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TECHNICAL REPORT

IMT cellular networks;
Mobile/Fixed Communication Network (MFCN)
in the frequency range 6 425 - 7 125 MHz

Reference

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Keywords

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Executive Summary

In Europe the frequency range 6 425 - 7 125 MHz is currently (October 2019) being mostly used for Fixed Services (FS) and Fixed Satellite Services (FSS) on a primary basis. While the ever-increasing user demand for mobile broadband is pushing industry, academia and regulatory bodies to search for new spectrum, the frequency range 6 425 - 7 125 MHz, it is seen as a possible contender to meet this demand.

Clause 6 includes the main technical specifications of the NR Base Station (BS) and NR mobile User Equipment (UE) which can potentially be incorporated for this frequency range.

The present document does not include the co-existence studies to analyse the risk of interference between incumbent services and the 5G NR technology, which can be the next step in the process of feasibility study.

Introduction

More than two and a half decades after the launch of GSM (2G), a new generation of mobile network technology is at our doorstep with the release of 5G New Radio (NR) technical specification by 3GPP™ (http://www.3gpp.org/DynaReport/38-series.htm). This transition from 4G (known as LTE and LTE-A) to 5G is also in line with the European Commission's vision for the Digital Single Market by 2025 [i.1].

In recent years, the demand for mobile broadband has increased exponentially. As per Ericsson Mobility Report, November 2018 [i.7], the mobile broadband subscriptions are growing at a rate of 15 % YoY (year-on-year), reaching 5,7 billion subscriptions. In Q3 2018 alone, LTE subscriptions increased by 200 million and now accounts for 58 % of the total subscriptions. The global mobile data traffic excluding traffic served by Wi-Fi® or WiMAX™ grew by a rate close to 79 % YoY in Q3 2018, fuelled primarily by high resolution video content. It also forecasts a staggering 8,9 billion mobile subscriptions (6,2 billion unique subscribers) including 1,5 billion 5G subscribers of Enhanced Mobile Broadband (eMBB) by 2023. The eMBB promises faster mobile broadband speed than its predecessor Mobile Broadband (MBB). One of the ways to achieve it is by using large blocks of spectrum which are rare to find in the lower part of the spectrum range (below 6 GHz).

The eMBB forms one of the primary pillars of 5G, the other two being Massive Machine-Type Communications (mMTC) and Ultra-Reliable and Low Latency Communications (URLLC). Considering this enormous user demand, the administrators and regulators are faced with the task of making room in the radio spectrum to adapt for all those new use cases. The radio spectrum is a limited resource, the future is to efficiently share the spectrum between different services, at the same time, keeping all the incumbent protected.

The International Telecommunication Union (ITU), in its Recommendation ITU-R M.2083-0 [i.4], has laid out the foundation and framework for the future development of International Mobile Telecommunication (IMT) 2020 and beyond. A snapshot of the three main pillars and the key capabilities of IMT 2020 and beyond as described in [i.4] are depicted in figures 0-1 and figures 0-2. ITU in its recommendation has also highlighted the importance of contiguous and wider bandwidth requirement to fulfil the need of users running high volume data applications on their smart devices.

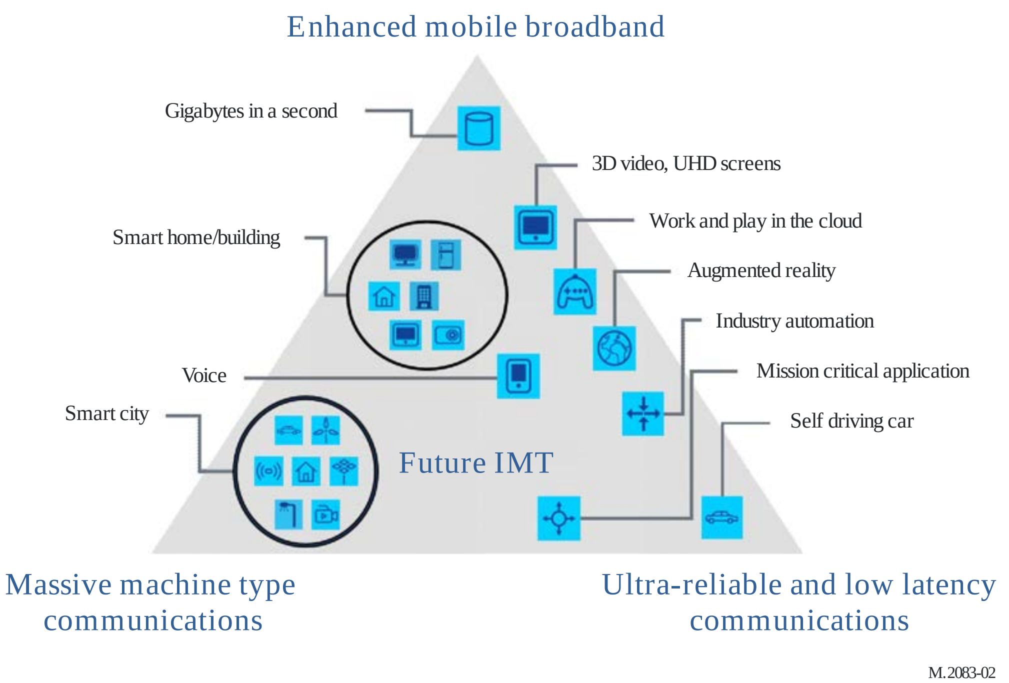

Figure 0-1: Usage scenarios of IMT for 2020 and beyond [i.4]

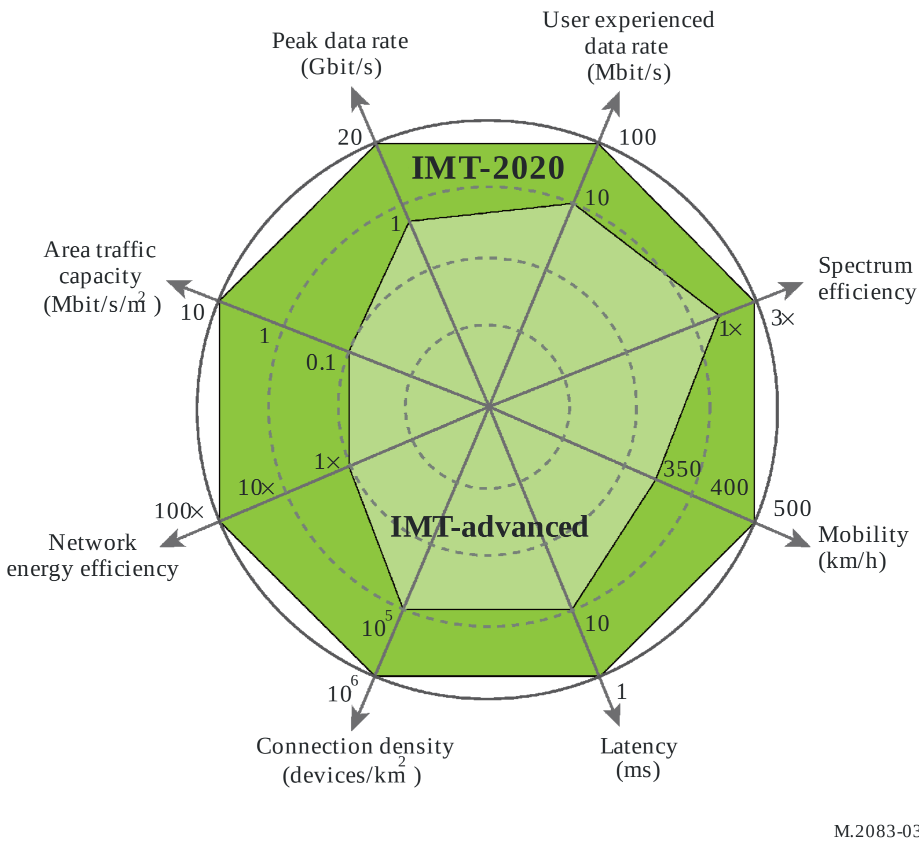

Figure 0-2: Enhancement of key capabilities from IMT-Advance to IMT-2020 [i.4]

The present document acknowledges the scarcity of the available spectrum and provides the justification for the need of additional spectrum for the Mobile/Fixed Communication Networks (MFCNs) including International Mobile Telecommunications (IMT) services in the frequency range 6 425 - 7 125 MHz.

1 Scope

The present document is about the possibility of sharing the frequency range 6 425 - 7 125 MHz between the incumbent services and MFCN (Mobile/Fixed Communication Network) services.

The present document provides the technical parameters of new entrant i.e. MFCN, current spectrum regulations, mitigation techniques and foreseen use cases and applications for the high data rate MFCN including IMT services in the frequency range 6 425 - 7 125 MHz.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Connectivity for a European Gigabit Society.

NOTE: Available at https://ec.europa.eu/digital-single-market/en/policies/improving-connectivity-and-access.

[i.2] ECC Report 254: "Operational guidelines for spectrum sharing to support the implementation of the current ECC framework in the 3600-3800 MHz range".

[i.3] ITU-R Radio Regulations, Articles, Edition of 2016, Volume 1.

NOTE: Available at http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/1.43.48.en.101.pdf.

[i.4] Recommendation ITU-R M.2083-0 (09/2015): "IMT Vision - Framework and overall objectives of the future development of IMT for 2020 and beyond".

[i.5] Recommendation ITU-R SM.329-12: "Unwanted emissions in the spurious domain". .

[i.6] Recommendation ITU-R SM.1541-6: "Unwanted emissions in the out-of-band domain".

[i.7] Ericsson Mobility Report November 2018.

NOTE: Available at https://www.ericsson.com/assets/local/mobility-report/documents/2018/ericsson-mobility-report-november-2018.pdf.

[i.8] Imperial College Business School: "How important are mobile broadband networks for global economic development?".

NOTE: Available at https://spiral.imperial.ac.uk/bitstream/10044/1/46208/2/Goodridge%202017-05.pdf.

[i.9] Nokia: "5G New Radio (NR) Physical Layer Overview and Performance".

NOTE: Available at http://ctw2018.ieee-ctw.org/files/2018/05/5G-NR-CTW-final.pdf.

[i.10] Huwey: "5G Spectrum Public Policy Position".

NOTE: Available at https://www.huawei.com/en/about-huawei/public-policy/5g-spectrum.

[i.11] ETSI TS 138 101-1: "5G; NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone (3GPP TS 38.101-1)".

[i.12] ETSI 138 104: "5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104)".

[i.13] 5G PPP: "5G PPP use cases and performance evaluation modeling" v1.0 - April 2016.

NOTE: Available at https://5g-ppp.eu/wp-content/uploads/2014/02/5G-PPP-use-cases-and-performance-evaluation-modeling_v1.0.pdf

[i.14] 3GPP RP-191523 (June 2019): "Status report for SI on RAN-centric data collection and utilization for LTE and NR".

[i.15] ETSI EN 301 908-24: "IMT cellular networks; Harmonised Standard for access to radio spectrum Part 24: New Radio (NR) Base Stations (BS)".

[i.16] ETSI TR 138 913 (15.0.0): "5G; Study on scenarios and requirements for next generation access technologies (3GPP TR 38.913 version 15.0.0 Release 15)".

[i.17] ERC Report 25: "The European table of frequency allocations and applications in the frequency range 8.3 kHz to 3000 GHz (ECA table)".

NOTE: Available at https://www.ecodocdb.dk/download/2ca5fcbd-4090/ERCREP025.pdf.

[i.18] GSMA: "The Mobile Economy 2018". .

NOTE: Available at https://www.gsma.com/mobileeconomy/wp-content/uploads/2018/05/The-Mobile-Economy-2018.pdf.

[i.19] ECC report 302: "Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925-6425 MHz".

NOTE: Available at https://www.ecodocdb.dk/download/cc03c766-35f8/ECC%20Report%20302.pdf.

[i.20] Recommendation ITU-R S.2367-0: "Sharing and compatibility between International Mobile Telecommunication systems and fixed-satellite service networks in the 5 850-6 425 MHz frequency range".

[i.21] Recommendation ITU-R F.2328-0: "Sharing and compatibility between international mobile telecommunication systems and fixed service systems in the 3 400-4 200 MHz frequency range".

[i.22] Recommendation ITU-R F.2326: "Sharing and compatibility study between indoor International Mobile Telecommunication small cells and fixed service stations in the 5 925-6 425 MHz frequency band".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

antenna connector: connector at the conducted interface of the *BS type 1-C*

BS type 1-C: NR base station operating at FR1 with requirements set consisting only of conducted requirements defined at individual *antenna connectors*

BS type 1-H: NR base station operating at FR1 with a requirement set consisting of conducted requirements defined at individual *TAB connectors* and OTA requirements defined at RIB

BS type 1-O: NR base station operating at FR1 with a requirement set consisting only of OTA requirements defined at the RIB

protection zone: geographical area (for a defined frequency range and time period) within which victim receivers will not be subject to harmful interference caused by interferer transmissions

radiated interface boundary: *operating band* specific radiated requirements reference where the radiated requirements apply

NOTE: For requirements based on EIRP/EIS, the *radiated interface boundary* is associated to the far-field region.

restriction zone: geographical area (normally applicable for a defined frequency range and time period) within which licensees are allowed to operate radio transmitters, under certain restrictive conditions (e.g. maximum e.i.r.p. limits and/or constraints on antenna parameters)

TAB connector: *transceiver array boundary* connector

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Δf	Separation between the channel edge frequency and the nominal -3 dB point of the measuring filter closest to the carrier frequency
Δf_{max}	f_offset_{max} minus half of the bandwidth of the measuring filter
f_offset	Separation between the channel edge frequency and the centre of the measuring filter
f_offset_{max}	The offset to the frequency Δf_{OBUE} outside the downlink *operating band*
MHz	Mega-Hertz
N_{RB}	Transmission bandwidth configuration, expressed in resource blocks
PRated,c	Rated output power (per carrier)

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3rd Generation Partnership Project
AAS	Active Antenna System
ACLR	Adjacent Channel Leakage Power Ratio
ACS	Adjacent Channel Selectivity
BS	Base Station
BW	Bandwidth
CA	Carrier Aggregation
CEPT	European Conference of Postal and Telecommunication Administrations
DC	Dual Connectivity
ECC	Electronic Communication Committee
eMBB	Enhanced Mobile Broadband
ERC	Electronic Radiocommunication Committee
FR	Frequency Range
FS	Fixed Services
FSS	Fixed Satellite Services
GDP	Gross Domestic Product
GSM	Global System for Mobile Communication
GSMA	Global System for Mobile Communication Association
GSO	Geostationary orbit
HST	High Speed Train
IAB	Integrated Access Backhaul
IMT	International Mobile Telecommunication
ITU	International Telecommunications Union
LA	Local Area
LOS	Line-of-site
LTE	Long-Term Evolution

MBB	Mobile BroadBand
MCS	Modulation and Coding Scheme
MFCN	Mobile/Fixed Communication Network
MIMO	Multiple Input Multiple Output
mMTC	Massive Machine-Type Communication
MR	Medium Range
MTC	Machine-Type Communication
NGSO	Non-Geostationary orbit
NR	New Radio
OBUE	Operating Band Unwanted Emissions
OTA	Over-The-Air
PSD	Power spectral density
RAN	Radio Access Network
RAT	Radio Access Technology
RF	Radio Frequency
RIB	Radiated Interface Boundary
RSU	Roadside Unit
SCS	SubCarrier Spacing
SHF	Super High Frequency
TAB	Transceiver Array Boundary
TRP	Total Radiated Power
TX	Transmitter
UE	User Equipment
URLLC	Ultra-Reliable and Low Latency Communications
WA	Wide Area
YoY	Year-over-Year

4 Market Trend and Information

Mobile communication is one of the most significant technological developments in recent history. It has transformed the ways of communication, seek information, learn and develop, experience entertainment and to execute business. The number of mobile subscriptions is growing at 4 % Year-over-Year (YoY) and reached a figure of 7,9 billion in Q3 2018. Almost 79 % of those subscriptions were mobile broadband, accessing internet via mobile broadband technology (MBB) [i.7].

The mobile data traffic has also grown massively with 54 % Year-over-Year (YoY) growth, Q1 2017-2018. This growth is both due to the increase in mobile subscriptions and the increase in average data volume per subscription, which is driven by rising consumptions of video content at increasingly higher resolutions. The mobile video traffic is expected to grow at 45 % annually through 2023 and constitute 73 % of the overall mobile data traffic. It is also expected that by 2023, more than 20 % of the mobile data traffic will be carried by 5G networks while the major share would still be held by LTE/LTE-A [i.7].

The mobile broadband technology has bridged the digital gap between the Internet-connected and unconnected people, especially in the developing countries. It has become a major factor in driving economic and social change. The study done by Imperial College Business School [i.8], reveals a direct relation between mobile broadband penetration and the Gross Domestic Product (GDP), for every 10 % increase in the MBB there is a 0,6 % to 2,8 % rise in GDP.

According to The Mobile Economy 2018 by GSMA Intelligence [i.18]: "In 2017, mobile technologies and services generated 4,5 % of GDP globally, a contribution that amounted to $3,6 trillion of economic value added. By 2022, this contribution will reach $4,6 trillion, or 5 % of GDP". At the same time, mobile technology is also at the forefront of the economic development of the developing countries providing digital connectivity.

5 Frequency allocation

5.0 General

In this clause, the frequency allocation valid at the time of creation of the present document has been presented.

5.1 ITU allocation

Article 5 of ITU Radio Regulations Edition 2016 [i.3] has allocated the frequencies 5 925 - 6 700 MHz and 6 700 - 7 075 MHz to the FIXED, FIXED-SATELLITE and MOBILE services respectively and 7 075 - 7 145 MHz to the FIXED and MOBILE services on primary basis in all three ITU regions, as depicted in table 5.1-1.

Table 5.1-1: Extract from the ITU Radio Regulations [i.3]

5570 - 6700 MHz		
Allocation to services		
Region 1	Region 2	Region 3
5925 - 6700	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE	

6700 - 7250 MHz		
Allocation to services		
Region 1	Region 2	Region 3
6700 - 7075	FIXED FIXED-SATELLITE (Earth-to-Space) (Space-to-Earth) MOBILE	
7075 - 7145	FIXED MOBILE	

NOTE 1: In the band 6 425 - 7 075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7 075 - 7 250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the Earth exploration-satellite (passive) and space research (passive) services in their future planning of the bands 6 425 - 7075 MHz and 7 075 - 7 250 MHz [i.3].

NOTE 2: In making assignments to stations of other services to which the band 6 650 - 6 675,2 MHz is allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see 4.5 and 4.6 and Article 29, WRC-07 [i.3]).

5.2 European allocation

Based on the information from the European table of frequency allocation and applications (https://efis.dk), the frequencies 5 925 - 6 700 MHz and 6 700 - 7 075 MHz have been allocated to the FIXED and FIXED-SATELLITE services on the primary basis and to the Earth Exploration-Satellite service on the secondary basis, whereas the frequencies 7 075 - 7 145 MHz to the FIXED and FIXED-SATELLITE services on the primary basis.

The ERC report 25 [i.17], approved on March 2019, also designated MOBILE SERVICE as one of the primary service in the frequency range 5 925 - 6 700 MHz following the same ITU allocation in Region 1.

Table 5.2-1: Extract from the European table of frequency allocations for 5 925 - 6 700 MHz [i.17]

RR Region 1 Allocation and RR footnotes applicable to CEPT	*European Common Allocation and ECA Footnotes*	*ECC/ERC harmonisation measure*	*Applications*	*Standard*	*Notes*
FIXED 5.457 FIXED-SATELLITE (EARTH-TO-SPACE) 5.457A 5.457B MOBILE 5.457C 5.149 5.440 5.458	FIXED FIXED-SATELLITE (EARTH-TO-SPACE) MOBILE Earth Exploration-Satellite (passive) 5.149 5.440 5.458		-		
		ECC/DEC/(05)09	ESV	EN 301 447	Within the band 5925-6425 MHz
		ECC/DEC/(05)09	FSS Earth stations	EN 301 443	Priority for civil networks
		ECC/REC/(14)06 ERC/REC 14-01 ERC/REC 14-02	Fixed	EN 302 217	Point-to-point
			Passive sensors (satellite)		For sea surface temperature, sea surface wind speed and soil moisture measurements
			Radio astronomy		Spectral line observations (e.g. methanol line), VLBI.
		ECC/DEC/(11)02 ERC/REC 70-03	Radiodetermination applications	EN 302 372 EN 302 729	Within the band 4500-7000 MHz for TLPR application and 6000-8500 MHz for LPR applications
		ECC/DEC/(06)04 ECC/DEC/(12)03	UWB applications	EN 302 065	Generic UWB as well as UWB on-board aircraft regulation within the band 6.0- 8.5 GHz

Table 5.2-2: Extract from the European table of frequency allocations for 6 700 - 7 075 MHz [i.17]

RR Region 1 Allocation and RR footnotes applicable to CEPT	*European Common Allocation and ECA Footnotes*	*ECC/ERC harmonisation measure*	*Applications*	*Standard*	*Notes*
FIXED FIXED-SATELLITE (EARTH-TO-SPACE) (SPACE-TO-EARTH) 5.441 MOBILE 5.458 5.458A 5.458B	FIXED FIXED-SATELLITE (EARTH-TO-SPACE) (SPACE-TO-EARTH) 5.441 Earth Exploration-Satellite (passive) 5.458 5.458A 5.458B		FSS Earth stations	EN 301 443	Within the band 6725-7025 MHz. Priority for civil networks
			Feeder links		
		ECC/REC/(14)06 ERC/REC 14-02	Fixed	EN 302 217	Point-to-point
		ERC/REC 25-10	PMSE	EN 302 064	Portable or mobile wireless video, cordless cameras, temporary P-t-P video links in 7-8.5 GHz tuning range
			Passive sensors (satellite)		For sea surface temperature, sea surface wind speed and soil moisture measurements
		ECC/DEC/(11)02 ERC/REC 70-03	Radiodetermination applications	EN 302 372 EN 302 729	Within the band 4500-7000 MHz for TLPR application. Within the band 6000-8500 MHz for LPR applications
		ECC/DEC/(06)04 ECC/DEC/(12)03	UWB applications	EN 302 065	Generic UWB as well as on-board aircraft regulation within the band 6.0-8.5 GHz

Table 5.2-3: Extract from the European table of frequency allocations for 7 075-7 145 MHz [i.17]

FIXED MOBILE 5.458 5.459	FIXED Earth Exploration-Satellite (passive) 5.458	ECC/REC/(02)06 ECC/REC/(14)06 ERC/REC 14-02	Fixed	EN 302 217	Point-to-point
		ERC/REC 25-10	PMSE	EN 302 064	Portable or mobile wireless video, cordless cameras, temporary P-t-P video links in 7-8.5 GHz tuning range
			Passive sensors (satellite)		For sea surface temperature, sea surface wind speed and soil moisture measurements
		ECC/DEC/(11)02 ERC/REC 70-03	Radiodetermination applications	EN 302 729	Within the band 6000-8500 MHz for LPR applications
		ECC/DEC/(06)04 ECC/DEC/(12)03	UWB applications	EN 302 065	Generic UWB as well as on-board aircraft regulation within the band 6.0-8.5 GHz

NOTE: The above extracts are from the European table of frequency allocations and applications in July 2019 [i.17]. For the most up-to-date version of the table, refer to https://www.efis.dk.

6 Technical requirements

6.0 General

3GPP has developed a NR RAT to comply with IMT-2020 requirements [i.4]. Related information on the 3GPP submission pf the NR to the IMT-2020 can be found in [i.14].

In the NR technical specifications, two Frequency Ranges (FR) are defined and are given in table 6.0-1.

Table 6.0-1: Frequency range designated for the mobile communication

Frequency Range designation	Corresponding frequency range
FR1	410 - 7 125 MHz
FR2	24 250 - 52 600 MHz

As the range of 6 425 - 7 125 MHz belongs to FR1, the FR2 aspects can are not applicable to the present document. Therefore, the technical requirements for both NR BS and NR UE have been referenced from 5G NR technical specifications in:

- ETSI TS 138 101-1 [i.11] for NR UE operating in FR1.
- ETSI TS 138 104 [i.12] for NR BS operating in FR1 or FR2, covering both the conducted and the radiated set of requirements.

There are multiple BS and UE requirements defined in the 3GPP's 5G NR technical specifications, but for the sake of simplicity only a selected subset related to the future work on the co-existence studies are referred and mentioned in the present document.

6.1 Transmitter requirements

6.1.0 General

The frequency range 6 425 - 7 125 MHz is a subset of Super High Frequency (SHF) defined by ITU [i.3], for the frequencies below 10 GHz, multipath propagation is the dominant limiting factor in fading. The techniques like diversity and equalization can be used to counter the effects of multipath propagation at both the transmitter and receiver parts of the communication system. Higher frequency signals attenuate more rapidly and cannot travel to a long distance, therefore BS in such scenario has a small range. The higher frequencies can accommodate higher bandwidths which makes it possible to increase the much-needed capacity of the communication network using 5G-based services, while the lower frequency with legacy services can promise coverage.

This clause is further divided into BS and UE transmitter parameters.

6.1.1 BS transmitter

6.1.1.0 General information - BS transmitter

There is wide range of requirements defined for the NR BS in 3GPP RAN WG4 specification ETSI TS 138 104 [i.12]. For the FR1 range, the NR BS can have non-AAS or AAS BS architecture. The non-AAS architecture has to comply to the conducted requirements, while the AAS BS architecture could comply to the conducted and/or radiated requirements.

Table 6.1.1.0-1 lists all the transmitter requirements defined for NR BS, including breakdown for AAS and non-AAS BS architectures, as well as the conducted and radiated requirement sets. Those requirement sets were composed into BS type 1-C, BS type 1-H and BS type 1-O, which are defined as follows:

BS type 1-C: NR base station operating at FR1 with requirements set consisting only of conducted requirements defined at individual *antenna connectors.*

BS type 1-H: NR base station operating at FR1 with a requirement set consisting of conducted requirements defined at individual *TAB connectors* and OTA requirements defined at RIB.

BS type 1-O: NR base station operating at FR1 with a requirement set consisting only of OTA requirements defined at the RIB.

Table 6.1.1.0-1 also includes references to the sections of ETSI TS 138 104 [i.12] describing all the listed requirements.

Table 6.1.1.0-1: NR BS transmitter requirement set applicability from ETSI TS 138 104 [i.2]

<table>
<tr><th colspan="2" rowspan="2">Requirement</th><th colspan="3">Requirement set</th></tr>
<tr><th>BS type 1-C
(non-AAS BS architecture)</th><th>BS type 1-H
(AAS BS architecture)</th><th>BS type 1-O
(AAS BS architecture)</th></tr>
<tr><td rowspan="9">Conducted requirements</td><td>BS output power</td><td>6.2</td><td>6.2</td><td rowspan="9">Not applicable</td></tr>
<tr><td>Output power dynamics</td><td>6.3</td><td>6.3</td></tr>
<tr><td>Transmit ON/OFF power</td><td>6.4</td><td>6.4</td></tr>
<tr><td>Transmitted signal quality</td><td>6.5</td><td>6.5</td></tr>
<tr><td>Occupied bandwidth</td><td>6.6.2</td><td>6.6.2</td></tr>
<tr><td>ACLR</td><td>6.6.3</td><td>6.6.3</td></tr>
<tr><td>Operating band unwanted emissions</td><td>6.6.4</td><td>6.6.4</td></tr>
<tr><td>Transmitter spurious emissions</td><td>6.6.5</td><td>6.6.5</td></tr>
<tr><td>Transmitter intermodulation</td><td>6.7</td><td>6.7</td></tr>
<tr><td rowspan="10">Radiated requirements</td><td>Radiated transmit power</td><td rowspan="10">Not applicable</td><td>9.2</td><td>9.2</td></tr>
<tr><td>OTA base station output power</td><td rowspan="9">Not applicable</td><td>9.3</td></tr>
<tr><td>OTA output power dynamics</td><td>9.4</td></tr>
<tr><td>OTA transmit ON/OFF power</td><td>9.5</td></tr>
<tr><td>OTA transmitted signal quality</td><td>9.6</td></tr>
<tr><td>OTA occupied bandwidth</td><td>9.7.2</td></tr>
<tr><td>OTA ACLR</td><td>9.7.3</td></tr>
<tr><td>OTA out-of-band emission</td><td>9.7.4</td></tr>
<tr><td>OTA transmitter spurious emission</td><td>9.7.5</td></tr>
<tr><td>OTA transmitter intermodulation</td><td>9.8</td></tr>
</table>

6.1.1.1 BS transmit power

Depending upon the base station class declaration, its maximum transmit power limit varies. Generally, for wide area BS which promises a long coverage, there is no defined power limit. The BS transmit power is classified as rated carrier out power, $P_{Rated,c}$. $P_{Rated,c}$ of BS is the mean power level for a specific carrier that the manufacturer has declared to be available at the antenna connector (in case of non-AAS product) during the transmitter ON period.

Table 6.1.1.1-1: Maximum transmit power according to the BS class

BS class	$P_{Rated,c}$
Wide Area BS	(see note)
Medium Range BS	≤ +38 dBm
Local Area BS	≤ +24 dBm
NOTE: There is no upper limit for the rated carrier output power of the Wide Area Base Station.	

6.1.1.2 BS channel bandwidth and configurations

Based on the type of applications IMT-2020 will support, 3GPP has divided channel arrangements in NR for the frequency range FR1 and FR2, although FR2 is out of the scope of the present document.

The NR supports scalable and flexible numerology in terms of sub-carrier spacing (SCS) and channel bandwidth to address different applications [i.9]. There are four different SCS defined in ETSI TS 138 104 [i.12]: 15 kHz, 30 kHz, 60 kHz and 120 kHz respectively, which is in contrast with LTE where only 15 kHz of SCS is available. Depending upon the available channel BW and user case, there is a freedom of choice between SCS, which can make the transmission more efficient. For example, the high frequencies with a large chunk of available spectrum could be used for extremely high data rate applications powered by the massive-MIMO and beam forming techniques using 120 kHz SCS [i.10].

For the FR1, a minimum of 5 MHz and a maximum of 100 MHz of channel bandwidth/transmission bandwidth is defined in ETSI TS 138 104 [i.12]. It is to be noted that the maximum supported UL/DL channel bandwidth can be different for the same band. Additionally, carrier-aggregation or dual-connectivity can concatenate multiple carriers to increase the total channel bandwidth. Table 6.1.1.2-1 illustrates the different numerology for the SCS and transmission bandwidth configurations available for the FR1.

Table 6.1.1.2-1: BS transmission bandwidth configuration for FR1

SCS [kHz]	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	40 MHz	50 MHz	60 MHz	70 MHz	80 MHz	90 MHz	100 MHz
	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}
15	25	52	79	106	133	160	216	270	N.A	N.A	N.A	N.A	N.A
30	11	24	38	51	65	78	106	133	162	189	217	[245]	273
60	N.A	11	18	24	31	38	51	65	79	93	107	[121]	135

The BS can support multiple carriers to the same UE or even different UE's within its channel bandwidth. For the extremely high data rate MFCN applications the large channel bandwidths are optimum.

6.1.1.3 BS unwanted emissions

Transmitter's unwanted emissions consist of spurious and out-of-band emissions. The spurious emissions are the emissions on a frequency, or frequencies, which are outside the necessary bandwidth, the level of which may be reduced without affecting the corresponding transmission of information.

Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out-of-band emissions [i.5].

The out-of-band emissions are the emissions on frequencies just outside the channel bandwidth, arising due to the modulation process and non-linearity in the transmitter but excluding spurious emissions [i.6]. The out-of-band emissions requirement for the BS transmitter is specified both in terms of Adjacent Channel Leakage Power Ratio (ACLR) and *Operating Band* Unwanted Emissions (OBUE).

The maximum offset of the *operating band* unwanted emissions mask from the *operating band* edge is Δf_{OBUE}. The Operating band unwanted emissions define all unwanted emissions in each supported downlink *operating band* plus the frequency ranges Δf_{OBUE} above and Δf_{OBUE} below each band. Unwanted emissions outside of this frequency range are limited by a spurious emissions requirement.

For *BS type 1-H* the unwanted emission requirements are applied per the *TAB connector TX min cell groups* for all the configurations supported by the BS. The *basic limits* and corresponding emissions scaling are defined in each relevant clause.

The OTA out-of-band emissions requirement for the BS type 1-O and *BS type 2-O* transmitter is specified both in terms of Adjacent Channel Leakage Power Ratio (ACLR) and Operating Band Unwanted Emissions (OBUE). The OTA Operating band unwanted emissions define all unwanted emissions in each supported downlink *operating band* plus the frequency ranges Δf_{OBUE} above and Δf_{OBUE} below each band. OTA Unwanted emissions outside of this frequency range are limited by an OTA spurious emissions requirement.

The values of Δf_{OBUE} are defined in table 6.1.1.3-1 for the NR *operating bands*.

Table 6.1.1.3-1: Maximum offset of OBUE outside the downlink *operating band*

BS type	*Operating band* characteristics	Δf_{OBUE} (MHz)
BS type 1-H	$F_{DL,high}$ - $F_{DL,low}$ < 100 MHz	10
	100 MHz ≤ $F_{DL,high}$ - $F_{DL,low}$ ≤ 900 MHz	40
BS type 1-C	$F_{DL,high}$ - $F_{DL,low}$ ≤ 200 MHz	10
	200 MHz < $F_{DL,high}$ - $F_{DL,low}$ ≤ 900 MHz	40
BS type 1-O	$F_{DL,high}$ - $F_{DL,low}$ < 100 MHz	10
	100 MHz ≤ $F_{DL,high}$ - $F_{DL,low}$ ≤ 900 MHz	40

Requirements for OTA unwanted emissions are captured using TRP, *directional requirements* or co-location requirements as described per requirement.

There are four important technical parameters that lie in the unwanted emission domain and are defined in ETSI TS 138 104 [i.12]:

- Occupied bandwidth/OTA occupied bandwidth.
- Adjacent Channel Leakage Power Ratio/OTA ACLR.
- Operating band unwanted emissions, OTA OBUE.
- Transmitter spurious emissions/OTA transmitter spurious emissions.

The operating band unwanted emission (also known as transmitter emission mask) is one of the four parameters and is often used in the co-existence studies. Depending upon the BS class (i.e. Wide Area BS, Medium Range BS or Local Area BS), its emission mask also varies.

Some of the unwanted emissions requirements are defined with the regional applicability, e.g. for the NR Local Area BS for the frequency range greater than 3 GHz to be deployed in Europe is specified in table 6.1.1.3-2. The related emission mask for Medium Range and Wide Area BS can be found in ETSI EN 301 908-24 [i.15].

Table 6.1.1.3-2: Local Area BS operating band unwanted emission limits (NR bands > 3 GHz)

Frequency offset of measurement filter -3 dB point, Δf	Frequency offset of measurement filter centre frequency, f_offset	*Basic limit* (see notes 1 and 2)	Measurement bandwidth
0 MHz ≤ Δf < 5 MHz	0,05 MHz ≤ f_offset < 5,05 MHz	$-28,2dBm - \frac{7}{5} \cdot \left(\frac{f\_offset}{MHz} - 0,05\right) dB$	100 kHz
5 MHz ≤ Δf < min(10 MHz, Δf_{max})	5,05 MHz ≤ f_offset < min(10,05 MHz, f_offset_{max})	-35,2 dBm	
10 MHz ≤ Δf ≤ Δf_{max}	10,05 MHz ≤ f_offset < f_offset_{max}	-37 dBm (see note 3)	
NOTE 1: For a BS supporting non-contiguous spectrum operation within any *operating band* the emission limits within sub-block gaps is calculated as a cumulative sum of contributions from adjacent sub blocks on each side of the sub block gap. Exception is Δf ≥ 10 MHz from both adjacent sub blocks on each side of the sub-block gap, where the emission limits within sub-block gaps should be -37 dBm/100 kHz.			
NOTE 2: For a *multi-band connector* with Inter RF Bandwidth gap < 2*Δf_{OBUE} the emission limits within the Inter RF Bandwidth gaps is calculated as a cumulative sum of contributions from adjacent sub-blocks or RF Bandwidth on each side of the Inter RF Bandwidth gap.			
NOTE 3: The requirement is not applicable when Δf_{max} < 10 MHz.			

The related OTA requirement is subject to the emissions scaling (and the modified emission levels), which is described in ETSI TS 138 104 [i.12].

6.1.2 UE transmitter

6.1.2.1 UE transmit power

Like the previous standards for the mobile broadband, 5G NR standard, the 3GPP 38 series also includes the four different UE transmit power classes. Clause 6.2 of ETSI TS 138 101-1 [i.11] explains in detail the UE transmit power limits for FR1.

6.1.2.2 UE channel bandwidth and configurations

Similar to the BS channel bandwidth and configuration defined in clause 6.1.1.2, the UE channel bandwidth configurations are defined in table 6.1.2.2-1.

Table 6.1.2.2-1: UE Channel bandwidth configurations for FR1

SCS (kHz)	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz	90 MHz	100 MHz
	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}	N_{RB}
15	25	52	79	106	133	160	216	270	N/A	N/A	N/A	N/A
30	11	24	38	51	65	78	106	133	162	217	245	273
60	N/A	11	18	24	31	38	51	65	79	107	121	135

6.2 Receiver parameters

6.2.0 General

Both the BS and UE receiver have a significant impact on the capacity and coverage of the cellular network. There is a direct relation between the receiver performance and the maximum transferable data throughput in the direction of receiver. Therefore, the receiver performance holds the key for optimum cellular network performance.

6.2.1 BS receiver

6.2.1.0 General information - BS receiver

Table 6.2.1.0-1 lists all the receiver requirements defined for NR BS, including breakdown for AAS and non-AAS BS architectures, as well as the conducted and radiated requirement sets.

Table 6.2.1.0-1: NR BS receiver requirement set applicability from ETSI TS 138 104 [i.2]

Requirement		Requirement set		
		BS type 1-C **(non-AAS BS architecture)**	***BS type 1-H*** **(AAS BS architecture)**	***BS type 1-O*** **(AAS BS architecture)**
Conducted requirements	Reference sensitivity level	7.2	7.2	Not applicable
	Dynamic range	7.3	7.3	
	In-band selectivity and blocking	7.4	7.4	
	Out-of-band blocking	7.5	7.5	
	Receiver spurious emissions	7.6	7.6	
	Receiver intermodulation	7.7	7.7	
	In-channel selectivity	7.8	7.8	
Radiated requirements	OTA sensitivity	Not applicable	10.2	10.2
	OTA reference sensitivity level		Not applicable	10.3
	OTA dynamic range			10.4
	OTA in-band selectivity and blocking			10.5
	OTA out-of-band blocking			10.6
	OTA receiver spurious emission			10.7
	OTA receiver intermodulation			10.8
	OTA in-channel selectivity			10.9

6.2.1.1 BS receiver sensitivity

The BS receiver sensitivity is defined in terms of $P_{REFSENS,}$ which is the minimum received power level for which the throughput is promised to be greater than or equal to the 95 % of the maximum throughput at the reference measurement channel. The reference measurement channel is dependable on MCS (modulation and coding scheme), channel bandwidth and other factors.

Clauses 7.2 and 10.2 of ETSI TS 138 104 [i.12] explain the conducted and over-the-air minimum receiver sensitivity requirements respectively.

In case of the OTA requirements, there is receiver sensitivity as well as receiver reference sensitivity requirements defined. Clause 10.2 of ETSI TS 138 104 [i.12] explain the OTA sensitivity, while clause 10.3 explain the OTA reference sensitivity requirements.

6.2.1.2 BS receiver selectivity and blocking

The presence of other radio devices in the proximity of receiver can cause interference to the wanted received signal and led to the degradation of communication link quality. Therefore, it is important for the receiver to filter out the unwanted signals it receives in the frequency near and far from its own.

Generally, the frequency offset of interfering frequency from the wanted frequency defines the two terms, Selectivity and Blocking. Blocking is defined mainly for the frequency offsets far away from the wanted frequency and Selectivity is defined for the frequency offsets close to the wanted receiver frequency. Selectivity for the BS is also known as Adjacent Channel Selectivity (ACS).

Clause 7.4 of ETSI TS 138 104 [i.12] explains the ACS and in-band blocking for the NR BS and their minimum requirements. While, clause 7.5 of ETSI TS 138 104 [i.12] explains the out-of-band blocking.

6.2.2 UE receiver

Similar to the BS, 3GPP NR defines the NR UE receiver characteristics. Clauses 7.3, 7.5 and 7.6 of ETSI TS 138 101-1 [i.11] describes the UE receiver reference sensitivity, adjacent channel selectivity and blocking characteristics respectively for FR1.

7 Use cases and applications

As described in Recommendation ITU-R M.2083-0 [i.4], IMT 2020 (5G) will support the new use cases and applications requiring very high data rate, ultra-low latency and high reliability and a large number of connected devices. Therefore, it not only provides business opportunity to the ecosystem of Network Providers, Equipment Manufacturer, Handset Manufacturers, Content Providers, etc. but to a whole new vertical of industry including, but not limited to, Automotive, Energy, Health, Industry 4.0, Public Safety and Transport [i.13].

Referring to the NR deployment scenarios addressed in ETSI TR 138 913 [i.16], their list is presented below:

1) Indoor hotspot: this scenario addressed an indoor case with relatively small coverage, high capacity and high user throughput driven by high density of low-mobility users. Sub-6 GHz spectrum (i.e. 4 GHz proxy frequency), or mmW frequencies (i.e. 30 and 70 GHz) were considered as carrier frequencies for this deployment scenario. This scenario is expected to be addressed by the LA BS class operating.

2) Dense urban: this is two-layer outdoor and outdoor-to-indoor scenario relying on the macro grid with continuous cellular layout, extended with randomly dropped micro sites. It is characterized by high user's density generating high traffic loads within dense urban areas. This scenario is expected to be addressed by the WA and MR BS classes. This scenario is well suited for CA or DC application.

3) Rural: this scenario is characterized by large coverage and continuous coverage provided over the rural areas, with the support of high-speed mobility, e.g. for the roads. Carrier frequencies considered were 700 MHz and 4 GHz, using single layer macro network.

4) Urban macro: this scenario is characterized with large cells and continuous coverage, serving outdoor and indoor users of low and medium mobility. The difference to the Dense urban scenario is that the Urban Marco is a one-layer macro layout. This scenario is addressed by WA BS only.

5) High speed train: this scenario addressed a special case of HST deployments, where dedicated macro nodes are deployed along the railway, providing continuous coverage along HST tracks for the purpose of consistent user experience and critical train communication reliability with very high mobility. This scenario is addressed by WA BS and the relay nodes deployed at the carrier(s). Applicability of this scenarios is expected to be limited.

6) Extreme long-distance coverage in low density areas (extreme rural): this scenario addresses very large areas with low user's density generating low-to-moderate user throughput. Coverage might be non-continuous, provided by single layer, isolated macro cells with the cell ranges of 100 km and more, operating below 3GHz. Due to this limitation, this NR scenario is not to be further considered.

7) Urban coverage for massive connection: this scenario addressed mMTC use case for outdoor and indoor MTC devices of varying velocities. The continuous coverage is provided by the macro nodes operating in 1 - 2 GHz range for good indoor penetration. Due to the 6 - 7 GHz propagation characteristics, this NR scenario is not to be further considered.

8) Highway scenario: this is one of the V2V/V2X scenarios considered during NR studies. It addresses 100 % users are in vehicles located on highways, with the average speed in range of 100 - 300 km/h. the operating frequency range was considered to be up to 6 GHz, with the coverage provided by the macro and RSU unit.

9) Urban Grid for Connected Car: this is one of the V2V/V2X scenarios considered during NR studies. This scenario differs from the above highway case and focuses on densely deployed vehicles placed in urban area. Lower velocities are considered here, as well as vehicle and pedestrian users.

10) Commercial Air to Ground scenario: this scenario addresses coverage for UEs located at commercial aircrafts (usually equipped with an onboard relay node) travelling at altitudes up to 15 km. The coverage is provided by upward pointed macro cells with very large area coverage (cell range of up to 100 km), operating at frequencies below 4 GHz.

11) Light aircraft scenario: this scenario is similar to the above one, with the difference of no relay node being considered at non-commercial aircrafts travelling at altitudes of up to 3 km, with smaller user's density. The coverage is provided by upward pointed macro cells with very large area coverage (cell range of up to 100 km), operating at frequencies below 4 GHz.

The above list of the NR deployment scenarios which were studied prior to the NR standard creation. Scenarios 1) Indoor hotspot, 2) Dense Urban, 4) Urban Macro, 5) High speed train, 8) Highway scenario and 9) Urban grid for connected car, seem suitable for provision using 6 425 - 7 125 MHz. More generally, applications that require mobile connectivity in urban areas with very high data rates and/or volumes could be provided using this band.

Some specific examples are: tele-video-consultation, tele-surgery and connected ambulance in the healthcare industry; entertainment in cars, traffic monitoring, smart and driverless cars, tele-operated driving in the mobility/transportation sector; immersive video-games and education, AR/VR at museums/events in the entertainment and education sectors.

In addition, 5G NR based networks can be used to provide high speed Fixed Wireless Access in areas where deployment of fiber is not possible or not cost effective. Finally, referring to the 3GPP Rel-16 work item on the Integrated Access Backhaul (IAB), the IAB scenario can also be considered as one of the potential benefits from the frequency range considered in the present document.

8 Compatibility and Sharing studies

At the time of completion of the present document, there were no compatibility and sharing studies evaluation results available between the MFCN and incumbent services in the frequency range 6 425 - 7 125 MHz. The present document provides the technical information as the baseline for the co-existence studies to be performed in the future. CEPT performs the compatibility and sharing studies for the introduction of new services in the CEPT countries (https://www.cept.org/cept/cept-members-units-and-admission-year). ITU-R also performs sharing studies before new services are allocated spectrum in the ITU Radio Regulations.

Both CEPT and ITU have conducted studies in the past that could be useful references for future studies of MFCN coexistence with the incumbent users in 6 425 - 7 125 MHz. In particular:

- ECC report 254 [i.2] provides guidelines for coexistence of MFCN with incumbent services in 3 600 - 3 800 MHz, namely the fixed service and the fixed satellite service (space-to-Earth).

- ECC report 302 [i.19] studies the compatibility and sharing between Radio Local Area Networks and incumbent services in and adjacent to 5 925 - 6 425 MHz.
- Recommendation ITU-R S.2367-0 [i.20] studies the compatibility and sharing between the mobile service (IMT) and the fixed satellite service (Earth-to-space) in 5 850 - 6 425 MHz.
- Recommendation ITU-R F.2328 [i.21] studies the compatibility and sharing between the mobile service (IMT) and the fixed service in 3 400 - 4 200 MHz.
- Recommendation ITU-R F.2326 [i.22] Sharing and compatibility study between indoor International Mobile Telecommunication small cells and fixed service stations in the 5 925 - 6 425 MHz frequency band.

9 Mitigation techniques

9.1 Mitigation Techniques related to FS

The following is a list of potential interference mitigation techniques in case of co-channel transmission which may help to reduce separation distances between the MFCN transmitter and FS receiver:

- Configurations of the AAS BS, avoid power directed towards the FS receiver
- Deployment of BS away from the main beam and LOS of FS link
- Indoor deployment
- Power limitations of the BS (local area or medium range)
- Power control mechanism

9.2 Mitigation Techniques related to FSS

The MFCN, including IMT, stations emit interference towards the FSS space receiver as shown in figure 9.2-1.

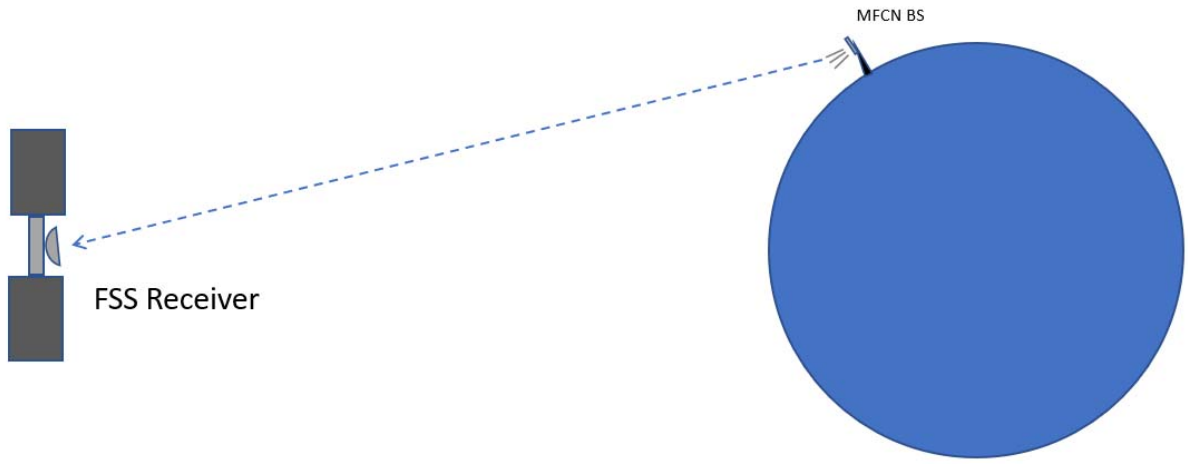

Figure 9.2-1: Co-channel Interference Scenario from MFCN BS into FSS receiver

The FSS service in this bands operates at geo stationary orbits (GSO) and non-geostationary orbits (NGSO). Some of the mitigation techniques are only applicable to GSO satellite systems.

The following is a list of potential interference mitigation techniques in case of co-channel transmission between the MFCN transmitter and FSS receiver:

- AAS BS deployment with beamforming capabilities.
- Deployment of BS with the antenna panel not facing the FSS receiver.
- Indoor deployment.
- Power limitations of the BS (local area or medium range BS).
- PSD per 1 000 km^2.
- Limitation of the number of base stations in a certain area (e.g. maximum number of base stations per 1 000 km^2).

10 Conclusion

The frequency range 6 425 - 7 125 MHz has the potential to support the growing demand for mobile broadband and other use-cases defined in clause 7. However, further feasibility studies are required to assess the challenges around the co-existence and compatibility of 5G NR technology with the incumbent services in the same frequency range and neighbouring frequencies respectively. The present document can be considered as the base for such studies to determine the technical conditions to use the MFCN in this band.

History

Document history		
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