

# SPECTRUM OCCUPATION AND PERSPECTIVES MILLIMETER BAND UTILIZATION FOR 5G NETWORKS

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## ABSTRACT

*Constantly increasing volume of data transmitted through the mobile communication networks and the needs of users to increase the data rates cause the rapid development of mobile networks. During 2012 and 2013 many vendors, operators, universities, research centers, as well as standardization and regulatory bodies have announced the beginning of their work on the development of a new generation of 5G mobile communications. The main goal of 5G technology developers is to provide data rates of more than 10 Gbit/s in the mobile wireless access networks. Considering the spectrum utilization in the frequency range up to 6 GHz, increasing of data rates will require the employment of new frequency ranges between 6-95 GHz. This article presents research results of the possibility of using frequency bands 27,5-95 GHz and their prioritization for 5G networks, current utilization of these ranges in Russia and cost of their release.*

**Keywords** - 5G, millimeter band, spectrum conversion, spectrum release, state budget.

## 1. INTRODUCTION

Emergence of mobile 5G technologies on the telecommunication market that expected in 2020 should significantly improve the quality of service provided to users under fast growing data volumes in mobile networks, as well as the growing number of wireless devices and the variety of wireless services [1-2].

It is supposed that the equipment on the basis of 5G technologies will be capable of transmitting data at speeds of more than 10 Gbit/s in mobile wireless networks [3-6]. The implementation of 5G technologies is aimed at increasing the efficiency of radio spectrum utilization in comparison with 4G mobile technologies (LTE Advanced). Considering the need of large frequency resources for a single channel 5G, exceeding 100 MHz, one of the most likely options for the development of a new generation of mobile communications will be the employment of higher frequency ranges between 6 - 95 GHz [7]. These issues have become a primary for the future World Radiocommunication Conferences (WRC) - 15 (Agenda item 1.1) and WRC-18, and Russian Communication Administration should formulate its position for this item.

Because of the particular use of radio spectrum in the bands 27,5 - 95 GHz in Russia an implementation of 5G technologies will require release and conversion of the radio spectrum and changes in the regulatory and legal framework of the industry.

## 2. SEARCH CRITERIA OF FREQUENCY RESOURCES FOR 5G

To investigate the applicability and acceptability of different frequency ranges for future development of 5G communications, in particular the bands 5,925 - 40,5 GHz and 40,5 - 95 GHz, search criteria of new frequency bands for 5G based on the 5G functional requirements [8], and the current properties of frequency bands that match selected search criteria, as well as the capabilities of each frequency band for the implementation of these requirements were determined.

In the framework of the European program of 5G, known as METIS project, are selected the following criteria to make a choice of suitable frequency bands [9]:

- Utilization of the frequency bands that according to Art.5 of the Radio Regulations of ITU-R are allocated on a primary basis for the categories of mobile/fixed radio services, or sharing utilization of a frequency band on a primary basis (including bands used for transport networks of mobile backhaul);
- Bandwidth: continuous frequency range of several hundred megahertz in the bands below 40,5 GHz and at least one gigahertz above 40,5 GHz are considered as the minimum requirement to meet the needs of users;
  - The first stage is not assumed to assess the possibility of carrier aggregation, i.e. the bandwidth must be continuous. However, if a search of such frequency ranges will not lead to positive results, the simple aggregation scenarios that combine a small number of non-contiguous portions of the spectrum can be assessed in the second phase of the METIS project.
  - Frequency ranges that allow deployment of only one network due to their width should not be excluded from consideration in the initial stage of investigation, i.e. there is no need to accommodate multiple networks simultaneously in the same frequency band.
- Consideration of candidate bands for the 5G should be conducted for both paired and unpaired spectrum

(networks with frequency division duplex and time division duplex).

- Availability of the regulatory basis for the frequency bands selected for the development of 5G is considered as an additional advantage.

In the following sections of this article the current distribution and utilization of radio frequency spectrum (RFS) that can be used for the development of 5G will be reviewed. Then, most promising frequency bands, that have real possibility of use, will be considered in more detail.

### 3. CANDIDATE BANDS FOR 5G DEVELOPMENT

Based on the criteria described above, special attention was paid to the millimeter bands, because these bands are the least loaded to date and allow to find frequency ranges from 500 MHz to 1 GHz appropriate for 5G.

Table 1 shows the analysis results of the frequency utilization in ranges from 27,5 to 40,5 GHz [8] according to the European table of frequency allocation and estimation of priorities for further studies of the frequency bands of future 5G mobile networks based on METIS design criteria.

The analysis of Table 1 shows that in the range 27,5–40,5 GHz there are four frequency bands that allocated on a primary basis for the categories of mobile/fixed radio services, which are most similar to utilization scenarios of 5G. Assessment of their current occupation by radio electronic systems (RES) of various radio services shows that one of them has a high occupation by radio-relay lines (RRL) and will be excluded from further study for the development of 5G. High priority for future research will have only one band 31,8 - 33,4 GHz. Two bands of the low part of the millimeter-wave (27,5 - 29,5 GHz and 31,0 - 31,3 GHz) received medium priority.

**Table 1.** Prioritization of frequency bands in the range 27,5–40,5 GHz

Frequency band, GHz	Bandwidth, GHz	Priority
27,5-29,5	2,0	Medium
31,0-31,3	0,3	Medium
31,8-33,4	1,6	High
36,0-37,0	1,0	Low

Second part of millimeter-wave range to be analyzed for the future development of 5G, was identified within 40,5 - 95,0 GHz. Assessment results of frequency bands priorities for further research of future development of mobile 5G networks based on METIS design criteria are shown in Table 2.

Assessment of the current occupation of the frequency range 40,5 - 95,0 GHz by RESs of various radio services based on researches of European Conference of Postal and Telecommunications Administrations (CEPT) showed that two of them, 43,5 – 45,5 GHz and 50,4 – 52,6 GHz have a high occupation by RRL in Europe, despite their attractive width over 2 GHz. These two bands are excluded from

further research of development of 5G networks. High priority for future research will have eight frequency bands and only one band 40,5 – 42,5 GHz in lower part of the range has received a medium priority.

Russian communication regulator has already established the possibility of using broadband fixed wireless access (BFWA) and fixed services in some parts of millimeter-wave range, that certainly makes it easier for utilization in future development of 5G.

**Table 2.** Prioritization of frequency bands in the range 40,5-95,0 GHz

Frequency band, GHz	Bandwidth, GHz	Priority
40,5 – 42,5	2	Medium
42,5 – 43,5	1	High
43,5 – 45,5	2	Low
45,5 – 47,0	1.5	High
47,2 – 50,2	3	High
50,4 – 52,6	2.2	Medium-low
55,78 – 57,0	1.22	High
57 - 66	7	High
66 - 71	5	High
71 - 76	5	High
81 - 86	5	High

The detailed estimates of the existing regulatory permits of State Radio Frequency Commission (SRFC) of Russia [10], which determine the possibility of using millimeter-wave for various RES, showed the possibility of using considered bands for the development of 5G in Russia (Table 3). Some of these bands are used by military RESs, and will require conversion in the future.

**Table 3.** Russian regulatory permits for using millimeter band

SRFC decision	Frequency band, GHz	Types of RES
№ 07-21-01-001 of 25.06.2007	27,5 - 29,5	RES of BFWA (27,8285 - 28,4445 GHz and 28,8365 - 29,4525 GHz)
№ 09-03-04-2 of 28.04.2009	27,5 - 29,5	Line of sight RRL
№ 05-10-01-001 of 28.11.2005	40,5 - 43,5	RES of BFWA
№ 08-23-04-001 of 26.02.2008	40,5 - 43,5	RES of BFWA (42,5 - 43,5 GHz)
№ 11-13-06-1 of 20.12.2011	58,25 - 63,25	RES of BFWA
№ 10-06-03-2 of 19.02.2010	63,0 - 64,0	RES of intelligent transport systems (ITS)
№ 10-07-04-1 of 15.07.2010	71,0 - 76,0 81,0 - 86,0	Line of sight RRL
№ 10-07-04-2 of 15.07.2010	92,0 - 94,0 94,1 - 95,0	Line of sight RRL

Table 3 shows that regulation rules are created in Russia for all frequency bands of millimeter-wave range, marked as high priority bands for development of 5G networks, except of the band of 31,8 – 33,4 GHz.

**4. SPECTRUM RELEASE AND REDEPLOYMENT ASPECTS FOR 5G DEVELOPMENT IN RUSSIA**

The analysis of the actual spectrum utilization by various radio services in the range 27,5 - 95 GHz shows that utilization of this frequency band for development 5G will require two procedures:

- spectrum release and redeployment of civil RESs;
- spectrum conversion and spectrum release of military bands.

Currently spectrum rescheduling and release issues are resolved by interested carriers without public funds, while the conversion procedure is possible only with public funds, because the law provides the purchase of arms and military equipment only from the state budget for the armed forces and release of the frequency bands used for military purposes.

Authors' estimation of millimeter band utilization by RES of mobile and fixed-line services in Russia showed active use of these bands by operators of mobile networks 2G/3G/4G for its RRL backhaul networks, and by operators of fixed broadband access services (Table 4).

**Table 4.** Number of RES working in millimeter band in Russia

Frequency band, GHz	Number of RES of fixed service	Number of RES of other services
27,5 - 29,5	312 - BFWA	25 - fixed-satellite
31 - 31,3	20 -RRL	not used
40,5 - 42,5	262 - BFWA	not used
42,5 - 43,5	84 - BFWA	not used
57,2 - 58,2	558 - RRL	not used
58,2 - 63,25	unlicensed band	no data
71 – 76	> 9000 RRL (TDD)	no data
	> 1000 RRL (FDD)	no data
81 - 86	> 1000 RRL (FDD)	no data

More than 1000 RES work in the band 27.5 - 66.0 GHz on the basis of individual licenses, moreover more than 11000 RRL work in the band 58.2 - 86 GHz on the unlicensed basis.

Assessing the economic costs of search and release of spectrum in the millimeter wave range, there is a need to consider the following costs:

- The cost of conducting research on each considered frequency band;
- The cost of removing and replacing spans RRL and base stations of BFWA;
- The cost of work on the organizational and technical measures in the frequency bands used by military RESs;

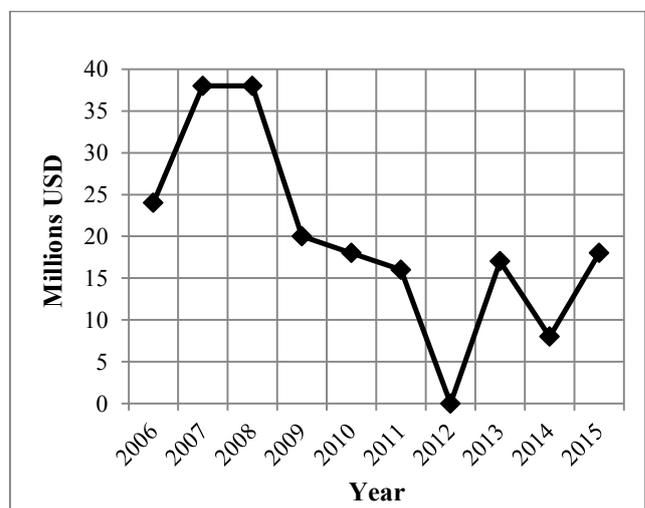
- The cost of spectrum conversion, including the transition to new types of military equipment and transfer of military RESs in other frequency bands.

The analysis of Table 4 shows that the release of the band 27,5 - 29,5 GHz from the RES of wireless access networks Local Multipoint Distribution Service (LMDS) technology may require from 10 to 50 million USD, based on the experience of the removal costs of RES of the Multichannel Multipoint Distribution Service (MMDS) networks in the band 2,5 -2,7 GHz. A similar level of costs may be required for the release of the bands 40,5-42,5 GHz and 42,5-43,5 GHz.

Costs for organizational and technical activities related to the redeployment of frequency assignments of RRL networks in the band 57,0 - 66,0 GHz will be from 1 to 5 thousand USD per RRL span. Considering the amount of RRLs working in Russia in this band, the total costs will be from 0,5 to 2,5 million USD. While the competition for the 5G frequencies was not held and operators have not received 5G licenses these costs for redeployment of frequency assignments can take on only the state budget.

Figure 1 shows the amounts of annual funding that are allocated by the Russian state budget on work for the conversion and spectrum release for the introduction of new radio technologies [11]. Comparison of these costs with the estimated costs for release of the spectrum in millimeter wave shows that some bands require higher funds to provide "clean bands" that may be offered on tender for granting 5G licenses. Return of state investments is only possible after the tender.

Conversion of millimeter bands from military RESs is a separate task, and was not considered in this article.



**Figure 1.** State budget costs on spectrum conversion and redeployment

**5. CONCLUSION**

Future implementation of 5G mobile networks in Russia may require the release of a number ranges of the millimeter band from RES of wireless access networks and fixed networks, the number of which currently estimated at more than 1000 RESs of BFWA and over 11000 RESs of RRL.

In scope of the millimeter band release activity by 2020 in order to grant licenses to the future 5G operators Russian regulator needs to plan the costs in the state budget, which can reach 100 million USD annually, that significantly exceeds the previous annual budget spending.

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