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# Co-Channel Interference from LEO Satellite Downlinks to 5G-NR Receivers in IMT Spectrum: An Experimental Study

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## Abstract

The integration of satellite and terrestrial networks within the same spectrum is a key enabler for extending mobile connectivity in future communication systems. In this context, the Direct Connectivity between Mobile Satellite Service and International Mobile Telecommunications user equipment (DC-MSS-IMT) paradigm, currently under study within the International Telecommunication Union [1], foresees the use of terrestrial IMT frequency bands by satellite systems to directly serve conventional mobile devices. This paper presents an experimental study to assess the coexistence between a terrestrial 5G-NR receiver and a co-channel interfering signal representative of a Low Earth Orbit (LEO) satellite downlink. A controlled laboratory setup in conducted configuration was implemented to ensure repeatability and accurate control of interference conditions. Measurements were performed over four carrier frequencies representative of IMT bands (763 MHz, 1482 MHz, 2150 MHz, and 2635 MHz) [2], considering different traffic load conditions (100% and 50%) and Doppler shifts associated with satellite motion. The interference impact was evaluated in terms of receiver desensitization, defined as the increase in the total received power relative to the baseline noise level [3]. The results show that a 1 dB desensitization threshold is consistently reached when the interfering signal power is approximately 5–6 dB below the receiver noise floor, corresponding to an interference-to-noise ratio (I/N) of about −6 dB. This behavior is observed across all tested frequency bands, traffic conditions, and Doppler scenarios, indicating limited sensitivity to frequency offsets within the considered range. The findings confirm the validity of commonly adopted coexistence criteria and provide experimentally derived reference values to support ongoing regulatory and technical studies on spectrum sharing between satellite and terrestrial IMT systems.

**Keywords:** satellite–terrestrial coexistence; Low Earth Orbit (LEO) satellites; co-channel interference; RF measurements; IMT bands; Doppler effect

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## 1. Introduction

The growing demand for ubiquitous mobile connectivity has recently stimulated significant interest in the integration of terrestrial and satellite communication infrastructures. In particular, the rapid development of Low Earth Orbit (LEO) satellite constellations has opened new opportunities for extending mobile services beyond the coverage limits of terrestrial cellular networks. In this context, an emerging approach known as Direct Connectivity between Mobile Satellite Service stations and International Mobile Telecommunications user equipment (DC-MSS-IMT) is currently under discussion within the Radiocommunication Sector of the International Telecommunication Union (ITU-R) [1]. The DC-MSS-IMT concept aims to enable direct satellite connectivity to conventional terrestrial mobile devices using spectrum allocated to IMT systems.

According to the framework defined by the International Telecommunication Union, IMT includes several generations of mobile communication systems, such as IMT-2000 (3G), IMT-

Advanced (4G), and IMT-2020 (5G). Within the DC-MSS-IMT paradigm, satellite transmissions would take place in terrestrial IMT frequency bands licensed to a Mobile Network Operator (MNO). In this model, satellite coverage would complement terrestrial cellular infrastructure, enabling extended or even global service availability while remaining under the end-to-end operational responsibility of the MNO.

Despite the potential advantages of such integrated architecture, current international radiocommunication regulations do not allow satellite communication systems to operate within terrestrial IMT bands over national territories. For this reason, the possibility of enabling DC-MSS-IMT operations in these bands is currently being evaluated within the Radiocommunication Sector of the International Telecommunication Union. A key technical concern associated with this scenario is the potential presence of interfering signals resulting from the shared use of IMT spectrum by terrestrial networks and satellite systems. This issue is particularly relevant in the sub-1 GHz frequency range, where IMT bands are widely used for wide-area terrestrial coverage and where LEO satellite downlinks could produce interference toward terrestrial receivers [4].

Such interference scenarios may become especially critical in cross-border regions where neighboring countries adopt different regulatory decisions regarding the authorization of satellite services in IMT bands. In these situations, terrestrial receivers operating close to national borders could be exposed to co-channel satellite signals transmitted from space, potentially affecting their performance [5].

In this context, the objective of this work is to evaluate the robustness of a terrestrial 5G New Radio (5G-NR) receiver when exposed to a co-channel satellite downlink signal. To ensure the generality of the analysis and to observe the behavior of RF receiver hardware under different frequency conditions, measurements were conducted across four distinct 3GPP frequency bands representative of current and potential future IMT spectrum allocations [2]:

- Band n28: 763 MHz
- Band n50: 1482 MHz
- Band n1: 2150 MHz
- Band n7: 2635 MHz

For each investigated carrier, the analysis focuses on two key parameters affecting interference conditions: (i) the power level of the satellite interfering signal and (ii) the frequency offset induced by the Doppler effect associated with the motion of a LEO satellite. By means of controlled laboratory measurements, this study provides experimental insights into the resilience of terrestrial 5G-NR receivers under satellite interference conditions. The results aim to contribute to the ongoing technical and regulatory discussions concerning the coexistence between satellite systems and terrestrial IMT networks in shared spectrum.

## 2. DC-MSS-IMT Service: Definition and Frequency Bands under Study

### 2.1. The DC-MSS-IMT Service Concept

The Mobile Satellite Service for Direct Connectivity with IMT User Equipment (DC-MSS-IMT) represents an emerging approach aimed at integrating satellite systems with the existing terrestrial International Mobile Telecommunications (IMT) ecosystem [1]. The primary objective of this concept is to extend mobile connectivity to remote, rural, and underserved areas, where terrestrial network deployment may be economically or technically challenging. In addition, satellite-enabled connectivity can improve the resilience of communication networks, particularly in the presence of infrastructure failures or natural disasters.

The integration of satellite communications into the mobile ecosystem has been formally addressed by the 3rd Generation Partnership Project (3GPP), which introduced Non-Terrestrial Networks (NTN) as part of the 5G architecture with the goal of supporting direct connectivity with conventional smartphones [6]. At the same time, the International Telecommunication Union (ITU)

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is currently conducting technical and regulatory studies aimed at identifying suitable frequency allocations that could support this type of service [1].

The frequency ranges under consideration for the DC-MSS-IMT service fall within the 694 MHz to 2.7 GHz spectrum, which broadly corresponds to the bands historically allocated to IMT systems.

### *2.2. Candidate Frequency Bands for DC-MSS-IMT*

Several frequency bands are currently under study within the working groups of the International Telecommunication Union — in particular Working Party 4C [7] and Working Party 5D [8] — as well as within European regulatory bodies such as the European Conference of Postal and Telecommunications Administrations (CEPT) [9]. These studies aim to evaluate the potential use of existing IMT bands for satellite systems capable of providing direct connectivity to mobile devices.

The candidate frequency ranges being considered for this service are summarized in Table 1, which lists the uplink and downlink bands currently under investigation for possible DC-MSS-IMT deployment [1].

**Table 1.** Candidate and frequencies under study for the DC-MSS-IMT service.

| **Option #** | **Uplink frequency (MHz)** | **Downlink frequency (MHz)** |
|---|---|---|
| 1 | 814/824-849 | 859/869-894 |
| 2 | 880-915 | 925-960 |
| 3 | 832-862 | 791-821 |
| 4 | 698-716 | 716-746 |
|  | 776-798 | 746-768 |
| 5 | 698-748 | 753-803 |
| 6 | 1 427-1 470 | 1 475-1 518 |
| 7 | 1 920-1 980 | 2 110-2 170 |
| 8 | 1 710-1 785 | 1 805-1 880 |
| 9 | 1 850-1 920 | 1 930-2 000 |
| 10 | 1 710-1 780 | 2 110-2 180 |
| 11 | 2 000-2 020 | 2 180-2 200 |
| 12 | 2 010-2 025 | 1 880-1 920 |
| 13 | 2 305-2 320 | 2 345-2 360 |
| 14 | 2 500-2 570 | 2 620-2 690 |

### *2.3. Operational Modes for DC-MSS-IMT Service Provision*

From an operational perspective, the DC-MSS-IMT service can be implemented in different ways depending on the regulatory framework and the commercial arrangements established within a given country.

Two main operational models can be identified:

1. **Complementary coverage model** – The satellite system operates in cooperation with an existing Mobile Network Operator (MNO), providing coverage in areas where terrestrial service is limited or unavailable. In this case, the satellite operator typically relies on a commercial agreement with the terrestrial MNO holding the spectrum license in that country.
2. **Standalone satellite operation model** – The satellite operator acquires the license to operate in a frequency band already allocated for IMT services within the country. In this scenario, the satellite system independently provides connectivity to end users.

In both cases, the satellite effectively operates as a space-borne base station, communicating directly with user terminals on the ground. The satellite payload typically includes phased-array antennas, enabling dynamic beamforming and beam steering toward user devices [10]. In addition to these antennas, satellites may also be equipped with high-gain parabolic antennas used for communication with ground stations, as well as optical inter-satellite links, which allow data transmission between satellites within the constellation.

Ground stations act as gateways to the terrestrial mobile network, providing connectivity between satellite-served user equipment and the broader communication infrastructure [11]. Through these gateway stations, mobile users connected via satellite can ultimately communicate with other users connected through terrestrial or satellite networks.

The coexistence between terrestrial IMT systems and satellite transmissions operating in the same frequency bands may generate potential interference scenarios, particularly in cross-border situations where regulatory authorizations differ between neighboring countries. An example of such an interference scenario associated with the DC-MSS-IMT service is illustrated in Figure 1.

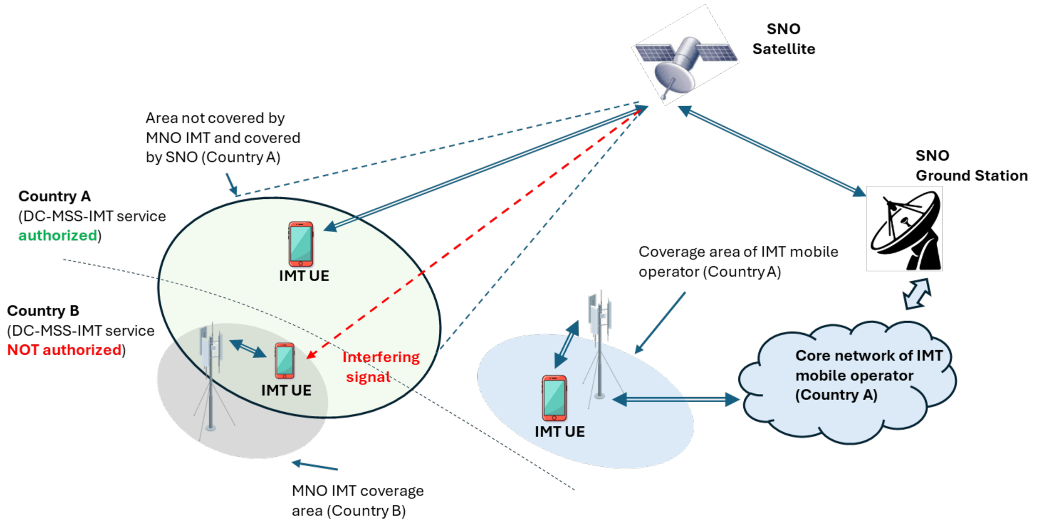

**Figure 1.** Interference scenario involving DC-MSS-IMT service.

### *2.4. LEO Satellite Constellations Considered for DC-MSS-IMT Studies*

Within the studies conducted in the Radiocommunication Sector of the International Telecommunication Union (ITU-R), several Low Earth Orbit (LEO) satellite constellations have been identified as reference systems for compatibility and coexistence analyses between the DC-MSS-IMT service and terrestrial IMT networks. These reference constellations are used to evaluate potential interference scenarios and to support the technical studies required for future regulatory decisions [1].

The main characteristics of the constellations considered in these studies are summarized in Table 2. These constellations represent relevant operational configurations for evaluating interference conditions. In particular, the number of satellites within a constellation play a significant role in coexistence analyses, since a higher satellite density increases the probability that undesired interference situations may occur, especially in geographical areas located near the boundaries of regions where the service is authorized.

As shown in the table, each constellation is associated with a specific set of operating frequency bands. Consequently, compatibility studies focusing on the constellation referred to as System 1 typically consider only a single Frequency Division Duplex (FDD) band pair, namely 2.5–2.57 GHz for the Earth-to-space link (uplink) and 2.62–2.69 GHz for the space-to-Earth link (downlink).

Among the constellations currently under consideration, the one referred to as System 3-1 is particularly relevant for interference studies. This constellation configuration (illustrated in Figure 2) consists of 28 orbital planes inclined by 53° with respect to the Earth's equatorial plane. Each orbital plane contains 120 satellites, spaced by approximately 3° along the orbit and operating at an altitude of approximately 525 km.

Such a configuration represents a highly dense LEO constellation and is therefore particularly useful for evaluating worst-case coexistence conditions between satellite and terrestrial systems. Constellations with similar orbital characteristics are already being deployed commercially, although currently with a smaller number of operational satellites compared with the configuration considered in these reference studies [12].

**Table 2.** Some reference LEO satellite constellations considered in DC-MSS-IMT coexistence studies.

| System ID | System 1 | System 2 | System 3-1 | System 3-2 |
|---|---|---|---|---|
| Frequency Bands (MHz) | 2 500-2 570/ 2 620-2 690 | 694/698-960<br>1 427-1 518<br>1 710-1 785/1 805-1 880<br>1 920-1 980/2 110-2 170<br>2 010-2 025/1 880-1 920<br>2 300-2 400<br>2 500-2 690 | 698-960<br>1 427-1 518<br>1 710-2 025/2 110-2 200<br>2 500-2 690 | |
| Altitude (km) | 680 | 500 | 525 | 340 |
| Inclination (deg) | 97 | 55 | 53 | 53 |
| Number of orbital planes | 12 | 60 | 28 | 48 |
| Satellite number per orbital plane | 60 | 60 | 120 | 110 |
| Total number of satellites | 720 | 3600 | 3360 | 5280 |

## 3. Background on Receiver Desensitization and Interference Criteria

Receiver blocking, also referred to as desensitization, represents a key metric used to evaluate the capability of a receiver to correctly process a desired modulated signal in the presence of an undesired input signal transmitted within the same frequency band [3]. In practical terms, desensitization quantifies the degradation of receiver sensitivity caused by interference.

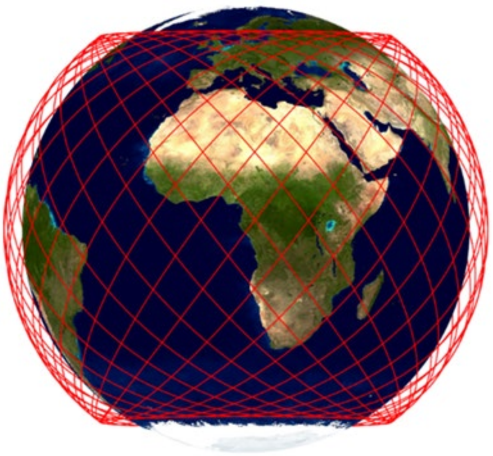

**Figure 2.** Example configuration of the System 3-1 LEO constellation.

In many coexistence studies and European regulatory reports produced within the European Conference of Postal and Telecommunications Administrations Electronic Communications Committee (ECC), an operational criterion of 1 dB desensitization is commonly adopted as a practical threshold beyond which significant performance degradation of terrestrial stations may occur [13]. The same threshold is frequently used as a reference point in coexistence analyses developed within the 3rd Generation Partnership Project (3GPP) [13].

From a practical measurement perspective, receiver desensitization can be evaluated by observing the increase in the total received power spectral density when an interfering signal is present. This increase corresponds to the difference between the combined power of noise and interference and the baseline noise level. The degradation can therefore be expressed as

$$Degradation(\text{dB}) = (N + I)_{measured} - N_{baseline}$$

where:

$(N + I)_{measured}$: is the power spectral density measured by the noise marker of a spectrum analyzer in the presence of the interfering signal;

$N_{baseline}$ : is the baseline noise power spectral density measured in the absence of interference (i.e., only the victim signal and the receiver thermal noise).

Within coexistence analyses conducted in the 3rd Generation Partnership Project, particularly for non-harmonic interference scenarios, the maximum tolerated degradation is generally assumed not to exceed 1 dB. At this level, the combined power $N + I$ is approximately 26% higher than the thermal noise power $N$ of the receiver. This value is commonly considered a practical threshold at which system-level performance degradation—such as throughput reduction or Block Error Rate (BLER) increase—may start to become measurable.

Furthermore, a degradation of 1 dB corresponds to an interference-to-noise ratio ($I/N$) of approximately −6 dB. This condition implies that the interfering signal is considered acceptable only when its power remains at least 6 dB below the receiver thermal noise level. Such a criterion is widely used in spectrum sharing and coexistence studies as a conservative benchmark for protecting the performance of terrestrial receivers [14].

### *3.1. Limitations of this Approach and Interpretation of Expected Results*

A desensitization metric based on the ratio $(N + I)/N$ may **underestimate or misrepresent** the actual performance degradation, especially in the presence of Doppler-induced frequency misalignment. This limitation becomes particularly relevant when evaluating the impact of the **Doppler effect** induced by LEO satellite motion. The Doppler shift introduces a **time-varying frequency offset** between the interfering and victim signals, which affects not only the total received power but also the **spectral overlap and instantaneous interference distribution** across the resource grid. In such conditions, the interference impact may manifest through mechanisms that are not directly reflected by a simple increase in integrated power.

Despite these limitations, the adopted approach remains valuable for deriving **conservative and reproducible interference thresholds**, which are commonly used in regulatory and coexistence studies. The results of this work are therefore expected to provide:

- an estimation of the **maximum allowable interfering power** corresponding to a 1 dB degradation threshold under realistic signal conditions,
- an assessment of how this threshold varies as a function of **frequency band** and **Doppler shift**,
- a set of **experimentally derived reference values** that can support compatibility studies between satellite and terrestrial IMT systems.

It is important to note that the outcomes of this study should be interpreted as **power-based coexistence indicators**, rather than direct predictors of end-to-end communication performance (e.g., throughput or error rate). Nevertheless, they provide a meaningful and practical basis for evaluating the robustness of terrestrial receivers in emerging DC-MSS-IMT scenarios.

## 4. Experimental Setup

To evaluate the robustness of a terrestrial 5G-NR receiver when exposed to one or more satellite downlink signals operating on the same carrier frequency, a controlled laboratory experimental setup

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was developed. The measurements were conducted in a conducted configuration, allowing precise control of the signal parameters while ensuring high repeatability and complete isolation from external radio-frequency interference.

The experimental configuration was designed to emulate a co-channel interference scenario between a terrestrial 5G-NR signal (victim) and a satellite-generated signal representing the downlink transmission from a Low Earth Orbit (LEO) satellite. The conducted approach enables accurate adjustment of the interfering signal power and frequency offset, thereby allowing the systematic evaluation of receiver desensitization under controlled conditions.

### 4.1. Instrumentation

The measurements were carried out using the following RF instruments:

- **Noise Signal Generator** (Victim receiver): Rohde & Schwarz SMBV100A
- Used to generate the reference noise signal of the terrestrial victim 5G-NR receiver.
- **Interference Signal Generator** (LEO Signal): Rohde & Schwarz SMU200A
- Used to generate the 5G-NR interfering signal representing the LEO satellite transmission and having key features as outlined in Table 3.
- **Spectrum Analyzer**: Rohde & Schwarz FSEK 30 configured with the following parameters:
  - Resolution Bandwidth (RBW): 100 kHz
  - Detector: RMS
  - Trace Mode: Averaging
- **RF Combiner**: HP 11667A Power Splitter, used in reverse configuration as a broadband resistive combiner to combine the victim and interfering signals.

This instrumentation allowed precise control of the signal levels and frequency offsets required for the desensitization measurements described in the previous sections.

**Table 3.** 5G-NR interferer signal key features.

| Feature | Value |
|---|---|
| Standard | 3GPP Rel.15 |
| Modulation | 64QAM |
| Subcarrier Separation | 30kHz |
| Useful Band | 8.64 MHz |
| Resource Block x Subcarrier | 24 |

### 4.2. Measurement Configuration

Figure 3 illustrates the functional block diagram of the experimental setup, highlighting the physical connections between the signal generators, the RF combiner, and the measurement instrument.

The two signal paths—representing the victim terrestrial signal and the interfering satellite signal—are generated independently and then combined through the resistive combiner before being applied to the input of the measurement instrument.

This configuration allows independent control of:

- the power level of the interfering signal, and
- the frequency offset introduced to emulate the Doppler effect produced by a moving LEO satellite.

Such flexibility is essential for reproducing realistic interference conditions while maintaining a stable and repeatable laboratory environment.

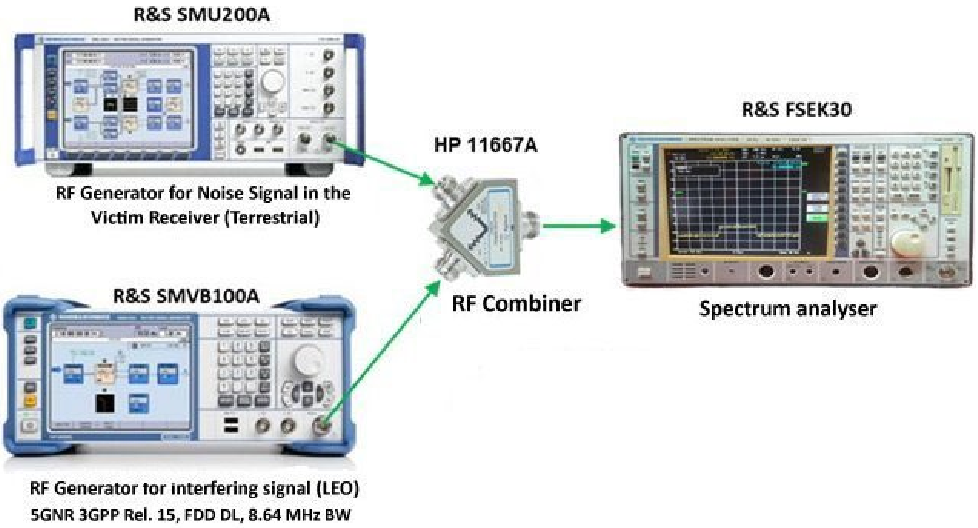

**Figure 3.** Functional block diagram of the experimental test setup.

### *4.3. Test Signal Characteristics*

The experimental measurements were carried out over a nominal **10 MHz bandwidth channels** (effective 8.64 MHz) centered at four different carrier frequencies: **763 MHz, 1482 MHz, 2150 MHz, and 2635 MHz**. These frequencies are representative of bands allocated by the International Telecommunication Union (ITU-R) to the **International Mobile Telecommunications (IMT)** service, thus ensuring the relevance of the analysis with respect to current and future spectrum usage scenarios.

The **interfering signal** considered in the experimental campaign was modeled as a transmission originating from a LEO satellite and compliant with 5G-NR 3GPP Release 15 specifications. Its center frequency was assumed to vary according to the Doppler conditions associated with satellite motion, and was therefore defined as:

$$f_{\text{interferer}} = f_{\text{victim}} \pm f_{\text{Doppler}}$$

where $f_{\text{victim}}$ is the carrier frequency of the terrestrial 5G-NR signal and $f_{\text{Doppler}}$ represents the frequency shift induced by the relative motion of the satellite.

Two operational conditions were considered for the interfering signal, corresponding to different **traffic load levels**:

- **100% resource utilization**, representing a fully loaded transmission scenario;
- **50% resource utilization**, representing a partially loaded condition.

These two cases allow the evaluation of interference effects under different levels of spectral occupancy, which may significantly influence the resulting desensitization.

The **noise affecting the terrestrial mobile receiver** was also modelled as a 5G NR Rel. 15 with 100% resource block utilisation, characterized by an average power level $P_{\text{target}}$ and asynchronous with respect the above-mentioned interfering signal. The choice of this kind of noise signal in place of a classical AWGN one is justified by the spectral shape, the peak-to-average power ratio and the time domain structure of the signal. In that sense it behaves like a real co-channel noise. $P_{\text{target}}$ represents the effective noise floor at the receiver input and is defined through the calibration procedure described in Section 5. Overall, the adopted signal configuration enables the reproduction of realistic interference conditions, combining **co-channel operation**, **Doppler-induced frequency shifts**, and **variable traffic load**, thereby providing a comprehensive framework for assessing 5G-NR receiver robustness in DC-MSS-IMT scenarios.

## 5. Calibration Methodology

To ensure the accuracy of the measurements, a calibration procedure was performed to compensate for the **insertion losses introduced by the RF combiner and connecting cables** in the experimental setup. The calibration was conducted at the **measurement reference plane**, corresponding to the RF input of the spectrum analyzer.

The objective of the calibration procedure was twofold:

(i) to characterize the **baseline noise level of measurement system**, and

(ii) to set a controlled and repeatable **power noise level for victim 5G-NR receiver**.

### *5.1. System Noise Characterization*

The first step of the calibration process consisted of measuring the **intrinsic noise floor of the measurement system**.

This measurement was performed with both RF signal generators switched off, ensuring that only the internal noise of the measurement chain was present at the analyzer input. The spectrum analyzer was configured with an **integration bandwidth of 8.64 MHz**, corresponding to the bandwidth used for the 5G-NR signals in the subsequent measurements.

Under these conditions, the measured noise power at the analyzer input in the above-mentioned carrier frequencies in the integration bandwidth are listed in Table 4.

**Table 4.** Noise power measured for different $f_{Carrier}$ at spectrum analyzer.

| $f_{Carrier}$ | $P_{\text{noise}}$ |
|---|---|
| 763 MHz | -83.0 dBm |
| 1482 MHz | -81.3 dBm |
| 2150 MHz | -81.6 dBm |
| 2635 MHz | -79.4 dBm |

This value represents the **baseline noise level of the measurement system**, including the analyzer noise contribution and the thermal noise associated with the RF chain.

### *5.2. Calibration of the Victim Noise Signal Level*

After determining the system noise floor, the level of the noise for the **victim 5G-NR receiver** was calibrated.

The goal of this calibration step was to ensure that the useful signal was **clearly distinguishable from the instrumental noise floor**, while still representing a **weak received signal**, consistent with conditions experienced by a mobile user at the edge of a cell coverage area.

For this purpose, an operational margin of **+10 dB above the signal analyzer noise level** was selected. The target noise power level at the spectrum analyzer input was therefore defined as:

$$N_{\text{baseline}} = P_{\text{noise}} + 10\ \text{dB}$$

which yields

**Table 5.** Baseline **n**oise power set for different $f_{Carrier}$ at spectrum analyzer.

| $f_{Carrier}$ | $N_{\text{baseline}}$ |
|---|---|
| 763 MHz | -73.0 dBm |
| 1482 MHz | -71.3 dBm |
| 2150 MHz | -71.6 dBm |
| 2635 MHz | -69.4 dBm |

The output power of the noise signal generator (Rohde & Schwarz SMU200A) was progressively increased until a stable power reading of $N_{\text{baseline}}$ in the integration bandwidth was observed at the input of the spectrum analyzer.

These values represent the **effective calibrated noise power level of the victim 5G-NR mobile receiver** and will used as a reference in the subsequent interference measurements.

## 6. Interfering Signal Power Sweep Procedure

Following the calibration of the victim signal level, a systematic procedure was implemented to evaluate the impact of the **LEO satellite interfering signal** on the 5G-NR receiver performance. The objective of this step was to determine the **interference power level corresponding to a 1 dB desensitization threshold**, as discussed in Section 2.

The interfering signal, generated by the Rohde & Schwarz SMBV100A, was initially set at a power level well below the system noise floor and then **progressively increased over a wide dynamic range from −105 dBm to -50 dBm**. The sweep was performed in controlled increments, allowing fine resolution around the expected desensitization region while still exploring extreme conditions for completeness.

At each power step, the total received power $(N+I)$at the input of the spectrum analyzer was measured, and the corresponding degradation was computed as:

$$Degradation\ \text{(dB)} = (N+I)_{measured} - N_{baseline}$$

The **interference threshold condition** was identified when the measured degradation reached **1 dB**, corresponding to the onset of measurable performance degradation of the 5G-NR receiver. The interfering power level at this point was recorded as the **maximum allowable interference level** for the given test configuration.

In parallel with the power sweep, the **frequency offset of the interfering signal** was adjusted to emulate the **Doppler effect** associated with a LEO satellite. For a satellite orbiting at an altitude of approximately **500 km**, the Doppler shift experienced at the receiver is a function of 5G-NR signal carrier frequency and depending on whether the satellite is approaching or moving away from the observation point.

Accordingly, the center frequency of interfering signal frequency was set as:

$$f_{\text{interferer}} = f_{\text{victim}} \pm f_{\text{Doppler}}$$

$$with\ f_{\text{Doppler}} \approx \begin{cases} 19.8\ \text{kHz} & \text{for}\quad f_{\text{Carrier}} = 0.763\ \text{GHz} \\ 38.4\ \text{kHz} & \text{for}\quad f_{\text{Carrier}} = 1.482\ \text{GHz} \\ 55.8\ \text{kHz} & \text{for}\quad f_{\text{Carrier}} = 2.150\ \text{GHz} \\ 68.4\ \text{kHz} & \text{for}\quad f_{\text{Carrier}} = 2.683\ \text{GHz} \end{cases}$$

This configuration represents a **realistic and near worst-case interference scenario**, in which the interfering signal remains largely overlapping with the victim signal bandwidth while introducing a frequency offset characteristic of LEO satellite motion.

The combined sweep over a **broad interfering power range** and **Doppler-induced frequency offsets** enabled a comprehensive evaluation of 5G-NR receiver robustness, capturing both weak and strong interference regimes under realistic satellite operating conditions.

## 7. Results

In this section, the results obtained from the experimental measurements carried out in the laboratory using the experimental setup described in section 4.1, in the four frequency bands 763 MHz, 1482 MHz, 2150 MHz, 2635 MHz, with signals whose characteristics have been described in section 4.3 and considering the measurement procedure described in section 6, are illustrated and analyzed. The results obtained from the experimental campaign are summarized in tables and figures, which report the **interfering signal levels required to produce a 1 dB desensitization** of the terrestrial receiver under operating conditions outlined in the previous sections. The analysis considers the four carrier frequencies representative of IMT bands and three satellite transmission conditions, corresponding to a LEO satellite **approaching the zenith, at zenith, and moving away from the zenith**, thus incorporating the impact of Doppler-induced frequency shifts

### *7.1. Outline of results for LEO 5G-NR full-rate traffic (100% of resource blocks)*

For the case of full traffic load (100% Resource Blocks), the results reported in Table 6 show that the interfering signal power required to reach the 1 dB degradation threshold is consistently close to the receiver noise floor across all frequency bands. In particular, the interfering signal levels are approximately 5 to 6 dB below the baseline noise level, regardless of the specific carrier frequency or Doppler condition. This behavior is further confirmed by the corresponding I/N values, reported in Table 7, which are consistently around −6 dB. These results are in strong agreement with the theoretical expectations discussed in Section 3, validating the adopted desensitization criterion.

A more detailed insight is provided by Figures 4–7, which illustrate the measured degradation as a function of the interfering signal power for each carrier frequency. In all cases, the degradation curves exhibit a monotonic increase with the interfering power, with a clear and well-defined intersection with the 1 dB degradation threshold. The figures also highlight the baseline noise level of the receiver, as defined in Section 5.2, providing a direct visual reference for interpreting the interference conditions leading to desensitization.

**Table 6.** 5G-NR LEO Sat signal level (100% RBs) on Earth at 1 dB Degradation.

| $f_{Carrier}$ (MHz) | $N_{baseline}$ (dBm) | Sat signal power at Zenith | Sat approaching the Zenith | | Sat moving away from Zenith | |
|---|---|---|---|---|---|---|
| | | | $\Delta f_{Doppler}$ | Sat signal power | $\Delta f_{Doppler}$ | Sat signal power |
| **763** | **-76.4** | -79.67 dBm | 19.2 kHz | -80.07 dBm | -19.2 kHz | -80.78 dBm |
| **1482** | **-71.3** | -77.67 dBm | 38.4 kHz | -77.17 dBm | -38.4 kHz | -77.17 dBm |
| **2150** | **-71.6** | -77.27 dBm | 55.8 kHz | -77.27 dBm | -55.8 kHz | -77.98 dBm |
| **2683** | **-69.4** | -74.87 dBm | 68.4 kHz | -75.27 dBm | -68.4 kHz | -75.07 dBm |

**Table 7.** $I_{interferer}$ / $N_{baseline}$ at 1 dB Degradation (5G-NR LEO Sat signal with 100% RBs).

| $f_{Carrier}$ (MHz) | $N_{baseline}$ (dBm) | 5G-NR LEO Sat signal level (RB 100%) on Earth at 1 dB Degradation | | | | |
|---|---|---|---|---|---|---|
| | | $I_{interferer}$ / $N_{baseline}$ at Zenith | Sat approaching the Zenith | | Sat moving away from Zenith | |
| | | | $\Delta f_{Doppler}$ | $I_{interferer}$ - $N_{baseline}$ | $\Delta f_{Doppler}$ | $I_{interferer}$ - $N_{baseline}$ |
| **763** | **-76.4** | -5.27 dB | 19.2 kHz | -5.67 dB | -19.2 kHz | -6.38 dB |
| **1482** | **-71.3** | -6.37 dB | 38.4 kHz | -5.87 dB | -38.4 kHz | -5.87 dB |
| **2150** | **-71.6** | -5.67 dB | 55.8 kHz | -5.67 dB | -55.8 kHz | -6.38 dB |
| **2683** | **-69.4** | -5.47 dB | 68.4 kHz | -5.87 dB | -68.4 kHz | -5.67 dB |

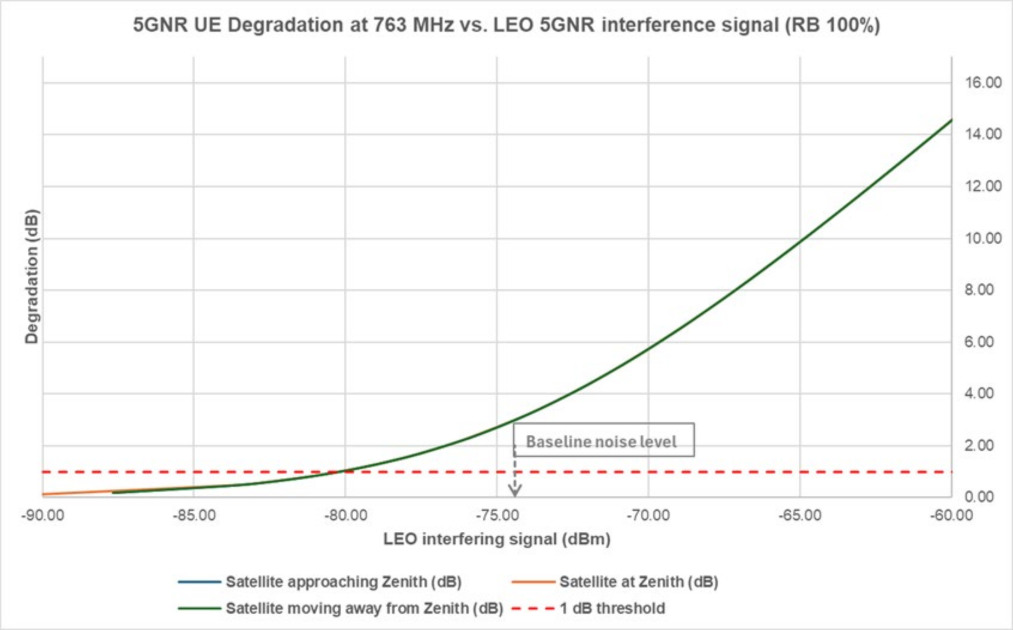

**Figure 4.** Measured Degradation with 100% RBs LEO Sat signal at $f_{Carrier}$=763 MHz.

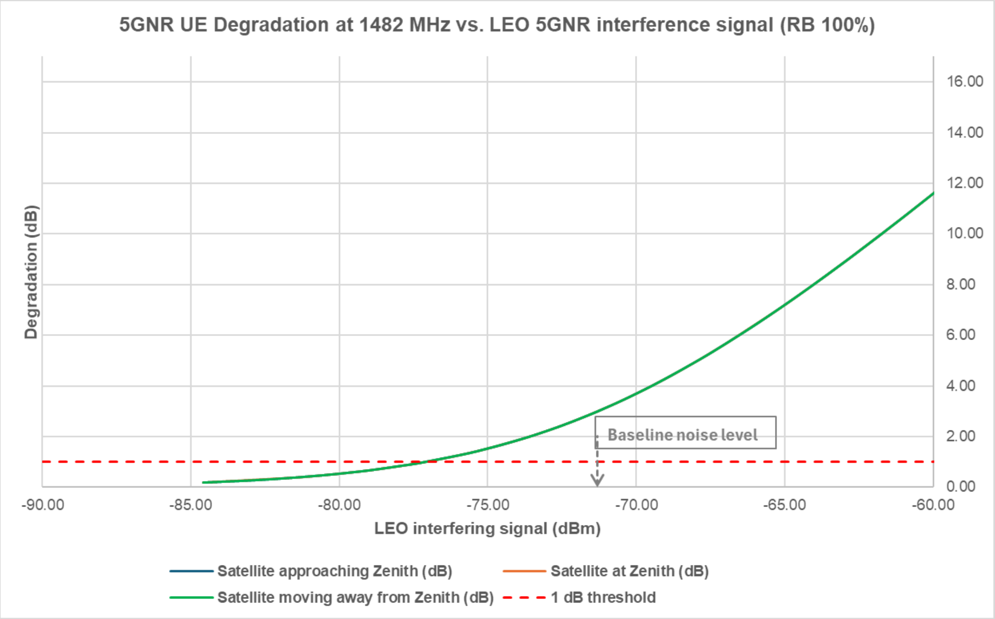

**Figure 5.** Measured Degradation with 100% RBs LEO Sat signal at $f_{Carrier}$=1482 MHz.

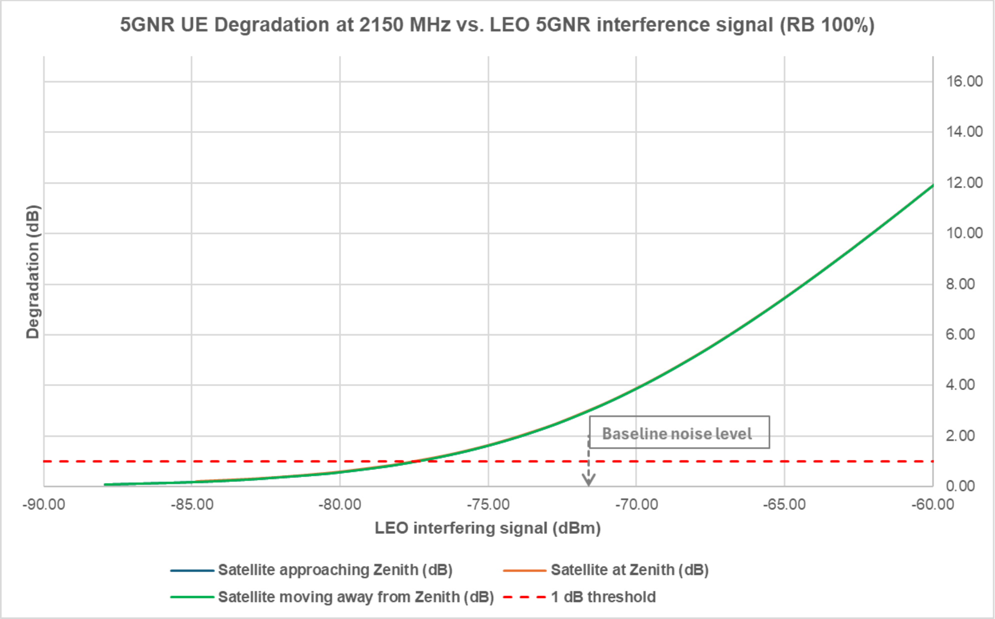

**Figure 6.** Measured Degradation with 100% RBs LEO Sat signal at $f_{Carrier}$=2150 MHz.

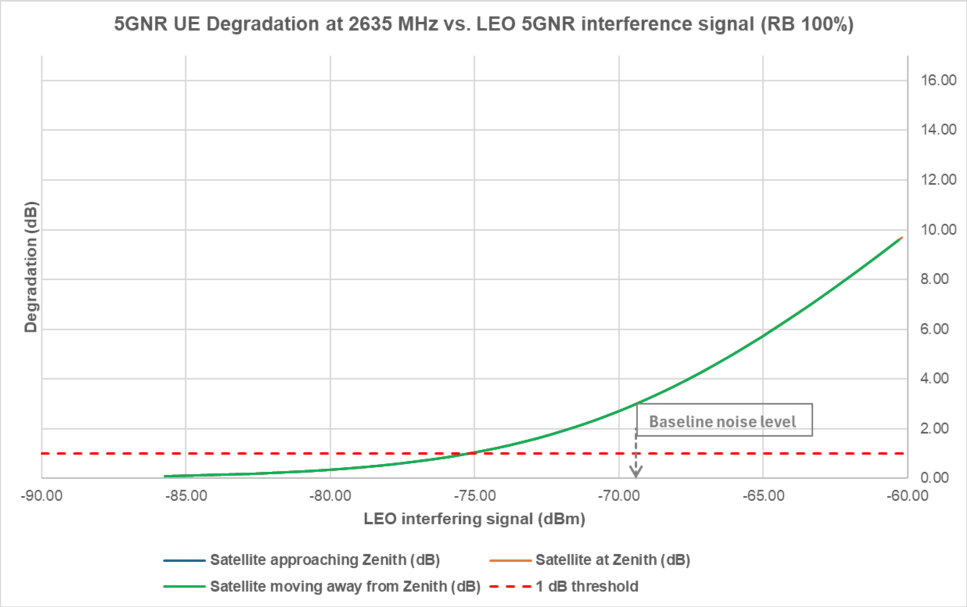

**Figure 7.** Measured Degradation with 100% RBs LEO Sat signal at $f_{Carrier}$=2635 MHz.

### *7.2. Outline of results for LEO 5G-NR half-rate traffic (50% of resource blocks)*

The results obtained for the partial traffic load condition (50% Resource Blocks), reported in Tables 8 and 9 and illustrated in Figures 8–11, show a behavior largely consistent with the full-load scenario. Also in this case, the interfering signal levels required to produce a 1 dB degradation remain close to the receiver noise floor, with corresponding I/N values again centered around −6 dB. Minor variations can be observed across frequency bands and Doppler conditions, but these differences remain limited within statistical variability of measurements and do not significantly alter the overall trend.

**Table 8.** 5G-NR LEO Sat signal level (50% RBs) on Earth at 1 dB Degradation.

| $f_{Carrier}$ (MHz) | $N_{baseline}$ (dBm) | Sat signal power at Zenith | Sat approaching the Zenith | | Sat moving away from Zenith | |
|---|---|---|---|---|---|---|
| | | | $\Delta f_{Doppler}$ | Sat signal power | $\Delta f_{Doppler}$ | Sat signal power |
| **763** | **-76.4** | -80.27 dBm | 19.2 kHz | -79.80 dBm | -19.2 kHz | -79.80 dBm |
| **1482** | **-71.3** | -77.17 dBm | 38.4 kHz | -77.17 dBm | -38.4 kHz | -77.47 dBm |
| **2150** | **-71.6** | -77.17 dBm | 55.8 kHz | -77.17 dBm | -55.8 kHz | -77.47 dBm |
| **2683** | **-69.4** | -74.57 dBm | 68.4 kHz | -75.27 dBm | -68.4 kHz | -74.57 dBm |

**Table 9.** $I_{interferer}$ / $N_{baseline}$ at 1 dB Degradation (5G-NR LEO Sat signal with 50% RBs).

| $f_{Carrier}$ (MHz) | $N_{baseline}$ (dBm) | 5G-NR LEO Sat signal level (RB 100%) on Earth at 1 dB Degradation | | | | |
|---|---|---|---|---|---|---|
| | | $I_{interferer}$ / $N_{baseline}$ at Zenith | Sat approaching the Zenith | | Sat moving away from Zenith | |
| | | | $\Delta f_{Doppler}$ | $I_{interferer}$ - $N_{baseline}$ | $\Delta f_{Doppler}$ | $I_{interferer}$ - $N_{baseline}$ |
| **763** | **-76.4** | -5.87 dB | 19.2 kHz | -5.4 dB | -19.2 kHz | -5.4 dB |
| **1482** | **-71.3** | -5.87 dB | 38.4 kHz | -5.87 dB | -38.4 kHz | -6.17 dB |
| **2150** | **-71.6** | -5.57 dB | 55.8 kHz | -5.57 dB | -55.8 kHz | -5.87 dB |
| **2683** | **-69.4** | -5.17 dB | 68.4 kHz | -5.87 dB | -68.4 kHz | -5.17 dB |

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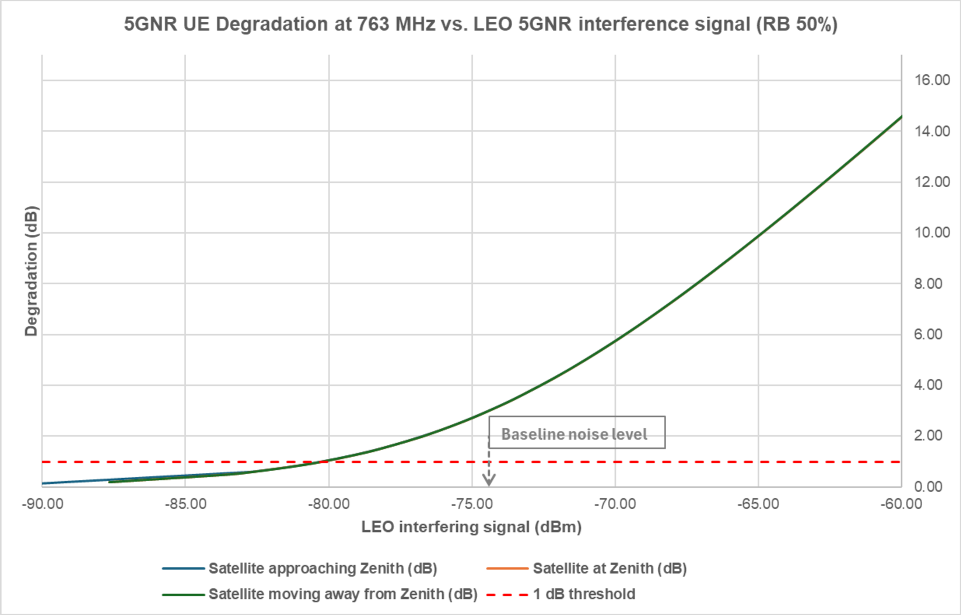

**Figure 8.** Measured Degradation with 50% RBs LEO Sat signal at $f_{Carrier}$=763 MHz.

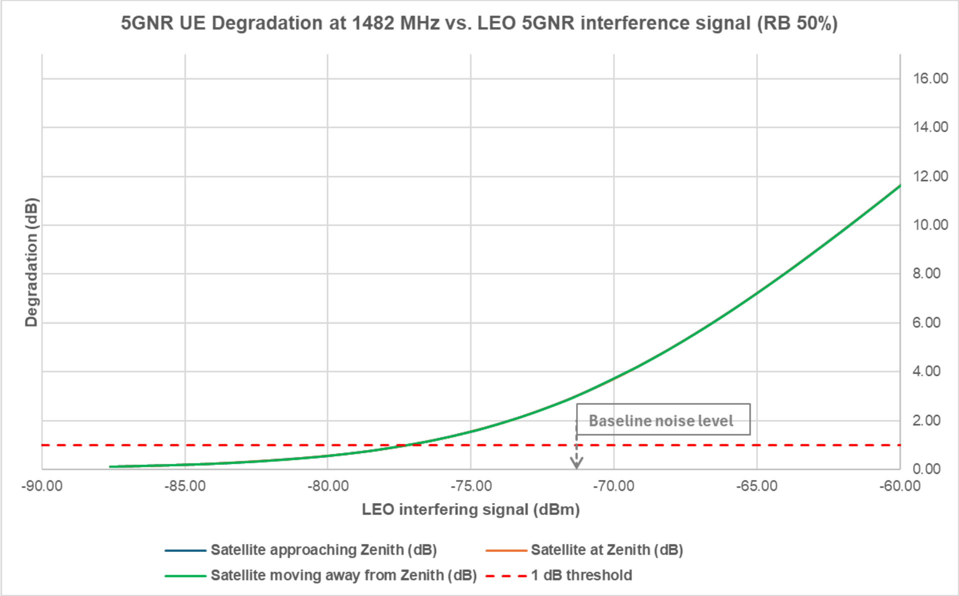

**Figure 9.** Measured Degradation with 50% RBs LEO Sat signal at $f_{Carrier}$=1482 MHz.

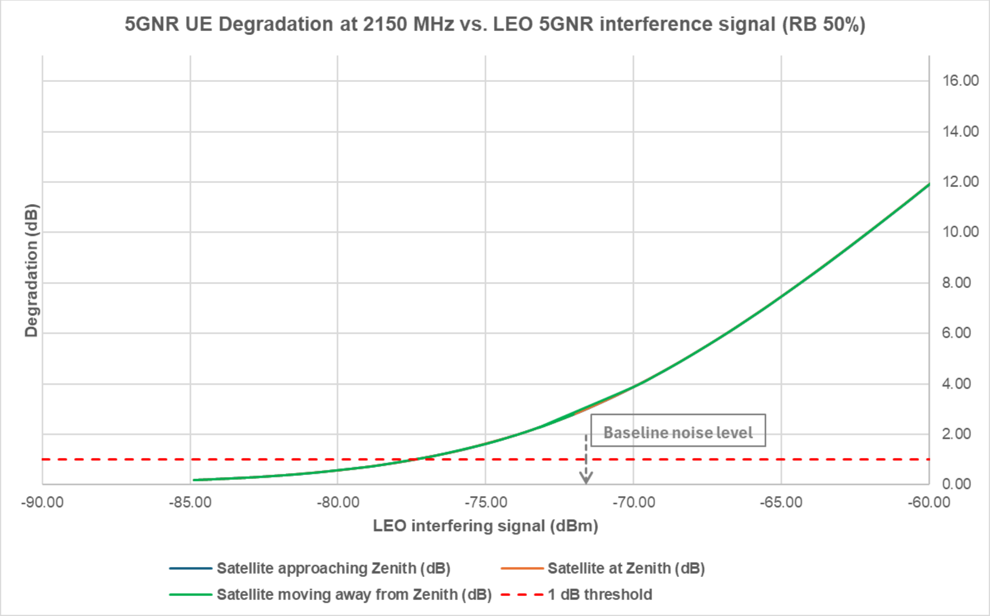

**Figure 10.** Measured Degradation with 50% RBs LEO Sat signal at $f_{Carrier}$=2150 MHz.

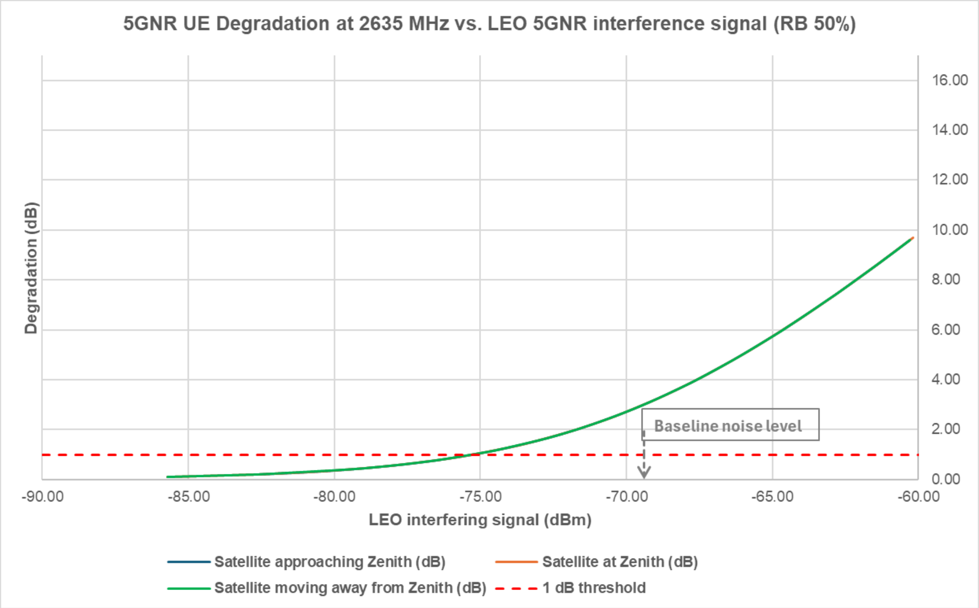

**Figure 11.** Measured Degradation with 50% RBs LEO Sat signal at $f_{Carrier}$=2635 MHz.

## 8. Discussion

According to the results shown in the previous Section, the impact of Doppler shift, associated with the satellite motion, appears to introduce negligible variations in the interference threshold, indicating that the receiver RF performance is primarily driven by the total interfering power rather than by small frequency offsets within the considered range.

Overall, the experimental results demonstrate that the 1 dB desensitization threshold corresponds to an interference level approximately 6 dB below the receiver noise floor, independently of the carrier frequency, traffic load, and Doppler condition considered. This finding confirms the robustness of the I/N ≈ −6 dB criterion as a practical and reliable indicator for coexistence studies between satellite and terrestrial IMT systems. Moreover, the limited sensitivity of the **results to Doppler shifts** suggests that, within the analyzed range, **power-based interference metrics remain**

**a valid and effective tool for assessing the impact of LEO satellite transmissions on terrestrial receivers**.

## 9. Conclusions

This work presented an experimental assessment of the **robustness of a terrestrial 5G-NR receiver** under co-channel interference generated by a LEO satellite signal within frequency bands allocated to IMT systems. The study was motivated by the ongoing discussions within the International Telecommunication Union on the potential introduction of the DC-MSS-IMT paradigm, which foresees the integration of satellite and terrestrial networks in shared spectrum.

A controlled laboratory campaign was conducted using a conducted setup, enabling precise and repeatable evaluation of interference conditions. The analysis covered four representative carrier frequencies and considered different operational scenarios, including varying **traffic loads (100% and 50%)** and **Doppler conditions** associated with satellite motion.

The experimental results consistently show that a **1 dB desensitization threshold** is reached when the interfering signal power is approximately **5–6 dB below the receiver noise floor**, corresponding to an **I/N ratio close to −6 dB**. This finding is in strong agreement with widely adopted coexistence criteria and confirms their applicability also in scenarios involving satellite-generated interference. Furthermore, the results indicate that **Doppler-induced frequency offsets**, within the range expected for LEO satellites, have a **limited impact** on the desensitization threshold, suggesting that the interference behavior is predominantly driven by the total interfering power received.

The comparison between full-load and partial-load traffic conditions shows only **minor variations** in the interference thresholds, indicating that the adopted methodology provides stable and consistent results across different signal occupancy levels. This further supports the use of **power-based metrics** as practical indicators for coexistence and compatibility studies.

At the same time, the study highlights some **limitations of relying solely on noise-based desensitization metrics**, particularly when the receiver background is modeled using structured signals such as 5G NR instead of pure thermal noise. In such cases, additional effects related to time–frequency resource allocation and signal dynamics may not be fully captured by simple power measurements.

Overall, the results of this work provide **experimentally validated reference values** that can support ongoing technical and regulatory studies on spectrum sharing between satellite and terrestrial IMT systems. Future work may extend this analysis by incorporating **system-level performance metrics** (e.g., throughput and BLER), as well as more advanced interference scenarios involving **time-varying channels, realistic propagation conditions, and multi-satellite environments**, in order to further refine the assessment of DC-MSS-IMT coexistence.

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## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| AWGN | Additive White Gaussian Noise |

| | |
|---|---|
| BLER | Block Error Rate |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| DC-MSS-IMT | Direct Connectivity between Mobile Satellite Service and IMT user equipment |
| ECC | Electronic Communications Committee (within CEPT) |
| FDD | Frequency Division Duplex |
| I/N | Interference-to-Noise ratio |
| IMT | International Mobile Telecommunications |
| ITU | International Telecommunication Union |
| ITU-R | ITU Radiocommunication Sector |
| LEO | Low Earth Orbit |
| MNO | Mobile Network Operator |
| MSS | Mobile Satellite Service |
| NR | New Radio |
| NTN | Non-Terrestrial Network |
| QAM | Quadrature Amplitude Modulation |
| RB | Resource Block |
| RBW | Resolution Bandwidth |
| RF | Radio Frequency |
| RMS | Root Mean Square |
| WP 4C / WP 5D | Working Party 4C / Working Party 5D (ITU-R Groups) |

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