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| U.S. Radiocommunications Sector  Fact Sheet | |
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| **Purpose/Objective:** Continue the work under WRC-27 Agenda Item 1.13 and contribute to Annex 7 of the last 4C’s chair report. | |
| **Abstract:** The proposed U.S. contribution provides edits to the current 4C Working Doc on AI 1.13. | |

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This contribution provides edits as well as new content to the doc 4C/77 Annex 7. Moreover, the United States propose a re-structuring of the document to ensure a better flow of information.

The United States proposes to use this document as baseline for drafting at the upcoming WP 4C meeting.

1. Introduction

A new agenda item 1.13 was approved at WRC-23 to study possible new allocations to the mobile-satellite service for direct connectivity between space stations and International Mobile Telecommunications (IMT) user equipment to complement terrestrial IMT network coverage in the frequency range between 694/698 MHz and 2.7 GHz, taking into account the IMT frequency arrangements addressed in the most recent version of Recommendation ITU-R M.1036, in accordance with Resolution **253 (WRC-23)**. The *resolves* 2 of this Resolution invites the ITU Radiocommunication Sector to study the spectrum requirements and technical, operational and regulatory matters related to the implementation of the mobile-satellite service (MSS) for direct connectivity to the IMT user equipment to complement the terrestrial IMT network coverage. This report aims to investigate technical and operational matters of MSS for direct connectivity to the IMT user equipment.

1. Definition of Direct-to-device communications and use cases

As described in *recognizing b)* of Res 253, the envisaged satellite system communicating directly with IMT user equipment utilized in terrestrial IMT networks may provide complementary coverage for mobile connectivity from space as a part of IMT networks to areas such as high mountains, remote islands and deserts, where it may not be sufficient to deploy terrestrial base stations. In addition, the envisaged satellite systems may provide alternative network resilience in case of failure of terrestrial IMT base stations due to unexpected incidents, such as natural disasters and network outages. Please see the Figure 1 below.

Figure 1



The envisaged satellite system to be considered in this agenda item is characterized as:

i) the frequency bands for the satellite system are the same as those for terrestrial IMT networks; and

ii) the same user equipment as those for terrestrial IMT network is used.

It is important to clarify how AI 1.13 focuses on direct-to-unmodified IMT user equipment using IMT bands. This represents a fundamental difference with respect to traditional MSS applications as well as MSS direct-to-modified device applications treated under AI 1.14.

1. **Candidate Bands for Study**

**FDD Frequency plan**

|  |  |  |
| --- | --- | --- |
| **M.1036 frequency arrangement** | **Mobile station transmitter (MHz)** | **Base station (space station) transmitter (MHz)** |
| A1 | 824-849 | 869-894 |
| A2 | 880-915 | 925-960 |
| A3 | 832-862 | 791-821 |
| A4 | 698-716  776-793 | 728-746  746-763 |
| A5/A7/A8/A9/A11 | 698-748 | 753-803 |
| G2 | 1427-1470 | 1475-1518 |
| B1/B4 | 1 920-1 980 | 2 110-2 170 |
| B2/B4 | 1 710-1 785 | 1 805-1 880 |
| B3 | 1850-1920 | 1930-2000 |
| C1 | 2 500-2 570 | 2 620-2 690 |

Complete list of sharing studies to be conducted

To be completed for the second draft

1. Technical characteristics of systems and networks intended to provide direct connectivity between space stations and unmodified IMT user equipment

**4.1 System A**

**4.1.2 Orbit and RF emission characteristics**

The following two tables summarize two orbit configurations of a system for direct-to-unmodified device communications.

Table 1: 525 km orbit configuration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Altitude (km) | Inclination (deg) | # Planes | Sats per plane | RAAN spacing (deg) | Total number of sats |
| 525 | 53 | 28 | 120 | 12.9 | 3360 |

Table 2: 340 km orbit configuration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Altitude (km) | Inclination (deg) | # Planes | Sats per plane | RAAN spacing (deg) | Total number of sats |
| 340 | 53 | 48 | 110 | 7.5 | 5280 |

The two configurations are mutually exclusive and should be studied separately.

**4.1.3 Emissions in the space-to-Earth direction**

In the space-to-Earth direction it is very important to distinguish between maximum PFD on the ground per sat and average PFD when considering the full constellation in operation:

* Maximum PFD per satellite: -80 dBW/m2/MHz
* Average PFD when considering the full constellation in operation: -TBD dBW/m2/MHz

**4.1.4 Antenna Pattern**

To be provided for the second draft.

**4.1.5 Out-of-band emissions to be used for out-of-band studies**

To be provided for the second draft.

**4.1.6 Emissions in the Earth-to-space direction**

The intended operations foresee communications from unmodified user equipment.

Depending on further analysis, studies for this direction might not be necessary given that the characteristics of the IMT mobile stations (i.e. user equipment) are envisaged to remain unchanged.

[Feedback from WP5D is expected with respect to this section]

**4.1.7 Modelling of operations**

This section contains important assumptions on how to model operations of systems and networks implementing direct-to-unmodified user equipment.

**4.1.7.1 Satellite selection mechanism and minimum elevation**

The appropriate satellite selection mechanism for System A is random satellite selection.

The minimum elevation to be used is TBD deg.

**4.1.7.2 Interference management technique implemented by System A**

System A uses software-based systems to dynamically manage emissions and remain within applicable aggregate limits to protect all relevant services.

**4.1.7.2.1 The “topology” function**

The “topology function” enables System A operator to dynamically meet applicable cross-border limits without fixed keep-out zones away from borders.

A visual example is offered by the figure below, based on the territory of the United States. The simulated field strength shows how emissions are adapted in cells close to the border with neighbouring countries.

[Section to be expanded for the second draft]

When modelling System A the topology function should be considered.

A green map of the united states

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*Figure 1: Simulated field strength over the territory of the United States*

**4.2 System B**

TBD

4.3 System C

TBD

1. Characteristics of systems and networks that are to be protected by systems intending to provide direct-to- unmodified device communications

5.1 Protection criterion for the envisaged satellite systems

To determine the performance of the envisaged satellite systems in the frequency bands under consideration, in addition to studying the interference impact of systems on existing radio services, it is advisable to conduct a study of the interference impact from existing radio services on the systems providing service to unmodified devices using IMT spectrum

Table 4 contains the proposed *I/N* values to be used when assessing the interference impact on the systems providing direct-to-unmodified devices using IMT spectrum.

TABLE 4

**Protection criterion for the envisaged satellite systems providing direct-to-unmodified communications**

|  |  |
| --- | --- |
| Long-term protection criterion (*I/N*) | −6 dB to be exceeded for up to 20% of the time |
| Short-term protection criterion (I/N) | TBD dB to be exceeded for up to TBD % of the time |

SINR operating range and mapping function

The following equations approximate the throughput over a channel with a given SINR (dB), when using link adaptation:

where:

*S*(*SINR*) Shannon bound, *S*(*SINR*) =log2(1 + 10*SINR*/10) (bps/Hz)

α Attenuation factor, representing implementation losses

*SINRMIN* Minimum SINR of the code set, dB

*SINRMAX* Maximum SINR of the code set, dB.

The parameters α, *SINRMIN* and *SINRMAX* can be chosen to represent different modem implementations and link conditions. The parameters proposed in Table 5 represent a baseline case, which assumes:

– 1:1 antenna configuration;

– AWGN channel model;

– Link Adaptation (see Table 5 for details of the highest and lowest rate codes);

– No HARQ.

Table 5

**Parameters describing baseline Link Level performance for 5G NR**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | DL | UL | Notes |
| α | 0.6 | 0.4 | Represents implementation losses |
| *SINRMIN*, dB | −10 | −10 | Based on QPSK, 1/8 rate (DL) & 1/5 rate (UL) |
| *SINRMAX*, dB | 30 | 22 | Based on 256-QAM, 0.93 rate (DL) & 64-QAM, 0.93 rate (UL) |

**5.2 Terrestrial IMT characteristics and protection criteria**

TBD

**5.3 Passive services in adjacent bands – characteristics and protection criteria**

TBD

6 High-level summary of sharing studies

7 Summary

ANNEXSharing and compatiblity studies

Editor’s note: Individual sharing studies will be included in this Annex.