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| Summary: | | |
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| Proposal: | | |
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DRAFT CEPT BRIEF ON AGENDA ITEM 1.6

1.6 to consider the development of a regulatory framework for non-GSO FSS satellite systems that may operate 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), in accordance with Resolution 159 (WRC-15).

# ISSUE

According to Resolution 159 (WRC‑15) “Studies 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)” to conduct:

1. studies of technical and operational issues and regulatory provisions for the operation of non-GSO FSS satellite systems in the frequency bands 37.5-42.5 GHz (space-to-Earth) and 47.2-48.9 GHz (limited to feeder links only), 48.9-50.2 GHz and 50.4-51.4 GHz (all Earth-to-space), while ensuring protection of GSO satellite networks in the FSS, MSS and BSS, without limiting or unduly constraining the future development of GSO networks across those bands, and without modifying the provisions of RR Article 21;
2. studies carried out under resolves to invite ITU-R 1 shall focus exclusively on the development of equivalent power flux-density limits produced at any point in the GSO by emissions from all the earth stations of a non-GSO system in the fixed-satellite service or into any geostationary FSS earth station, as appropriate;
3. studies and development of sharing conditions between non-GSO FSS systems operating in the frequency bands listed in resolves to invite ITU-R 1 above;
4. studies of possible necessary revisions to Resolution 750 (Rev.WRC-15) to ensure protection of the EESS (passive) in the frequency bands 36-37 GHz and 50.2-50.4 GHz from non-GSO FSS transmission, taking into account recognizing i) above, including study of aggregate FSS interference effects from networks and systems operating or planned to operate in the frequency bands described in resolves to invite ITU-R 1 above;
5. studies towards ensuring protection of the radio astronomy frequency bands 42.5-43.5 GHz, 48.94-49.04 GHz and 51.4-54.25 GHz from non-GSO FSS transmissions, taking into account recognizing i) above, including study of aggregate FSS interference effects from networks and systems operating or planned to operate in the frequency bands described in resolves to invite ITU-R 1 above.

# Preliminary CEPT position

CEPT supports the development of regulatory provisions, technical and operational conditions that would enable spectrally efficient operation of non-GSO FSS satellite systems in the frequency bands 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) while ensuring protection for GSO satellite networks and stations of other existing services including passive services in the adjacent frequency bands.

CEPT considers that the limits currently in Resolution 750 (Rev. WRC-15) are not sufficient for the protection of EESS (passive) in the adjacent frequency band 50.2-50.4 GHz from operation of non-GSO FSS satellite systems in the frequency bands under consideration in accordance with Resolution 159 (WRC-15). Appropriate unwanted emission limits for the protection of EESS (passive) are [-61.9] dBW/200 MHz for non-GSO user terminals and [-63] dBW/200 MHz for non-GSO gateways. CEPT is of the view that the effects of aggregate FSS interference from GSO satellite networks and non-GSO systems operating in the relevant bands should be taken into account to ensure the protection of the EESS (passive). CEPT considers that the unwanted emission limits for GSO FSS are not sufficient for the protection of EESS (passive) and should also be revised under WRC-19 AI 1.6. An appropriate unwanted emission limit is [-65.9] dBW/200 MHz for GSO.

CEPT supports the development of the new Recommendation ITU-R S. [50/40 GHz Sharing Methodology] which describes in particular the methodology to calculate the maximum permissible level of interference from non-GSO satellite systems specified as single entry and aggregate limits for: a) increase in unavailability time allowance for degradation of GSO networks short term performance objectives; b) a maximum reduction of the average throughput or spectral efficiency for GSO networks using Adaptive Coding Modulation. CEPT supports that this methodology takes into account the correlation between a fading event attenuating both the wanted signal and interfering signals in the frequency bands 40/50 GHz. In addition, CEPT supports that the conformity with these single-entry limits be evaluated using the calculation procedures in the new Recommendation ITU-R S.[50/40 GHz Sharing Methodology] and using the statistics of degradations due to the non-GSO system interference and fading issued from the latest versions of Recommendations ITU-R S.1503 and P.618, respectively.

CEPT also supports the development the new Recommendation ITU-R S. [50/40 GHz Reference links] which contains characteristics of representative FSS GSO reference links.

# Background

Article 22 of the Radio Regulations contains provisions to ensure compatibility of non-GSO FSS operations with GSO networks for the 14/11 GHz and 30/20 GHz bands. Among these provisions there are uplink and downlink equivalent power flux density (epfd↑ and epfd↓) limits to protect GSO networks from unacceptable interference pursuant to RR No. 22.2. There are currently no regulatory provisions for sharing between non-GSO systems and GSO networks in the 50/40 GHz frequency bands. Furthermore, there are currently no ITU-R defined protection requirements for 50/40 GHz band GSO networks.

Latest WP 4A meeting (03 – 14 July 2018, Geneva) received a number of contributions, which included some proposals on GSO FSS and non-GSO FSS, non-GSO FSS and EESS (passive), non-GSO FSS and non-GSO FSS studies.

Non-GSO FSS and GSO FSS studies

WP 4A considered the results of 10 technical studies relating to sharing between non-GSO FSS satellite systems using circular orbits and GSO networks in the 50/40 GHz bands.

Study 1 points to the need to develop regulations that facilitate maximizing the spectral efficiency of use of the 50/40 GHz bands and presents sharing considerations that should be taken into account, including technology and natural considerations such as propagation losses. The study presents an analysis of the generation of a epfd profile masks based on generic LEO constellations of 2 000 and 4 000 service vehicles. The analysis presents a background on the methodology for deriving aggregate epfd limits based on procedures carried out in lower frequency using Recommendations ITU-R S.1503, ITU-R P.618 and the sharing considerations given in Recommendation ITU-R S.1323. The analysis of this procedure on a representative LEO constellation shows that potential epfd↓ masks are very system specific and variable, depending on the particular operations of the non-GSO constellation chosen for defining a particular mask. The result of this study shows that there can be significant operational margin available to the GSO when propagation impairments are taken into account.

Study 2 provides a simulation and results of a study of the sharing between a non-GSO FSS satellite system in a circular equatorial orbit and a GSO system in the 48/38 GHz frequency bands. The results are shown in both epfd and I/N statistics. The C/N and C/(N+I) curves of the GSO system and the effect on availability due to interference from the non-GSO system are also provided. Based on the input assumptions, the results show that the unavailability targets in Recommendation ITU-R S.1323 and preliminary draft new Recommendation ITU-R S.[50/40 GHz FSS Sharing Methodology] of 10% increase are met.

Study 3 presents a comparison of the LEO system presented in Study 1 and the MEO system presented in Study 2. The purpose of the comparison in this study is to present an assessment of potential sharing of these two systems, with a view to maximize spectral efficiency in the 50/40 GHz band. The analysis provides a comparison of the representative interference profiles derived in Study 1 and Study 2 relating to non-GSO constellations in LEO and MEO orbits. The analysis shows that the methodology to determine the interference profiles is extremely dependent on the characteristics of the systems being evaluated. While epfd masks can be developed for a particular system, it is very difficult to define epfd masks that would allow all non-GSO systems to operate and provide for maximum spectrum efficiency, while still assuring that GSO protection criteria will always be observed. The analysis also shows that if masks are developed for the operation of one particular non-GSO system, a separate non-GSO system may not be able to meet the requirements from that mask. However, each system independently, and even in composite form, might be able to meet the protection criteria given in Recommendation ITU-R S.1323 and Preliminary Draft New Recommendation ITU-R S.[50/40 GHz FSS Sharing Methodology] with some margin.

Study 4 considers both the uplink and downlink interference from two different non-GSO systems into a GSO network at varying elevation angles. The two non-GSO systems modelled were a LEO system at 1 200 km and a MEO system at 8 062 km. The results of the study provide levels of interference into a GSO system from two different non-GSO systems, and should be considered when examining the co-existence between these two types of implementations of the FSS. It was also noted that this study did not include any propagation impairments other than free space path loss, although it was recognized that at these frequencies, rain and cloud attenuation have a significant impact on both, the wanted and interfering signals. If other attenuation losses are taken into account, it is expected that the resulting I/N ratios would be lower.

Study 5 is an analysis with a typical constellation deployment circular orbit LEO non-GSO FSS system consisting of 12 orbits with 28 satellites in each orbit, which provides a total of 336 satellites in the system. Assuming that the protection criterion for GSO FSS networks is a 10% increase to unavailability caused by the interference, the criterion was not exceeded for GSO beams from both low latitude and medium latitude scenarios in this study. The levels of emissions from the non-GSO system depicted in Study 5 were acceptable based on the assumptions in this study. Although the downlink pfd values of non-GSO system exceeded the pfd requirement in RR Table 21-4, this study concluded that the compatibility was achieved. Given that the non-GSO FSS system downlink transmitting power would need to be decreased to meet the RR Table 21-4 pfd limits, this lower power would further aid the sharing of non-GSO and GSO systems. It is worth to note that the proponents of this study should further clarify some questions raised by the meeting and currently reflected as editor's note.

Study 6 is an analysis regarding interference by a non-GSO system to a GSO system in the 50/40 GHz bands under different conditions in two operational scenarios for tracking the non-GSO satellites. Based on criterion of 10% increase in the unavailability caused by interference it was shown in this study that by the change in some of the parameters in tracking strategy, it is possible to decrease interference from a non-GSO system. It is concluded in Study 6 that frequency sharing between GSO and non-GSO satellite networks is possible using appropriate tracking strategy.

Study 7 is an analysis of the operation of non-GSO systems into GSO networks that use Adaptive Coding and Modulation (ACM).  This analysis discuss the operation of ACM in next generation GSO systems and potential procedures in terms of impact on data rate that can be taken into account for protection of these types of ACM operations.  The analysis produces several results regarding the impact of non-GSO systems on GSO operations using ACM.  The analysis concludes that further work is required to address how to account for the operations of non-GSO systems and the protection of GSO operations employing ACM.

In Study 8, for every C/N+I value of the GSO link, it is possible to determine the corresponding unavailability purely due to propagation effects using ITU-R Recommendation P.618. Limiting the increase of such unavailability (or decrease in capacity for networks using adaptive coding) is the basis to establish the constraints to be imposed to non-GSO systems. Indeed, the non-GSO interference on the GSO links should be limited in a way that the unavailability of the GSO systems is not increased above a defined level that is often expressed in percentage of the unavailability due to propagation effects. For GSO networks using adaptive coding and modulation, the non-GSO interference should be limited in a way that it is at the origin of a specific maximum percentage of decrease in the amount of throughput of the GSO network. Using this approach, the permissible interference levels induced by non-GSO systems on a GSO link are completely independent of the characteristics or number of non-GSO system(s) and are only dependent on the GSO link to be protected. Based on this approach, maximum interference can be transformed into aggregate epfd limits. It is worth to note that there was no agreement with the validity of this methodology on the process of the generation of epfd values to protect GSO networks, further work is required on this topic and this is currently reflected as editor's note.

Study 9 provides simulations and results to verify the applicability of the methodology to calculate the increase in unavailability to GSO reference links from interference of non-GSO systems. For the simulations, a Commercial Off-the-Shelf software is used to simulate the interference from a non-GSO system into the reference GSO links. The technical characteristics of the GSO reference links used were from links provided by SES and Telesat not considering the particular performance objectives for those links. The non-GSO systems modelled had altitudes of 1200 km and 1400 km, both with circular orbits.

For each link assessed in this study, rain fading was modelled using Recommendation ITU-R P.618, with the local rain rates provided by Recommendation ITU-R P.837. The fading noise temperature was calculated in accordance with rain characteristics. It was assumed that the rain fade of the wanted links and the interference links were 100% correlated (as the software was limited to 0% or 100%). The percentage of unavailability due to rain was determined for each segment of the forward and return links. For the purpose of these simulations, it was assumed that the GSO links were unavailable if the C/N was below the specified thresholds. The percentage of unavailability due to the combined impact of the rain and the non-GSO interference was then determined, using a C/(N+I) objective of 12 dB. In order to avoid main-beam interference, GSO arc avoidance of 3º and 6º was applied in the uplink.

Results demonstrate that the highest increase in unavailability created by one non-GSO system is 2.7%. It is also shown that when a larger GSO arc avoidance angle is applied, the increase in unavailability of the GSO link is reduced. The absence of GSO arc avoidance leads to high increases in unavailability. Finally, it is noted that most of the increase in unavailability is caused by interference into the downlink segments of the GSO links, while the impact on the uplink is almost negligible. It is worth to note that the methodology used to obtain the total unavailability of the system and the corresponding results need to be assessed further, taking into account the overall (uplink and downlink) C/N+I obtained for each link and this is currently reflected as editor's note.

Study 10 investigates the impact on the spectral efficiency of a GSO network employing Adaptive Coding and Modulation (ACM) that is subjected to interference from an NGSO network. The study considers the sensitivity of ACM systems to variations in the ratio of I/N rather than epfd.

Operation of V-Band NGSO systems has the potential to cause interference to GSO networks operating in this band – downlinks in 37.5-42.5 GHz (space-to-Earth), and uplinks in 47.2-50.2 GHz (earth-to-space) and 50.4-51.4 GHz (Earth-to-space). The ITU has addressed similar concerns in FSS bands below 30 GHz by imposing epfd limits on NGSO systems. This study demonstrates that imposing fixed limits on epfd or I/N are not necessarily good protection measures considering the characteristics of the interference generated by NGSO systems and the capabilities of satellite networks employing ACM; the spectral efficiency of an ACM system subject to interference is a better indicator. Two scenarios of interference from a NGSO system into the downlink of a GSO network were considered. In the first case, the GSO earth station was assumed to be at a higher lattitude (Saskatoon, Canada). In this case the interference had minimal impact on the spectral efficiency of a link employing ACM. In the second case, the GSO earth station was assumed to be at a lower latitude (Peru). Study has provided the time function of the interference for the second case, which had short duration I/N peaks at around 33 dB. The analysis and calculations show that even with such high peaks in I/N, the long-term spectral reduction in efficiency for the second case was about 2%.

These results demonstrate that imposing a constraint on epfd, which is equivalent to imposing a constraint on I/N is not an equitable sharing criteria. The results further support the concept of a criterion that limits the reduction in spectral efficiency for systems employing ACM.

Thus, the results of the studies carried out in ITU-R showed that compatibility between non-GSO FSS satellite systems using circular orbits and GSO networks in the 50/40 GHz bands is achievable taking into account the operational scenarios for tracking the non-GSO satellites (GSO avoidance angle, minimum elevation angle etc.)

WP 4A stated that it is important that each study clearly states the assumptions made, especially regarding deployments and propagation models.

ITU-R studies have shown that in the 50/40 GHz frequency bands, propagation impairments such as rain, cloud and gaseous absorption exist that can substantially affect FSS satellite links. To account for the differences in propagation from lower frequency bands, a new ITU-R Recommendation on sharing criteria for FSS systems in the 50/40 GHz frequency bands is being developed in parallel with the studies associated with this agenda item. This proposed new Recommendation aims to establish appropriate protection criteria and maximum permissible levels of interference for emissions between FSS networks (GSO/FSS; non‑GSO/FSS; GSO and non-GSO/MSS feeder links) operating co-frequency in the 50/40 GHz frequency bands.

Non-GSO FSS and non-GSO FSS studies

WP 4A considered two studies, which were developed to describe mitigation techniques, such as orbital avoidance angles and earth station diversity, to allow for sharing between co-frequency non-GSO FSS systems. The objective of this study is to determine the effectiveness of such techniques for sharing between next-generation non-GSO FSS constellations. These studies examine the effectiveness of orbital separation angles and earth station site diversity in mitigating interference events between non-GSO FSS systems.

Non-GSO FSS and RAS studies

WP 4A considered two studies on compatibility with RAS.

Study 1 relates to the protection of the RAS in the 42.5-43.5 GHz frequency band from interference caused by transmissions from space stations of non-GSO satellite systems. It is noted that RR No. 5.551H establishes equivalent power flux density (epfd) limits that shall not be exceeded by all space stations in any non-GSO satellite system for more than 2% of the time. As far as non-GSO satellite systems are concerned, therefore, it appears that there are already mandatory provisions in the Radio Regulations to adequately protect the RAS in the frequency band 42.5-43.5 GHz. This study describes a methodology that can be used to ensure conformance to the limits in RR No. 5.551H of a hypothetical non-GSO satellite system operating in the 42.45.5 GHz frequency band. Study 1 computes the aggregate unwanted emission levels produced by a non-GSO FSS system at the radio astronomy site using the procedure described in Recommendation ITU-R S.1586. The study was performed with the assumption that the pfd of each satellite is constant (no angular evolution of the pfd) and that each satellite emits all the time and the received pfd limit at the RAS station is the level defined in RR No. 5.551I. For a constellation of 720 satellites (18 planes, 40 satellites per plane) the radio astronomy protection criteria will be exceeded by around 26 dB. The amount of power excess scales logarithmically with the number of satellites of a constellation. The study may be completed in the following way:

* Simulation of angular variability of the satellite pfd (e.g. using steering spot beams) rather than a constant pfd
* Clarification on what kinds of mitigation measures are possible to reach the required attenuation at a RAS station

Study 2 relates to the protection of RAS systems from non-GSO satellite systems operating in the 47.2‑50.2 GHz and 50.4-51.4 GHz frequency bands. The results of the performed static analysis showed that coordination/ separation distances will be needed to protect RAS stations in the frequency band 48.94-49.04 GHz, 51.4-54.25 GHz from the in band, out-of-band and spurious emissions of non-GSO FSS ES. The resulting coordination zones correspond to the values described in Recommendation ITU-R RA.1031.The studies are being carried out for the RAS in the frequency bands 48.94-49.04 and 51.4-54.25 GHz using protection criteria received from WP 7D.

It was noted during the WP 4A meetings that the 51.4-54.25 GHz frequency band is the subject of RR No. 5.556 “In the bands 51.4-54.25 GHz, 58.2-59 GHz and 64-65 GHz, radio astronomy observations may be carried out under national arrangements” and does not constitute an allocation.

Non-GSO FSS and EESS (passive) studies

The EESS (passive) frequency bands mentioned in Resolution 159 (WRC-15) are 36-37 GHz and 50.2-50.4 GHz. Both frequency bands are allocated worldwide to the EESS (passive) on a primary basis in the Table of Frequency Allocations of RR Article 5.

WP 4A considered six studies for the EESS (passive) in the PDNR. In the discussions of the studies, it was noted that a non-GSO earth station deployment model is essential to determine the amount of interference that an EESS (passive) sensor may receive.

Study 1 examined the interference into the 50.2-50.4 GHz frequency band through two methodologies and determined that interference caused by the four specific non-GSO systems analyzed does not aggregate on a power basis for small percentages of time but that the aggregate interference environment is from the dominant link. This study demonstrated that to maintain the non-GSO contribution to the established aggregate FSS interference environment allowed by Resolution 750 (Rev.WRC-15), the aggregate power in excess of -166 dBW/200 MHz for no more than 0.01% of the time over an area of 2 000 000 km2 in the frequency band 50.2‑50.4 GHz was calculated to be 0.2 dB higher than what is currently experienced from a single FSS non-GSO system with MEOSAT-X characteristics. To remove this minor excess and maintain the existing non-GSO FSS interference profile, a 3 dB decrease of the input power to the antenna flange may be appropriate for the new FSS non-GSO satellite systems..

Study 2 examined the interference into the 36-37 GHz band and indicated that the probability of exceeding the acceptable EESS interference level is at least two orders of magnitude lower than the 0.1% criterion in the 36-37 GHz frequency band.

Study 3 was an interference analysis in the 50.2-50.4 GHz band examining all four EESS sensor types over nine different measurement areas across the world. This study explored the effects of gateway and user terminal and additionally considered the aggregate effects of multiple non-GSO systems. This study determined that the worst case aggregate interference exceeded the protection criteria specified by Recommendation ITU-R RS.2017 by 74.3dB using an out of band power of 0 dBW/200 MHz reducing the out of band power to ‑10 dBW/200 MHz, which is the current limit for gateways in Resolution 750 (Rev.WRC-15), the exceedance would be 64.3 dB however the needed out of band limit to meet the protection criteria would be the same. When considering GSO and non-GSO interference separately, it was demonstrated that the GSO FSS gateway earth stations can cause 25.3 dB of exceedance at elevation angles below 70 degrees and as much as 74.3dB with elevation angles above 70 degrees when considering an input power of 0 dBW/200 MHz. Non-GSO FSS earth stations (aggregate of gateways and user terminals) caused 58.8 dB of exceedance of the protection criteria when considering an input power of 0 dBW/200 MHz reducing the out of band power to -10 dBW/200 MHz, which is the current limit for gateways in Resolution 750 (Rev.WRC-15), the exceedance would be 48.8 dB, however the needed out of band limit to meet the protection criteria would be the same. When considering how interference from multiple non-GSO systems aggregates, the analyses demonstrated that aggregation could increase the exceedance of the EESS protection criteria by more than 11 dB over the exceedance that was calculated for a single system, depending on specific systems considered and in what order they are analysed..

Study 4 examined the interference into the 50.2-50.4 GHz frequency band and determined that limits provided in Resolution 750 (Rev.WRC-15) provided reduced interference levels, but were still not sufficient to meet the interference criteria. An additional attenuation of 17 dB for gateway links and up to 44 dB for service links would still be required. These values are determined by the sensitivity of the push-broom sensor. To protect the conical and the mechanical nadir sensors, attenuation of 3.3 dB and 18 dB would be required for gateways and user terminals, respectively. With respect to the 36-37 GHz frequency band, the study showed that when using a worst-case OOBE mask, the interference criteria was not exceeded for the EESS sensors studied in the 36-37 GHz frequency band and for the non-GSO FSS systems modelled. As such, a more refined study to better model OOBE into the EESS (passive) systems was not undertaken. These results suggest that non-GSO FSS systems and EESS (passive) systems in the 37 GHz range are compatible.

Study 5 determined that an out of band limit to protect the EESS (passive) in the 50.2-50.4 GHz band of -65.9 dBW/200MHz would be needed for GSO FSS earth stations (without any constraint on the GSO FSS elevation angle), -63 dBW/200MHz for non-GSO Gateway earth stations and a limit of -61.9 dBW/200MHz is needed for user terminals. This is assuming a 3 dB apportionment of the EESS (passive) protection criterion. It is noted that the value obtained for non-GSO systems in Study 5 is similar to the one obtained for non-GSO systems in Study 3 and for non-GSO services links in Study 4 (none of these 2 studies considered apportionment). The existing limit for GSO FSS was also shown to be insufficient to cover all cases analysed and would need to be revised. The study showed that an appropriate limit for GSO would be -65.9 dBW/200 MHz. However, it could be relaxed below a given elevation angle if needed.

Study 6 results have shown that that the protection criteria for GSO EESS (passive) systems is exceeded by 46 dB. Therefore -66 dBW/200 MHz for non-GSO gateways earth stations is needed if there is no avoidance angle for the non-GSO FSS earth stations. In order to protect GSO EESS (passive) systems in the 50.2-50.4 GHz band, the GSO avoidance angle for the non-GSO FSS earth stations should not be less than 10° when the OOB emissions from each FSS ES is limited to -20 dBW/200 MHz..

As a result WP 4A updated:

* Working Document towards a Preliminary Draft New Report ITU-R S.[50/40 GSO-NGSO SHARING] on sharing between 50/40 GHz GSO FSS networks and non-GSO FSS systems;
* Working Document towards a Preliminary Draft New Report ITU-R S.[ 50/40 GHz ADJACENT BAND STUDIES] on the protection of EESS (passive) and RAS systems from non-GSO fixed satellite systems operating in the 37.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz frequency bands;
* Working document towards a Preliminary Draft New Report ITU-R S.[50/40 NGSO-NGSO SHARING] on study of mitigation techniques between non-GSO FSS systems;
* Work plan for WRC-19 Agenda item 1.6;
* Working document towards draft CPM Text for WRC-19 agenda item 1.6;
* Preliminary draft new Recommendation ITU-R S.[50/40 GHZ FSS SHARING METHODOLOGY] - Maximum permissible levels of interference in a GSO FSS network caused by co-directional GSO and non-GSO FSS systems and in non-GSO FSS systems caused by other co-directional non-GSO FSS systems operating in the 50/40 GHz frequency bands.
* Working Document towards a Preliminary Draft New Recommendation ITU-R S.[50/40 GHz REFERENCE LINKS] - Satellite system characteristics to be considered in frequency sharing analyses within the fixed-satellite service in the frequency bands 37.5-39.5 GHz, 39.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz

Additionally, CEPT considered a contribution presented in the 7th meeting of PTB, in September 2018. This contribution presented studies on the interference of a non-GSO FSS system into EESS (passive) sensors in the frequency band 50.2-50.4 GHz, based on parameters of a pushbroom sensor and operational parameters of a non-GSO FSS system. Given that the pushbroom sensor had been identified as the most sensitive sensor to interference from non-GSO systems, this study defined a more accurate model for this type of sensor. While other studies only considered the beam with the worst-case interference level, this study considered all the 90 beams that take measurements within the measurement area under study at a specific moment. This had a significant impact on the percentage of time when the threshold is exceeded. On the other hand, this study introduced uplink power control in the non-GSO earth station, which adjusts the transmitted power to maintain a constant power at the spacecraft receiving antenna. As a consequence, the e.i.r.p. transmitted towards the zenith is significantly reduced and so are the levels of interference in the EESS sensor. The study considered a single gateway site, with ten gateway antennas, within the measurement area.

# List of relevant documents

ITU-Documentation:

* WP4A Chairman's Report 4A/826

Annex 4 – Preliminary draft new Report ITU-R S.[50/40 GSO-NGSO SHARING] on sharing between 50/40 GHz GSO networks and non-GSO systems

Annex 11 – Working document towards a preliminary draft new Report ITU-R S.[ 50/40 GHz ADJACENT BAND STUDIES] on the protection of EESS (passive) and RAS systems from non‑GSO fixed satellite systems operating in the 37.5-42.5 GHz, 47.2‑50.2 GHz and 50.4-51.4 GHz frequency bands

Annex 10 – Working document towards a preliminary draft new Report ITU-R S.[50/40 NGSO-NGSO SHARING] on study of mitigation techniques between non-GSO FSS systems

Annex 1 – Preliminary draft new Recommendation ITU-R S. [50/40 GHZ FSS SHARING METHODOLOGY] - Maximum permissible levels of interference in a satellite network (GSO and non-GSO) in the fixed-satellite service caused by other co-directional FSS and BSS networks operating in 50/40 GHz frequency bands

Annex 5 – Working document towards preliminary draft new Recommendation ITU-R S.[50/40 GHz REFERENCE LINKS] - Satellite system characteristics to be considered in frequency sharing analyses within the fixed-satellite service in the frequency bands 37.5-39.5 GHz, 39.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz

Annex 29 – Working document towards draft CPM Text for WRC-19 agenda item 1.6

* Recommendation ITU-R S.1323 – Maximum permissible levels of interference in a satellite network (GSO/FSS; non-GSO/FSS; non-GSO/MSS feeder links) in the fixed-satellite service caused by other codirectional FSS networks below 30 GHz
* Recommendation ITU-R S.1325 – Simulation methodologies for determining statistics of short-term interference between co-frequency, codirectional non-geostationary-satellite orbit fixed-satellite service systems in circular orbits and other non-geostationary fixed-satellite service systems in circular orbits or geostationary-satellite orbit fixed-satellite service networks;
* Recommendation ITU-R S.1328 – Satellite system characteristics to be considered in frequency sharing analyses within the fixed-satellite service
* Recommendation ITU-R S.1529 – Frequency sharing of the bands 19.7-20.2 GHz and 29.5-30.0 GHz between systems in the mobile-satellite service and systems in the fixed-satellite service
* Recommendation ITU-R S.1557 – Operational requirements and characteristics of fixed-satellite service systems operating in the 50/40 GHz bands for use in sharing studies between the fixed-satellite service and the fixed service
* Recommendation ITU-R RS.1861 – Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz
* Recommendation ITU-R RS.2017 – Performance and interference criteria for satellite passive remote sensing
* Recommendation ITU-R SM.1542– The protection of passive services from unwanted emissions
* Recommendation ITU-R SM.1633 – Compatibility analysis between a passive service and an active service allocated in adjacent and nearby bands
* Report ITU-R SM.2092 – Studies related to the impact of active services allocated in adjacent or nearby bands on Earth exploration-satellite service (passive)
* Report ITU-R SM.2091 – Studies related to the impact of active services allocated in adjacent or nearby bands on radio astronomy service
* Report ITU-R RS.2095 – Sharing of the 36-37 GHz band by the fixed and mobile services and the Earth exploration-satellite service (passive)
* Recommendation [ITU-R RA.314](http://www.itu.int/rec/R-REC-RA.1513/en) – Preferred frequency bands for radio astronomical measurements
* Recommendation [ITU-R RA.517](http://www.itu.int/rec/R-REC-RA.1513/en) – Protection of the radio astronomy service from transmitters operating in adjacent bands
* Recommendation [ITU-R RA.611](http://www.itu.int/rec/R-REC-RA.1513/en) – Protection of the radio astronomy service from spurious emissions
* Recommendation [ITU-R RA.769-2](http://www.itu.int/rec/R-REC-RA.769/en) – Protection criteria used for radio astronomical measurements
* Recommendation [ITU-R RA.1031](http://www.itu.int/rec/R-REC-RA.1513/en) – Protection of the radio astronomy service in frequency bands shared with other services
* Recommendation [ITU-R RA.1513](http://www.itu.int/rec/R-REC-RA.1513/en) – Levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the radio astronomy service on a primary basis
* Recommendation [ITU-R RA.1631](http://www.itu.int/rec/R-REC-RA.1513/en) – Reference radio astronomy antenna pattern to be used for compatibility analyses between non-GSO systems and radio astronomy service stations based on the epfd concept
* Recommendation [ITU-R S.1586-1](http://www.itu.int/rec/R-REC-S.1586/en) – Calculation of unwanted emission levels produced by a non-geostationary fixed-satellite service system at radio astronomy sites
* Recommendation ITU-R SA.1396 – Protection criteria for the space research service in the 37-38 and 40-40.5 GHz bands
* Recommendation ITU-R SA.2079 – Frequency sharing between SRS and FSS (space-to-Earth) systems in the 37.5-38 GHz band Report ITU-R RA.2126 – Techniques for mitigation of radio frequency interference in radio astronomy
* Report ITU-R RA.2131 – Supplementary information on the detrimental threshold levels of interference to radio astronomy observations in Recommendation ITU-R RA.769
* Report ITU-R RA.2188 – Power flux-density and e.i.r.p. levels potentially damaging to radio astronomy receivers

CEPT and/or ECC Documentation:

* ERC/DEC/(00)02 ERC Decision of 27 March 2000 on the use of the band 37.5 - 40.5 GHz by the fixed service and Earth stations of the fixed - satellite service (space-to-Earth)
* ECC/DEC/(05)08 The availability of frequency bands for high density applications in the Fixed-Satellite Service (space-to-Earth and Earth-to-space). Approved 24 June 2005/ Amended 8 March 2013
* [ECC/DEC/(02)04 The use of the band 40.5 – 42.5 GHz by terrestrial (fixed service/ broadcasting service) systems and uncoordinated Earth stations in the fixed satellite service and broadcasting-satellite service (space to Earth)](http://www.efis.dk/documents/15427)
* ERC/REC 12-11 Radio frequency channel arrangements for Fixed Service systems operation in the bands 48.5-50.2 / 50.9-52.6 GHz

# Actions to be taken

To prepare proposals to preliminary draft new Report ITU-R S.[NGSO 50/40 GHz SHARING]

To consider aggregate interference effect on RAS from FSS GSO satellite networks and non-GSO systems operating in the relevant bands

To consider technical, operational and regulatory provisions that would take into account the effect of aggregate interference into incumbent services

To prepare proposals to preliminary draft new Report on protection of EESS (passive) and RAS systems from non‑GSO fixed satellite systems operating in the 37.5-42.5 GHz, 47.2‑50.2 GHz and 50.4-51.4 GHz frequency bands

To prepare proposals to revise, if and as appropriate, Resolution 750 (Rev.WRC-15) for non-GSO systems, based on studies of aggregate FSS interference effects from GSO satellite networks and non-GSO systems operating in the adjacent bands

Update a preliminary draft new Recommendation ITU-R S. [50/40 GHZ FSS SHARING METHODOLOGY] - Maximum permissible levels of interference in a satellite network (GSO and non-GSO) in the fixed-satellite service caused by other co-directional FSS and BSS networks operating in the 50/40 GHz frequency bands

Update a preliminary draft new Recommendation ITU-R S.[50/40 GHz REFERENCE LINKS]

To continue studying the correct modelling of EESS pusbroom sensors and revise, if and as appropriate, the current studies from NGSO FSS into EESS (passive);

To carry out studies towards ensuring protection of the Space research service in the frequency band 37/38 GHz (space-to-Earth) from non-GSO FSS LEO and MEO transmissions;

To prepare proposals to the draft CPM Report

# Relevant information from outside CEPT (examples of these are below)

## European Union (date of proposal)

## Regional telecommunication organisations

APT (March 2018)

APT Members support studies on technical and operational issues and regulatory provisions of non-GSO FSS 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) while ensuring protection to GSO satellite networks in FSS, MSS and BSS, and other existing services in the same bands as well as protection of the EESS (passive) in the frequency bands 36-37 GHz and 50.2-50.4 GHz and the radio astronomy in the frequency bands 42.5-43.5 GHz, 48.94-49.04 GHz and 51.4-54.25 GHz.

ATU (September 2017)

The APM19-2 agreed to:

Support the studies under Resolution 159 (WRC-15) which aim at developing a regulatory framework for new non-GSO FSS satellite systems, while protecting GSO FSS systems in the frequency bands above 30 GHz.

Encourage administrations to contribute towards further development of the three working documents in WP4A.

Note that the overlap in frequency bands with other AIs should not be an issue because this AI does not involve spectrum allocation/identification but rather regulatory framework for non-GSO FSS satellite systems in the stated four bands.

Arab Group (April 2017)

Protect the fixed-satellite service systems in GSO either by adequate epfd levels or any other methodologies or according to wave propagation models in the frequency bands above 30 GHz.

Consult the satellite operators of the team to determine the epfd value that ensures the protection of the satellite networks in the geostationary orbital positions and the opinion for the proposed mechanism.

CITEL (July 2018)

Administrations (USA, Canada, Brazil, and Mexico) support studies under WRC-19 Agenda Item 1.6 regarding the development of a regulatory framework for non-GSO satellite systems in the existing FSS allocations in the 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) frequency bands under the terms of Resolution 159 (WRC-15) and to take appropriate action based on the results of these studies.

For the protection of GSO systems, Canada supports the approach of determining the maximum single-entry and aggregate increase in GSO unavailability caused by non-GSO systems. This method will require a set of GSO reference links for implementation.

As set forth in Resolution 159 (WRC-15), any regulatory framework that is developed must guarantee protection of geostationary satellite networks without limiting or unduly constraining the future development of geostationary networks across these bands. As a result, Mexico supports the current work being done in WP 4A focusing on establishing an appropriate and efficient methodology to facilitate the development of non-geostationary systems in these bands, as long as protection of existing and planned geostationary networks is guaranteed, without imposing any kind of technical or operational limitations to these geostationary networks.

For the band 36-37 GHz: Canada, Brazil, and Mexico are of the view that based on the results of studies, EESS (passive) systems operating in the 36- 37 GHz band and non-GSO FSS systems are compatible and no regulatory measures are required to address the compatibility between these two services.

For the band 50.2-50.4 GHz: Canada, Brazil, and Mexico are of the view that based on the results of studies, mitigation techniques and/or regulatory measures such as revising the current unwanted emission limits in Resolution 750 (WRC-15) are required to ensure compatibility between EESS (passive) systems operating in the band 50.2-50.4 GHz and non-GSO FSS systems. Canada, Brazil, and Mexico are of the view that the use of the 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) by non-GSO FSS systems should be subject to coordination procedures under No. 9.12.

Regarding resolves 4 and 5 of Resolution 159 (WRC-15), Brazil and Mexico are of the view that changes to the FSS GSO limits in Resolution 750 (Rev. WRC-15) fall outside the scope of Agenda item 1.6.

RCC (September 2017)

The RCC Administrations consider that studies on technical and operational issues and regulatory provisions in order to ensure operation of non-GSO FSS satellite systems in the frequency bands 37.5-42.5 GHz (space-to-Earth), 47.2-48.9 GHz (limited to feeder links), 48.9-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) shall ensure protection to GSO satellite networks in FSS, MSS and BSS, and also to stations of other existing services in the same and adjacent frequency bands.

The RCC Administrations consider that technical conditions and regulatory provisions should be developed to ensure sharing of the considered frequency bands between non-GSO FSS systems.

The RCC Administrations consider that protection shall be ensured to EESS (passive) in the frequency bands 36-37 GHz, 47.5-48.5 GHz and 50.2-50.4 GHz, and also to the radio astronomy service in the frequency bands 42.5-43.5 GHz, 48.94-49.04 GHz and 51.4-54.25 GHz from non-GSO FSS transmissions.

The RCC Administrations consider that the conditions for compatibility between FSS and EESS (passive) systems shall take into account the possibility of the impact on EESS (passive) of aggregate interference from GSO FSS networks and non-GSO FSS systems in the frequency bands 37.5-42.5 GHz (space-to-Earth), 47.2-48.9 GHz (limited to feeder links), 48.9-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) and, if needed, they shall be reflected in Resolution 750 (Rev. WRC-15).

The RCC Administrations are in favour of the development of new Recommendation ITU-R S.[Methodology to assess FSS compatibility in the 50/40 GHz bands] for establishment of the appropriate protection criteria and maximum permissible levels of interferences from non-GSO FSS systems to GSO FSS networks in 40/50 GHz bands. At the same time, the criterion, which is based on the compliance of non-GSO FSS system with the requirements for maximum permissible increase in the percentage of unavailability for GSO FSS link, specified in new Recommendation ITU-R S.[Methodology to assess FSS compatibility in the 50/40 GHz bands], shall be used when developing limitations in Article 22 of Radio Regulations, that ensure adequate protection of GSO FSS systems..

## International organisations

IATA (date of proposal)

ICAO (date of proposal)

IMO (date of proposal)

SFCG, ESA (September, 2018)

SFCG supports the revision of the current limits in Resolution 750 (Rev. WRC-15) for the band 50.2-50.4 GHz to protect EESS (passive) for both NGSO and GSO systems taking into account that studies have demonstrated the limits in Resolution 750 (Rev. WRC-15) do not sufficiently protect passive services in the band. Therefore SFCG supports Method D, Option 1 of the draft CPM text (ITU-R WP4A Chairman Report 4A/826 Annex 29). Studies have shown that compatibility between EESS (passive) and NGSO FSS in the band 36-37 GHz is achieved, noting however that they did not address the cold calibration channel.

It is to be noted that sharing studies for SRS and EESS earth stations in the bands 37.5-38 GHz and 40-40.5 GHz are not listed in Resolution 159 (WRC-15). These studies will have to be addressed by WP 7B through the revision of Report ITU-R SA.2307 and Recommendation ITU-R SA.2079 for the band 37.5-38 GHz, and additional new report and recommendation for the band 40-40.5 GHz.

WMO and EUMETNET (February 2017)

EUMETNET

No opposition to the development of a regulatory framework for non-GSO FSS satellite systems in the 37.5-51.4 GHz range provided that protection of EESS (Earth-to-space), EESS (passive) and ground-based radiometers is ensured.

WMO

WMO supports the development of a regulatory framework (including revisions to Resolution 750 (Rev.WRC-15) for non-GSO FSS satellite systems in the 37.5-51.4 GHz range provided that protection of EESS (Earth-to-space) in the band 40-40.5 GHz and EESS (passive) in the bands 36-37 GHz and 50.2-50.4 GHz is ensured by including appropriate unwanted emission limits in Resolution 750 (rev. WRC-15).

WMO would appreciate the development of a solution to ensure the effective operation of the ground-based radiometers in the 50.4-51.4 GHz frequency band.

## Regional organisations

Eurocontrol (date of proposal)

NATO (19 June, 2018)

NATO Military Assessment:

Based on the current situation there are no known impacts to military capabilities.

NATO Position:

No position at this stage.

## No position at this stage. OTHER INTERNATIONAL AND REGIONAL ORGANISATIONS

EBU (date of proposal)

GSMA (date of proposal)

CRAF (March 2017)

CRAF supports the protection of existing RAS and EESS (passive) allocations in the 42.5 - 43.5 GHz, 48.94 - 49.04 GHz, and 50.2 - 50.4 GHz. No changes should be made to the RR unless acceptable sharing and compatibility criteria are developed with the RAS and EESS (passive).