PAPER • OPEN ACCESS

Overview of 4G, 5G radio spectrum spectrum in the world and Kazakhstan

To cite this article: A S Tolegenova *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **934** 012055

IOP Conf. Series: Materials Science and Engineering **934** (2020) 012055 doi:10.1088/1757-899X/934/1/012055

Overview of 4G, 5G radio spectrum spectrum in the world and Kazakhstan

A S Tolegenova[1], A B Zhanys[1], S N Nurkasymova[2] and L A Soboleva[1]

[1]Kazakh Agrotechnical University named after Saken Seifyllin, Republic of Kazakhstan

[2]Eurasian National University. L.N.Gumilev 010000 Republic of Kazakhstan, Nur-Sultan

E-mail: aray.zhanys@gmail.com, SauleNurkasim@mail.ru

Annotation: Mobile operators support data transfer on 2G (GRPS, EDGE), 3G (EV-DO, HSPA) networks. In some regions, data services are provided on WiMax networks. In 2012 ALTEL launched 4GLTE data distribution network. GSM standard in Kazakhstan has started to decline in mobile communication revenue since its first launch in 2013. By the end of 2015, they totaled 19% to 249 bln. tenge. In February 2016, income from voice communications was less than the revenue from Internet access services. Mobile communication in Kazakhstan is carried out in GSM (900, 1800) and UMTS (900, 2100) formats. In 2012 the mobile accessibility index was 120%. Mobile accessibility in Kazakhstan in 2015 will increase by 185%, to 31 mln. SIM card is already registered. More than 35% of these SIM cards (11 million) are Internet access. GSM and UMTS mobile operators are: Kcell and Activ trademarks are owned by Kcell (GSM Kazakhstan OJSC JSC Kazakhtelecom OJSC until 2012) (controlling interest is owned by TeliaSonera, acquired by Kazakhtelecom JSC,% Scandinavian-Turkish holding of FinTur 47); Altel JSC (owned by Kazakhtelecom JSC), ALTEL 4G GSM + LTE (the share of the company in the mobile market is 3.6% (December 2012). Altel JSC - First national mobile operator of the Republic of Kazakhstan [1]."Kar-Tel" LLP (subsidiary of Russian holding Vympel-Communications) and "Beeline Business" (previously K-Mobile)); Mobile Telecom-Service LLP (former Neo) with Tele2 trademark. Kcell (KCEL) is a mobile operator GSM900, GSM1800, UMTS / WCDMA (2100 MHz), LTE / 4G, LTE Advanced (700/800 MHz and 1700/1800 MHz). "Activ" and "Kcell" brands. In 2018, KazakhTlecom acquired the shares.

1. Introdusion

Telephones - Basic Routes: 4.928 million (2018). Cell Phones - Cell Phones: 14,995 million (2019). Phone code: +7.

Inside: between cities through landlines, radio relay connections and satellite communications. The number of registered connections has gradually increased and reached 40 per 100 people. Mobile (mobile) connections are rapidly increasing and their number is about 88 per 100 people.

International: international communication network with the post-soviet republics and China and microwave radio-relay communication. Via Trans-Asia-Europe (TAE) satellite and fiber-optic cable. Satellite ground stations: Intelsat. KazSAT-1, KazSAT-2, KazSAT-3, Kazakhstan series of satellites KazSAT-4.

In 2019, the World Radiocommunication Conference (WRC-19) will be held every four years. The most probable radio frequency bands for communication are:

- 24.25-27.5 GHz, 37-43.5 GHz;
- The range 70/80 GHz may be agreed on RAD-19;
- For RAD-19 5G, the band 31.8-33.4 GHz is virtually impossible to agree on since it is problematic to ensure compatibility with existing services.

With regard to low frequencies, there is no final solution for bandwidth and bandwidth for 5G. In Kazakhstan, the majority of the 3,4-3,8 GHz band is received by military personnel.

The LTE Union has proposed the use of the non-standard 4.4-4.99 GHz frequency band for the 5G European zone. This will allow increasing the frequency spectrum for deploying new generation cellular networks. However, there is no commercial equipment for this range of frequencies.

Modern mobile communication is dense within distributed frequencies and 5G networks receive additional frequencies - now in a short, millimeters range of radio waves from 30 to 300 GHz.

Their length (1-10 mm) is smaller than the usual centimeter wave for cellular communication. They give a lot of data, but they are far away and easily protected. It is necessary to deploy a dense network of small cellular communication to help them.

In low-density environments, this process may take years, but engineers work with technologies that let the short wave be transmitted to longer distances up to several kilometers [2].

2. Overview of telecommunication operators in Kazakhstan

Delivery stations: AM-60, FM-24, Shortwave-14 (2018). Radio: 11.47 million (2018). Television stations: 26 (plus 14 repetitions) (2018). Internet service providers: 18 (with their own international channels) (2018). Internet host: 180,217 (2018)

Internet users: 400,000 (2009); 1,247,000 (20011); 5 300 000 (2016). Internet domain:. <Url>.

The company was founded in 1998 and is mainly focused on the corporate segment, Kcell, focused on the mass market, and offers mobile services under the brand Activ. As of December 31, 2016 the subscriber base of Kcell was 9 986 thousand people.

Kcell was established on September 30, 1998. February 7, 1999 - Kcell brand was launched. On September 9, 1999 the brand ActiV was launched. In 2004, the company's subscriber base amounted to $ 1.5 million. Man. In December 2007, the 6 millionth subscriber was added. That year more than 5,000 settlements were covered. In 2009 Kcell corporate brand was restored. In 2010, Kcell hosted the OSCE Summit and VII Winter Asian Winter Games

In 2016, Kcell launched a 4G / LTE commercial network. Together with Beeline Kazakhstan, the agreement on the joint 4G / LTE network was significantly accelerated. This agreement has allowed us to provide high-quality services while reducing capital costs and accelerating network deployment. By the end of December 2016, coverage of 4G / LTE network from Kcell reached 35% of Kazakhstan's population. In the first half of 2017, residents of Ridder, Taraz, Turkestan, Kyzylorda, Petropavlovsk, Shemonaikha and Ekibastuz had access to 4G / LTE high-speed mobile Internet. From May 12, 2017, the company has developed 4G + (LTE Advanced) communication.

In the beginning of 2016 the development of entertainment services in the network of mobility in mob (mobi-tv, mob-music, mobi-press, mobi-cinema, book) started [3].

3. Analysis of the current telecommunication network of Nur-Sultan

Number of mobile subscribers in the Republic of Kazakhstan is 31.2 mln. The subscriber base increased by 7.1% per annum (by the end of March 2018), the density of cellular communication numbers per 100 people increased from 167 to 176.

According to the Committee for Communication, Informatization and Information of the Ministry of Internal Affairs of the Republic of Kazakhstan, by mid-February, Kcell is one of the leading telecommunication operators, representing 31% of all base stations in the country (9384 units), Tele2 26% 7 712 Unit), Beeline share is estimated at 24% (7193 base stations); Altel has 19% of 5,678 base stations.

In the regional context, the base stations are clearly distributed among operators. Thus, Kcell dominates in 16 to 10 areas. The Company is located in Atyrau and Mangistau oblasts (54% of market and 45% respectively) in South Kazakhstan region (43%) and Astana agglomeration (38% in Astana and 45% in Akmola region). In Almaty, Kcell has priority over the number of base stations with Altel - 29% of online accounts for each of the operators. Altel also trusts Astana, which owns 29% of the base network. The share of Tele2 in the Karaganda region is 37%, Zhambyl and Kostanai oblasts (34%), and 30% of base stations in EKR. Beeline's position is stronger in Western Kazakhstan (39% of total base stations) and Pavlodar region (31%).

Out of the total number of base stations, 17.5 thousand (58% of the network) support 2G standard; There are 10 thousand (34%) 3G subscribers, and only 4 out of 292 stations (8%). So far, all 4G stations have been owned by Altel, but in 2018 all Kazakhstani operators have the right to operate at LTE frequency and serve as standard 4G, and experts predict the increase in competition in this sector (Figure 1).

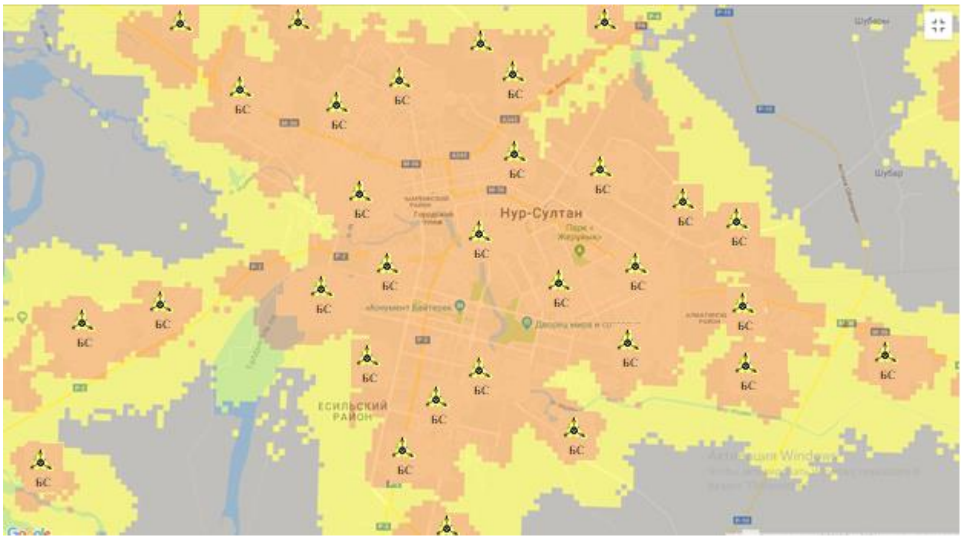

Fig. 1: Wireless 4G era in Nur City

The number of base stations affects the coverage area and, consequently, ensures a high level of cellular communication. The highest density of base stations in population density is observed in Astana and Atyrau regions where one station serves an average of 1 thousand people. Each station in Almaty, Mangystau and North Kazakhstan oblasts has about 1.5 thousand people. The largest truck belonging to the base stations of the Karaganda region - 4,3 thousand, in the West Kazakhstan region - 3,1 thousand people [4].

4. Selecting base stations and antennas

The optimal solution for choosing equipment is Huawei DBS 3900 base station.

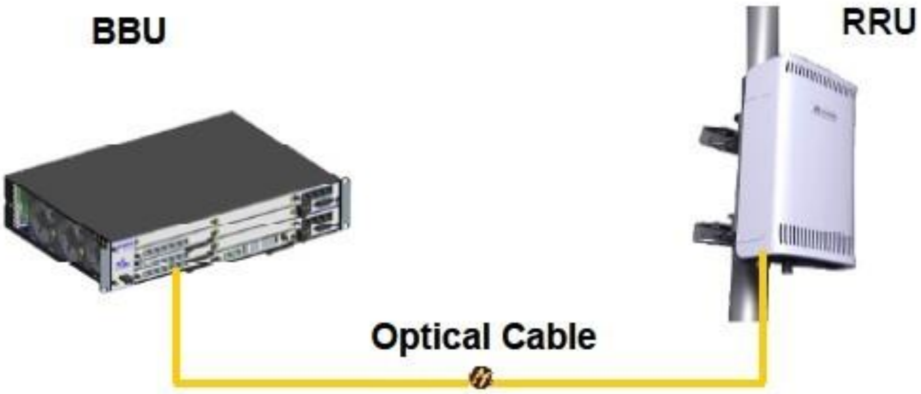

Fig. 2: Optical communication between the base station and the antenna

Huawei DBS3900 base station DBS3900 is a distributed base station that uses the HuaweiBTS platform. Being the base station of the mobile communication system, the DBS3900 consists of the Base Frequency Processing Unit (BBU) and Remote Radio Frequency Units (RRU).

The DBS3900 uses an external radio frequency module that meets the requirements of construction networks in terms of capacities, flexibility, and upgrades.

The Huawei-RRU3929 remote radio station base station is selected. Installed near the antenna. RRU3929 is a portable radio frequency unit. Provides basic and radio frequency signals processing. One RRU3929 is a function of two transceivers. If two RRU3929 modules are installed at the RRU3929 substation, they perform the function of the four transceivers. RRU3929 is easy and easy to install. Substrate RRU3929 can be installed on steel fittings, wall or concrete base. The RRU3929 and BBU3900 units use the CPRI interface, which provides the use of two modular optical cables. This will allow you to significantly reduce the cost of building a room, installing equipment and operating costs. Introducing the DBS3900 with the integrated BTS will speed up the development of cellular networks, ensure their compatibility with other networks, and exploit broadband technologies [5].

BBU3900 is a basic unit processing unit for centralized management and maintenance, as well as centralized equipment for providing base station signal processing and providing standard reference signal.

The device has physical interfaces for communicating with BSC and RRU3004.

The BBU3900 is mounted on a 2 U cabinet with a height of 47.5 cm and can be installed in a 19 "cabinet or wall mounted.

BBU3900 installs additional Abis interface controls and GPRS synchronization signals. BBU3900 - compact equipment, easy installation. It consumes a small amount of energy and offers a full range of services.

The DBS3900 DBS3900 features have the following advantages in providing coverage:

- RRU3929 supports cascade connection of three RRU modules. One RRU module is installed within 40 km of CWU;
- static sensitivity of the TCH / FS channel -113 dBm (normal temperature at normal temperature);
- RRU3929 maximum output power is 40 W (900 M) or 30 W (1800 m);
- maximum configurations up to 12 hundred and multi-purpose network support;
- Supported broadcast distribution and "Antenna upgrade".

BBU3929 supports 72 transmitters.

Network features. E1 / T1, optical FE, radio relay and satellite broadcast support. Supports structure (topology) - star, tree, chain, ring and mixed topology. GSMb and UMTSBBU3900. Optimized messages using the Abis interface. Support for BTS and BSC packages detection and recovery. When the synchronization system operates in an internal vibration mode, the system can operate continuously for 7 days.

Support for different synchronization modes: Support for synchronization synchronization from Abis interface, support for GPS synchronization, 2MHz BITS external sync.

RRU3929 operates in the bands 1800 MHz and 900 MHz. For sites with GSM / UMTS / LTE configuration, 6 RRU3929 is required. For sites with GSM / LTE configuration, 3 RRU3929 is required.

BBU is characterized by high environmental adaptability:

- Operating Temperature Range: -20 C ~ 55 C
- BBU can work with a wide range of operating voltage: -
- 38.4 V DC ~ -57 V DC (rated voltage -48 V DC).

The used power supply converts 220V AC to -48V DC for BBU operation. RRU - Environmentally friendly equipment. RRU has a closed integral structure. Water resistant to IP65 standard. Measures against moisture, saline and saline fog are in accordance with Class 1 specification.RRU Operating Temperature Range: -40 C ~ +50 CRRU can operate with a wide range of operating voltage ranges: -36 V DC ~ -57 V DC (rated voltage -48 V DC). The used RRU power source is 220V AC - 48V AC. Remote Electronic Grinding (RET) antenna support. Using the RET antennas enables you to adjust the coverage of the network by adjusting the angle of antennas in the car hall. At the same time, the cost of maintenance and maintenance can be saved [6].

Support for double polar antennas reduces the number of antennas in the cell. AISG1.1 protocol support.

To compare the results obtained with the simplified model calculations for Macro-Cells by Okumura-Hat, we obtain the next radius of coverage (1.06 +1.47) / 2 = 1.27.

Calculating the number of base stations (BTS) After determining the value of the cell radius (P 1270 m), we place the base stations on the Taldykorgan map. At the same time, we take into consideration the effectiveness of the sector allocation. That is, to the non-residential areas of the city, to the enterprises and factories.

As a result, the required number of 4G stations will depend on the area of Nur-Sultan about 100 square meters. km, no settlement.

Let's sum up the results:

- coverage area - 100 km2;
- Total network accessibility - 1088 000 subscribers;
- Subscriber density - 10880ab / km2.

Mobile device antennas should be short enough and light enough for space design to create smartphone designs. F-shaped antennas (planar inverted-F antenna - PIFA) are a good choice for mobile communication devices, as they meet the small size, power and efficiency requirements. These antennas support multi-channel frequencies for connecting mobile devices, WiFi, and Bluetooth technologies, making them the best candidates for IoT-compliant objects and devices.

In this example, the antenna is part of a 5G mobile device and is a PIFF construction in the ABS case (Acrylonitrile butadiene stirrine (ABS) - PTFE - PTFE - PTFE - based fluoroplast) mounted on thermoplastic FR4 panels. and a composite silicon substrate is covered with glass. The antenna itself consists of a thin copper layer with high permeability from the PTFE block, which has a concentrated port between the excellent conductivity (PEC) screen and the sensor contact (for these specialists and the antenna signal is transmitted by signal) and also located near the feeder, the impedance used to match the PEC screen to another contact. Provides design antenna compatibility to fit the antenna to a 50 Ω reference value.

Antenna modeling can be performed on the boundary conditions of the PEC for its electrodes due to the low operating frequency in the communication network. The loss of metal may not be due to the high conductivity of the copper layer. PIFA radiation is modeled in a spherical area surrounded by a perfectly coincident layer (PML) that imitates the irradiation in infinite space. Availability of boundary conditions ensures the absence of airborne energy sources. A port with an impedance center of 50 OM for excitation of PIAA and for estimating its incoming resistance.

By using simulation, PIFA can calculate and visualize the field share. The results indicate that the strongest field is located at the top of the specimen in one of the remote ends of the electrode from the remote sensor contact. These results are similar to data for a quarter-wave monopoly antenna, which is actually PIFA precursors [7].

The simple alignment does not meet the requirements for using the network. In addition, operators assume that space for the installation of antennas for Massive MIMO technology is supposed to provide smooth evolution. As a result, the only antenna that combines all tapes with a bandwidth of less than 3 GHz and a massive MIMO space should have a standard antenna of 5G technology (Figure 3).

Fig. 3: The solution for the installation of a 5G technology-oriented antenna for Telefonica Deutschland

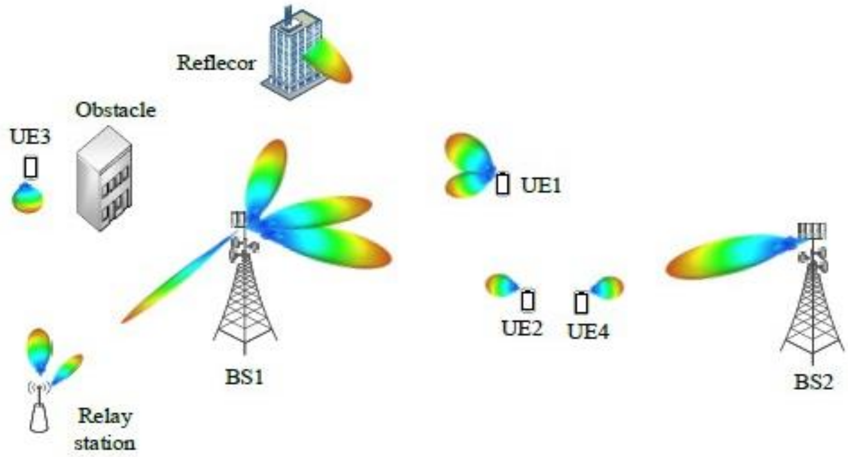

Fig. 4: The principle of working Massive MIMO antenna

In the process of transition from 4G to 4.5G / 5G, there was a lack of space to install the antennas when placing the lines. As part of the allocation of 700 MHz, 1400 MHz and other new bands, the 4T4R technology has become a standard configuration.
We consider a serious problem in the prospective evolution of broadband networks that make the antenna installation a challenge to the network. Huawei and Telefonica Deutschland offer antenna installation solutions that include 5G technology and include a 14-port multi-band antenna and an MGIM antenna of 5 GHz.
The installation of the antenna set up by Telephoneica Deutschland and Huawei 5G will help solve the problem of spatial deficiencies, "said Jaime Lluch, Director of the Telephony Deutschland radio network [8].

5. Application of 5G additional technologies

It is important to note the additional technologies used in the new generation standard:
Massive MIMO. Technology allows one subscriber to send up to 8 data streams. It is a complex of several antennas, which forms an express diagram of the route. The use of multiple radiation levels improves the level of acceptance of the signal and eliminates the interference of other subscribers with a positive effect on network bandwidth and frequency spectrum.
M2M. M2M technology is needed to interact with devices without the direct involvement of the person, ie to automate processes. The scope of M2M is very broad. For example, in payment terminals, security systems, and vehicle management systems. Technology minimizes processes and also reduces their dependence on human factor, allowing rapid response to system failures.
Flexible Duplex is a technology that can be used to streamline the traffic, for example, in the upstream channel you can send information to the downstream channel.
FBMC / UFMC (Filter Bank Multicarrier / Universal Filter Multi-Carrier). The technology allows to achieve spectral efficiency and improve channel selectivity.
Ultra-dense networking - this technology allows you to organize dense networks due to virtualization, thanks to which you can serve a large number of subscribers in a dedicated area, which in turn allows to create a complex network hierarchy.
One of the obstacles to launch 5G standard networks is a shortage of frequency resources. The resources in future networks, including millimeters, should be expanded. The primary band for the 5G network creates a band that is less than 6 GHz. It is planned to use 6Ghz for further universal access and organization of backbone communication.
Test equipment for 5G network was tested at the end of 2016 in a number of countries, including Kazakhstan. During the testing of the equipment, indicators that are close to the required values have been obtained from next generation networks [9].

6. Design of 5G network in Nur-Sultan city model

When switching to modern standards of the fourth and fifth generation, the stations should only be connected to fiber optics to meet their requirements. In modern BS design, optical fibers are an integral part of providing information between BS components and blocks. For example, the following illustration shows the construction of a modern base station using a fiber optic cable (Figure 5) to transfer the data from the RRU (remote control) antenna (orange).

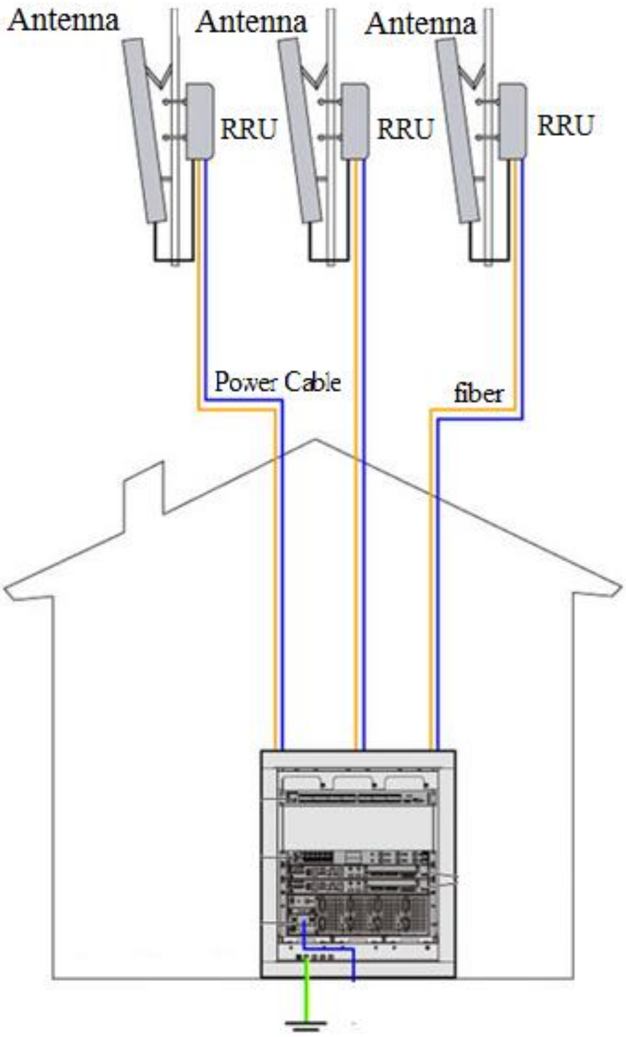

Fig. 5: An example of the base station and antenna accommodation.

Equipment of the base station is located in non-residential areas of the building or is installed in special containers (installed on walls or poles) as modern equipment is very compact and easily accessible to a server computer's system unit. The radio module is often installed near the antenna, which reduces the power loss and dissipation of the antenna. Here are three modules installed directly on Flexi Multiradio base station equipment (Fig. 6).

Fig. 6: Base station Flexi Multiradio

Another important technology to achieve greater spectrum effect is the mass media. The MIMO array is sometimes called large-scale MIMO; the number of antennas on the base station is much more than the number of MIMO formats available for the signal source. A large number of base station antennas with respect to user devices are responsible for channel-side, which gives greater benefit to quasi-orthogonal and spectral effects [10].

Designers face difficulties in scaling up the number of antennas hundreds of scales:
- The simulation speed of the traditional antenna design tools for large antennas arrays is slow.
- It is difficult to model the antenna jack.
- Hybrid radiation is required to optimize the number of radio frequency circuits (Figure 7).

Fig. 7: Masive MIMO antenna

Qualcomm has introduced antennas and transmitters to smartphones designed to work in the 5G promising standards. The first mobile devices with such modules are expected to appear in the first half of 2019.

5G data technology is still described by the IMT-2020 standard of the International Telecommunication Union. It is assumed that 5G networks maintain data rates at a much higher level than previous generations, and also support a large number of devices connected to the base station. The standard features of the standard are not yet approved, but 5G networks will use 4G networks and two main frequency ranges from 600 MHz to 6 GHz, to be used from 24 to 86 GHz. The greatest increase in data transmission speeds and other features is associated with the second band, called mmWave because it will be transmitted by millimeter radio waves.

Qualcomm has introduced a compact antenna module QTM052 intended for smartphones and other mobile devices. It works with the Snapdragon X50 modem introduced in 2017, which was successfully tested in 2017. The module is made up of four antennas forming an array of phased antennas. In this regard, it controls the direction of radiation and thus improves the signal quality. The module supports three frequency bands - 26.5-29.5 gigahertz (n257), 27.5-28.35 gigahertz (261) and 37-40 gigahertz (n260). The devices with the Snapdragon X50 modem can use up to four antennas, which will allow the hands to weaken the signal depending on the hands or other factors. The company has already started producing the module serial production from the manufacturer, and its serial devices should be available in the market in the first half of 2019 [11].

Qualcomm also introduced the QPM56xx module for operation with 3.3-4.4 GHz (n77), 3.3-3.8 GHz (n78) and 4.4-5.0 GHz (6 GHz) n79). The company has begun manufacturing production modules for the manufacturer of this device.

While some features of the 5G standard have not yet been approved, some telecom operators have begun implementing this technology. For example, the two largest US mobile operators, AT & T, recently announced that it will use 5G communication networks in 12 cities across the country by the end of 2018.

In order to evaluate the performance of new 5G algorithms and architectures, engineers must prove the concept prototype and prepare new trials for field trials. Typically, prototypes are made using FPGA hardware with built-in processors for some parts of the design. These platforms are often known as hardware testing and they provide fast testing and testing of new technologies and design changes in this area.

It may be difficult for the usual R & D team to implement FPGA-based radio prototypes and test sites without external assistance. R & D engineers have expertise in strong signal processing and communication algorithm development, but hardware experience is minimal. This experience increases the difference between discrepancy and workflow. While R & D engineers typically use high-end languages such as MatLab, hardware engineers use their own design tools and hardware descriptive languages (HDLs).

Leading companies have made model designs with MATLAB and Simulink to eliminate these deficiencies and allow R & D engineers to quickly switch to new 5G algorithms and make changes to their FPGA-based test platforms.

There were network equipment suppliers and wireless operators. Public testing for 5G technology is described in the real world. In field tests, many parameters are measured and dynamically monitored, such as signal signal (RSRP) and received signal quality (RSRQ). The performance of the system is recorded by a wide range of signals and a wide range of parameters.

After accepting the measurements, designers can get useful and effective results from the data. Compared to 4G systems, 5G field trials collect data far beyond data collection and analysis at high speeds and mass MMIM radiation specimens [12].

If implemented properly, this visualization architecture will allow engineers to comprehensively depict system performance in real world scenarios and display results for network planning decisions reporting.

The field test system requires a test and analysis system that supports extensive data capture, data processing, analysis, and sharing of results (Figure 8).

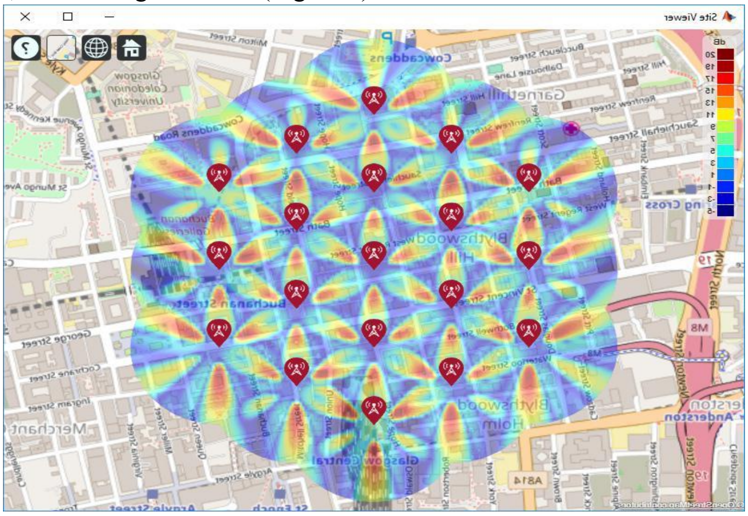

Fig. 8: Base stations location in wireless 5G era

It was decided to cover the issue with subscriber-focused network coverage and accessibility, ie the coverage of the network's network will be adapted to the needs of subscribers rather than the network of the previous generation. It is planned to use automatic antenna arrays that dynamically change the antenna structure of the antenna systems. It is also planned to use the range of all available frequencies, particularly within a short range of millimeters [13].

The 5G network architecture is divided into three internal systems (clouds), and cloud technologies that do not exist in the modern world:

Access cloud (Access) means the addition of distributed and centralized access technologies and systems. Also backward compatibility with 4G and 3G networks is planned;

Cloud Management - session management, mobility and quality of services;
Transport cloud (Forward) - transmission of physical data to the network by high reliability, speed and load balancing.
Small nucleus with small radius. Unlike the nest and the macro cell. Small honey and equipment for their production. The concept includes femtones and pecio cells in the cellular network, as well as other solutions to address the problem of wireless access to data networks by forming areas with very minimal radius of networks in the network. high density data, high position at home or abroad. Small nucleus with small radius. Unlike the nest and the macro cell. Small honey and equipment for their production. The concept includes femtones and pecio cells in the cellular network, as well as other solutions to address the problem of wireless access to data networks by forming areas with very minimal radius of networks in the network. high density data, high position at home or abroad.
Setting up a small unit for bussing, KPN and JCDecaux outdoor advertising operator was conducted in Amsterdam, the Netherlands. The Ericsson Radio 2203 (C-RAN) bus station was located on the Rembrandt Square. The device supports the aggregation of the carrier b3 + b20 (800 MHz and 1800 MHz).
For the rest of the world, including Russia, the theme of installing small urban infrastructure is not new, for example, several times in the MTS 2014 to install small open cells at bus stations within the pilot project. The company has told about Moscow, St. Petersburg, Novosibirsk, Chelyabinsk, Yekaterinburg, Nizhny Novgorod, Kazan. The equipment was tested differently - NEC, Alcatel-Lucent and Nokia. Installation of kiosks, lighting poles, and advertising structures [14].
This month, a pilot project was launched in Bern, Switzerland. The small boxes of the Ericsson Vault remote radio transceiver protected by the IP68 standard are installed on the ventilated hatches located on the fiber-optic infrastructure of the main network. The surface of the Antenna system is located just across the Katrein Street Connect (Figure 9).

Fig. 9: Placement of SW in city center

I've heard about it for the first time, but the idea of using locals for the deployment of railway base stations was discussed at Motorola at the end of the 1990s. But I have not heard about practical actions yet [15].
RadioPlanner software is intended for calculating and optimizing radio coverage when designing mobile networks, terrestrial radio and television broadcasting from 30 MHz to 3000 MHz. (figure 10)

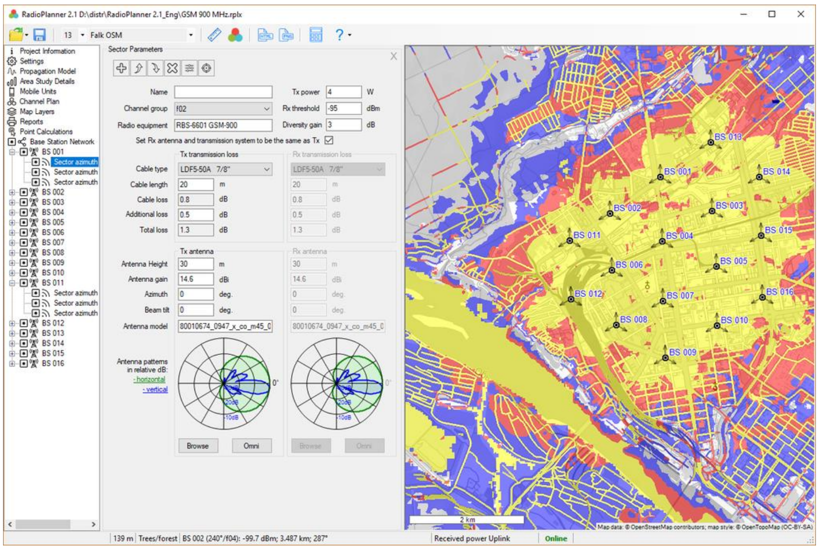

Fig. 10: Setting the angle of the directional diagram of base stations located through RadioPlanner 2.1.

7. Conclusion

In any case, 5G networks in the city should be condensed and it is clear that smaller cells are used. The choice of installation is a challenging issue, where technical capabilities are important, as well as important conditions, as well as the conditions for leasing electric and transportation. All the issues are being resolved, but at the same time remain economically viable for the operator - this task is not trivial. Promoting creativity is unlikely that operators will be able to live without dwindling due to the increase in the number of users of mobile broadband access and the increase in the consumption of mobile traffic.

Main features of RadioPlanner. Method for forecasting a predetermined method for a particular route for land-to-ground services in UU and VHF groups The calculation of the radiofrequency zones using the GIS-propagation method according to the recommendation of ITU-R P.1812-3 (09/2013), as well as the GOST- R 55897-2013 Mobile Radio Networks. Areas of activity. Methods of calculation. Quantitative Height (CMV) Shuttle Radar With TopographyMission (SRTM) 3. Using a Resilient Barrier Barrier (Urban Construction, Suburban, Forests, Water Surface), Resistant to OpenStreetMap and Global Forest Change Projects [16].

Use maps that are automatically downloaded from TOPO CTT, Open Street Map, Google, Bing, and any other tile servers as a mapping substrate. The mappings of the Radio Planner 2.1 software are illustrated in figures A1 - A5 (Figure 11-15).

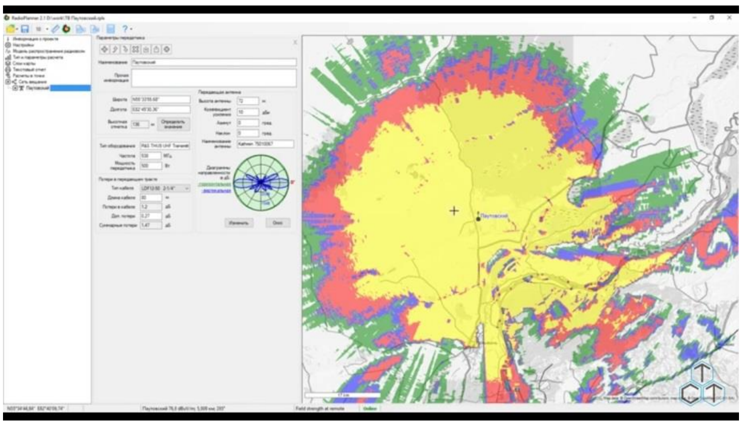

Fig. 11: RadioPlanner 2.1 will open a map of the city using Google Maps

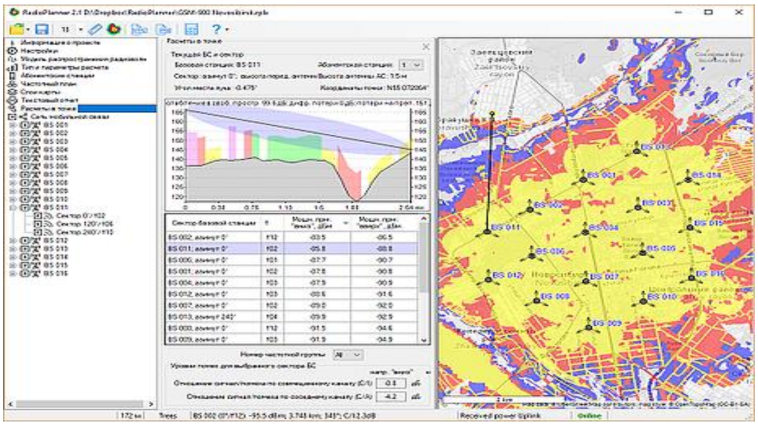

Fig. 12: Placing base stations on the map in RadioPlanner 2.1

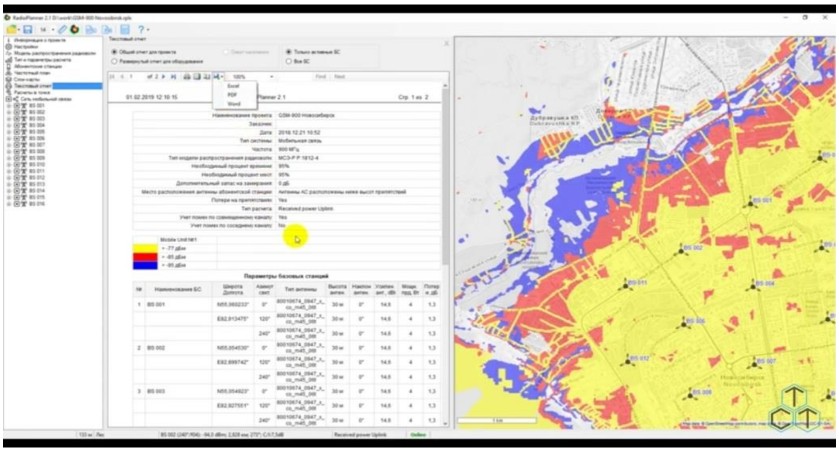

Fig. 13: Defining the optimal angle of base stations in RadioPlanner 2.1

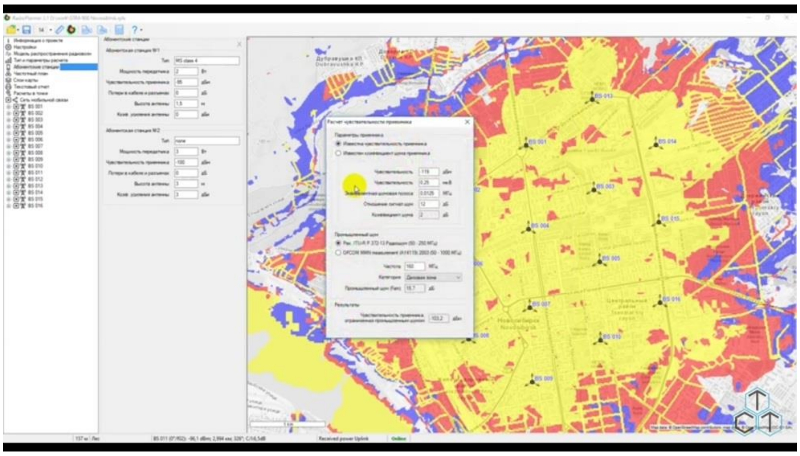

Fig. 14: Determine the duration of the base station optimal angle in RadioPlanner 2.1

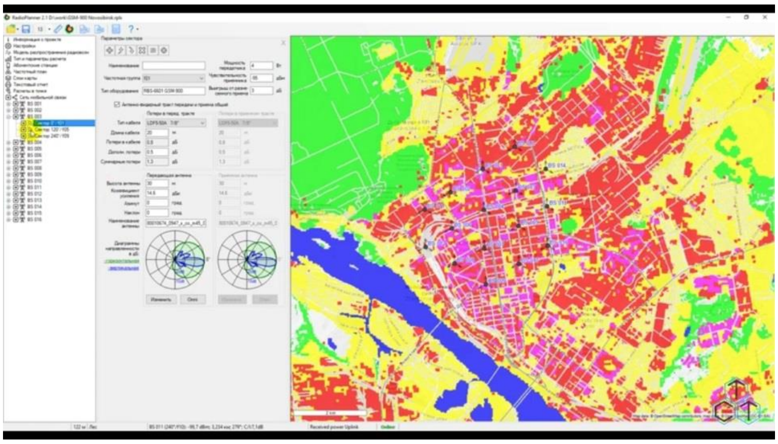

Fig. 15: Result of settings configured in RadioPlanner 2.1

References

[1] Masashi Kishimota “5G Mobile Communications”. 2015 16 S 49-56

[2] Steputin A N and Nikolayev A D 2016 Kniga dvukhtomnik «Mobil'naya svyaz' na puti k 6G». **8**. S. 9-12.

[3] Denisov D 2013 Tekhnologii 5G setey. **3** S. 56-58

[4] 3GPP TS 36 104: «E-UTRA Base Station (BS) radio transmission and reception» (Release 9). April 2011.

[5] Kim A V and Tikhvinskiy V O 2013 Novyy mobil'nyy gorizont: itogi MWC-13. 3 S. 15-18.

[6] Tikhvinskiy V O, Arkhipkin V YA 2013 LTE World Summit-2013: na puti k 5G. Zhurnal Elektrosvyaz'. 7 S 19-21.

[7] Sporyshev K A,Tkachev A M and Postolnyi A S 2008 Analiz podhodov k ocenke prognoziruemyh zon obsluzivania bazovymi stanciami v sistemah podvijnoy radiosvazi.Harkovskii universitet Wozdushnyh Sil im. I.Kojeduba, Harkov..

[8] Niri S G 2013 Towards 5G//LTE World Summit-2013.Hardouin E.5G:an operator’s perspective// LTE World Summit.

[9] Osseiran A 2013 The 5G Mobile and Wireless Communications: Challenges and Scenarios//LTE World Summit-.

[10] Azar Y, Wong G N, Wang K, Mayzus R, Schulz J K, Zhao H, Gutierrez Hwang D and Rappaport T S 2013 28 GHz Propagation Measurements for Outdoor Cellular Communications Using Steerable Beam Antennas in New York City: 2013 IEEE International Conference on Communications (ICC). — Budapest, Hungary. June 9-13.

[11] Likontsev D N 2008 Spetsial'nyye voprosy kursa rasprostraneniya radiovoln Tashkent.

[12] Babkov B Yu 2011 Obshie podhodi k zadacham planirovania i optimizacii 2G – 4G setey podvizhnoy svyazi. Sankt-Peterburg.

[13] Tikhvinskiy V O, Yurchuk A B and Terent'yev S V 2010 Seti mobil'noy svyazi LTE. Tekhnologii i arkhitektura. – M: Eko-Trendz 284 s.

[14] Harri Holma and Antti Toskala 2009 LTE for UMTS. OFDMA and CS-FDMA Based Radio Access. – John Wiley Ltd.

[15] Stefania Sesia 2009 LTE. The UMTS Long Term Evilution. From Theory to Practice. – John Wiley Ltd.