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|  | | **Addendum 2 to**  **Document RAG18/1-E** |
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| Director, Radiocommunication Bureau | | |
| COST RECOVERY FOR NON-GEOSTATIONARY SATELLITE SYSTEMS | | |

# 1 Introduction

At its 2017 session, the Council instructed the Radiocommunication Bureau to submit a study on the technical issues arising in connection with processing of complex non-geostationary satellite (non-GSO) systems. In particular, it was requested to study whether there is a possibility for the individual non-GSO filings (API/coordination/notification) containing non-homogeneous satellite orbits with differing altitudes and inclinations, and/or different constellation configurations, to be separated into filings containing each individual constellation or individual types of satellite orbit, for the purposes of processing by the Bureau.

Section 2 of this document presents the main conclusions of the study on the technical issues arising in connection with processing of complex non-geostationary satellite (non-GSO) systems.

Section 3 summarises the comments made in answer to this study by the Radio Regulations Board and ITU-R Working Parties.

Section 4 lists the main technical and regulatory issues associated with the idea of splitting non-GSO filings containing non-homogeneous satellite orbits.

Section 5 recalls some notable facts about Council 2005 where the current cost recovery structure was agreed following three years of complex discussions.

On the basis of sections 2 to 5, section 6 proposes three possible specific procedures for cost recovery of non-GSO satellite systems that, in accordance with the instruction of Council 2017, the Bureau could provide to assist delegates in submitting proposals to Council 2018.

As requested by the Council, this document only addresses the case of non-GSO satellite systems and does not propose any change for GSO satellite networks.

# 2 Initial study by the Radiocommunication Bureau

In response to the abovementioned Council 2017 decision, the Radiocommunication Bureau prepared a study addressing the technical issues arising in connection with processing of complex non-GSO satellite network filing systems to clarify technical issues such as but not limited to procedures in particular, elements required for processing of non-geostationary satellite (non-GSO) networks in addition to those for GSO network. This study was submitted to the Radio Regulations Board (see Addendum 8 to Document RRB17-3) and to ITU-R Working Parties 4A (see Document 4A/408), 4B (see Document 4B/88), 4C (see Document 4C/256), 7B (see Document 7B/188) and 7C (see Document 7C/176) for their consideration and comments.

The main findings of the study are summarized below:

– While the validation of data and examination of coordination requests of non-GSO satellite networks involves processes similar to GSO satellite networks, additional data items specific to non-GSO satellite networks are required in Appendix 4 of the Radio Regulations: orbital parameters, orientation angles of space station beam, satellite antenna gain and spreading loss as a function of elevation angle, maximum and average beam peak eirp, use of station-keeping to maintain a repeating ground track, time that it takes for the constellation to return to its starting position, specific precession rate, pfd/e.i.r.p. masks, information on the exclusion zone, etc. Along with these additional data requirements, notifying administrations often submit notes containing descriptions, clarifications and precisions, which the Bureau has to analyse, examine and translate for the publication in the special sections. This has an implication on the time required for the treatment for completeness of non-GSO satellite systems.

– Cost recovery units per notice have increased: prior to the 2013-2014 period, requests for coordination for non-GSO satellite networks had an average number of cost recovery units of less than 100. Since this period, the average number of cost recovery units of requests for coordination for such networks increased to more than 12 000 units, with one CR/C published with 254,000 units. The variable part of the cost recovery fee is capped to 100 units according to Council Decision 482.

– The overall size of the non-GSO satellite systems has increased: since 2013, satellite systems consisting of tens of thousands of satellites (from 70 000 to more than 230 000 satellites) have been published in CR/C special sections. APIs for non-GSO satellite networks using frequency bands that are not subject to coordination and containing thousands of satellites have also been received.

– The number of different orbital altitudes within the filing affects the number of pfd examinations to be performed: if a non-GSO satellite network has more than one altitude within its constellation, then pfd calculations need to be performed for each of the different altitudes. If there is pfd excess and an unfavourable finding is to be given, the beam would need to be firstly split in order to correctly represent the relationship between orbits and beams, followed by splitting on a group level in order to give findings to the frequency assignment accordingly. Furthermore, some of the larger non-GSO satellite networks received had an unprecedented scale of complexity in terms of varying altitude and beam configurations which went beyond the capacity of the database tables and had to be treated manually using other means, especially concerning modifications to coordination requests of non-GSO satellite networks. Prior to the 2013-2014 period, the number of different altitudes in a request for coordination for a non-GSO satellite network was 1, after that period, there are several non-GSO satellite networks that have multiple (up to 7) different altitudes.

– The number of different orbit inclinations within the filing has also increased: in the period prior to 2013-2014, the number of unique inclination angles for a non-GSO satellite network was, on average, one. However, following this period, the number of unique inclination angles received went up to 20 for some non-GSO satellite networks. In order to identify the list of administrations for coordination and agreement seeking under Nos. 9.14 or 9.21/C, the visibility of the non-GSO satellite network in respect of terrestrial services has to be determined. This factor depends on the combination of inclination angle and the altitude of the non-GSO satellites. Hence, the increased number of unique inclination angles in combination with altitude contributed to the increased complexity in examination of non-GSO satellite networks.

– Coordination requests for non-GSO satellite networks may contain more than one mutually exclusive configuration, i.e. set of orbital characteristics. The configuration that would finally be put into operation will be determined at the notification stage at the latest. This provides the notifying administration with the flexibility to coordinate the frequency assignments using different orbital configurations, while notifying and bringing into use only one configuration. However, this requires the Bureau to examine them in practice as separate satellite systems, especially in terms of epfd examination. Prior to the 2013/2014 period, all non-GSO satellite networks submitted to the Bureau contained only one configuration. Since then, Bureau has received non-GSO satellite networks with up to 10 mutually exclusive configurations. Even if WRC-15 endorsed the suggestion of the BR Director to limit the extent of acceptable flexibility for a request for coordination of a non-GSO satellite system only to either those where all frequency assignments are to be operated simultaneously or to those where there is a clear indication that the different sub-sets of orbital characteristics would be mutually exclusive (see §§ 1.39 to 1.42 of Document CMR15/505 – Minutes of the eighth plenary meeting), this endorsement was made from a regulatory point of view, noting that Council is the only competent body to assess the financial consequences in terms of cost-recovery.

– Equivalent power flux-density (epfd) examinations are specific to non-GSO satellite systems operating in the fixed-satellite service in certain frequency bands where provisions Nos. 22.5C, 22.5D, 22.5F, 9.7A or 9.7B apply. With the examination software recently made available to it, the Bureau has initiated the regulatory epfd examination. Beside running the software examination itself, the overall process involves several associated tasks: data completeness examination, XML mask validation, SNS Data Validation, epfd validation scenario preparation, result processing, additional workload relating to the examination of the cases requiring longer run-time, publication of epfd results, assistance to administrations, maintenance and technical support of epfd validation software, creation, maintenance and technical support of computer-aided tools. Factors affecting processing time for epfd examination include the total number of different scenarios, the number of applicable limits, the number of satellites used in each scenario and whether No. 9.7B applies or not.

– To establish coordination requirements under No. 9.7B, the epfd validation software has to calculate epfd values for more than 40 very large earth stations. Since these earth stations have very large antennas (more than 10 meters in diameter) with antenna beam width of less than 0.2 degrees, the epfd algorithm requires a large amount of time steps in the calculations to make sure that in-line events are obtained. For large constellations, this requires a very significant time to complete, even longer than Article 22 calculations. No. 9.7A similarly requires calculation versus all existing non-GSO satellite networks.

The study concluded by presenting a possible cost recovery scheme for non-GSO satellite systems, which was based on the previous conclusions. This scheme introduces a new calculation mechanism for the units and new categories of submissions in Decision 482.

# 3 Summary of comments

## 3.1 ITU-R Working Party 4A

In a Note to the Chairman of ITU-R Study Group 4 (see Document 4/39), Working Party 4A noted that the BR study was submitted just prior to its meeting so that there was limited scope for administrations to provide studies to this meeting. Nonetheless, Working Party 4A expressed the view that the establishment of Cost Recovery charges applicable to non-GSO systems should be transparent and that such charges should ensure a fair and appropriate sharing of associated processing costs for various types of satellite networks. Working Party 4A also emphasized that such overall costs should consider the actual time spent by ITU staff on processing filings. Working Party 4A noted that no analysis of GSO networks is provided for comparison. Finally, Working Party 4A pointed out that the issue of bringing into use for non-GSO satellite systems was currently being extensively studied and there are aspects of that issue that could have an impact on non-GSO cost recovery.

## 3.2 ITU-R Working Party 4C

In a Note to the Chairman of ITU-R Study Group 4 (see Revision 1 to Document 4/35), Working Party 4C noted that the BR study was submitted just prior to its meeting so that there was limited scope for administrations to provide studies to this meeting. Nonetheless, Working Party 4C expressed the view that Cost Recovery charges applicable to non-GSO systems should ensure a fair and appropriate sharing of associated processing costs for various types of satellite networks. Working Party 4C noted that no analysis of GSO networks was provided for comparison and that there was no specific assessment about the treatment for non-GSO satellites with short duration missions.

## 3.3 ITU-R Working Parties 7B and 7C

In a joint reply to the BR Director (see Annex 18 to Document 7B/238 equivalent to Annex 18 to Document 7C/200), Working Parties 7B and 7C noted that, while the issue is particularly critical for the case of large non-GSO satellite networks in the fixed-satellite and mobile services, it is of importance for both Working Parties because large constellations of EESS satellites (not subject to coordination under Section II of Article 9) are considered as contributing to the problem and the resulting increased average duration of the BR processing before publication impacts all filings, not just the ones causing this delay. Therefore, all notifying administrations are being negatively impacted regardless of their filing.

Working Parties 7B and 7C understood the additional complexity for the BR in dealing with these large constellations with many variable parameters and therefore agreed with the need to provide sufficient resources to the BR to address the problem. Consequently, both Working Parties 7B and 7C fully agreed with the principle that the cost to be recovered from the processing of these filings should be attributed to the cost of the service provided by the BR and recognized that the exact algorithm to be used to define the modular cost of a non-GSO filing should be left to the BR, being the entity best placed to study the labour hours and other cost implications of the various elements of a non-GSO filing.

## 3.4 Radio Regulations Board

At its 76th meeting, the Radio Regulations Board included the issue of cost recovery for the non-GSO satellite systems in its Summary of Decisions (see item 3f of Document RRB17-3/10) and noted that although this matter is within the responsibilities of the Council, the cost recovery model has an impact on the process of the examination and treatment of filings. The Board observed that modifications to the cost recovery model should be simple, understandable, fully transparent; should properly reflect the use of the resources by the Bureau and should not affect smaller or simpler systems, in particular when they are not subject to coordination or epfd limits. The Board encouraged the Bureau to provide projections on what the application of the new model would lead to, compared with the current model, as well as a comparison of current and estimated future costs (staff and software). The Board further observed that the cost ceiling in the current model was equivalent to having a flat fee for more complex satellite networks, irrespective of their complexity and the amount of effort required for their examination and treatment. The Board encouraged the Bureau to continue to develop the model in consultation with the relevant ITU-R working parties before submitting it to the Council for consideration.

# 4 Issues associated with splitting non-GSO filings containing non-homogeneous satellite orbits

Council 2017 requested in particular to study whether there is a possibility for the individual non-GSO filings (API/coordination/notification) containing non-homogeneous satellite orbits with differing altitudes and inclinations, and/or different constellation configurations, to be separated into filings containing each individual constellation or individual types of satellite orbit, for the purposes of processing by the Bureau.

Care should be exercised when analyzing this possibility because “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 Master International Frequency Register (…)”. (see No. 8.1 of the Radio Regulations). Moreover, No. 8.1.1 explains that the expression “frequency assignment” shall be associated with § A.4 of Annex 2 to Appendix 4 (“Orbital Information”) wherever this expression relates to a geostationary or non-geostationary space station.

As mentioned in section 2, WRC-15 endorsed the suggestion of the BR Director to limit the extent of acceptable flexibility for a request for coordination of a non-GSO satellite system only to either those where all frequency assignments are to be operated simultaneously or to those where there is a clear indication that the different sub-sets of orbital characteristics would be mutually exclusive. Therefore individual non-GSO satellite systems containing non-homogeneous satellite orbits with differing altitudes and inclinations, and/or different constellation configurations could be considered under two categories:

– Systems using non-homogeneous satellite orbits where all frequency assignments are to be operated simultaneously: in accordance with No. 8.1 of the Radio Regulations, frequency assignments to such systems should not be split because they reflect the actual operations of the planned systems. Moreover, depending on the characteristics of the system, splitting it could introduce additional difficulties if inter-satellite links are implemented to communicate within the system between different types of orbits. Finally, for such systems subject to epfd limits in Article 22, such split would raise the issue of a possible misapplication of single-entry epfd limits. This issue was on the agenda of WRC-03 as agenda item 1.19: “to consider regulatory provisions to avoid misapplication of the non-GSO FSS single-entry limits in Article 22 based on the results of ITU-R studies carried out in accordance with Resolution 135 (WRC-2000)”. This Resolution resolved “that misapplication of the single-entry limits in Article 22, either by artificial splitting or by combining of non-GSO systems, shall not be permitted.” Moreover, Annex 1 to Resolution 135 (WRC-2000) contained a process to be followed by the Radiocommunication Bureau in developing and implementing procedures to avoid misapplication of non-GSO FSS single-entry limits in Article 22. Section 3.1 of Chapter 3 of the CPM report on WRC-03 agenda item 1.19 explains that “the only reason for misapplication of these single entry epfd limits by artificially splitting or combining non-GSO FSS systems, will be to lower the epfd levels and therefore to get a favourable finding status as a result of this regulatory examination.” The CPM report therefore concluded that the “problem raised by Resolution 135 (WRC-2000) is not new or specific to certain non-GSO FSS systems. No difficulties have been experienced so far with similar limits, which could be similarly misapplied. The current Radio Regulations are adequate. No further studies are required therefore insofar as "invite ITU-R" section of Resolution 135 (WRC-2000) is concerned the Resolution may be suppressed.” Noting the conclusions of the ITU-R studies and based on the proposals submitted by Administrations, WRC-03 decided to entirely suppress Resolution 135 (WRC-2000). It is however important to note that ITU-R did not conclude that the resolves part of the Resolution was inappropriate. **It is therefore not advisable to split systems using non-homogeneous satellite orbits where all frequency assignments are to be operated simultaneously, especially when they contain frequency assignments subject to epfd limits set forth in Article 22 of the Radio Regulations, in order to avoid to purposefully create situations that were feared and prohibited at the time of adoption of the epfd limits**.

– Systems where there is a clear indication that the different sub-sets of orbital characteristics would be mutually exclusive: such situation will only occur at coordination stage (it may not appear at API stage because no detailed regulatory examination is performed at this stage) since there is a requirement to choose only one configuration at notification stage. In effect, each configuration represents one satellite system and should correspond to one separate satellite filing, which tends to advocate for the possibility to split these systems according to their submitted configurations, but WRC-15 added a regulatory nuance that may prove particularly useful during the complex and likely challenging coordination process of these large non-GSO satellite systems: mutually exclusive configurations provide an additional information to other administrations involved in the coordination process because they know that only one configuration will be possibly brought into use. **Noting the explicit decision of WRC-15, it is not advisable to split systems using non-homogeneous satellite orbits where there is a clear indication that the different sub-sets of orbital characteristics would be mutually exclusive. However, this conclusion stems from a regulatory analysis, which does not hinder the Council to separately charge each mutually exclusive configurations from a cost-recovery point of view while keeping the regulatory unity of the filing, as decided by WRC-15.**

# 5 Notable facts at Council 2005

The current structure of Decision 482 was essentially decided by Council 2005 after a number of disputed methodologies were tried and three years of intense work were performed by an Ad hoc Group of Council. In 2005, these cost-recovery discussions were mainly related to GSO satellite networks and were extremely complex.

Document C05/29 on cost recovery for the processing of satellite network filings that is referenced in the current version of Decision 482 (see *considering* *ebis*) was the basis for the decision by the Council.

During Council 2005, the Finance Committee established an Ad-hoc Group on Cost Recovery for Satellite Network Filings that held 7 meetings over 5 days. This Ad-hoc Group “agreed to concentrate its efforts in reviewing and examining Document C05/29 in order to arrive to a methodology for processing charges” of satellite networks but introduced various amendments in the proposed fee values in order to achieve a consensus (e.g. due to a too small statistical base for category N3, the Ad-hoc Group proposed to retain Category N3 with cost recovery fee equivalent to that of Category N2 ; in a similar manner, the Ad-hoc Group proposed to fix the cost recovery fee for category C3 at the level of 70% of that proposed in Document C05/29 ; for notification, the Ad-hoc Group proposed to apply 70% of the fee for cases where the application of No. 11.32A was not requested, with the remaining 30% to be charged to a subsequent request, if any, for application of No. 11.32A).

According to Document C05/29, the introduction of a ceiling in the amount that can be invoiced for satellite cost recovery was mainly based on two reasons: on the one hand, in absence of a ceiling, “some specific satellite network filings would continue to give rise to large number of units, resulting in invoices of very important amount that administrations would keep on not paying; the increase of overdue payments and unpaid invoices result in shortfall of treasury for the Union to be covered by other sources of funding such as assessed contributions;” on the other hand, “in order to reduce the number of units and thus the resulting fees, administrations would continue providing the minimum necessary information which practice, in the longer term, will jeopardize the value of the SNS database and is detrimental for proper application and the function of the Radio Regulations in securing coordinated use of frequencies and avoidance of mutual radio interference.”

# 6 Possible specific procedures for cost recovery of non-GSO satellite systems

Noting that Council 2005 finally agreed to the current structure of Decision 482, as well as most of the fee values, thanks to a compromise between all parties, three possible specific procedures for cost recovery of non-GSO satellite systems are proposed.

It should be noted that these three procedures are not mutually exclusive and could complement each other. As usual with any evolution of Decision 482, no retroactive application of these procedures are envisaged.

## 6.1 Procedure A – Computing separately charges for mutually exclusive configurations

As explained in section 4 above, in satellite systems where there is a clear indication that the different sub-sets of orbital characteristics would be mutually exclusive, each configuration represents one satellite system and the Bureau is required to examine them in practice as separate satellite systems. Noting the explicit regulatory decision of WRC-15,ProcedureA would maintainthe regulatory integrity of the filing but would require that each mutually exclusive configuration is charged separately.

Such a procedure can be implemented by a footnote to the Table contained in the Annex to Decision 482. Because this regulatory possibility is limited to the stage of coordination, the footnote would apply only to categories C1 to C3. An example of such footnote could be:

“For coordination requests of a non-geostationary satellite network where the notifying administration has indicated that the different sub-sets of orbital characteristics would be mutually exclusive, the processing charges are separately computed for each of the sub-sets and thereafter added to produce the processing charge of the satellite network.”

The advantage of this approach is that it maintains consistency with the regulatory decision by WRC-15, is simple, understandable and fully transparent and does not affect smaller or simpler systems that only have one set of orbital characteristics.

## 6.2 Procedure B – Limiting the flat fee to a maximum number of units

At the time of Council 2005, available statistics for non-GSO satellite systems were limited (31 filings with an average of 45 units per filing, the maximum number of units for a single filing being 576) therefore the flat fee above 100 units was understood as an average between satellite systems of similar complexity and was adopted based on the value chosen for GSO satellite networks. It should be noted that, prior to the period 2013-2014, this assumption proved to be remarkably valid (in the period 2005-2012, there were 46 filings with an average of 53 units per filing, the maximum number of units for a single filing being 639). Council 2005 never envisioned that there could be coordination requests with up to 254000 units.

Therefore, Procedure B would limit the flat fee to a maximum number of units (e.g. 1000 if the pre-2013/2014 period is chosen as reference). Beyond this maximum number, any supplementary unit would be charged at a value equal to the flat fee divided by the maximum number of unit.

## 6.3 Procedure C – Introducing an additional fee for cases subject to Article 22 epfd limits

As mentioned in section 5, at Council 2005, cost-recovery discussions were mainly related to GSO satellite networks. Moreover, even if epfd limits were adopted since 5 years, no epfd validation software was available and WRC-03 even adopted Resolution 85 to provide the BR with an interim method of examination of non-GSO filings subject to epfd limits. Consequently, no statistics of costs related to epfd examination were available and hence were considered when establishing the various values contained in Decision 482.

Now that the epfd software is available and that epfd examinations have begun to be conducted by the Radiocommunication Bureau, the Bureau will be in a position to compute statistics of processing time of epfd examinations compared to the number of units of the non-GSO satellite network. However, to produce such statistics, additional examinations need to be completed in order to have a representative set of data.

Two approaches can however already be considered:

– If the processing time of epfd examinations is strongly correlated with the number of units of the non-GSO satellite network, the following example of footnote could be added to categories C1/C2/C3 and N1/N2/N3/N4: “For non-geostationary satellite networks to which Nos. 22.5C, 22.5D, 22.5F or 9.7B apply, or for earth stations to which No. 9.7A applies, the processing charges are increased by [x]%.”

– If the processing time of epfd examinations is not strongly correlated with the number of units (see sections 2.8 and 3 of Document 4A/408 for an explanation of the reason why such a situation could occur), the following example of footnote could be added to categories C1/C2/C3 and N1/N2/N3/N4: “For non-geostationary satellite networks to which Nos. 22.5C, 22.5D, 22.5F or 9.7B apply, or for earth stations to which No. 9.7A applies, the processing charges are increased by [y] CHF.”

# 7 Conclusion

After having presented the main conclusions of the BR study on the technical issues arising in connection with processing of complex non-geostationary satellite (non-GSO) systems and having summarized comments made in answer to this study by the Radio Regulations Board and ITU-R Working Parties, this document lists the main technical and regulatory issues associated with the idea of splitting non-GSO filings containing non-homogeneous satellite orbits, recalls some notable facts about Council 2005 and, on that basis, proposes three possible specific procedures for cost recovery of non-GSO satellite systems that, in accordance with the instruction of Council 2017, the Bureau could provide to assist delegates in submitting proposals to Council 2018.

The advice of the Radiocommunication Advisory Group on these proposals would be extremely useful in view of the preparation of the final BR study to be submitted to the Council.

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