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SPECTRUM ASPECTS &
WRC-23 PREPARATIONS

ITU-APT Foundation of India (IAFI)¹

NEXT STEPS ON RR No. 21.5

1 Introduction

From [WRC-19 Document 550](#) and the [minutes of the twelfth WRC-19 Plenary meeting](#): “ITU-R is invited to study, as a matter of urgency, the applicability of the limit specified in No. 21.5 of the Radio Regulations to IMT stations, that use an antenna that consists of an array of active elements, with a view to recommend ways for its possible replacement or revision for such stations, as well as any necessary updates to Table 21-2 related to terrestrial and space services sharing frequency bands. Furthermore, the ITU-R is invited to study, as a matter of urgency, verification of No. 21.5 regarding the notification of IMT stations that use an antenna that consists of an array of active elements, as appropriate.” (**Responsible Group: Working Party (WP) 5D**)”.

2 Discussion

Various issues relating to the applicability of the limit specified in RR No. 21.5 to the active antenna systems (AAS) used by IMT stations has been discussed in previous WP 5D meetings as well as during WRC-19 (Refer WRC-19 Document 550).

After the last meeting of WP 5D, the issue was discussed between chairman of SG 4 and SG 5. Note from the Chairmen of Study Group 4 and Study Group (SG) 5 to Working Parties 4A, 4C and 5D in Document [5D/407](#) may be seen in this regard. In this meeting, the following was agreed:

- “a) WP 5D should continue to work, discuss, and develop a working document in order to responds to the questions from BR on this issue and progress this document to a certain level of stability, keeping in view the protection of satellite services and the provisions of Resolution 242 (WRC-19) in mind.
- c) Once the work in WP 5D has reached a level of maturity, the results may be liaised back to WPs 4A and 4C before the document is finalized by the WP 5D and sent to the BR Director.

¹ ITU-APT Foundation of India (IAFI) is a new Sector Member of ITU-R. Details of IAFI can be seen at itu-apt.org.

- d) If needed, a joint session between experts from WPs 4A, 4C and 5D should be organised, to clarify that satellite service protection is not impacted.”

The discussion of RR No. **21.5** emanates from the need to ensure interference free operations between co-primary services.

It is essential to maintain an interference free operations environment for all Radio services. IAFI also notes that after an extensive study by Task Group (TG) 5/1 of WRC-19 cycle, the outcome of WRC-19 towards the identification of IMT spectrum bands above 24 GHz vide provisions of Resolution **242 (WRC-19)** ensured the protection of other co-primary services including satellite services. It is noted that RR No. **21.5** applies to all fixed and mobile stations (operating in the applicable frequency bands) and applies irrespective of whether the stations are notified to the BR.

It is further noted that IMT systems have been using MIMO and as and when required, these IMT stations have been notified to the ITU-R through the existing process. RR No. **21.5** limits the power delivered by “a transmitter to the antenna of a station”. There is a concern that applying the RR No. **21.5** limit to the power delivered to each radiating element of an AAS antenna could result in a significant increase in the radiated power to space stations operating in the same frequency bands, which could lead to excessive interference. It is clear that RR No. **21.3** limits the equivalent isotropically radiated power (e.i.r.p.) of a station, i.e., the collection of transmitters and antennas, set at +55 dBW. However, noting that this value of +55 dBW as mentioned in RR No. **21.3** is also a typical value for a VSAT e.i.r.p., it can be seen that this limit is not an effective limit on its own to protect satellite uplinks.

Broadly there are two possible approaches regarding RR No. **21.5**:

- (1) that the RR No. **21.5** applies to the total power delivered to the antenna where an antenna consists of an array of active elements;
- (2) that the RR No. **21.5** applies to each individual radiating element of an array of active elements.

3 Proposal

Noting the agreement in Document 5D/407, It is proposed that WP 5D should proceed with the further development of the working document towards a draft “Note to the Director of the Radiocommunication Bureau on urgent studies requested by WRC-19 in Document 550”, based on the document carried forward from the previous meeting. In this contribution, further changes are proposed to this document in the attachment to this contribution. Our contributions are highlighted

ATTACHMENT 4.9

Source: Document 5D/TEMP/241(Rev.2)

Working document towards a draft Note to the Director of the Radiocommunication Bureau on urgent studies requested by WRC-19 in Document 550

Background

The applicability of the limit specified in RR No. **21.5** of the Radio Regulations to IMT stations, that use an antenna consisting of array of active elements was discussed by the WRC-19 as seen from [WRC-19 Document 550](#) –

“ITU-R is invited to study, as a matter of urgency, the applicability of the limit specified in RR No. **21.5** of the Radio Regulations to IMT stations, that use an antenna that consists of an array of active elements, with a view to recommend ways for its possible replacement or revision for such stations, as well as any necessary updates to RR Table **21-2** related to terrestrial and space services sharing frequency bands.

Furthermore, the ITU-R is invited to study, as a matter of urgency, verification of RR No. **21.5** regarding the notification of IMT stations that use an antenna that consists of an array of active elements, as appropriate.” (Responsible Group: WP 5D)

RR No. **21.5** states:

“**21.5** 3) The power delivered by a transmitter to the antenna of a station in the fixed or mobile services shall not exceed +13 dBW in frequency bands between 1 GHz and 10 GHz, or +10 dBW in frequency bands above 10 GHz, except as cited in No. **21.5A**. (WRC-2000)”

[However, “the power delivered by a transmitter to the antenna of a station” (i.e., conducted power), is not available in the case of IMT stations using an antenna that consist of an array of active elements.]

RR No. **21.2** states:

“**21.2** As far as practicable, sites for transmitting stations, in the fixed or mobile service, employing maximum values of equivalent isotropically radiated power (e.i.r.p.) exceeding the values given in Table **21-1** in the frequency bands indicated, should be selected so that the direction of maximum radiation of any antenna will be separated from the geostationary-satellite orbit by at least the angle in degrees shown in the Table, taking into account the effect of atmospheric refraction.

TABLE 21-1

| Frequency band (GHz) | e.i.r.p. value (dBW) (see also Nos. 21.2 and 21.4) | Minimum separation angle with respect to geostationary-satellite orbit (degrees) |
|--------------------------|--|--|
| 1-10 | +35 | 2 |
| 10-15 | +45 | 1.5 |
| 25.25-27.5 | +24 (in any 1 MHz band) | 1.5 |
| Other bands above 15 GHz | +55 | No limit ³ |

“

2 Overview of the issue

It is essential to maintain an interference free operations environment for all services that are allocated in accordance with the Radio Regulations. It is noted that RR No. 21.5 applies to all fixed and mobile stations (operating in the applicable frequency bands) and applies irrespective of whether the stations are notified to the BR or not.

IMT systems have been using MIMO and as and when required, these IMT stations have been notified to the ITU-R through the existing process. RR No. 21.5 limits the power delivered by “a transmitter to the antenna of a station”.

Application of the RR No. 21.5 limit to the power delivered to each radiating element of an AAS antenna could lead to erroneous results that will indicate a significant increase in the radiated power to space stations operating in the same frequency bands, leading to an interpretation of excessive interference.

It is clear that RR No. 21.3 limits the equivalent isotropically radiated power (e.i.r.p.) of a station, i.e., the collection of transmitters and antennas, set at +55 dBW. However, noting that this value of +55 dBW as mentioned in RR No. 21.3 is also a typical value for a VSAT e.i.r.p., it can be seen that this limit is not an effective limit on its own to protect satellite uplinks.

Broadly there are two possible approaches regarding RR No. 21.5:

- (1) that the RR No. 21.5 applies to the total power delivered to the antenna where an antenna consists of an array of active elements;
- (2) that the RR No. 21.5 applies to each individual radiating element of an array of active elements.

[Editor's notes: With respect to this issue, the meeting had received several proposals which are contained in the following part of this working document. They have been briefly discussed. No agreement has yet been reached on any of them.]

[Editor's note: On the request of the WP 5D, the BR provided informal information on this matter to the 36th meeting, as shown in the Annex to this working document.]

3 Proposed approaches

[Editor's notes: There are seven proposed approaches listed below, which can be put into two categories, Approach #1 to Approach #4 support Total Radiated Power or Power delivered to the antenna which indicate total power of all antenna elements of IMT station consists of an array of active elements, Approach #5 to Approach #7 support that “a transmitter” specified in the RR No. 21.5 to be interpreted as single/every transmitter.]

In order to address this issue, the following approaches were proposed so far.

Approach #1 *[Editor's note: Document 5D/45 (F), 5D/205 (F), 5D/287 (F)]*

In the case of IMT stations using an antenna that consist of an array of active elements, “the power delivered by a transmitter to the antenna of a station” is calculated as follows:

$$P = TRP - \varepsilon$$

where:

P power delivered to the antenna (dBW);

TRP Total Radiated Power (dBW);
 ε antenna efficiency (dB).

Updates from Document [5D/287](#).

Therefore, RR No. **21.5** should normally be applied as follows:

$$P_{conducted} < 10 \text{ dBW} \quad \text{or} \quad TRP < 10 \text{ dBW} + \varepsilon \text{ (dB)}$$

For example, with $\varepsilon = -3$ dB, the power limit from RR No. **21.5** above 10 GHz (+10 dBW) would correspond to a 37 dBm limit for Total Radiated Power.

Antenna efficiency could be taken into account in the application of RR No. **21.5** to AAS. The application of a bandwidth correction factor is not specific to AAS/IMT stations and may also be considered.

Approach #2 [Editor's note: Document 5D/172(Rev.1) (RUS), 5D/272 (RUS), see Attachment 1]

In the case of IMT stations using an antenna that consist of an array of active elements, "the power delivered by a transmitter to the antenna of a station" is calculated as follows:

$$P = P_{AE} \text{ (dBW)} + 10 \text{Log}(N) \text{ (dB)} - 10 \text{Log}\left(\frac{\Delta f}{200 \text{ MHz}}\right) \text{ (dB)} - 3 \text{ (dB)}$$

where:

P Power delivered to the antenna (dBW);
 P_{AE} Power of one active element in array of AAS (dBW);
 Δf Channel bandwidth (MHz);
 N Number of active elements in array of AAS.

Updates from Document [5D/272](#).

Verification of RR No. **21.5** temporarily for the of IMT stations which antenna is integrated with array of active elements shall be applied as follows:

$$P < 10 \text{ dBW}$$

where P is the value of Item 8AA from the notification form.

Approach #3 [Editor's note: Document 5D/185 (J), 5D/250 (J)]

In the case of IMT stations using an antenna that consist of an array of active elements, instead of "the power delivered by a transmitter to the antenna of a station", Total Radiated Power (TRP) is used as an alternative measure.

Update from Document [5D/250](#).

We consider that this limit on radiated power of a "station" in RR No. **21.3** alone would not be sufficient to provide adequate protection for the space services. ... We support utilizing the TRP when applying the limit in RR No. **21.5** to IMT stations using AAS.

When applying the limit in RR No. **21.5** to IMT stations using AAS, we support utilizing the TRP as an alternative measure rather than trying to convert the TRP to the power delivered to the antenna.

[i]f WP 5D could agree on using the TRP instead of the conducted power for RR No. **21.5** in the case of IMT stations using AAS, we would like to further discuss how to reflect this agreement into RR No. **21.5** and Appendix 4.

Approach #4 [Editor's note: Document 5D/326(ESOA)]

ESOA proposes that:

- RR No. **21.5** power limits should apply to all IMT stations consistently with the intention of the provision, which is to protect satellite reception.
- Necessary modifications to Article 21 be prepared to enable the RR No. **21.5** limits to be correctly applied to IMT antennas that use an array of active elements. This includes the application of a correction factor on RR No. **21.5** limits (limit on power delivered to the antenna) to take account of IMT antenna gain, efficiency and bandwidth. Some clarification of "antenna of a station" is also needed for application to active array antennas.
- An update of RR Table **21-2** is required to include bands identified for IMT by WRC-19 which are allocated to satellite services in the Earth-to-space direction and not yet included in RR Table **21-2**.

Approach #5 [Editor's note: Document 5D/181 (USA), 5D/285 (USA), see Attachment 2]

In the case of IMT stations using an antenna that consist of an array of active elements, "the power delivered by a transmitter to the antenna of a station" is interpreted as the power delivered by a single transceiver to the antenna of an IMT station.

Addition from Document [5D/285](#)

RR No. **21.5** is only required in the case when the radiated power is not supplied, it should not be mandatory for notification. Hence, administrations notifying IMT stations using AAS only need to provide the elements of radiated power in data item 8B for verification.

Approach #6 [Editor's note: Document 5D/311(EGY & UAE)]

Support the application of appropriate RR provisions to the relevant systems and services without any necessary revisions or modifications to the RR No. **21.5**.

RR No. **21.5** can be applied to the AAS system by considering every transmitter of the AAS system separately.

Approach #7 [Editor's note: Document 5D/300(GSMA), see Attachment 3]

In the case of IMT stations that use an antenna that consists of an array of active elements, RR No. **21.5** applies to the power delivered by a single transmitter to the radiating element(s) connected to that transmitter through the antenna transmission line (ref. RR Nos. **1.157** to **1.159**). It is also clear that RR No. **21.3** limits the equivalent isotropically radiated power (e.i.r.p.) of a station, i.e. the collection of transmitters and antennas, set at +55 dBW.

Section 2 proposed Notes to BR

[Editor's notes: Below are three proposed draft Notes to the Director of the BR received up to this meeting, however due to the divergences on some key issues, the meeting need to discuss and solve these divergences before determining the content of the Note to the Director of the BR.]

[Editor's notes: Below are some issues/questions extracted from the input contributions with regard to the direction at which the Note to the Director of the BR to be drafted

- 1 For IMT stations that use an antenna that consists of an array of active elements, what is the interpretation of "the power delivered by a transmitter to the antenna" as defined in RR No. **21.5** in the context of IMT station using AAS? The total power of all antenna elements or single power of one element?
- 2 For IMT stations that use an antenna that consists of an array of active elements, should 8AA in RR Appendix 4 be a mandatory field or optional? And, is radiated power 8B enough for verification of notification if/when 8AA is not provided.
- 3 How to obtain/measure the value of "power of one active element in array of AAS?"



[Editor's Note: On the request of the WP 5D, the BR provided informal information on this matter as shown in this Annex.]

ANNEX 2

Informal BR document concerning the Working Party 5D questions related to RR No. 21.5

BR is pleased to inform the Drafting Group (DG) Article 21.5 of the requested clarifications.

1 *What does BR expect from WP 5D?*

When it receives a notice, BR examines its conformity with respect to No. **11.31** of the Radio Regulations. For an assignment made to a station of the terrestrial service in a frequency band shared with the space service (Earth-to-space), it examines compliance of the notice with respect to criteria given in RR Nos. **21.3**, **21.4**, **21.5** and **21.5A**.

According to Appendix 4 of the RR, for an assignment in the frequency bands allocated to the terrestrial services shared with the space services, the data elements 8AA (power delivered to the antenna) and 8B (maximum radiated power) are mandatory to be notified.

For a station having an active antenna system (AAS), some administrations asked the question how to obtain and notify the data element 8AA.

To assist administrations, BR needs a guideline agreed in ITU-R (WP 5D). BR is anticipating that Working Party (WP) 5D would provide guidelines that can be used by administrations in obtaining the data element 8AA for a station employing AAS. It is important that such guidelines are easily implementable by all administrations including those of developing countries.

Once the guidelines are available BR would propose the Radio Regulation Board to consider and adopt a Rule of Procedure, as necessary, to make them mandatory for application.

2 *What data elements are necessary for protection of the receiving space station on the geostationary orbit?*

From a regulatory point of view, the BR is checking compliance with regulatory provisions like RR Nos. **21.3**, **21.4** and **21.5**. based on the data items listed in Annex 1 to Appendix 4 of the RR and submitted by administrations in their notices. The BR is not computing the level of interference received by each space station from each terrestrial station. Based on the current wording of RR Nos. **21.3**, **21.4** and **21.5**, both data elements 8AA (the power delivered to the antenna) and 8B (the radiated power) are required for the BR to perform its regulatory analysis of terrestrial notices.

The BR checked the history of provisions RR Nos. **21.3**, **21.4** and **21.5**. It has been found that the power limits of RR No. **21.5** were introduced by EARC-63 and WARC-71 for the frequency below and above 10 GHz respectively. From the

documents of these conferences, it could be concluded that both limits were required for the protection of receiving space stations. (Some related conference documents are contained in Annexes 1-3 to this document.)

In addition, Recommendation [ITU-R SF.355](#) (the first version was approved in 1963) stipulates, *inter alia*, “Outside its main beam the gain of a terrestrial-station antenna is largely independent of the in-beam gain. Consequently, when the satellite is not in the main beam the interference may be controlled by limiting the total power fed to the antenna rather than by limiting the e.i.r.p. The total interference entering the main beam of the satellite antenna therefore depends upon the number of terrestrial stations within the coverage area and the average of their antenna gains in the direction of the satellite. Other parameters of the satellite which are relevant to the calculation are mentioned in the previous section.”

3 *When to notify an IMT station using AAS to the BR, if provided information on a power delivered by a transmitter to each antenna element of that station which meets the RR No. 21.5 limits, along with the RR No. 21.3 limit for e.i.r.p., would that notification be acceptable by BR?*

BR believes that we are not in the position to decide whether it is acceptable or not. The BR’s notice processing system is designed to receive any notice if it includes all the required data elements as mentioned in the RR Appendix 4.

[5D/407](#) (Chairmen SG 4 and SG 5)

ANNEX 3

Note from the Chairmen of Study Group 4 and Study Group 5 to Working Parties 4A, 4C and 5D

During their recent meetings, Working Parties 4A and 4C discussed the work being done by WP 5D on the antenna modelling for active antenna systems (AAS), i.e. an antenna that consists of an array of active elements, used by IMT stations and the applicability of the limit specified in RR No. **21.5** for such IMT stations as well as the notification of IMT stations that use such AAS. This latter issue is based on WRC-19 Document 550.

In the course of the discussions on these topics, there were diverging views and no consensus was reached on how to make progress and whether or not to involve other WPs, such as WPs 4A and 4C, in the work being conducted by WP 5D on these issues. It was also noted that CPM23-1 designated WP 5D as the responsible group for the latter of these two issues.

In view of the above, the Chairmen of Study Groups 4 and 5 have reviewed the issues and further discussed possible ways forward, according to the following agreed guidance:

- Firstly, WP 5D should continue to work, discuss, and develop a document with a certain level of stability.
- The preliminary results reached in WP 5D should not impact the protection of satellite services.
- Once the work in WP 5D has reached a level of maturity, the results should be liaised to WPs 4A and 4C before any document is finalized and sent to the BR Director.
- If needed, a joint session between experts from WPs 4A, 4C and 5D should be organised, to clarify that satellite service protection is not impacted.

Working Parties 4A, 4C and 5D are invited to consider the above agreed guidance and take appropriate actions, accordingly.

The Chairmen of Study Groups 4 and 5 will coordinate any additional arrangement that could improve the cooperation on this matter, if required.
