INVITED PAPER *Special Section on Satellite Communication Technologies in Conjunction with Main Topics of JC-SAT2015*

Topics Arising from the WRC-15 with Respect to Satellite-Related Agenda Items

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SUMMARY Along with remarkable advancement of radiocommunication services including satellite services, the radio-frequency spectrum and geostationary-satellite orbit are getting congested. WRC-15 was held in November 2015 to study and implement efficient use of those natural resources. There were a number of satellite-related agenda items associated with frequency allocation, new usages of satellite communications and satellite regulatory issues. This paper overviews the outcome from these agenda items of WRC-15 as well as the agenda items for the next WRC (i.e. the WRC-19).

key words: *world radiocommunication conference, spectrum allocations, satellite service, sharing and compatibility studies, IMT identification*

1. Introduction

A WRC (World Radiocommunication Conference) is convened in order to consider specific radiocommunication matters and undertake revisions of Radio Regulations (RR) every three to four years. The RR forms a part of the ITU (International Telecommunication Union) Convention and stipulates various provisions to facilitate equitable access to and rational use of the natural resources of the radio-frequency spectrum and the geostationary-satellite orbit. Frequency allocation to radiocommunication services over geographic regions is at the core of RR. Revisions of RR take place only at a WRC.

The WRC-15 was held in Geneva from November 2–27, 2015 with approximately 3,800 attendees from 162 member states [1].

In this paper, Sect. 2 describes the outline and structure of WRC-15 to provide the overview of the conference. Section 3 describes the outcomes from WRC-15 focusing on satellite related agenda items. Section 4 describes agenda items of WRC-19. In this section, agenda items related to terrestrial services (fixed and mobile services) are presented as well as satellite related agenda items since there are a number of agenda items to study sharing between satellite services and terrestrial services. Then, this paper is concluded.

2. Outline and Structure of WRC-15

The structure of WRC-15 is shown in Figure 1. In the conference, agenda items were considered in the following manner:

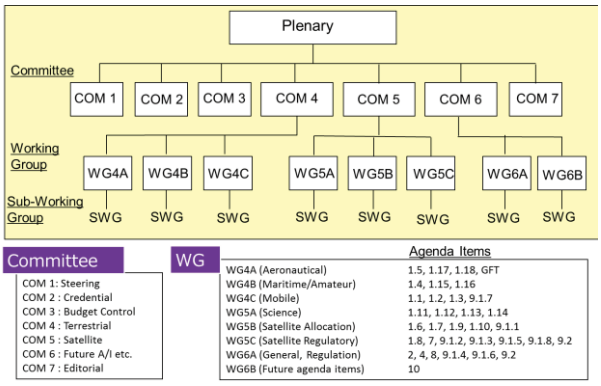

Fig. 1 Structure of WRC-15.

- The agenda items were agreed to at the previous WRC (the WRC-12 in this case) and finalized by the following Council.
- Agenda items were considered within the hierarchy consisting of the Plenary, Committees, Working Groups (WGs) and Sub Working Groups (SWGs) as shown in Fig. 1.
- The management members of the conference (i.e. the Chairman/ Vice Chairmen of Plenary and the Chairman of Committees) were appointed taking into account geographical distribution and balance.
- In consideration of each agenda item, the relevant part of the Conference Preparatory Meeting (CPM) Report* was referred to. In the CPM Report, the background, the summary of studies, methods to satisfy the agenda item and regulatory/procedural considerations on the agenda item are described.

In a WRC, the final decision on a matter is subject to a vote although the chairman tries to resolve any issues by consensus (i.e. tries to avoid putting an issue to a vote) during a meeting. If an issue goes to a vote as a last resort, each member state is equally entitled to cast a ballot. This implies that a proposal by a group of countries is more powerful than that by a single country. It should be also noted that six regional groups consisting of APT (Asia Pacific Telecommunity), ASMG (Arab Spectrum Management

Manuscript received February 11, 2016.
Manuscript revised June 6, 2016.
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DOI: 10.1587/transcom.2016ATI0001

*The CPM Report covers all the agenda items of the WRC. For each agenda item, a "responsible group", which is normally a working party of ITU-R Study Group (see footnote 2), is appointed to draft the texts of the agenda item. The CPM Report is finalized at the CPM which is held about 6 months prior to the WRC.

Group), ATU (African Telecommunications Union), CEPT (Conference of European Postal and Telecommunications Administration), CITEL (The Inter-American Telecommunication Commission) and RCC (Regional Commonwealth in the field of Communications) hold regional preparatory meetings prior to the conference in order to establish common proposals on agenda items so that they can gain an advantage in the consideration of issues through the power that a group of countries can wield. The revised provisions of RR come into force on January 1 in the second year following the WRC (i.e. January 1, 2017 in the case of WRC-15).

The agenda items of the WRC-15 relating to satellite services are listed in Table 1 [2]. Under agenda item 9.1, there are eight issues (9.1.1 to 9.1.8) and four of them are satellite-related issues. As shown in Table 1, there are many satellite-related agenda items for which the responsible groups for preparing the relevant part of CPM Report are WPs of ITU-R Study Group 4 (i.e. WP4A, WP4B or WP4C)[†].

Note that Region 1, Region 2 and Region 3 represents the following geographical areas specified in the RR:

Region 1: Europe/Africa/Middle East (including Iraq, the former Soviet Union and Mongolia)

Region 2: the Americas, Greenland and some eastern Pacific islands

Region 3: Asia and Oceania (including Iran)

3. Outcomes from the WRC-15

In this section, major outcomes of satellite-related agenda items of the WRC-15 are presented and discussed [3].

3.1 Frequency Allocations for Satellite Services

Frequency allocations for satellite services (FSS and MSS) were considered in the context of a number of agenda items. The results of the considerations on these agenda items are summarized in Table 2.

There were a number of agenda items for new allocations to FSS/MSS below 30 GHz. However, in summary, no major allocations were agreed to due to difficulties in sharing with terrestrial and passive services.

3.2 New Usages of Satellite Communications

New usages of satellite communication were considered under several agenda items. The results of considerations on these agenda items are described in the following.

Table 1 List of agenda items of WRC-15 (Relating to satellite services).

Agenda item	Topic	Responsible group
1.5	Use of frequency bands allocated to the FSS for the control and non-payload communications of UAS (*1) in non-segregated airspaces	WP5B
1.6.1/ 1.6.2	Additional primary allocations to the FSS in 10-17 GHz band in Region 1 and 13-17 GHz band in Region 3	WP4A
1.7	Compatibility between new systems of the ARNS (*2) and FSS in 5091-5150 MHz	WP4A
1.8	Provisions relating to ESV (*3) operating in FSS networks in the 6 GHz and 14 GHz bands	WP4A
1.9.1/ 1.9.2	Allocation to the FSS and MSS in the 7-8 GHz band	WP4A WP4C
1.10	Additional primary allocations to the MSS within the 22-26 GHz band	WP4C
7	Implementation of Resolution 86 of the Plenipotentiary Conference	WP4A SC(*5)
9	Report of the Director, BR (*6)	
9.1	Activities of the Radiocommunication Sector since WRC-12	(*4)
9.2	Any difficulties or inconsistencies encountered in the application of the Radio Regulations;	N/a
9.3	Action in response to Resolution 80 (Rev.WRC-07)	WP4A
10	Preliminary agenda for the subsequent conference and on possible agenda items for future conferences	
Special	Global Flight Tracking (GFT) for civil aviation	N/a

(*1) Unmanned Aircraft Systems

(*2) Aeronautical Radio Navigation Service

(*3) Earth Stations on board Vessels

(*4) The responsible group is different depending on the issue (9.1.1-9.1.8).

(*5) SC stands for "Special Committee" which addresses procedural and regulatory matters.

(*6) BR stands for Radiocommunication Bureau which provides administrative and technical support in activities of ITU-R.

3.2.1 Global Flight Tracking (GFT)

Worldwide discussions on the need for global flight tracking were spurred following the disappearance and tragic loss of Malaysian Airlines Flight MH370 in March 2014 with 239 people on board. In addition, the need for coordinated action by ITU and other relevant organizations was recognized. In October 2014, the ITU Plenipotentiary Conference meeting (PP-14) in Busan instructed WRC-15 to consider global flight tracking as part of its agenda as a special arrangement. In WRC-15, an agreement was reached on the allocation of radio-frequency spectrum for global flight tracking in civil aviation for improved safety, that is, to allocate the frequency band of 1087.7–1092.3 MHz to the aeronautical mobile-satellite service (Earth-to-space) for reception by space stations of the Automatic Dependent Surveillance-Broadcast (ADS-B) signals from aircraft transmitters. This will facilitate reporting the position of aircraft equipped with

[†]In ITU Radio Communication sector (ITU-R), there are 6 Study Groups (SG1, SG3, SG4, SG5, SG6 and SG7). SG 4 is responsible to study matters of satellite services. SGs set up Working Parties (WPs) to facilitate completion of their works. The SG4 has 3 WPs (WP4A, WP4B and WP4C). WP4A is responsible for efficient uses of the spectrum and orbit of Fixed Satellite Service (FSS) and Broadcast Satellite Service (BSS). WP4C is responsible for those of Mobile Satellite Service (MSS) and Radio Determination Satellite Service (RDSS). WP4B is responsible for system/performance issues of FSS, BSS and MSS.

Table 2 Results of frequency allocations for satellite services.

Agenda item	Results
1.6.1/ 1.6.2	(a)The frequency band 13.4-13.65 GHz is allocated to the downlink (space-to-Earth) of FSS in Region 1. (b)The frequency bands 14.5-14.75 GHz in Region 1 and 2 and 14.5-14.8 GHz in Region 3 are allocated to the uplink (Earth-to-space) of FSS. (*1)(*2)
1.7	The FSS allocation in 5091-5150 MHz is to be maintained even after 2016.
1.9.1	No additional allocation for FSS in 7-8 GHz band.
1.9.2	The frequency band 7375-7750 MHz is allocated to the downlink of the maritime mobile satellite service (MMSS).
1.10	No additional allocation for MSS in 22-26 GHz band.

(*1) In the use of this frequency band for FSS, the limitation on feeder links for BSS is removed in some countries (30 countries in Regions 1 & 2 and 9 countries in Region 3).
(*2) Such use of FSS is subject to technical and operational conditions such as:
- FSS earth stations have a minimum antenna diameter of 6 m.
- The power flux density produced by the earth station does not exceed -151.5 dB(W/m^2/4 kHz) at all altitudes from 0 to 19000 m above sea level at 22 km seaward from all coasts.
- The location of the earth station shall keep a separation distance of at least 500 km from the border of other countries unless shorter distances are explicitly agreed to.

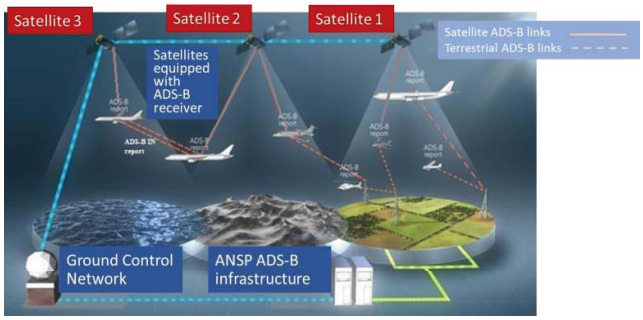

Fig. 2 Concept of global flight tracking system.

ADS-B anywhere in the world, including oceanic, polar and other remote areas as shown in Fig. 2 [4]. The International Civil Aviation Organization (ICAO) will address the performance criteria for satellite reception of ADS-B signals according to its established Standards And Recommended Practices (SARPs) [5].

3.2.2 Unmanned Aircraft System (UAS)

In WRC-12, regulatory actions and allocations regarding the UAS was considered. As a result, 5030–5091 MHz band was allocated to AM(R)S[†] and identified for the use of UAS. It was also agreed to further study the use of FSS for Control and Non-Payload Communication (CNPC) links in non-segregated airspaces in WRC-15. WRC-15 agreed that the FSS bands of 11/12/14/20/30 GHz are to be used for CNPC links of UAS in non-segregated airspaces through consideration of agenda item 1.5. This will enable the control of an aircraft flying in oceanic regions over satellite links. The agreement opened the way for the development by ICAO of worldwide standards for UAS, and identified the regulatory conditions that may be applied to such a system internationally. The resolution of WRC-15 on regulatory provisions concerning the operation of UAS contains the following major elements:

- The relevant international aeronautical standard (SARPs) shall be adopted by ICAO prior to commencement of the use of UAS.
- The UAS shall be designed so as to be able to accept the interference from terrestrial services and other FSS networks.
- The UAS shall not cause harmful interference to terrestrial services of other administrations (in particular, pfd limits to protect fixed services are specified in the 14 GHz band) or to other FSS networks.
- The assignment associated with the FSS networks for UAS CNPC links shall be the one that has been successfully coordinated under Article 9 and recorded in the Master International Frequency Register (MIFR)[††] with favorable findings.
- The progress of implementation of UAS CNPC links including the development of SARPs by ICAO will be reviewed at the subsequent WRCs (i.e. WRC-19 and WRC-23).

3.2.3 Earth Stations in Motion (ESIM) and Earth Stations Onboard Vessels (ESV)

WRC-15 agreed to facilitate the global deployment of Earth Stations In Motion (ESIM) in the 19.7–20.2 and 29.5–30.0 GHz frequency bands in the FSS, paving the way for satellite systems to provide global broadband connectivity for the transportation community by realizing the ESIM concept. Earth stations on-board moving platforms, such as ships, trains and aircraft, will be able to communicate with high power multiple spot beam satellites, allowing transmission rates in the order of 10–50 Mbit/s [6]. Note that this subject was not listed in the agenda items of WRC-15 such as 1.XX but was considered under agenda item 9.2 (“any difficulties or inconsistencies encountered in the application of the Radio Regulations” in the Report of BR Director) as a special exception. A new resolution with respect to the use of ESIM such as the off-axis e.i.r.p. density levels and the protection of terrestrial systems operating in the same frequency band was adopted. The off-axis e.i.r.p. density levels requirements of ESIM are equivalent to those of “fixed” (not in motion) earth stations as specified in Recommendation ITU-R S.524-9.

The provisions relating to operational conditions of

[†]Aeronautical mobile (R) service reserved for communications relating to safety and regularity of flights primarily along national or international civil air routes.

[††]The MIFR contains frequency assignments by administrations. The international rights and obligations of administrations in respect of their own and other administrations frequency assignments shall be derived from the recording of those assignments in the MIFR.

ESV (Earth Station onboard Vessel) were reviewed under agenda item 1.8. In particular, the minimum distances from the coastline without prior agreement from the coastal state ("minimum distances") and the minimum antenna diameter of ESV were studied taking into account the number of passes of ships and reduction of maximum e.i.r.p. spectral density towards horizon in 6 GHz and 14 GHz band in order to duly protect stations of fixed service. It was assumed that the smaller the antenna diameter of ESV, the more frequently ships pass leading to more interference. As a result, a new provision to allow ESV antennas with a minimum diameter of 1.2 m in the 6 GHz band was adopted on the condition that the minimum distance be 330 km in this case in addition to the existing minimum distance of 300 km with a minimum antenna diameter of 2.4 m. No changes were invoked pertaining to the provisions for the 14 GHz band.

3.3 Satellite Regulatory Issues

Satellite regulatory issues were extensively discussed under agenda items 7 and 9.

3.3.1 Review of an Advanced Publication, Coordination, Notification and Recording Procedures for Frequency Assignments Pertaining to Satellite Networks

Agenda item 7 is to consider possible changes and other options in an advance publication, coordination, notification and recording procedures for frequency assignments pertaining to satellite networks, in accordance with Resolution 86 (Rev.WRC 07) to facilitate rational, efficient, and economical use of radio frequencies and any associated orbits, including the geostationary satellite orbit. Under this agenda item, 20 issues were discussed in WRC-15. Major outcomes are as follows:

- It was agreed to bypass the Advanced Publication of Information (API)[†] mechanism for satellite networks subject to coordination. Instead, an API is automatically generated as soon as a new coordination request is received by the BR. As a result of this modification, the procedure is simplified and is expected to be accelerated. In particular, it becomes possible for an administration to start the coordination of a new satellite network without waiting for six months, which is a constraint in the existing procedures. As a result of introduction of the new concept, a number of changes have been invoked in the provisions in Articles 9 and 11. A new resolution to specify the transitional measures for the elimination of API was adopted since the application of existing API shall be terminated six months before the enforcement of revised RR (i.e. 1 January 2017). It should be noted that the API mechanism for satellite networks not subject to coordination remains the same.
- WRC-15 discussed the issue on the utilization of one space station to bring frequency assignment at different orbital locations into use within a short period of time (so called "satellite hopping" issue) and adopted a new resolution on this issue. The satellite hopping derives from the situation where a frequency assignment in an orbital location may be cancelled unless it is duly brought into use within a specified duration. The essence of the new resolution is that the notifying administration shall provide the BR with the information on the space station such as its last orbital location where the space station was used to bring into use (BIU)[††] frequency assignments, the satellite network with which the frequency assignments above were associated and so forth when a space station that has previously been used at a different orbital location within past three years is used for the BIU of a new frequency assignment. This mechanism would contribute to alleviating the "satellite hopping" problem by making the associated information more transparent.
- RR No. 11.49 is to specify that an administration is allowed to suspend the use of a recorded frequency assignment to a space station for three years and to also oblige the administration to inform the BR of the suspension as soon as possible when it lasts for longer than six months. However, there had not been any regulatory procedures to address the possible situation of an administration failing to inform the BR accordingly. In WRC-15, RR No. 11.49 was modified so that a three-year allowance period for suspension shall be reduced by the amount of delay in the information to the BR from the initial six months (e.g. if the administration informs the BR ten months after the start of suspension, the allowance for suspension will be 32 months (four months are deducted) instead of 36 months.). It is expected that administrations would be encouraged to submit a report of suspension in a timely manner by introducing this new mechanism.

3.3.2 Reduction of the Coordination Arc and Technical Criteria Use in Application of RR 9.41 in Respect of Coordination under RR 9.7

The use of orbit and spectrum resources is increasing and there are more difficulties in getting access to spectrum for new satellite networks. For these reasons, improved ways to accommodate new networks and facilitating more efficient use of the spectrum resources are sought while at the same

[†]As a first step in the process of frequency coordination and notification (Article 9 and 11 in RR), an administration was required to submit characteristics of satellite networks and systems they intended to effect coordination with other administrations 6 month prior to initiating the coordination to inform other administrations of a new incoming satellite network.

[††]The BIU indicates that a new frequency assignment is brought into use for its operation. If such an assignment is not brought in use or suspended for a certain period of time, it may be cancelled in accordance with relevant provisions of RR.

time ensuring sufficient protection of existing networks operating in accordance with the RR. WRC-12 decided to reduce the coordination arc in the 6/4 GHz and 14/10/11/12 GHz frequency bands, but also decided to further study possible additional reductions in the coordination arcs[†] as well as to examine the effectiveness and appropriateness of the current criterion ($\Delta T/T > 6\%$) used in the application of RR No. 9.41, where an administration operating a satellite network outside the coordination arc is entitled to submit a request to the BR for its inclusion into the list of satellite networks to be coordinated, and consider any other possible alternatives. WRC-15 adopted a new resolution on this matter containing the following elements:

- The coordination arc of the 6 GHz band is reduced from 8 to 7 degrees.
- The coordination arc of the 14/10/11/12 GHz band is reduced from 7 to 6 degrees.
- No changes to the coordination arc of 30/20 GHz (8 degrees).
- The power flux density (pfd) values are newly introduced as the criteria to assess the probability of harmful interference under RR No. 11.32A in the 6 GHz band (not for the 4 GHz band) and 14/10/11/12 GHz band. These pfd criteria are applied only to the satellite networks outside the coordination arc.
- No changes to the criteria in the application of RR 9.41.

As a result of further reduction in the coordination arc, coordination procedures would be accelerated by decreasing the number of satellite networks to be coordinated with. Also, the introduction of pfd criteria in the application of RR 11.32A would simplify the examination procedure as it is a single criterion unlike the C/I criterion which had been used in its application. (In the C/I criterion, the threshold value would vary depending on the transmission power of satellite and the antenna sizes of earth stations. Therefore, it cannot be a single criterion.)

4. Agenda Items of WRC-19

In this section, WRC-19 agenda items are explained from the perspectives of sharing and compatibility studies to/from International Mobile Telecommunications (IMT) systems, based on the results from the first session of the Conference Preparatory Meeting for WRC-19 (CPM19-1) held immediately after WRC-15. The sharing and compatibility studies are subjects to be completed by WRC-19 for investigating feasibility of sharing and compatibility between IMT and other services including satellite related. This section is organized from the viewpoint of IMT because IMT involves many frequency bands for its sharing with other services among agenda items of WRC-19 therefore such structure would help understanding overview of WRC-19 topics.

[†]In the coordination process between geostationary satellite networks, a new FSS network is obliged to coordinate with any FSS networks with a space station within the orbital arc of certain angular separation from the nominal orbital position of the space station of new FSS network ("coordination arc") unless requested in accordance with RR 9.41 (see above).

Table 3 WRC-19 agenda items related to IMT and satellite.

WRC-19 agenda item	Topics	Responsible group
1.13	Additional band for IMT	TG 5/1[*1]
9.1 (issue 9.1.1)	Terrestrial and satellite components of IMT	WP 4C (for satellite component of IMT) WP 5D (for terrestrial component of IMT)
9.1 (issue 9.1.2)	IMT and BSS (sound)[*2] of 1 452-1 492 MHz in R1 and R3	WP 4A (for BSS (sound)) WP 5D (for IMT)

[*1] The creation of TG 5/1 will be discussed at the meeting of Study Group 5 to be held in May 2016.
[*2] BSS (sound) means broadcasting-satellite service for audio broadcasting.

4.1 Sharing and Compatibility Studies for IMT with Incumbent Services

CPM19-1 decided allocation of ITU-R preparatory tasks for WRC-19 and WP 5D was assigned some of the agenda items as the responsible or concerned group [7]. Table 3 indicates agenda items where WP 5D is the responsible group or responsible for some elements within the agenda items. Under the agenda items, WP5D needs to study spectrum-related issues and prepare appropriate outputs such as draft CPM texts.

4.1.1 Additional Band for IMT under WRC-19 Agenda Item 1.13

CPM19-1 agreed to study frequency-related matters for IMT identification including possible additional allocations to mobile service on a primary basis in the portion(s) of the frequency range between 24.25 and 86 GHz for the future development of IMT for 2020 and beyond.

ITU-R was invited to conduct and complete appropriate sharing and compatibility studies in time for WRC-19, taking into account the protection of services to which the band is allocated on a primary basis, for the following frequency bands:

- 24.25–27.5 GHz, 37–40.5 GHz, 42.5–43.5 GHz, 45.5–47 GHz, 47.2–50.2 GHz, 50.4–52.6 GHz, 66–76 GHz and 81–86 GHz, currently allocated to mobile service on a primary basis
- 31.8–33.4 GHz, 40.5–42.5 GHz and 47–47.2 GHz, required additional allocations to mobile service on a primary basis

The outcome of the CPM19-1 gave the responsibility for carrying out interference studies and drafting the CPM text to Task Group 5/1 (TG 5/1), the creation of which will be discussed at the meeting of Study Group 5 scheduled in May 2016.

4.1.2 Terrestrial and Satellite Components of IMT under WRC-19 Agenda Item 9.1 (issue 9.1.1)

CPM19-1 decided to initiate study for implementation of IMT in the frequency bands 1 885–2 025 MHz and 2 110–2 200 MHz. It was invited to study possible technical and operational measures to ensure coexistence and compatibility between the terrestrial component of IMT and the satellite component of IMT in the frequency bands 1 980–2 010 MHz and 2 170–2 200 MHz where those frequency bands are shared by mobile service and the mobile-satellite service in different countries, in particular for the deployment of independent satellite and terrestrial components of IMT and to facilitate development of both the satellite and terrestrial components of IMT. WP 5D is responsible for study on the terrestrial component of IMT, whereas WP 4C is responsible for study on the satellite component of IMT.

4.1.3 IMT and Broadcasting Satellite Service (BSS) (sound) in Regions 1 and 3 under WRC-19 Agenda Item 9.1 (issue 9.1.2)

CPM19-1 agreed to initiate study on the compatibility of IMT and BSS (sound) in the frequency band 1 452–1 492 MHz in Regions 1 and 3. Study is required to determine the need for bilateral coordination between IMT systems and BSS earth stations until WRC-19 defines regulatory and technical conditions for this bilateral coordination. It was also decided that WP 5D should be the group responsible for the study with respect to IMT systems, and that WP 4A should be the group responsible for the study with respect to BSS (sound). WP 5D will need to liaise with WP 4A to consider its work plan and complete the study.

4.2 Sharing and Compatibility Studies among WRC-19 Agenda Items

Under three agenda items of WRC-19 in Table 4 targeting frequency bands overlap with some portions of those studied in WRC-19 agenda item 1.13. Since it was identified in CPM19-1 that there were several frequency band overlaps among the agenda items of WRC-19 in Table 5, it is necessary to conduct sharing and compatibility studies between services for the overlapped frequency bands concerned.

In the following agenda items actions are required for conducting and completing studies in time for WRC-19.

4.2.1 NGSO FSS under WRC-19 Agenda Item 1.6

CPM19-1 agreed to initiate studies, as the responsible group in WP 4A, of technical, operational issues and regulatory provisions for non-geostationary fixed-satellite services satellite systems in the frequency bands 37.5–39.5 GHz (space-to-Earth), 39.5–42.5 GHz (space-to-Earth), 47.2–50.2 GHz (Earth-to-space) and 50.4–51.4 GHz (Earth-to-space).

Table 4 WRC-19 agenda items related to IMT bands.

WRC-19 agenda item	Topic	Responsible group
1.6	NGSO FSS in various IMT bands	WP 4A
1.14	HAPS in fixed service	WP 5C
9.1 (issue 9.1.9)	FSS (Earth-to-space) in 51.4-52.4 GHz	WP 4A

Table 5 Overlapped frequencies among WRC-19 agenda items.

1.6 NGSO FSS	1.13 IMT	1.14 HAPS	9.1 (Issue 9.1.9) FSS
	24.25-27.5	24.25-27.5 (Region 2)	
37.5-39.5 (s-E*)	37-40.5	38-39.5 (globally)	
39.5-42.5 (s-E*)	40.5-42.5		
47.2-50.2 (E-s*)	47.2-50.2		
50.4-51.4 (E-s*)	50.4-52.6		51.4-52.4 (E-s*)

* E-s: Earth-to space; s-E: space-to-Earth.
Note: Values in this table express frequencies in GHz

It is noted that there are overlaps of frequency bands in agenda item 1.13 for 37.5–42.5 GHz (space-to-Earth), 47.2–50.2 GHz (Earth-to-space) and 50.4–51.4 GHz (Earth-to-space).

4.2.2 HAPS in Fixed Service under WRC-19 Agenda Item 1.14

CPM19-1 agreed to study, as the responsible group in WP 5C, how to facilitate access to broadband applications delivered by high-altitude platform stations. ITU-R was invited to study additional spectrum needs for gateway and fixed terminal links for HAPS to provide broadband connectivity in the fixed service. In order to meet any spectrum needs, the following frequency bands already allocated to the fixed service on a primary basis are to be studied.

- 38–39.5 GHz on a global level
- 21.4–22 GHz and 24.25–27.5 GHz in Region 2 on a regional level

There are overlaps of the frequency bands in agenda item 1.13 for 24.25–27.5 GHz in Region 2 and 38–39.5 GHz globally.

4.2.3 FSS (Earth-to-space) in 51.4–52.4 GHz under WRC-19 Agenda Item 9.1 (issue 9.1.9)

CPM19-1 agreed to initiate studies, as the responsible group in WP 4A, related to spectrum needs and possible allocation of the frequency band 51.4–52.4 GHz to the fixed-satellite service (Earth-to-space). Taking into account the fact that the frequency band is currently allocated to fixed and mobile services, studies need to be conducted for new primary allocations to the FSS in the frequency band limited to FSS feeder links for geostationary orbit use.

It should be noted that there is overlap of a frequency

band in agenda item 1.13 for 51.4–52.4 (Earth-to-space).

4.3 Other Important Features Related Sharing and Compatibility Studies Towards WRC-19

Technical study to develop IMT system modes for use in sharing and compatibility studies and a study on ESIM under WRC-19 agenda item 1.5 are explained in the following Sects. 4.3.1 and 4.3.2, respectively.

4.3.1 Modelling and Simulation of IMT Networks for Use in Sharing and Compatibility Studies

Having proceeded to the sharing and compatibility studies described in Sects. 4.1 and 4.2, WP 5D is required to develop a new ITU-R Recommendation on modelling and simulation of transmissions from IMT networks for use in sharing and compatibility studies with the completion target being no later than March 31, 2017. The developed new Recommendation would contain the methodology for modelling and simulation of IMT networks for use in sharing and compatibility studies between IMT and other systems including satellite related [8]. It is therefore important to incorporate those necessary modelling for sharing and compatibility scenarios between IMT and satellite related services in order to reflect realistic modelling. In higher frequency bands where the focus is consideration of IMT identification, smaller coverage is typically provided due to the propagation characteristics. In this case, applying a specific operation concept for local coverage might be appropriate [9]. Considering IMT systems in higher frequency bands are generally used to serve local coverage areas using small cells and hot spot deployments, extending modelling of IMT networks based on deployment scenarios and propagation characteristics are subjects for further study.

4.3.2 ESIM under WRC-19 Agenda Item 1.5

CPM19-1 decided to initiate studies on use of the frequency bands 17.7–19.7 GHz (space-to-Earth) and 27.5–29.5 GHz (Earth-to-space) by ESIM communicating with geostationary space stations in FSS. It is invited to study in ITU-R the technical and operational characteristics and user requirements of different types of ESIM that operate or plan to operate within GSO FSS allocations in those frequency bands. The frequency bands are targeted to extend continuously those allocated in WRC-15 as explained in Sect. 3.2.3, considering some of needs for mobile communications including global broadband satellite services can be met by allowing ESIM in those frequency bands. It is, therefore, required to study for sharing and compatibility between ESIM operating with GSO FSS networks and current and planned stations of existing services allocated in the frequency bands to ensure protection of services allocated in the bands.

5. Conclusion

Major outputs of satellite-related agenda items at WRC-15 are summarized as follows:

- There were a number of agenda items for new allocations to FSS/MSS below 30 GHz. However, no major allocations were agreed to due to difficulties in the sharing with terrestrial and passive services.
- New usages of the FSS frequency band for mobile platforms such as ESIM and UAS were agreed on. Also, the 1090 MHz band was allocated to AMS(R)S[†] to implement a global flight tracking system.
- Because of heavy congestion of GSO, regulatory provisions for coordination and notification were vigorously reviewed anticipating continued discussion in the next cycle towards WRC-19.

Major topics arising out of the satellite-related agenda items at WRC-19 are summarized as follows:

- A number of agenda items relating to compatibility between IMT and satellite services have been raised. (Terrestrial/ satellite IMT in 2 GHz band, BSS (sound) and IMT in 1.4 GHz band and some portions of the frequency range 24.25–86 GHz under agenda item 1.13.) Assuming that there are difficulties associated with new allocations below 24 GHz, a number of agenda items for the possible use of higher frequency bands have been suggested. Sharing and compatibility studies between IMT and other services, i.e. FSS, NGSO FSS and FS, are to be conducted considering realistic modelling and simulation of IMT networks for the studies.
- It was agreed to study on one of important topics for future satellite communication, extending frequency bands for ESIM to meet a need for mobile communications including global broadband satellite services towards WRC-19.

Recently, innovations in satellite communication technologies (spacecraft, earth stations and so forth) are under way towards providing novel and evolved uses of satellite communications. On the other hand, the radio-frequency spectrum and geostationary satellite-orbit, which are essential elements to realize innovative satellite services and uses, are getting congested. As a matter of fact, a number of subjects dealt with in recent WRCs are related to sharing and co-existence between radiocommunication services. It would be worth for researcher of satellite communications overviewing the outcome of WRC-15 and keeping an eye on discussions on concerning agenda items towards WRC-19.

[†]Aeronautical Mobile Satellite Service reserved for communications relating to safety and regularity of flights primarily along national or international civil air routes.

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