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| **Radiocommunication Study Groups** |  |
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| Source: Document 5A/TEMP/111 | **Annex 23 to Document 5A/359-E** |
| **11 May 2021** |
| **English only** |
| Annex 23 to Working Party 5A Chairman’s Report | |
| WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT  new Report ITU-R M.[LMS.Conditions>275GHz] | |
| Assessment of mitigation techniques and specific conditions to be applied to the land mobile service applications in the frequency bands 296-306 GHz,  313-318 GHz and 333-356 GHz, to ensure the protection of earth exploration-satellite service (passive) applications in accordance with RR No. 5.564A | |

([Question ITU-R 256/5](http://www.itu.int/pub/R-QUE-SG05.256))

[Editor’s note : The development of this report and related studies have to be performed in close cooperation with WP 7C and WP 7D (see document [5A/225](https://www.itu.int/md/R19-WP5A-C-0225/en))]

(…)

# 1 Introduction

The objective of this Report is to address the relevant aspects of RR No. **5.564A** and assess the specific conditions necessary to ensure the protection of Earth exploration-satellite service (passive) applications in the frequency bands 296-306 GHz, 313‑318 GHz and 333-356 GHz, to be determined in accordance with RR No. **5.564A**:

5.564A For the operation of fixed and land mobile service applications in frequency bands in the range 275-450 GHz:

The frequency bands 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz are identified for use by administrations for the implementation of land mobile and fixed service applications, where no specific conditions are necessary to protect Earth exploration-satellite service (passive) applications.

The frequency bands 296-306 GHz, 313-318 GHz and 333-356 GHz may only be used by fixed and land mobile service applications when specific conditions to ensure the protection of Earth exploration-satellite service (passive) applications are determined in accordance with Resolution **731 (Rev.WRC-19)**.

In those portions of the frequency range 275-450 GHz where radio astronomy applications are used, specific conditions (e.g. minimum separation distances and/or avoidance angles) may be necessary to ensure protection of radio astronomy sites from land mobile and/or fixed service applications, on a case-by-case basis in accordance with Resolution **731 (Rev.WRC-19)**.

The use of the above-mentioned frequency bands by land mobile and fixed service applications does not preclude use by, and does not establish priority over, any other applications of radio services in the range of 275-450 GHz.      (WRC‑19)

The results of sharing and compatibility studies between LMS and FS applications planning to operate in the frequency range 275-450 GHz and passive services (radio astronomy service and Earth exploration-satellite service (passive)) that have been done pre-WRC-19 in [Report ITU-R SM.2450](https://www.itu.int/pub/R-REP-SM.2450) remain valid; however, these studies conducted prior to WRC-19 did not seek to develop specific conditions (such as power limits, shielding requirements and/or elevation angle restrictions, etc.) that could facilitate sharing with EESS and focused on identifying spectrum for LMS/FS applications, where such restrictions would not be necessary to protect the passive services.

# 2 Related Recommendations and Reports

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| [Recommendation ITU-R M.1825](http://www.itu.int/rec/R-REC-M.1825/en): | Guidance on technical parameters and methodologies for sharing studies related to systems in the land mobile service |
| [Recommendation ITU-R P.676](https://www.itu.int/rec/R-REC-P.676/en): | Attenuation by atmospheric gases |
| [Recommendation ITU-R P.838](https://www.itu.int/rec/R-REC-P.838/en): | Specific attenuation model for rain for use in prediction methods |
| [Recommendation ITU-R P.840](https://www.itu.int/rec/R-REC-P.840/en): | Attenuation due to clouds and fog |
| [Recommendation ITU-R P.2109](https://www.itu.int/rec/R-REC-P.2109): | Prediction of building entry loss |
| [Recommendation ITU-R RS.2017](https://www.itu.int/rec/R-REC-RS.2017/en): | Performance and interference criteria for satellite passive remote sensing |
| Report [ITU-R M.2417](https://www.itu.int/pub/R-REP-M.2417): | Technical and operational characteristics of land-mobile service applications in the frequency range 275-450 GHz |
| [Report ITU-R RS.2431](https://www.itu.int/pub/R-REP-RS.2431): | Technical and operational characteristics of EESS (passive) systems in the frequency range 275-450 GHz |
| [Report ITU-R SM.2352](https://www.itu.int/pub/R-REP-SM.2352): | Technology trends of active services in the frequency range 275‑3 000 GHz |
| [Report ITU-R SM.2450](https://www.itu.int/pub/R-REP-SM.2450): | Sharing and compatibility studies between land-mobile, fixed and passive services in the frequency range 275-450 GHz |
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# 3 List of acronyms and abbreviations

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| … |  |
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# 4 System characteristics of Earth exploration-satellite service (passive) operating in the frequency range 275-450 GHz, relevant for the mobile service

## 4.1Technical characteristics

[Editor’s note: Summarize key elements from Recommendation [ITU-R RS.2017](https://www.itu.int/pub/R-REP-RS.2017).]

Table 1  
(**Source: Recommendation ITU-R RS.2017**)

Performance criteria for satellite passive remote sensing in the frequency range 296-306 GHz and 313-355.6 GHz

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency band(s)  (GHz) | Required ΔTe (K) | Data availability(1) (%) | Scan mode  (N, C, L)(2) |
| 296-306 | 0.2/0.005(3) | 99.99/99(3) | N, L |
| 313.5-355.6 | 0.3/0.005(3) | 99.99/99(3) | N, C, L |
| (1) Data availability is the percentage of area or time for which accurate data is available for a specified sensor measurement area or sensor measurement time. For a 99.99% data availability, the measurement area is a square on the Earth of 2 000 000 km2, unless otherwise justified; for a 99.9% data availability, the measurement area is a square on the Earth of 10 000 000 km2 unless otherwise justified; for a 99% data availability the measurement time is 24 h, unless otherwise justified.  (2) N: Nadir, Nadir scan modes concentrate on sounding or viewing the Earth’s surface at angles of nearly perpendicular incidence. The scan terminates at the surface or at various levels in the atmosphere according to the weighting functions. L: Limb, Limb scan modes view the atmosphere “on edge” and terminate in space rather than at the surface, and accordingly are weighted zero at the surface and maximum at the tangent point height. C: Conical, Conical scan modes view the Earth’s surface by rotating the antenna at an offset angle from the nadir direction.  (3) First number for nadir or conical modes and second number for microwave limb sounding applications. | | | |

TABLE 2  
(**Source: Recommendation ITU-R RS. 2017)**

Interference criteria for satellite passive remote sensing in the frequency range 296-306 GHz and 313-355.6 GHz

| Frequency band(s)  (GHz) | Reference bandwidth (MHz) | Maximum interference level  (dBW) | Percentage of area or time permissible interference level may be exceeded(1) (%) | Scan mode  (N, C, L)(2) |
| --- | --- | --- | --- | --- |
| 296-306 | 200/3(3) | −160/−194(3) | 0.01/1(3) | N, L |
| 313.5-355.6 | 200/3(3) | −158/−194(3) | 0.01/1(3) | N, C, L |

The above notes under Table 1 also applies to Table 2.

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## 4.2Overview of EESS (passive) systems operating in the frequency range 296 GHz -355.6 GHz

*TBD*

# 5 Overview of planned land-mobile service applications in the frequency range 275-450 GHz

Report ITU-R M.2417 provides the technical and operational characteristics of land-mobile service applications in the frequency range 275-450 GHz for sharing and compatibility studies, including:

– Close proximity mobile systems (CPMSs)

– KIOSK downloading mobile systems

– Ticket gate downloading mobile systems

– Inter-chip communication systems

– Intra-device communications

– Wireless links for data centres

– Virtual reality systems

– Industrial systems

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**6 Propagation considerations**

*TBD*

# 7 Mitigation techniques and specific conditions to be applied to the land mobile service applications

This section provides a list of possible mitigation techniques and specific conditions to be applied to the land mobile service applications to ensure the protection of EESS (passive) applications in the frequency bands 296-306 GHz, 313-318 GHz and 333-356 GHz.

For each mitigation technique under consideration, together with their application conditions, if any, a detailed description is made including the way it is expected to improve sharing with EESS (passive) systems. In addition, an assessment of their effectiveness is also made, including relevant additional sharing studies in comparison to the previous studies given in [Report ITU-R SM.2450](https://www.itu.int/pub/R-REP-SM.2450).

[Editor’s Note: the abovementioned assessment and sharing studies have to be performed in close cooperation with WP7C and WP7D (see document 5A/225)].

The following possible mitigation techniques and specific conditions are assessed:

– Technique A,

– Technique B

– …/…

[Editor’s Note: The intent is to narrow down the list of possible mitigation techniques described below (from Recommendation ITU-R M.1825) and keep only those that may be worthwhile studying for this application]

[Recommendation ITU-R M.1825](http://www.itu.int/rec/R-REC-M.1825/en) outlines several mitigation techniques that can be investigated, among others, to assess their applicability for the applications above 275 GHz.

The possible mitigation techniques can be classified into four main types:

– SPEC: Methods related to specifications

– PERF: Equipment performance (supplier improving the equipment performance)

– SESS: Site engineering on single site

– DEPL: Deployment relationship between sites.

The following is a list of various existing interference mitigation techniques. Not all techniques are applicable to all types of systems, for example site shielding can be helpful for fixed systems but can not be used for mobile terminals. Similarly, some of these techniques are useful at both ends of an interfering link, while other techniques can only be applied to the interfering transmitter or to the victim receiver.

*Site selection* – Choosing a site to minimize potential interference. (SESS, DEPL)

*Physical shielding* – Using natural terrain, buildings, special purpose fencing to block signal in undesired directions. (SESS)

*Antenna separation* – Coupling between two antennas located in the same site can be reduced by separating the antennas vertically, horizontally or back-to-back by a few metres. (SESS)

*Antenna orientation* – Orienting the antenna of a directional, fixed system away from other radio systems. Physical constraints of system geometry often limit flexibility in antenna orientation. (SESS, DEPL)

*Antenna tilting* – A special case of antenna orientation where the vertical antenna pattern and antenna down-tilt may be used to tailor coverage and hence reduce interference outside of the served area. Especially applicable to system base stations, but the effects on coverage may make this technique undesirable in many cases. (SESS, DEPL)

*Diversity combining* – A technique of coherently combining the signals from multiple antennas to produce a gain. (SESS)

NOTE 1 – Diversity combining uses all antenna elements at all times for each user, creating an antenna pattern that dynamically adjusts to the propagation environment.

*Cross polarization* – The use of cross polarization can be used to introduce as much as 25‑30 dB of discrimination. (DEPL)

*Frequency coordination* – Coordination of frequency selection between neighbouring systems so as to reduce the potential for interference. (DEPL)

*Synchronized time division* – The mitigation brought by ensuring adjacent band systems synchronize their transmission and reception to avoid situations where a system is transmits during the time interval when the adjacent band system is receiving. (DEPL)

*Transmitter and receiver filtering* – Filtering is the ideal technique for avoiding, causing, or receiving adjacent channel interference. (PERF)

*Smart antennas* – A smart antenna system combines multiple antenna elements with a signal-processing capability to optimize its radiation and/or reception pattern automatically in response to the signal environment. The benefit from the use of smart antennas on sharing is due to the fact that the RF energy radiated by antenna arrays is both lower than that from conventional antennas for the same e.i.r.p. and focused in limited, specific regions of a cell rather than wide sectors. (SPEC, PERF)

NOTE 1 – The two major categories of smart antennas, based on the choice of transmit strategy, are adaptive antennas and switched-beam antennas.

*Dynamic channel selection techniques* – The radio system can potentially use one of a number of channels within a band for each transmission. The radio system listens on all of those channels to determine which ones are occupied and dynamically chooses the channel to be used accordingly. Such techniques include for example Dynamic Frequency Selection or Detect and Avoid mechanisms. (SPEC)

*Static channel selection techniques* – Before transmitting, the radio system listens on predetermined sub-channel(s) to determine whether a channel is appropriate for transmission. Such techniques include, for example, listen before talk or other static detect and avoid mechanisms. (SPEC)

*Frequency hopping* – The use of frequency hopping means that a radio system will only be using a particular frequency a small portion of the time and thus interference will only be caused or received for a brief moment and be unlikely to interfere with system operation. Dynamic frequency hopping goes a step further by eliminating channels from the hop sequence if they are being used by another system. (SPEC)

*Spread spectrum techniques* – As defined in Recommendation ITU-R SM.1055, the average energy of the transmitted signal is spread over a bandwidth which is much wider than the information bandwidth. This includes, for example, techniques such as Frequency Hopping spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS). (SPEC)

*Adaptive power control* – Systems using adaptive power control transmit using just enough power for a signal to go through. This minimizes the total amount of radio power that could potentially interfere with other systems and allows systems to adapt to poor conditions by temporarily increasing the transmitted power level. (SPEC)

*Adaptive modulation* – Changing to a lower-order modulation scheme can allow a radio system to continue to operate in the presence of interference, although at some loss in system capacity. (SPEC)

*Frequency diversity* **–** Diversity reception in which several radio channels are used with appropriate frequency separations. (SPEC)

*Duty cycle, time division* – The mitigation is brought by a division of time such that various transmitters do not transmit simultaneously. (SPEC)

Different technical solutions for mitigation may offer a different level of mitigation to devices of the same kind as compared to devices of a different kind. The level of mitigation may depend on the technology used and often on a combination of technical requirements.

*[Editor’s Note: Other mitigation techniques for consideration beyond those in Rec. ITU-R M.1825 may be added here].*

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