**Radiocommunication Study Groups**

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**Japan**

# PROPOSED REVISION TO WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT ITU-R SM.[275-450GHZ_SHARING]

## Sharing and compatibility studies between land-mobile, fixed and passive services in the frequency range 275-450 GHz

At November 2017 WP1A meeting, WP1A updated a working document towards a preliminary draft new Report ITU-R SM.[275-450 GHZ_SHARING] and attached to the chairman's report (Annex 3 to Document 1A/260).

The contributing groups of WRC-19 agenda item 1.15, i.e. WP5A and WP5C completed the studies on technical and operational characteristics and spectrum needs of the specific LMS and FS applications to be operated in either a whole band or parts of the frequency band 275-450 GHz, and published Report ITU-R M.2417 and F.2416, respectively.

WP1A has been made communications with WPs3J, 3K and 3M on 300-GHz propagation characteristics including the clutter loss and building entry loss models. However, one important element for sharing and compatibility studies between LMS applications and passive services was not discussed between WP1A and WPs3J, 3K and 3M. In the LMS deployment scenarios to be operated in the frequency band 275-325 GHz, CPMS applications are used indoors and the almost all antenna elevation of CPMS fixed devices for KIOSK and ticket gate downloading mobile systems is +90°. Those CPMS fixed devices start to operate when CPMS mobile devices are closely placed on those devices. CPMS mobile devices can also be used to shield the radiation power form the CPMS fixed devices to the air because of close proximity contact. Even though two devices are faced very closely, the leakage power may be radiated from interspace between two devices. This unwanted leakage power caused by the imperfect spatial contiguity should be evaluated according to the deployment scenarios and the blocking loss should be included in the studies. Additionally, the antenna elevation of CPMS mobile devices is -90°, the back-lobe antenna gain should also be taken into account for sharing and compatibility studies between LMS applications and EESS (passive) services. Japan is of the view that those elements should be taken into account in the studies between LMS applications and three types of EESS (passive) services whose scanning modes are Nadir, Limb, and Conical.

Report ITU-R M.2417 specifies the technical and operational characteristics of CPMS which will operate in the frequency band 275-325 GHz and 275-450 GHz which are called as CPMS applications and enhance CPMS applications, respectively. In the CPMS applications, the percentage of indoor CPMS fixed deployment is 100 %, but that of the enhanced CPMS application is 90 %. Japan is of the view that the 10 % outdoor devices of CPMS applications should be taken into account for the sharing study in the band 275-325 GHz. Recommendation ITU-R P.2109 provides the BEL model which can only give BEL distributions for frequencies up to 100 GHz. Japan is of the view that the extrapolation value from the model at 300 GHz should not be utilized for the sharing study, but the value identified by Recommendation ITU-R P.2109 at 100 GHz could be applied for the sharing study although the value at 100 GHz is estimated to be much lower than that at 300 GHz.

Regarding the sharing study between FS applications and EESS passive sensors, Japan submitted one sharing study between FS applications and Nadir scanning mode sensor which is included in section 5 to Annex 4 to the working document. Japan reviewed the elevation and azimuth distribution of FS antennas in the footprint area of EESS passive sensors and not only updates the study result for Nadir scanning mode sensor provided at the last meeting but also provides the sharing study results between FS applications and the Conical and Limb scanning mode sensors.

On this basis, Japan proposes a revision to working document towards a preliminary draft new Report ITU-R SM.[300GHZ_SHARING] and to elevate a draft new Report SM.[300GHZ_SHARING] because of its stability and maturity (see Attachment 1).

**Attachment:** 1

# ATTACHMENT

## [DRAFT] NEW REPORT ITU-R SM.[275-450GHZ_SHARING]

## 1 Introduction

WRC-19 agenda item 1.15 calls for studies to identify frequency bands for use by administrations for the land mobile and fixed services applications operating in the frequency range 275-450 GHz, in accordance with Resolution **767 (WRC-15)**. Resolution **767 (WRC-15)** *invites* ITU-R to conduct sharing and compatibility studies between land mobile service (LMS) and fixed service (FS) applications and passive services planned to operate in the frequency range 275-450 GHz and to identify candidate frequency bands for use by systems in LMS and FS applications, while maintaining protection of the passive services identified in RR No. **5.565**.

This Report provides 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)).

## 2 Related ITU-R Recommendations and Reports

*{Editorial note: The references below may be updated to the latest document references}*

| | |
|---|---|
| Recommendation ITU-R M.2003 | Multiple Gigabit Wireless Systems in frequencies around 60 GHz |
| Recommendation ITU-R M.2101 | Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies |
| Recommendation ITU-R P.452 | Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz |
| Recommendation ITU-R P.525 | Calculation of free-space attenuation |
| Recommendation ITU-R P.619 | Propagation data required for the evaluation if interference between stations in space and those on the surface of the earth |
| Recommendation ITU-R P.676 | Attenuation by atmospheric gases |
| Recommendation ITU-R P.840 | Attenuation due to clouds and fog |
| Recommendation ITU-R P.2108 | Prediction of Clutter Loss |
| Recommendation ITU-R P.2109 | Prediction of Building Entry Loss |
| Recommendation ITU-R RA.314 | Preferred frequency bands for radio astronomical measurements.” This gives frequencies of spectral lines of greatest importance to radio astronomy within the band 275-450 GHz. In this context, the spectral lines of carbon monoxide (CO) at 345.777 GHz and 330.588 GHz are of exceptional importance to radio astronomy |
| Recommendation ITU-R RA.769 | Protection criteria used for radio astronomical measurements |

| | |
|---|---|
| Recommendation ITU-R RA.1031 | Protection of the radio astronomy service in frequency bands shared with other services |
| Recommendation ITU-R RA.1272 | Protection of radio astronomy measurements above 60 GHz from ground based interference |
| Recommendation ITU-R RA.1513 | 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 RS.1813 | Reference antenna pattern for passive sensors operating in the Earth exploration-satellite service (passive) to be used in compatibility analyses in the frequency range 1.4-100 GHz |
| Recommendation ITU-R RS.2017 | Performance and Interference criteria for satellite passive remote sensing |
| Recommendation ITU-R RS.1813 | Reference antenna pattern for passive sensors operating in the Earth exploration-satellite service (passive) to be used in compatibility analyses in the frequency range 1.4-100 GHz |
| Recommendation ITU-R F.699 | Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to about 70 GHz |
| Recommendation ITU-R F.1245 | Mathematical model of average and related radiation patterns for line-of-sight point-to-point fixed wireless system antennas for use in certain coordination studies and interference assessment in the frequency range from 1 GHz to about 70 GHz |
| Report ITU-R F.2239 | Coexistence between fixed service operating in 71-76 GHz, 81-86 GHz and 92-94 GHz bands and passive services |
| Report ITU-R F.2416 : | Technical and operational characteristics and applications of the fixed service operating in the frequency band 275-450 GHz |
| Report ITU-R M.2417 | Technical and operational characteristics and applications of the land mobile service operating in the frequency band 275-450 GHz |
| Report ITU-R RA.2189 | Sharing between the radio astronomy service and active services in the frequency range 275-3 000 GHz |
| Report ITU-R RS.2194 | Passive bands of scientific interest to EESS/SRS from 275 to 3 000 GHz |
| Report ITU-R RS.[275-450 GHz Chars]<br>(Annex 16 to Document 7C/200) | Technical and operational characteristics of EESS (passive) systems in the frequency range 275 to 450 GHz |

| | |
|---|---|
| Report ITU-R SM.2352 | Technology trends of active services in the frequency range 275-3 000 GHz |

# 3 List of acronyms and abbreviations

*[No proposal to change]*

# 4 Regulatory information above 275 GHz

*[No proposal to change]*

# 5 System characteristics

## 5.1 System characteristics of land mobile service applications operating in the frequency range 275-450 GHz

*[No proposal to change]*

## 5.2 System characteristics of fixed service applications operating in the frequency range 275-450 GHz

*[No proposal to change]*

*[Editorial note: This section is taken from* Report ITU-R F.[300GHZ_FS_CHAR], *it will be updated according to information received from WP 5C*)

## 5.3 System characteristics of radio astronomy service operating in the frequency range 275-450 GHz

*[No proposal to change]*

*[Editorial note: This section is taken from* to Document 1A/93, *it will be updated according to information received from WP 7D*)]

## 5.4 System characteristics of Earth exploration-satellite service (passive) operating in the frequency range 275-450 GHz

*[No proposal to change]*

# 6 Considerations for sharing and compatibility studies

*[No proposal to change]*

# 7 Interference scenarios from land mobile and fixed service applications operating in the band 275-450 GHz to the passive services 'identified' in RR No. 5.565

According to RR No. **5.565**, the bands 275-323 GHz, 327-371 GHz, 388-424 GHz and 426-442 are identified for RAS while the bands 275-286 GHz, 296-306 GHz, 313-356 GHz, 361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz and 439-467 GHz are 'identified' for EESS (passive). The following sharing and compatibility studies have been addressed, as shown in Figure 7:

1 LMS application operating in the band 275-450 GHz with respect to the protection of EESS stations operating in the bands 275-286 GHz, 296-306 GHz, 313-356 GHz,

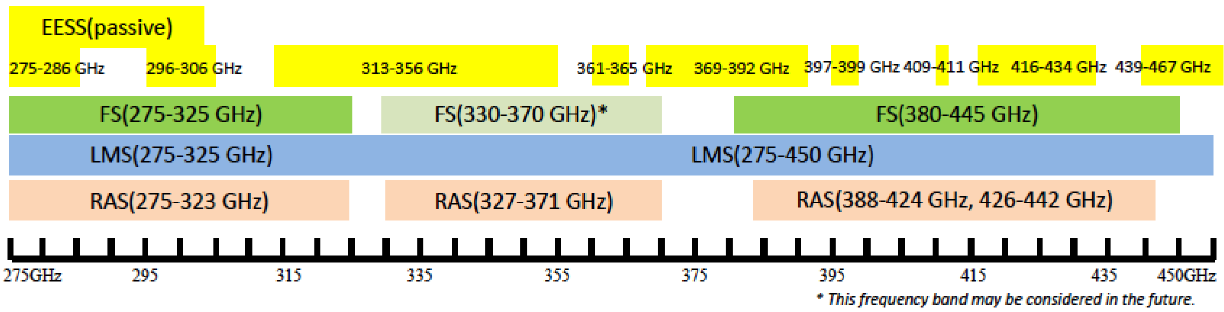
361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz and 439-467 GHz;

2 FS application operating in the band 275-450 GHz with respect to the protection of EESS stations operating in the bands 275-286 GHz, 296-306 GHz, 313-356 GHz, 361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz and 439-450 GHz;

3 LMS application operating in the band 275-450 GHz with respect to the protection of RAS stations operating in the bands 275-323 GHz, 327-371 GHz, 388-424 GHz and 426-442 GHz;

4 FS application operating in the band 275-450 GHz with respect to the protection of RAS stations operating in the bands 275-323 GHz, 327-371 GHz, 388-424 GHz and 426-442 GHz.

FIGURE 7




### 7.1 Interference scenarios from LMS applications operating in the band 275-450 GHz to EESS (passive) and RAS

The two interference scenarios listed in Table 15 are shown in Figure 8 and considered between LMS application and passive services.

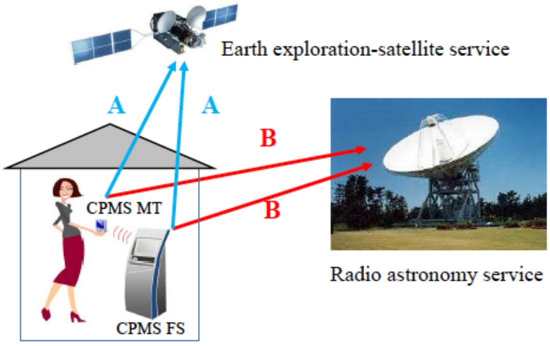
TABLE 15

**Interference scenarios**

| Scenario | Interfering | Interfered with | Propagation model (See Annex 3) |
|---|---|---|---|
| A | LMS mobile terminal fixed station | EESS sensor | Rec. ITU-R P.619, Rec. ITU-R P.2108,Rec. ITU-R P.2109 |
| B | LMS mobile terminal fixed station | RAS station | Rec. ITU-R P.452, Rec. ITU-R P.2108, Rec. ITU-R P.2109 |
| | | | |

FIGURE 8

**Illustration of interference scenarios between LMS application and passive services**




## 7.2 Interference scenarios from FS applications operating in the band 275-450 GHz to the EESS (passive) and RAS

The two interference scenarios listed in Table 16 are considered between FS application (fronthaul/backhaul) and passive services.

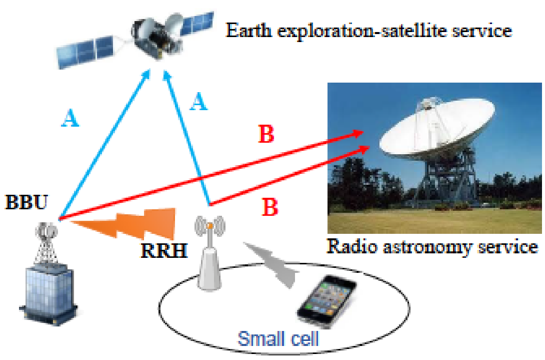
TABLE 16

**Interference scenarios**

| Scenario | Interfering | Interfered with | Propagation model (See Annex 3) |
|---|---|---|---|
| A | Fronthaul/Backhaul | EESS sensors | Rec. ITU-R P.619, Rec. ITU-R P.2108 |
| B | Fronthaul/Backhaul | RAS station | Rec. ITU-R P.452, Rec. ITU-R P.2108 |
| | | | |

FIGURE 9

**Illustration of interference scenarios between FS application and passive services**



# 8 Sharing and compatibility studies related to EESS (passive)

## 8.1 Sharing and compatibility studies between LMS application and earth exploration-satellite service (passive)

Sharing studies between LMS applications and EESS (passive) are detailed in Annex 4.

An interference analysis was done to assess the compatibility between LMS applications (specifically CPMS devices) and EESS (passive) devices in bands identified for use by EESS limb sounders. The results of this study are contained in Annex 4 Section 4 of this report. The results of this study demonstrate that CMPS applications will not interfere with EESS (passive) limb sounders. As the bands 275-286 and 409-411 GHz are only used by limb sounders, those bands are deemed compatible with CPMS applications. Further study with respect to other LMS applications, other EESS (passive) sensor types and other bands is still needed.

Study 4 provides the static and aggregate analysis in the 275-325 GHz frequency range. This analysis evaluated the compatibility between CPMS devices and EESS passive sensors. This study determined that CPMS devices evaluated may not interfere with EESS passive sensors in the frequency band 275-325 GHz under the condition of both 90-% indoor use having 56-dB BEL at 100 GHz and 100-% outdoor use having 20-dB blocking loss by mobile devices.

## 8.2 Sharing and compatibility studies between FS application and earth exploration-satellite service (passive)

Several sharing and compatibility studies were performed to support the identification of frequencies bands that could be used by FS applications. These studies are detailed in Annex 4.

Study 2 focused on a both static and aggregate analysis FS stations and an EESS (passive) satellite for four different pointing scenarios across the 275 – 450 GHz frequency range. This study found compatibility in the frequency bands 380-392 GHz and 439-450 GHz. However, this study considered a measurement area of 992000km$^2$ which is significantly larger than the maximum footprint of that particular EESS sensor type (100km$^2$).

Study 3 analysed the interference potential that may result from FS applications operating in the 275 -450 GHz frequency range to the EESS (passive) systems. The approach taken in these analyses was to perform a single FOV analysis of each type of passive sensor. The analysis would then determine the necessary FS and LMS application device deployment density that would be cause exceed the Rec. ITU-R RS.2017 interference threshold protection level. Those densities were then evaluated for their ability to be realized and compatibility was assessed based on this criteria. This study found that compatibility was achieved in the frequency bands: [TBD].

Study 4 provides the static and aggregate analysis in the 275-325 GHz frequency range. This analysis evaluated the compatibility between FS station and EESS passive sensor. This study determined that FS stations evaluated may interfere with EESS passive sensors in the frequency bands 296-306 GHz and 313-319 GHz.

Study 5 concluded that the following bands currently identified for EESS (passive) in RR N° **5.565** cannot be made available to the FS: 296-306 GHz, 313-320 GHz and 331-356 GHz. In the remaining parts of the 275-450 GHz range, FS identification can be envisaged. These bands would be enough to accommodate FS spectrum requirements of 50 GHz.

## 8.3 Summary of the sharing and compatibility studies related to EESS (passive)

The studies concluded that the following bands currently identified for EESS (passive) in RR N° **5.565** cannot be made available to the FS: 296-306 GHz, 313-319 GHz and 331-356 GHz. In the remaining parts of the 275-450 GHz range, FS identification could be made noting that these results do not include compatibility with the radio astronomy service, which is addressed in the following section.

The studies also concluded that the frequency band 275-325 GHz can be made available to LMS applications.

# 9 Sharing and compatibility studies related to RAS

## 9.1 Sharing and compatibility studies between LMS application and radio astronomy service

Several sharing and compatibility studies were performed to support the identification of frequencies bands that could be used by LMS applications. These studies are detailed in Annex 5.

## 9.2 Sharing studies between FS application and radio astronomy service

Several sharing and compatibility studies were performed to support the identification of frequencies bands that could be used by FS applications. These studies are detailed in Annex 5.

Study 1 contains two examples under conditions typical of those encountered in the vicinity of sites used for radio astronomical observations. The two geometries studies were: FS link and RAS on the same flat plane, with the FS link azimuth angle varying, and FS link and RAS are at different heights, with the FS beam fixed at the azimuth of the RAS operation and with its elevation angle varying. Three frequencies are used in the study: 275 GHz, 345 GHz and 412 GHz. This study concluded that separation distances and avoidance angle may be needed to protect RAS sites, as atmospheric losses alone are not sufficient to ensure compatibility.

Study 2 contains several calculations of necessary separation distances when considering the FS station and the RAS site at a variety of altitudes. The study indicated that separation distances of 1-150km may be needed if clutter loss is not accounted for. Separation distances of less than [5m] were calculated when clutter loss is taken into account.

## 9.3 Summary of the sharing and compatibility studies related to RAS

Atmospheric attenuation independent of free-space losses at 275–450 GHz is not sufficient to provide compatibility between FS and RAS operations in the absence of other considerations. Separation distances between RAS stations and FS stations should be considered depending on the deployment environment of FS stations

For the case of operations at the same geographic elevation, it is necessary that FS beams do not point too nearly toward an RAS site. The size of the avoidance angle will depend on the details of the actual FS beam pattern that is used in any situation, among other variables. For the case of high-elevation RAS operations in direct line of sight of FS operations at much lower elevations, FS beams may be directed in azimuth toward the RAS site at frequencies near the higher end of the band or at sufficiently horizontal separations.

Scenarios involving aggregate interference from multiple-entry FS deployments will require detailed modelling based on the details of each situation and must be evaluated on a case by case basis.

# 10 Summary

[TBD]

# ANNEX 1

*[No proposal to change]*

ANNEX 2

## Extrapolation of building entry loss and clutter loss from Recommendations ITU-R P.2108 and ITU-R P.2109 for sharing and compatibility studies

This Annex estimated building entry loss (BEL) and clutter loss at 300-GHz band using extrapolation of the results of Recommendations ITU-R P.2109 and ITU-R P.2108. Figure A2-1 shows the extrapolated building loss at 300-GHz band of about 73 dB in the condition of thermally-efficient building and no additional loss at the building façade for simplicity.  However while the median value of BEL can be extrapolation from the model, the entire distribution of the BEL would be needed in order to utilize this information in the sharing studies; in its present form the BEL model can only give BEL distributions for frequencies up to 100 GHz.

Figure A2-2 shows the extrapolated median clutter loss for the satellite path at p=50% with the different elevation angles. However while the median value of clutter loss cannot be used in the sharing and compatibility studies; the entire distribution of the Clutter loss values for a given frequency and elevation would need to be used. This distribution can be calculated from the Clutter model. Since the clutter loss for the satellite path with an elevation angle of 90 degree is close to zero, the clutter loss is not added for the studies between LMS application and EESS (passive). Figure A3-3 shows the extrapolated clutter loss using Recommendation ITU-R P.2109.

FIGURE A2-1

**Extrapolation of building entry loss for LMS application using Recommendation ITU-R P.2108**

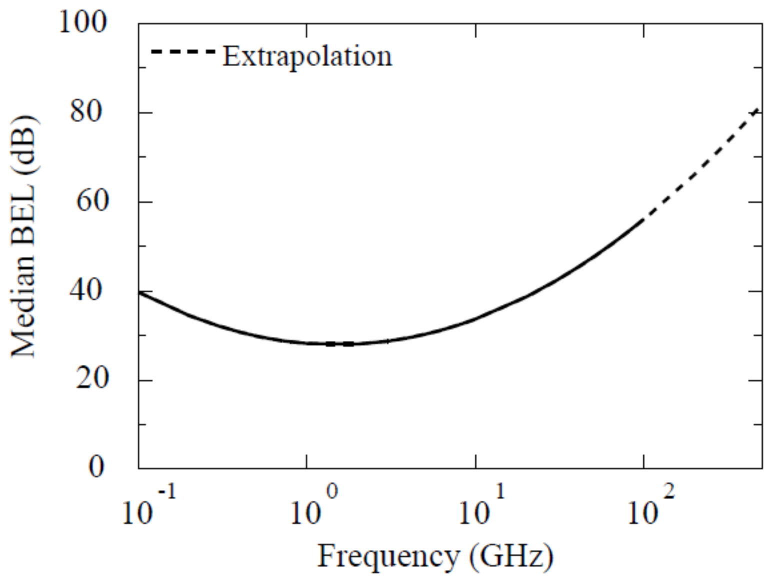
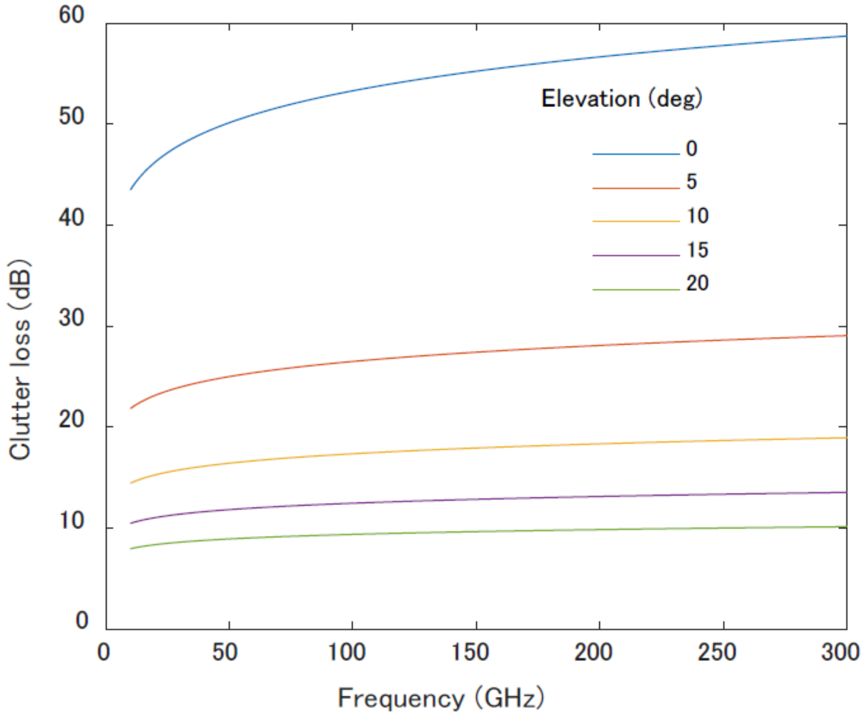


FIGURE A2-2

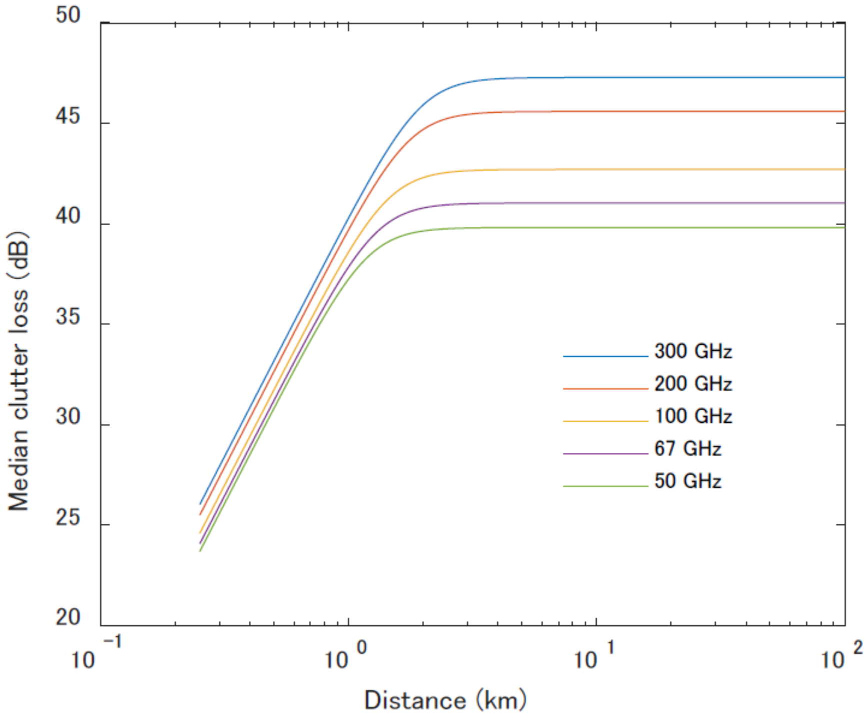
**Extrapolation of median clutter loss (p=50%) for the satellite path using Recommendation ITU-R P.2109**




Footnote: The entire distribution of the Clutter model would need to be used in the sharing and compatibility analysis.

FIGURE A2-3

**Clutter loss for the terrestrial path extrapolated using Recommendation P.2109**



ANNEX 3

*[No proposal to change]*

ANNEX 4

## Sharing studies between LMS and FS applications and Earth exploration satellite service

## 1 Introduction

This annex provides the results of four sharing studies (Study 2, 3 4 and 5) between EESS (passive) and FS and LMS applications in the bands identified for EESS (passive) in the 275 -450 GHz frequency range.

The frequency bands under study are given in RR **No. 5.565**, namely:
275-286 GHz, 296-306 GHz, 313-356 GHz, 361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz and 439-467 GHz.

It should be noted that due to the fact that the bands 275-286 GHz and 409-411 GHz are limited to the use of EESS (passive) limb sounders, they are already assumed, by principle, to be available for identification for land-mobile and fixed services identification.

It can also be noted that Study 1 depicts the initial static analysis of sharing between FS and EESS (passive) and was performed before the FS characteristics were finalised. It was however felt as valuable to keep it as a reference study

## 2 Study 1: Static analysis between FS/LMS and EESS (passive)

*[Editorial note: Study 1 was performed before characteristics of FS and LMs have been available. Therefore this study may be updated or deleted in the future.]*

*[No proposal to change]*

## 3 Study 2: Assessment of FS interference to EESS (passive)

*[No proposal to change]*

## 4 Study 3: Compatibility analyses between EESS (passive) and FS/LMS in the 275-450 GHz frequency range

## *[No proposal to change]*5 Study 4: Static and aggregate analysis of sharing between FS/LMS stations and EESS (passive)

### 5.1 Introduction

The frequency bands 275-286 GHz, 296-306 GHz and 313-356 GHz are identified for use for Earth exploration-satellite service (passive), and a lot of satellite passive remote sensing systems are operated as shown in Table 12 of the main body of this report. This section provides the sharing study results between FS/LMS stations and EESS passive sensors.

### 5.2 Received power level of EESS passive sensor

The received power of EESS antenna is given by the following equation :

$$P_R = P_T + G_T + G_R - L_{BW} - PL - A$$

where

$P_R$: the power at the output port of the receive antenna;

$P_T$: the power at the input port of the transmit antenna;

$G_T$: the gain of the transmit antenna in the direction of the receive antenna;

$G_R$: the gain of the receive antenna in the direction of the transmit antenna;

$L_{BW}$: the bandwidth limiting factor;

$PL$: the "traditional" path loss between transmit and receive antennas due to geometric spreading and terrain blockage;

$A$: the additional loss factor due to atmospheric absorption.

The parameters in the frequency band 275-325 GHz in Tables 7 and 8 of the main body of this report are used for calculation of the received power level of EESS (passive) whose characteristics are based on ICI in Table 14 of the main body of this report. The gain of the FS antenna at the zenith direction is assumed to be -13 dBi in accordance with Recommendation ITU-R F.1245. The path loss from a terrestrial point to EESS (passive) whose altitude is 817 km is referred from Figure 5 of the main body of this report. Although three altitudes of 0 m and 1,000 m where LMS/FS antennas are placed are considered for sharing and compatibility analyses, the study results are summarized by use of the altitude less than 1,000 m because major large cities whose population is over 10 million in the world are located between 0 m and 1,000 m.

## 5.3 LMS deployment

The deployment scenarios of LMS applications are provided in section 5.1.1 in the main body of this report. In the LMS deployment in the frequency band 275-325 GHz, CPMS applications are used indoors and the almost all antenna elevation of CPMS fixed devices for KIOSK and ticket gate downloading mobile systems is +90°. Those CPMS fixed devices start to operate when CPMS mobile devices are closely placed on those devices. CPMS mobile devices can also be used to shield the radiation power form the CPMS fixed devices to the air because of close proximity contact. Even though two devices are faced very closely, the leakage power may be radiated from interspace between two devices. This unwanted leakage power caused by the imperfect spatial contiguity is measured using KIOSK devices and estimated to be 20 dB below the output power of CPMS fixed device (see Annex 6). The blocking loss by CPMS mobile device should be used for the sharing study. Additionally, the antenna elevation of CPMS mobile devices is -90°, the back-lobe antenna gain should also be taken into account for sharing and compatibility studies.

The following table summarizes the technical and operational parameters used for the sharing studies between LMS application such as KIOSK downloading mobile system and EESS (passive) services.

TABLE A4-X1

**Summary of technical and operational parameters of CPMS applications to be used for sharing studies**

| Parameters | Values | Remark |
|---|---|---|
| Frequency range (GHz) | 275-325 | CPMS application in Report ITU-R M.2417 |
| Antenna elevation (degree) | 90 | CPMS fixed device |
| | -90 | CPMS mobile device |
| Back sidelobe gain of Horn antenna (dB) | -4.8 | Recommendation ITU-R F.1245 |
| Blocking loss (dB) | 20 | Annex 6 of this report |
| Indoor CPMS fixed device deployment (%) | 90 | The value of the enhanced CPMS application in Report ITU-R M.2417 is applied. |
| Building entry loss (dB) | 56 | The value at 100 GHz identified by Recommendation P.2109 for thermally-efficient structure is applied. |

## 5.4 FS deployment

The deployment scenarios of FS applications are provided in section 5.2.1 in the main body of this report. The elevation and azimuth angles are assumed to be distributed uniformly from +20 to -20 degrees and from 0 to 360 degrees in the footprint areas of EESS passive sensors, respectively. The antenna gain of FS stations to EESS passive sensors are determined from the nadir angles. The aggregate transmitting power is calculated using the parameters of FS link density and footprint area. Since FS applications in the frequency band 275-325 GHz are evaluated in this study, FS link density of 4.2/km2 is used for the calculation.

## 5.5 Study results between CPMS application and EESS passive sensors

The following parameters are used for calculation of aggregate received power of EESS passive sensors. Three bands, 275-286 GHz, 296-306 GHz and 313-325 GHz which are identified for use of EESS passive sensors are assessed in accordance with section 5.2. Figure A4-X1 summarizes the study results which show the band 275-325 GHz is available for LMS applications in the condition of indoor use (90 %) with BEL of 56 dB at 100 GHz and outdoor use (10 %) (Figure A4-X1 (b1)), or outdoor use (100 %) with a blocking loss of 20 dB by mobile devices (Figure A4-X1 (b2)). Although the BEL of 56 dB at 100 GHz recommended by Recommendation ITU-R P.2109 is much lower value than that at 300 GHz which is not covered by Recommendation ITU-R P.2109, the BEL of 56 dB is used for calculation as reference which provides the worst-case scenario. As indicated in Figure A4-X1 (b1), both CPMS and enhanced CPMS application scenarios provided in Report ITU-R M.2417 do not interfere with Nadir scanning mode sensor in the frequency band 275-325 GHz. Figure A4-X1 (b2) shows the calculation results where all CPMS devices are used in outdoor only which are not included in LMS operational characteristics in Report ITU-R M.2417, but this LMS scenario gives the worst-case interference to EESS passive sensors. The blocking loss of 20 dB which is measured using a prototype KIOSK station (CPMS fixed device) and CPMS mobile device. The CPMS applications also do not interfere with Nadir scanning mode sensor in the frequency band 275-325 GHz if the blocking loss is included in the analysis.

TABLE A4-X2

**Summary of parameters to be used for sharing studies**

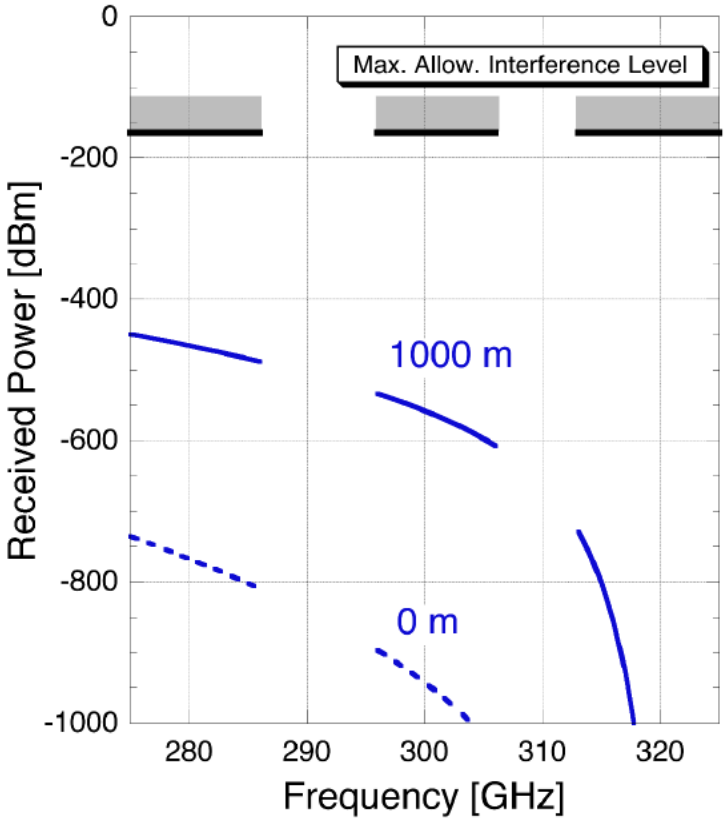
| EESS sensors (Table 13) | Received bandwidth of sensors (MHz) | Antenna gain of CPMS devices (dBi) | Nadir angle (degree) | Aggregate effect |
|---|---|---|---|---|
| Limb | 3 | 30 (fixed) | 0 | N/A<br>Ponting of 30-dBi antenna to EESS sensor (Worst-case scenario) |
| Nadir[1] | 200 | 30 (fixed)<br>-4.8 (mobile) | 90 | Footprint=200 $km^2$<br>Device density=0.6/km2<br>Number of devices=120<br>Activity factor=0.76%<br>Aggregate transmitting power=9.6dBm |
| Conical | 200 | -8.6 (fixed)<br>-4.8 (mobile) | 53 | |

1 Received power to Nadir scanning mode sensor is calculated at 90- degree zenith direction only.

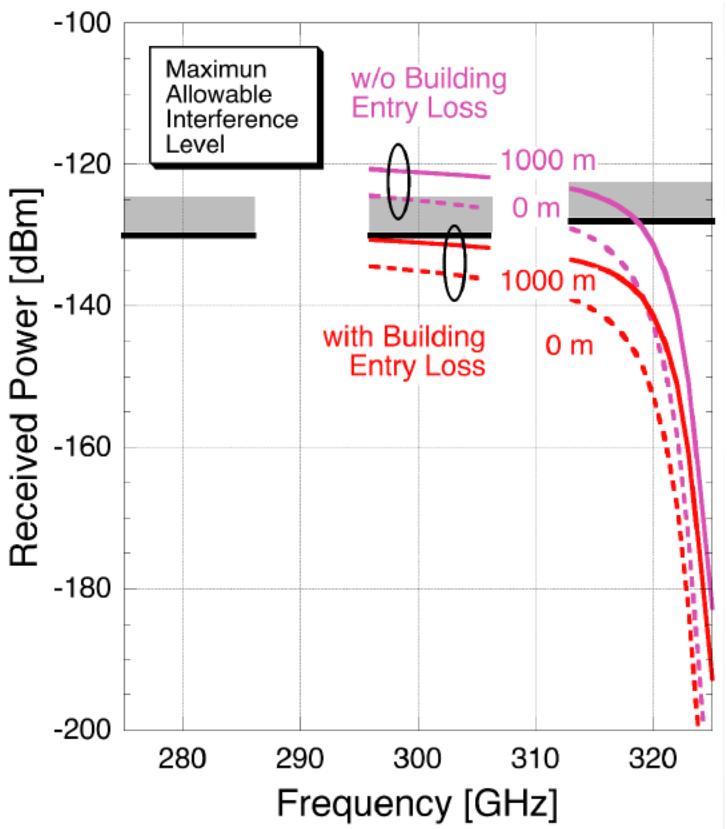
FIGURE A4-X1

**Received power level of EESS passive sensors**

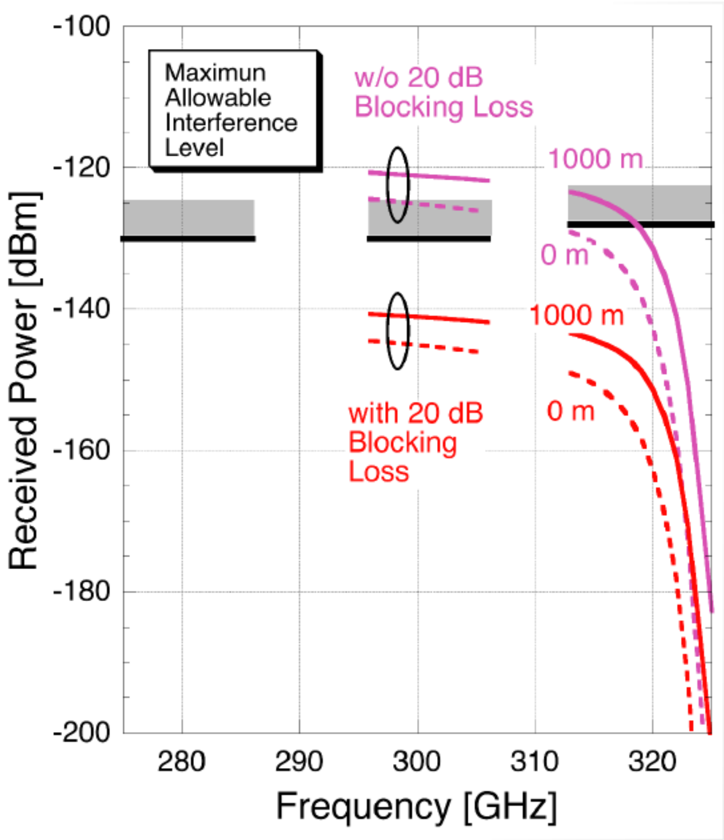
**(a) Limb**



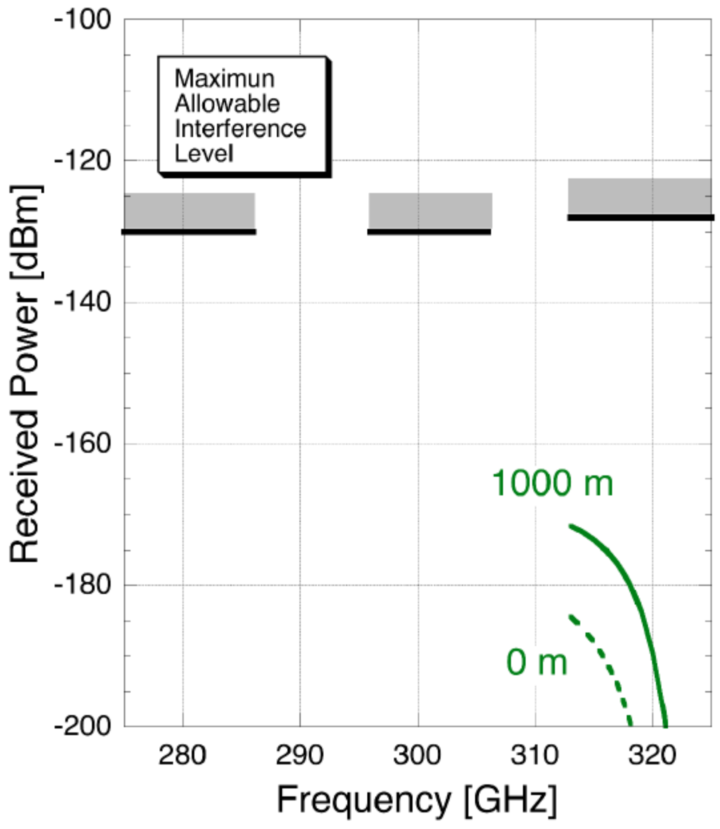

**(b1) Nadir (90 degree only)**



**(b2) Nadir (90 degree only)**




**(c) Conical**



## 5.6 Study results between FS application and EESS passive sensors

The following parameters are used for calculation of aggregate received power of EESS passive sensors. Three bands, 275-286 GHz, 296-306 GHz and 313-325 GHz which are identified for use of EESS passive sensors are assessed in accordance with section 5.2. The aggregate power from FS stations at the altitudes of 0 m and 1,000 m are calculated to evaluate the received power of three types of EESS passive sensors.

TABLE A4-X3

**Summary of parameters to be used for sharing studies**

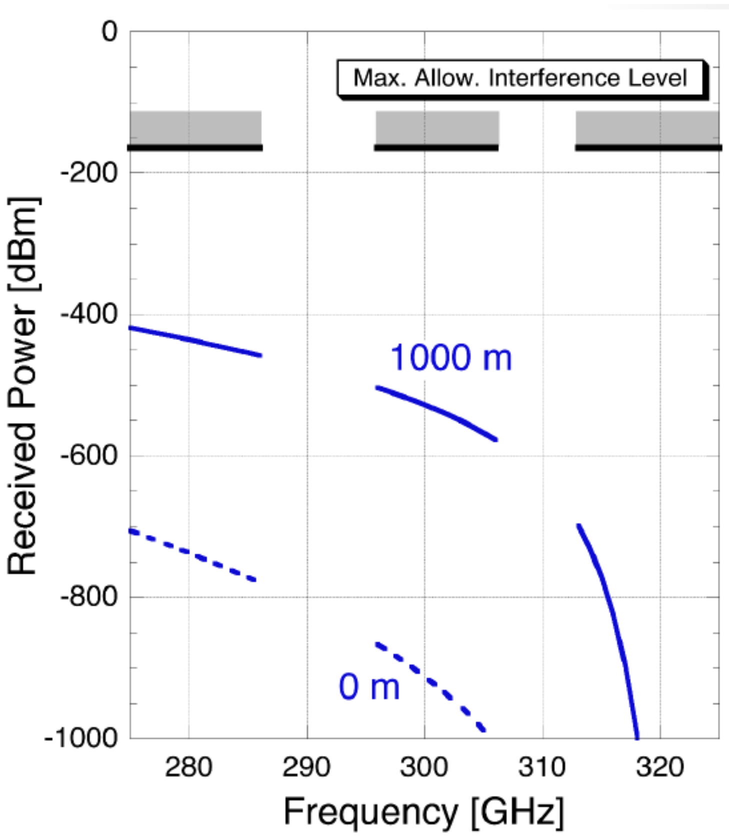
| EESS sensors (Table 13) | Received bandwidth of sensors (MHz) | Nadir angle (degree) | FS antenna gain (dBi) | Elevation angle (degree) | Azimuth angle (degree) | Aggregate effect |
|---|---|---|---|---|---|---|
| Limb | 3 | 0 | 50 | 0<br>(Worst case scenario) | 0<br>(Worst case scenario) | N/A<br>Pointing of 50-dBi antenna to EESS sensor (Worst-case scenario) |
| Nadir | 200 | 90 | -13 | From -20 to +20 | From 0 to 360 | Footprint=200 $km^2$<br>FS link density=4.2/$km^2$<br>Number of transmitter=1,680<br>Aggregate effect=32.3 dB |
| Conical | 200 | 53 | -6.3 | From -20 to +20 | From 0 to 360 | |

Figure A4-X2 shows the calculated results of the received power level of EESS passive sensors. Both the limb and conical scanning mode sensors are calculated in the condition of the altitude of 0 m and 1,000 m where FS stations are placed, as shown in Figure A4-X2 (a) and (c), respectively. No interference from FS stations is observed in the analysis. However, FS stations interfere with the nadir scanning mode sensor in the frequency band 296-306 GHz, even if the altitude of FS stations is 0 m, as shown in Figure 4A-X2 (b). However, if the FS station is placed on the altitude of 1,000 m, the received power is larger than the maximum interference level in the frequency band 313-319 GHz. In summary, the band 275-286 GHz, 286-296 GHz and 319-325 GHz are available to FS applications without any conditions.

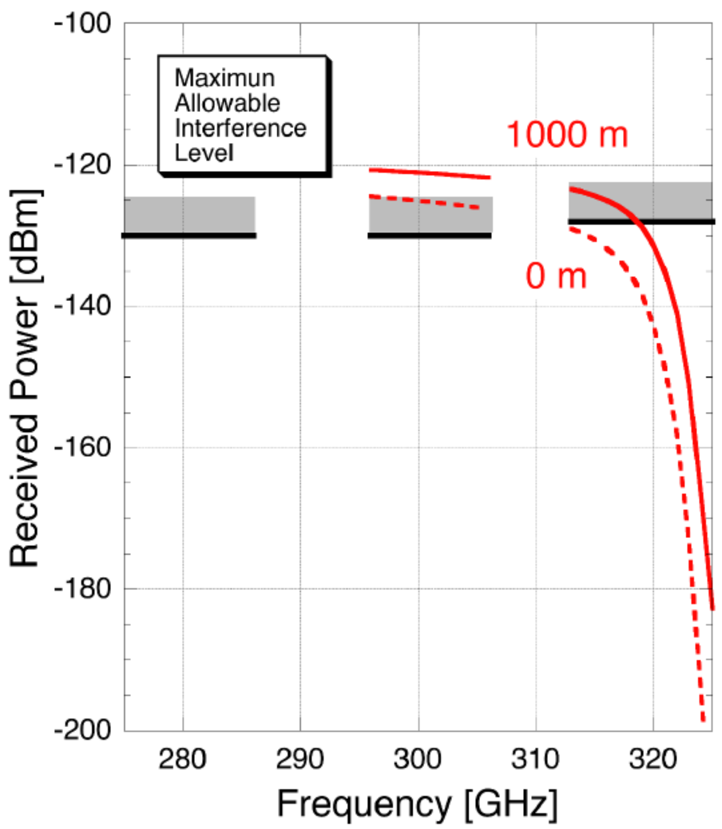
FIGURE A4-X2

**Received power level of EESS passive sensors**

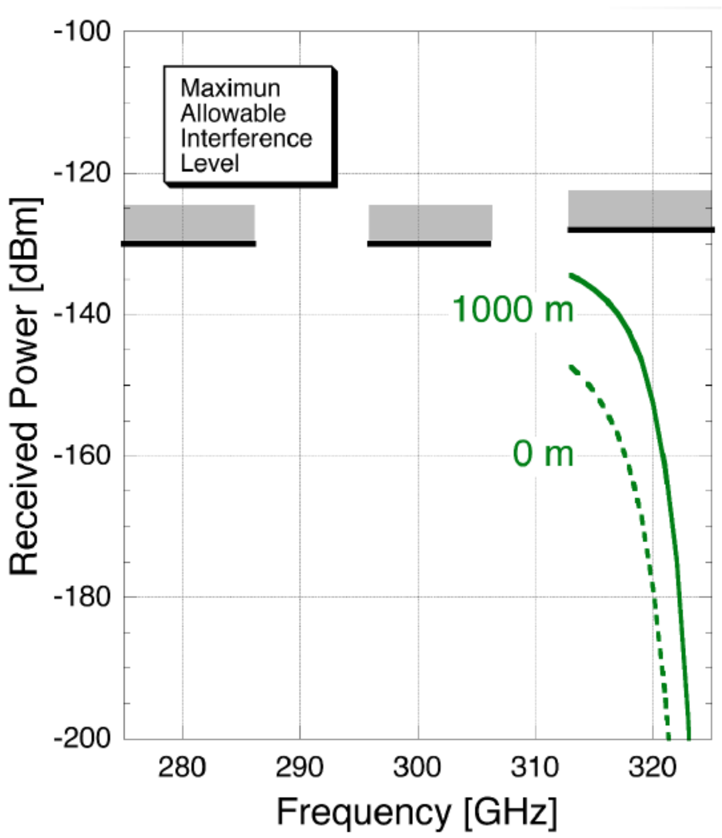
**(a)Limb**




**(b) Nadir (90 dgree only)**



**(c) Conical**




2000 m

0 m

### 5.7 Summary of Study 4

The band 275-325 GHz is available for use of LMS applications in the condition of both 90-% indoor use and 10-% outdoor use of CPMS devices and 100-% outdoor use of CPMS devices having the blocking loss caused by the mobile devices. Th[illegible]s 275-286 GHz, 286-296 GHz, 306-313 GHz and 319-325 GHz are available for use of FS applications without any conditions.

## 6 Study 5: Compatibility analyses between EESS (passive) and FS in the 275-450 GHz frequency range (Aggregate case)

*[No proposal to change]*

ANNEX 5

# Sharing studies between LMS and FS applications and radio astronomy service

## 1 Study 1: Compatibility between RAS and FS operations in the spectrum band 275-450 GHz

*[No proposal to change]*

## 2 Study 2: Compatibility analysis between FS and RAS in the 275-325 GHz band

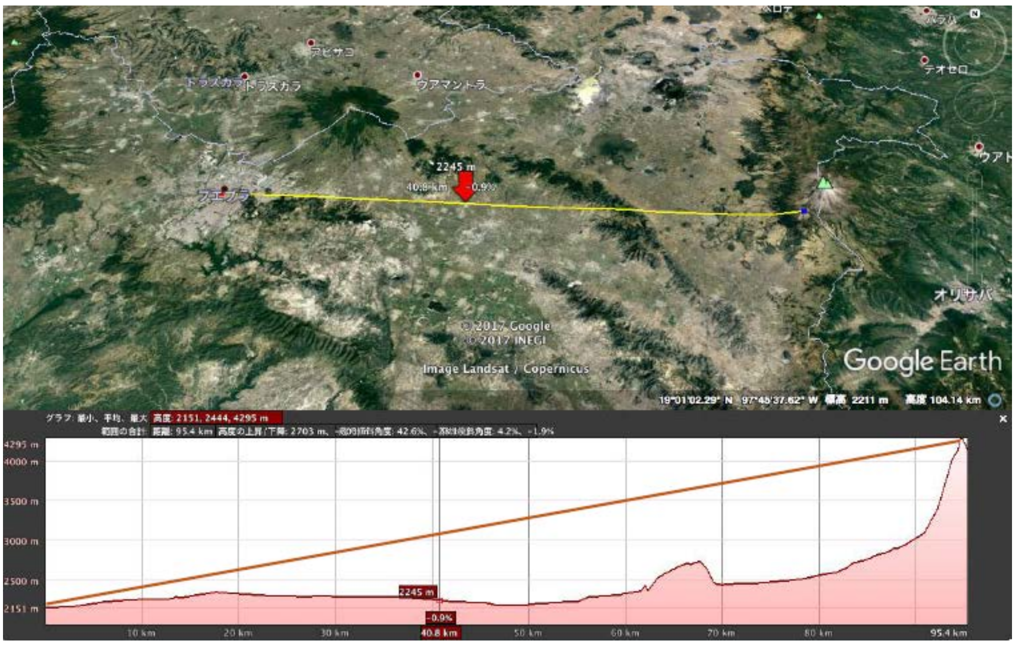
As Report ITU-R RA.2189 indicated, the worst-case interference scenario is that transmitting antennas of LMS or FS stations are directly pointing at a radio telescope, with both transmitter and telescope at a high elevation. However, LMS stations output power and antenna gain are expected to be much lower than that of FS applications. Given this the following sharing study focuses on interference between outdoor FS stations and the radio astronomy service.

### 2.1 RAS sites

Table 10 summarizes radio astronomy sites whose locations are almost on high mountaintop and isolated areas. The distance, for example, between Granada (0.24 M) and Pico de Veleta, Grenoble (0.15 M) and Plateau de Bure, Puebla (2.5 M) and Sierra Negra are 20 km, 60 km and 90 km, respectively. 300-GHz fronthaul/backhaul may not be deployed in Granada and Grenoble due to low population. The 300-GHz fronthaul/backhaul may be deployed in dense urban area of Puebla because of high population, but the other two cities may not deploy the 300-GHz system due to the lack of traffic. Figure A5-1 shows the terrain profile between Puebla and Large Millimeter Telescope in Sierra Negra. There is possibility of line-of-sight propagation path whose distance is about 40 km.

FIGURE A5-6

**Terrain profile between Puebla and LMT in Sierra Negra**



## 2.2 Protection of RAS stations from FS stations operating in the 275-350 GHz band

Figure A5-1 shows the minimum separation distances between the FS station whose output power is 20 dBm, antenna gain 50dB, as shown in Table 5 and a radio telescope. A similar "close-to-worst-case" terrestrial scenario for interference to the radio astronomy service in Report ITU-R RA.2189 is also used for calculation without both rainfall and foggy atmospheric attenuation, but the altitude of both FS and RAS antennas is changed from 0 m 4000 m for evaluation of the separation distance. The minimum separation distance is calculated from Equation (1).

$$P_R = P_T + G_T + G_R - P_L - Pclutter - A \geq S_H \qquad (1)$$

where:

- $P_R$: received power of radio telescope site;
- $P_T$: FS transmitter power shown in Table 2;
- $G_T$: FS antenna gain shown in Table 2;
- $G_R$: antenna gain of the radio telescope in the direction of the transmitter, which is assumed to be 0 dBi in accordance with Recommendation ITU-R RA.769;
- $P_L$: free-space loss in accordance with Recommendation ITU-R P.525;
- $Pclutter$: *Clutter loss as shown in Table A3-3*;
- $A$: atmospheric attenuation in accordance with Recommendation ITU-R P.676;
- $SH$: Threshold level of interference detrimental to radio astronomy observations in Table 4.

The calculation results clearly indicate that the separation distance below 45 km which is shorter than that between Puebla and Sierra Negra, that even between Grenoble and Plateau de Bure can be achieved, if the estimated clutter loss shown in Annex 2 is added in the calculation. However, the entire distribution of the clutter loss is preferable for estimation of the separation distance. Since the levels of interference detrimental to radio astronomy observations at 265 GHz and 305 GHz are only specified in Table 8, the levels between 265 GHz and 345 GHz are interpolated using linear approximation, as shown in Table A5-1. It should be noted that the terrain shielding and the deviation of FS antenna direction form the pointing direction to RAS station, as well as the change of an altitude from 3 000 m to 0 m of FS station may further reduce the separation distance. Figure A5-8 shows the separation distance without clutter loss.

FIGURE A5-7

**Minimum separation distance including estimated clutter loss between FS station and radio telescope which does not exceed radio astronomy interference thresholds given in Table A5-1**

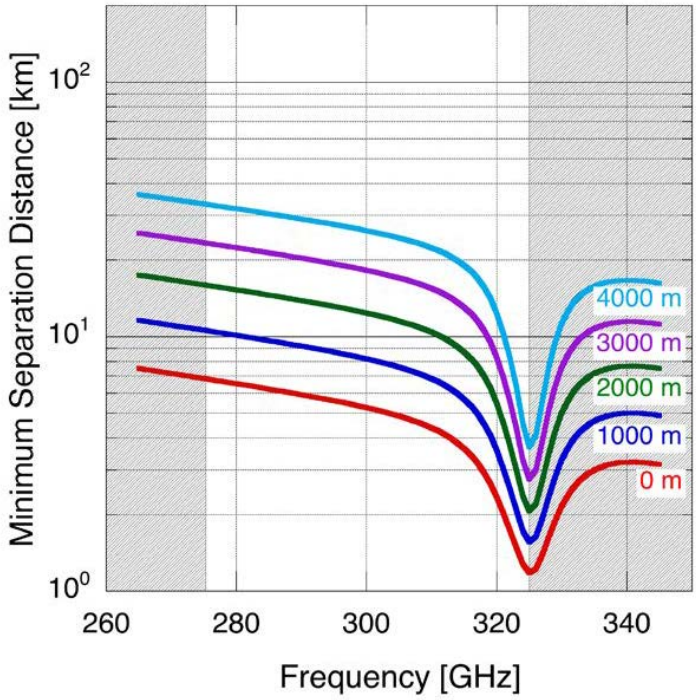
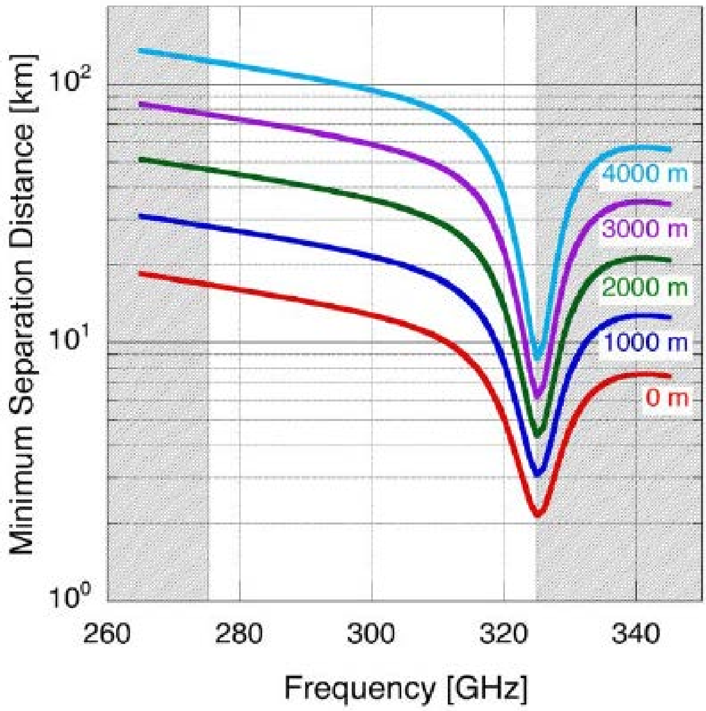



FIGURE A5-8

**Minimum separation distance without clutter loss between FS station and radio telescope which does not exceed radio astronomy interference thresholds given in Table A5-1**



*[Japan's note: Table A5-1 should be here because Document 1A/242 proposed this table next to Figure A5-8.]*

TABLE A5-1

**Interpolation of threshold levels of interference calculated from Table 10 of the main body of this report**

| Frequency (GHz) | $S_H$ (dB(W/(m$^2$ · Hz))) | Frequency (GHz) | $S_H$ (dB(W/(m$^2$ · Hz))) | Frequency (GHz) | $S_H$ (dB(W/(m$^2$ · Hz))) |
|---|---|---|---|---|---|
| 265 | -195.4[1] | 295 | -194.05 | 325 | -192.7 |
| 270 | -195.175 | 300 | -193.825 | 330 | -192.475 |
| 275 | -194.95 | 305 | -193.6 | 335 | -192.25 |
| 280 | -194.725 | 310 | -193.375 | 340 | -192.025 |
| 285 | -194.5 | 315 | -193.15 | 345 | -191.8[1] |
| 290 | -194.275 | 320 | -192.925 | | |

[1] The threshold levels at 265 GHz and 345 GHz were provided from Table 5 of the main body of this report and the others are calculated by linear interpolation approximation.

## 2.3 Summary of Study 2

Atmospheric attenuation is not sufficient to provide compatibility between FS and RAS stations in the absence of other techniques. However, the terrain shielding, the deviation of FS antenna direction from the pointing direction to RAS station, and the change of an altitude from 3 000 m to 0 m of FS station further reduce the separation distance. These specific conditions are necessary for protection of RAS station, on a case by case basis.

# 3 Study 3: Protection of RAS stations from FS stations operating in the 275-450 GHz band

*[No proposal to change, but this section should be Study 3 in the 275-450 GHz. Also, Table A5-1 at the end of section 2.3 should be moved to section 2.2.]*

*Editorial Note: [The studies above considered only the median clutter loss as extrapolated from Figure in Annex 2 of this report (47dB). In order for these static analysis to represent the worst case sharing conditions this value needs to be re-examined and re-evaluated using the minimum clutter loss value.]*

ANNEX 6

# Leakage power measurement in the frequency range 280-320 GHz

In this Annex, the unwanted leakage power from interspace between CPMS fixed and mobile devices is provided by the measurement results in the frequency range 280-320 GHz.

## 1 Radiation power in the vertical plane of KIOSK station

### 1.1 Measurement setup

Radiation power from the interspace between CPMS fixed and mobile devices is measured by using continuous signal wave in the frequency range of 280-320 GHz with 10 GHz step. Figure A6-1 shows the measurement set up for radiation power in the vertical plane of KIOSK station where CPMS fixed device is installed. Table A6-1 summarizes the measurement parameters. The KIOSK station consists of metal body, LCD monitor with PC function, glass window for connection between CPMS fixed and mobile devices, CPMS fixed device and its positioning actuator. The communication window is made of the glass with low loss property. The signal from CPMS fixed device is transmitted to CPMS mobile device placed on the window through the glass window. In the measurement configuration, the distance from receiver to window is 2.13 m and the distance from window to transmitter is 0.375 m. Thus, the distance between transmitter and receiver is about 2.5 m. KIOSK station is rotated around a vertical line including CPMS fixed device antenna as a centre axis.

The two radiation power patterns are measured when CPMS mobile device is set on the communication window and it is not on the window. Figure A6-2 shows the external view when CPMS mobile device is set on the communication window of KIOSK station and it is not on the window.

FIGURE A6-1

**Measurement setup of radiation power from the KIOSK station**

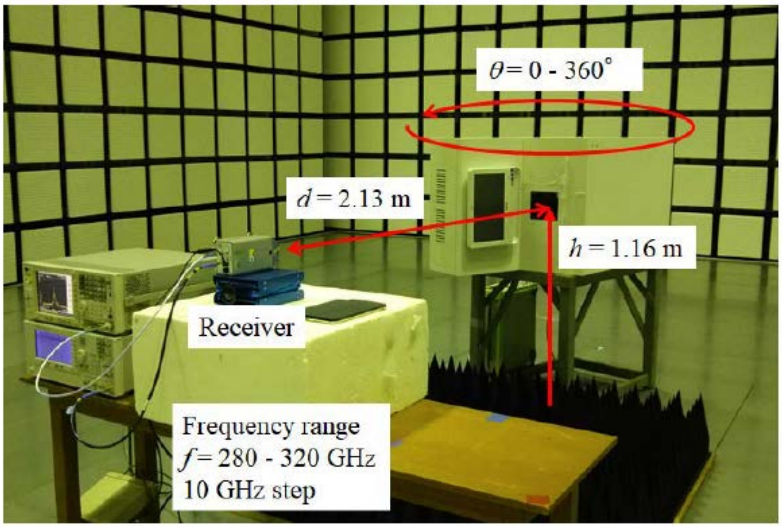


TABLE A6-1

**Measurement parameters**

| | |
|---|---|
| Measured frequency | 280-320 GHz (10 GHz step) |
| Output power | -15 dBm |
| TX and RX antennas | Rectangular horn<br>Gain: 25 dBi (HPBW 10 degree) |

FIGURE A6-2

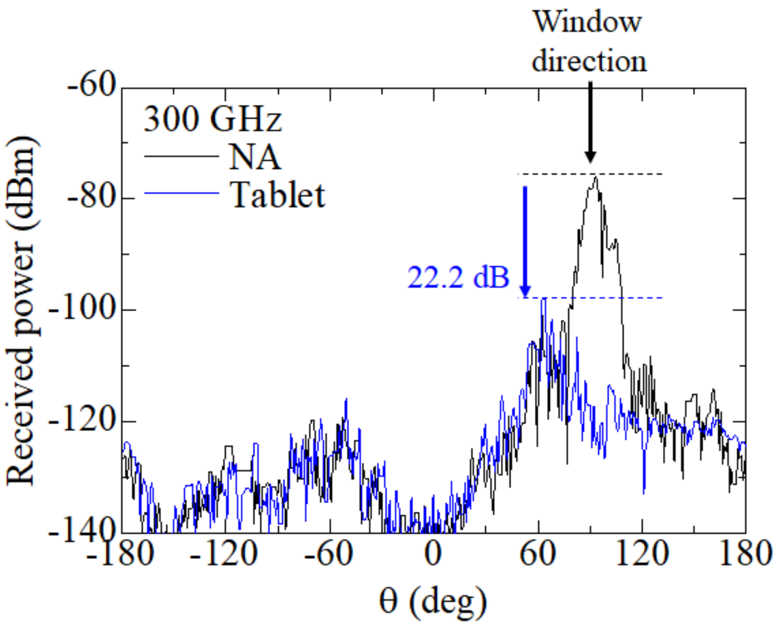
**(a) Window only** **(b) Tablet PC on the window**

## 1.2 Measurement results

Figure A6-3 shows the measurement results of radiation power directivity in the vertical plane of the KIOSK station. If CPMS mobile devices is not set on the communication window as shown in Figure A6-2a, the strongest radiation direction is the window direction. One other hand, the peak power is decreased of 22.2 dB and 18.5 dB respectively when COMS mobile device is set on the communication window. The attenuation of received power indicates the blocking loss by the device. Thus, the leakage power from KOISK station is observed, but the leakage power level is 20 dB below the output power of CPMS fixed device.

FIGURE A6-3

**Measured radiation power directivity in vertical plane of the KIOSK terminal.**



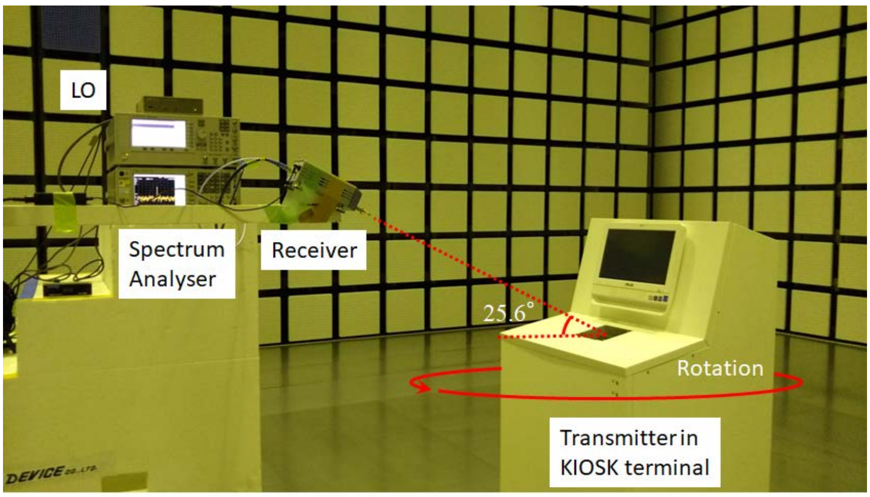

## 2. Radiation power in the direction of θ = 25.6 degree from KIOSK station

### 2.1 Measurement setup

The elevation at ground of EESS passive sensor with conical scanning mode is 25.6 degree. In order to measure radiation power to that direction, the radiation power is measured using the system shown in Figure A6-4.

FIGURE A6-4

**Measurement setup of radiation power in the direction of θ = 25.6 degree from the KIOSK station**

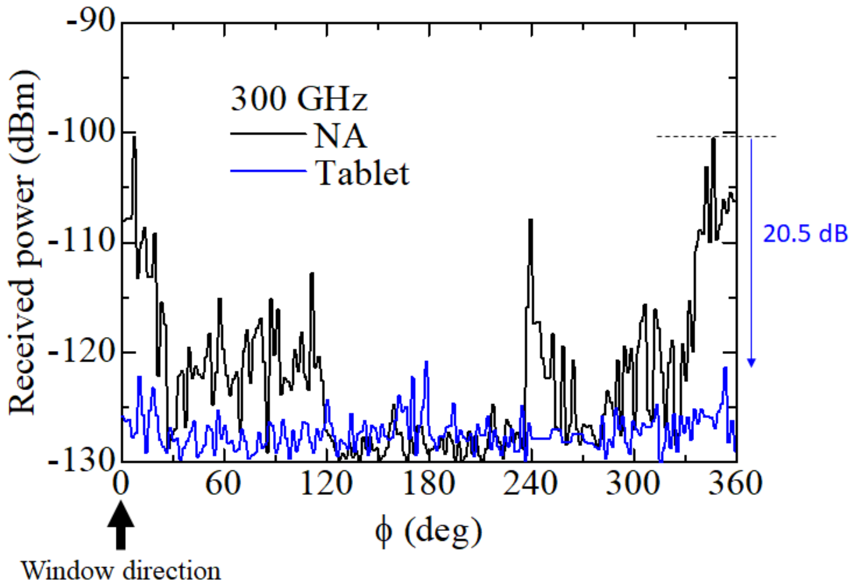



### 2.2 Measurement results

Measured radiation power pattern is shown in Figure A6-5. The similar blocking loss of 20.5 dB by CPMS mobile device is observed.

FIGURE A6-5

**Measurement setup of radiation power in the direction of θ = 25.6 degree from the KIOSK station**




## 3. Summary

The leakage power from interspace between CPMS fixed and mobile devices is observed and the level of the unwanted leakage power is 20 dB below the output power of CPMS fixed device. The blocking loss of 20 dB should be introduced for the sharing study between LMS application and passive services.

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