA-CNPC] (WRC-15)

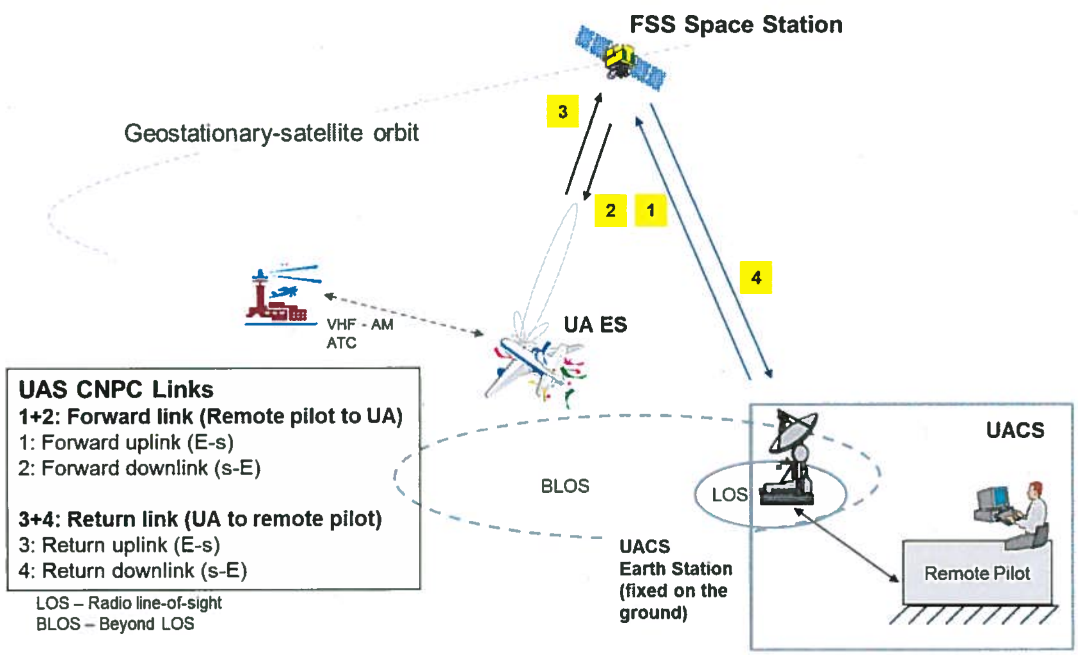
UA CNPC links ~~architecture~~

~~**1 UA CNPC FSS Links**~~

FIGURE 1

Elements of UAS architecture using the FSS

~~**Typical BLOS CNPC links in an unmanned aircraft system**~~



~~The forward and return (UAS) links via an FSS network~~

UNITED STATES OF AMERICA

DRAFT PROPOSALS FOR THE WORK OF THE CONFERENCE

Agenda Item 9.0: *to consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with Article 7 of the Constitution.*

Background Information: The global demand for broadband communications continues unabated and is not location specific. Such demand includes requirements of connectivity for users on vessels, aircraft and vehicles that operate at both fixed locations and while in motion, often in very remote parts of the globe. The ITU for many years has and continues to address ways of meeting this important need. State of the art 30/20 GHz GSO FSS satellite networks and earth stations that employ advanced technology available today are capable of meeting the connectivity requirements of broadband users on vehicles and vessels, including high-throughput applications.

Advances in satellite manufacturing and directional earth station technology, particularly the development of multi-axis stabilized earth station antennas capable of maintaining a high degree of pointing accuracy while stationary or on rapidly moving platforms, have made earth stations with very stable pointing characteristics both available and practical. These earth stations can operate in the same interference environment, and comply with same regulatory and technical constraints as typical GSO FSS earth stations. Satellite network operators are designing, coordinating, and bringing into use GSO FSS networks that can offer both stationary and moving broadband services using a single stabilized directional antenna within existing GSO FSS technical parameters.

The ITU-R, which has been studying deployment of -earth stations in motion operating with GSO FSS networks for many years, has adopted Report S.2223, "technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3 to 30.0 GHz". Additional technical work continues in the ITU-R, with the Preliminary Draft New Recommendation, ITU-R S.[GSO FSS E/S in 29.5-30.0 GHz], "technical and operational requirements for earth stations on moving platforms operating with geostationary FSS satellite networks in the bands 29.5-30.0/19.7-20.2 GHz" ("Recommendation"), expected to be approved prior to WRC-15. The 'upper 500 MHz' of the 30/20 GHz band was studied first because the band is predominately allocated to satellite services. The FSS (Earth-to-space) bands between 27.5-29.5 GHz are shared on a global basis with the fixed and mobile services as well as other users and, therefore, more study on use of these bands by earth stations in motion is required.

The Recommendation provides technical and operational guidelines to Administrations that wish to deploy earth stations on moving platforms communicating with geostationary space stations in the fixed-satellite service in the bands 19.7-20.2 GHz and 29.5-30.0 GHz. The Recommendation includes a set of recommended off-axis e.i.r.p. spectral density levels for earth stations in motion as well as an overview of various satellite tracking and pointing techniques that will enable these earth stations to communicate with GSO space stations in the FSS without causing interference at levels in excess of that caused by conventional FSS earth stations.

Currently, in accordance with No. **5.526**, of the Radio Regulations, a satellite network which is both in the FSS and in the MSS can include links between the FSS portion of the network and earth stations in motion using frequency assignments in the bands 19.7-20.2 GHz (space-to-Earth) and 29.5-30.0 GHz (Earth-to-space) in Region 2 and in the bands 20.1-20.2 GHz (space-to-Earth) and 29.9-30.0 GHz (Earth-to-space) in Regions 1 and 3. The Radiocommunication

Bureau in implementing this footnote introduced through a Circular Letter a new class of earth station, UC, for use by Administrations when filing an earth station while in motion associated with a space station in the FSS in the bands listed in No. 5.526 (see CR/358). The Circular Letter also noted that in the absence of particular criteria the BR's findings will be based on existing criteria for FSS links in the relevant bands, as appropriate. Thus, the demand for broadband satellite communications to single earth stations that are used at fixed locations and while in motion can be met in 500 megahertz in Region 2 but only 100 megahertz in Regions 1 and 3. Given that the demand from many users of these satellite services, e.g., shipping companies, is global and cannot be met in only 100 megahertz of spectrum, the United States proposes to complement No. **5.526** by adding a new footnote to the FSS allocation in all three regions in the 29.5-30 GHz and 19.7-20.2 GHz bands to make clear in the Radio Regulations that earth stations while stationary or in motion may communicate with GSO FSS networks on the same basis as conventional FSS earth stations. The United States also proposes an associated Resolution that provides technical and operational guidance, based on the studies in the ITU-R, for administrations when deploying earth stations that will operate while in motion.

Adoption of this proposal will provide 500 megahertz in both the uplink and downlink to support these important and growing global broadband requirements, on an equal basis in all three Regions and result in rational and efficient use of the radio spectrum resource. Adoption of this proposal will also allow the coordination, notification and recording of these earth stations on an equal basis in all three Regions.

Proposals:

ARTICLE 5

Frequency allocations

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

MOD USA/9/1

18.4-22 GHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
.....		
19.7-20.1 FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B ADD 5.XXX Mobile-satellite (space-to-Earth) 5.524	**19.7-20.1** FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B ADD 5.XXX MOBILE-SATELLITE (space-to-Earth) 5.524 5.525 5.526 5.527 5.528 5.529	**19.7-20.1** FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B ADD 5.XXX Mobile-satellite (space-to-Earth) 5.524
20.1-20.2	FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B ADD 5.XXX MOBILE-SATELLITE (space-to-Earth) 5.524 5.525 5.526 5.527 5.528	
.....		

Reason: Changes required to Article 5 Table of Frequency Allocations to facilitate the introduction of earth stations in motion.

MOD USA/9/2

24.75-29.9 GHz

Allocation to services		
.....		
29.5-29.9 FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 ADD 5.XXX Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542	**29.5-29.9** FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 ADD 5.XXX MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.525 5.526 5.527 5.529 5.540	**29.5-29.9** FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 ADD 5.XXX Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542

Reason: Changes required to Article 5 Table of Frequency Allocations to facilitate the introduction of earth stations in motion.

MOD **USA/9/3**

29.9-34.2 GHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
29.9-30 5.XXX	FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 ADD MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.543 5.525 5.526 5.527 5.538 5.540 5.542	

Reason: Changes required to Article 5 Table of Frequency Allocations to facilitate the introduction of earth stations in motion.

ADD **USA/9/4**

5.XXX In the bands 19.7-20.2 GHz and 29.5-30 GHz, earth stations that are in motion may communicate with geostationary space stations of the fixed-satellite service. Operation of earth stations while in motion shall be in accordance with Resolution XXX.

Reason: Adoption of this proposal would provide the availability of 500 megahertz in both the uplink and downlink to support important and growing global broadband communication requirements for users on ships, airplanes, and land vehicles, on an equal basis in all three Regions and result in rational and efficient use of the radio spectrum resource. This also allows the coordination, notification and recording of these earth stations on an equal basis in all three Regions.

ADD **USA/9/5**

RESOLUTION XXX (WRC-15)

Use of the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz by earth stations in motion communicating with geostationary space stations of the fixed-satellite service

The World Radiocommunication Conference (Geneva, 2015)

considering

a) that the bands 19.7-20.2 GHz and 29.5-30.0 GHz are globally allocated on a primary basis to the FSS and that there are a large number of FSS satellite networks operating in these frequency bands at the geostationary satellite orbit (GSO);

b) that there is an increasing need for mobile communications, including global broadband satellite services, and that some of this need can be met by allowing earth stations that can operate while stationary or in motion on platforms (such as ships, aircraft and land vehicles) to communicate with space stations of the FSS operating in the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz;

c) that this Conference has adopted No. **5.XXX** in order to address this need;

d) that GSO FSS networks in the bands 19.7-20.2 GHz and 29.5-30.0 GHz, are required to be coordinated in accordance with the provisions of Article **9** and **11** of the Radio Regulations;

e) that earth stations in motion are currently communicating with GSO FSS networks in the bands 19.7-20.2 GHz and 29.5-30.0 GHz, and there are plans to expand the use of such earth stations with operational and future GSO FSS networks;

f) that the ITU-R has studied the technical and operational use of these earth stations in motion in the referenced bands;

considering further

a) that some administrations have addressed this matter nationally or regionally by adopting technical and operational criteria for the operation of earth stations in motion communicating with GSO FSS networks;

b) that a consistent approach to deployment of these earth stations in motion will support this important and growing global broadband communication requirement;

c) that these earth stations in motion will operate consistent with the coordination agreements between administrations applicable to the GSO FSS networks with which they communicate;

resolves

1 that administrations authorizing earth stations in motion communicating with GSO FSS networks in the band 19.7-20.2 GHz and 29.5-30.0 GHz require that GSO FSS operators employing earth stations in motion:

a. comply with the off-axis e.i.r.p. density levels given in Annex 1 or other levels mutually coordinated with other affected satellite network operators and their administrations;

b. employ techniques such as those described in Annex 2 that allow the tracking of the wanted GSO FSS satellite and that are resistant to capturing and tracking adjacent GSO satellites;

c. immediately reduce or cease transmission when the earth station antenna mispointing would result in exceeding the levels referred to in *resolves 1a)*;

d. be subject to permanent monitoring and control by a Network Control and Monitoring Center (NCMC) or equivalent facility and that these earth stations be capable to receive and act upon at least "enable transmission" and "disable transmission" commands from the NCMC. In addition, it should be possible for the NCMC to monitor the operation of an earth station in motion to determine if it is malfunctioning;

e. maintain points of contact for the purpose of tracing any suspected cases of interference from Earth stations in motion; and

f. not claim greater protection for such earth stations in the 19.7-20.2 GHz band than the level afforded to stationary FSS earth stations.

Annex 1

Off axis e.i.r.p. density levels for earth stations in motion communicating with geostationary space stations of the fixed-satellite service in the band 29.5-30.0 GHz

This Annex provides a set of recommended off-axis e.i.r.p. levels for earth stations in motion operating in the band 29.5-30.0 GHz. However, as stated in resolves 1a, other levels may be coordinated between satellite operators and administrations.

Earth stations in motion operating in GSO FSS networks transmitting in the band 29.5-30.0 GHz should be designed in such a manner that at any angle, θ, which is 2° or more from the vector from the earth station antenna to the wanted GSO FSS satellite (see Figure 1 below for the reference geometry of an earth station in motion compared to an earth station at a fixed location), the e.i.r.p. density in any direction within 3° of the GSO, should not exceed the following values:

Angle θ	**Maximum e.i.r.p. per 40 kHz**
$2° \leq \theta \leq 7°$	$(19 - 25 \log \theta)$ dB(W/40 kHz)
$7° < \theta \leq 9.2°$	−2 dB(W/40 kHz)
$9.2° < \theta \leq 48°$	$(22 - 25 \log \theta)$ dB(W/40 kHz)
$48° < \theta \leq 180°$	−10 dB(W/40 kHz)

NOTE 1 – The values above should be maximal values under clear-sky conditions. In case of networks employing uplink power control, these levels should include any additional margins above the minimum clear-sky level necessary for the implementation of uplink power control. When uplink power control (UPC) is used and rain fade makes UPC necessary, the levels stated above may be exceeded for the duration of that rain fade period. When uplink power control is not used and the e.i.r.p. density levels given above are not met, different values could be used in compliance with the values agreed to through bilateral coordination of GSO FSS satellite networks.

NOTE 2 – The e.i.r.p. density levels for angles of θ less than 2 may be determined from GSO FSS coordination agreements taking into account the specific parameters of the two GSO FSS satellite networks.

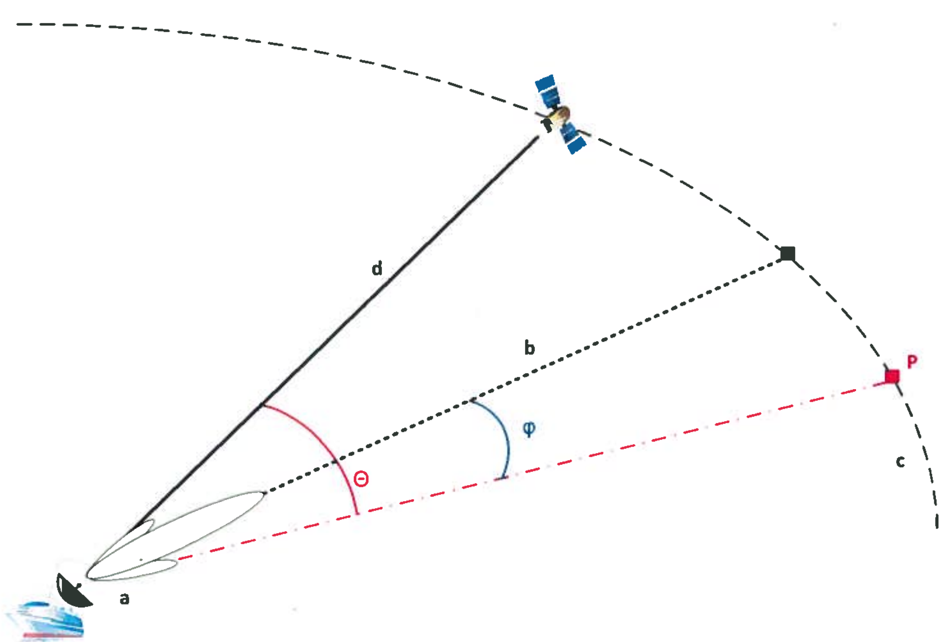
NOTE 3 – For geostationary space stations in the fixed-satellite service with which the earth stations in motion are expected to transmit simultaneously in the same 40 kHz band, e.g., employing code division multiple access (CDMA), the maximum e.i.r.p. density values should be decreased by 10 log(N) dB, where N is the number of earth stations in motion that are in the receive satellite beam of the satellite with which these earth stations are communicating and that are expected to transmit simultaneously on the same frequency. Alternative methods may be used as long as the maximum e.i.r.p. density values are met in the aggregate.

NOTE 4 – potential aggregate interference from earth stations in motion operating with satellites using multi-spot frequency reuse technologies should be taken into account in coordination between the GSO FSS satellite operators and their administrations.

NOTE 5 – Earth stations in motion operating in the band 29.5-30.0 GHz that have lower elevation angles to the GSO will require higher e.i.r.p. levels relative to the same terminals at higher elevation angles to achieve the same power flux-densities (pfds) at the GSO due to the combined effect of increased distance and atmospheric absorption. Earth stations with low elevation angles may exceed the above levels by the following amount:

Elevation angle to GSO (ε)	Increase in e.i.r.p. spectral density (dB)
$\varepsilon < 5°$	2.5
$5° < \varepsilon \leq 30°$	$3 - 0.1\,\varepsilon$

Figure 1 below illustrates the definition of angle θ [1].



[1] In Figure 1 proportions are illustrative and not to scale.

where:

a represents the earth station in motion;

b represents the boresight of the earth station antenna;

c represents the geostationary satellite orbit (GSO);

d represents the vector from the earth station in motion to the wanted GSO FSS satellite;

φ represents the angle between the boresight of the earth station antenna and a point P on the GSO arc;

ϑ represents the angle between the vector d and point P on the GSO arc;

P represents a generic point on the GSO arc to which angles ϑ and φ ~~are~~ refer ~~to~~.

Annex 2

Satellite tracking and pointing techniques of earth stations in motion communicating with geostationary space stations of the fixed-satellite service in the bands 19.7-20.2 GHz and 29.5-30.0 GHz

1 Introduction

Earth stations operating while in motion employ relatively high gain directional antennas with multiple-axis stabilization that allows the signal quality of the link between the earth station antenna and the wanted GSO FSS satellite (and vice versa) to be high. To maintain the signal quality it is also necessary for these earth stations to maintain high pointing accuracy towards the wanted GSO FSS satellite. This Annex describes algorithms that may be employed by earth stations that operate in motion for tracking of the wanted satellite as well as techniques that reduce the possibility of capturing and tracking an adjacent GSO satellite.

There are well-known techniques for antenna tracking of a GSO FSS satellite which can be classified into two categories: those that make use of *open-loop* algorithms and those that make use of *RF closed-loop* algorithms. The following subsections provide a brief description of each of the two types.

1.1 Open-loop pointing technique

An *open-loop* pointing technique employs a process of calculating the azimuth A and elevation E based upon the position of the earth station antenna on the earth (i.e., its latitude and longitude, acquired, for example, through a GPS signal) and the nominal longitude of the wanted satellite. The following equations show the relationship between the variables mentioned above:

$$A = \arctan\left(\frac{\tan L}{\sin l}\right) \tag{1}$$

$$\varepsilon = \arctan\left(\frac{\cos\Phi - \frac{R_E}{R_E+R_0}}{\sin\Phi}\right) \tag{2}$$

where:

l is the earth station latitude;

L is the earth station relative longitude[2];

$\cos\Phi = \cos l \cos L$;

R_E is the earth radius;

R_0 is the altitude of the satellite.

Due to the movement (relative to the earth station) of the GSO FSS satellite within its *station-keeping box*, depending on the width of the main beam of the earth station antenna, the azimuth and elevation angles of that antenna might need to be adjusted at consecutive instants in order for the link between the earth station and the satellite not to be deteriorated or – eventually – lost. By employing an *open-loop* pointing strategy, the angles are calculated in advance for each instant by taking into account the predicted apparent movement of the GSO satellite. Earth stations in motion typically operate as part of a network and under control of a network

[2] The relative longitude is defined as the absolute value of the difference from the longitude of the earth station to that of the GSO satellite.

management system. One method employed by network operators is to broadcast satellite ephemeris data as part of a system bulletin board message that is repeated regularly. Earth stations operating in motion may download this updated ephemeris information and use it as part of the pointing solution to maintain accurate pointing toward the GSO satellite over time. This information is then used by the Antenna Control Unit (ACU), as well as information about the orientation of the antenna platform from an inertial reference unit (IRU) to calculate the earth station antenna pointing angles to the GSO satellite.

1.2 RF closed-loop tracking technique

The second technique – RF closed-loop tracking – employs an algorithm that minimizes the pointing error by analysis of a pre-determined signal received from the wanted GSO satellite. Since earth stations in motion can change their position on the earth continuously and GSO FSS spacecraft move about within their orbital station keeping limits, this technique may be more accurate than the open-loop method. The *RF closed-loop* automatic tracking technique consists in adjusting, at successive steps, the antenna pointing by maximising the strength of a reference signal or a carrier transmitted by the wanted space station. In addition to an accuracy that can be very high (up to $0.05 \cdot \theta_{3dB}$[3]), an advantage of this procedure is its autonomy, since the information used for tracking does not rely on the accuracy of the orbital data of the wanted GSO FSS satellite.

Furthermore, the precision with which the earth station in motion points at the wanted GSO FSS satellite can be increased and maintained by an *inertial platform* in which the earth station antenna is installed. Such platforms are equipped with angular rate gyroscopes that can accurately measure the angular speed in pitch, yaw and roll to allow the servo-loops of the ACU to account for the platform's motion.

Figure 2a and *Figure 2b* provide example block diagrams for earth station antenna systems using *open-loop* pointing and using *RF closed-loop* tracking, respectively. The figures illustrate the relationships between the different elements composing the typical antenna system used by an earth station in motion to perform the pointing and tracking of the wanted satellite network.

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[3] θ_{3dB} is the 3 dB angular width of the earth station in motion antenna and can be approximated by the following:

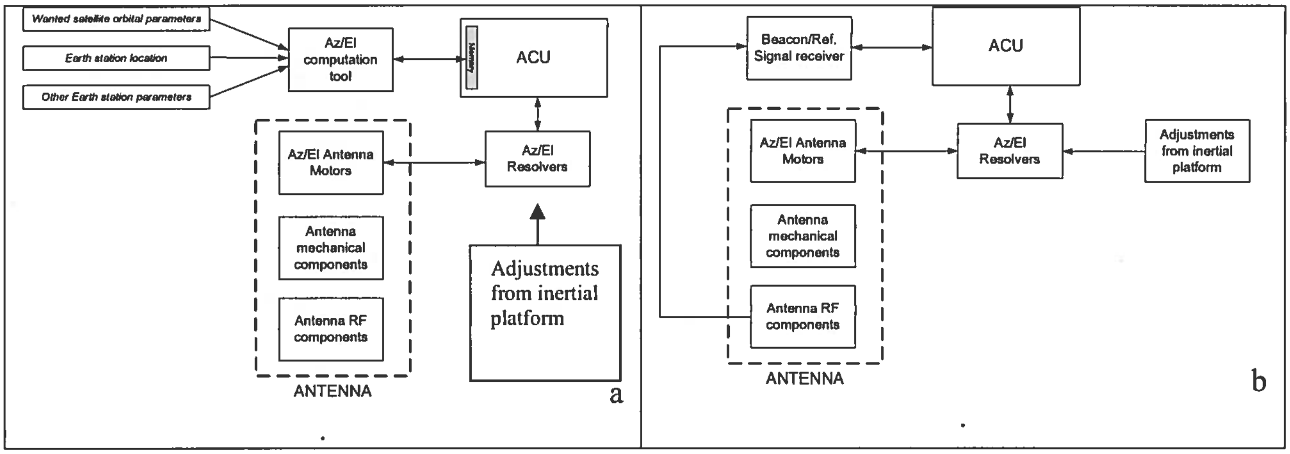
$$\theta_{3dB} = 70\,\frac{\lambda}{D}$$

where:

λ is the transmission wavelength (in m); and

D is the earth station antenna diameter (in m).

FIGURE 2



2 Summary

Meeting the limits specified in Annex 1 of this Resolution helps to minimize potential harmful interference from mis-pointing of earth stations in motion.

Taking into account the pointing accuracy and tracking capabilities of earth stations in motion, it is important to implement measures to ensure that GSO FSS satellite networks located near the wanted GSO FSS satellite do not receive harmful interference from these earth stations. This Annex provides two example measures that can be applied to ensure that earth stations in motion comply with the e.i.r.p. density limits specified above.

In the case of the open-loop pointing technique, the maximum mis-pointing of the earth station is determined by design and operational knowledge of wanted GSO satellite station keeping manoeuvers and the maximum transmitted e.i.r.p of the earth station is set accordingly to ensure that the recommended limits are met.

In the case of the *RF closed-loop* tracking technique, the antenna pointing is continuously adjusted by maximising a pre-determined signal received from the wanted GSO FSS satellite. The choice of the signal is up to the satellite operator – some employ a separate carrier, such as a satellite beacon, while others use the same wide band carrier as that used for the forward link. The technical parameters of the signal employed by the RF closed-loop algorithm are important and should be coordinated between GSO FSS satellite network operators. This is to ensure, the pointing error to the wanted geostationary satellite can be determined instantaneously, so that continuous adjustments to the transmitted e.i.r.p. can be applied, as needed. In the case of both open and closed loop systems, the earth station ceases transmission if it loses its wanted GSO FSS satellite acquisition.

Reason: Adoption of this proposal would provide the availability of 500 megahertz in both the uplink and downlink to support important and growing global broadband communication requirements for users on ships, airplanes, and land vehicles, on an equal basis in all three Regions and result in rational and efficient use of the radio spectrum resource. This also allows the coordination, notification and recording of these earth stations on an equal basis in all three Regions.