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KIGEiT

A SHORT TALE OF SOCIETY 5.0 HOW TO LIVE AND FUNCTION IN THE TIMES OF INDUSTRY 4.0 AND 5G NETWORK

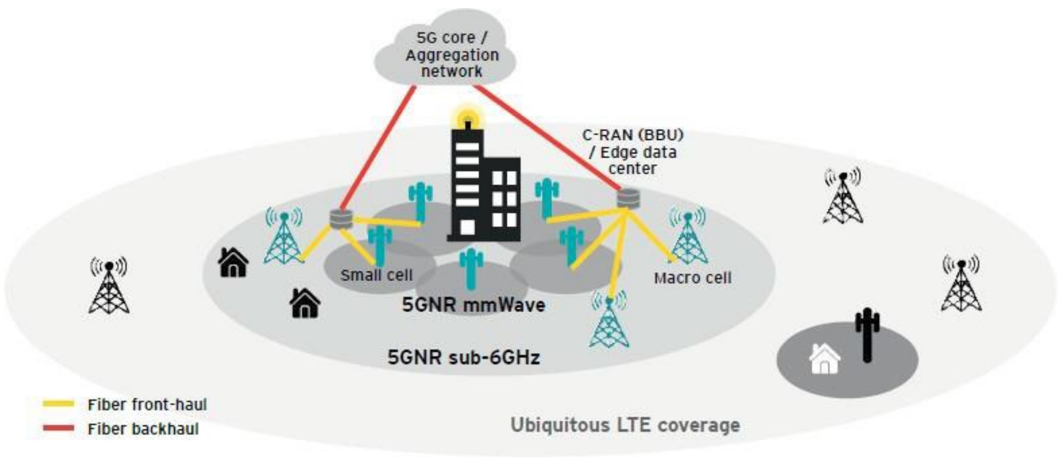
ATTACHMENT 2

TECHNICAL CONDITIONS FOR 5G DEVELOPMENT

NETWORK TOPOLOGY

MT-2020 is a set of ITU-R requirements for 5G networks. To meet the requirements defined this way, in particular for medium and peak gigabyte data transmission rates, or low delays, 5G network stations must be connected via optical fibers. This is a diametric difference to the 2G-4G network, as their topology was dominated by historically copper links with E1 bit rate, followed by radio links or ATM, Metro Ethernet and MPLS / IP connections. Importantly, optical fiber connection applies not only to macro cells (up to several dozen km), but also micro (up to 2 km) and pico cells (several dozen meters).

It is also necessary to implement the so-called dense networks understood as using multiple base stations with short ranges, which will significantly increase the spectral efficiency and thus the offered bit rate to the customer. In the 5G network, large-scale cells go away into a network of cells consisting of a large number of small cells.



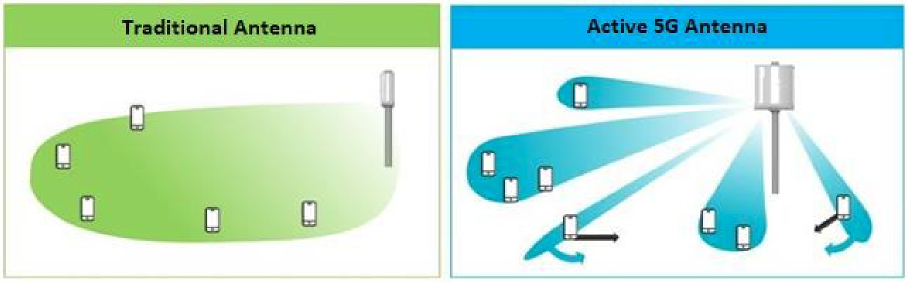
With the above in mind, in practice it means that there will be many more 5G base stations and they will be placed closer to people and devices. These stations will be installed on street lamps, kiosks or stops to ensure high throughputs. It is also planned to integrate base stations with other smart city solutions, also used for other purposes, e.g. monitoring urban traffic. In addition, a significant number of antennas will be installed indoors, especially public buildings, including stadiums, train stations and shopping centers.

It should be emphasized that the antennas installed close to people will be smaller than the current ones and they will not be similar in size to current macro cell transmitters. This is a fundamental difference and an element of misunderstanding we meet in public space.

COMPARISON AND ANALYSIS OF PEM ON 5G NETWORKS COMPARED TO CURRENT MOBILE PHONE SYSTEMS (3G/4G/5G)

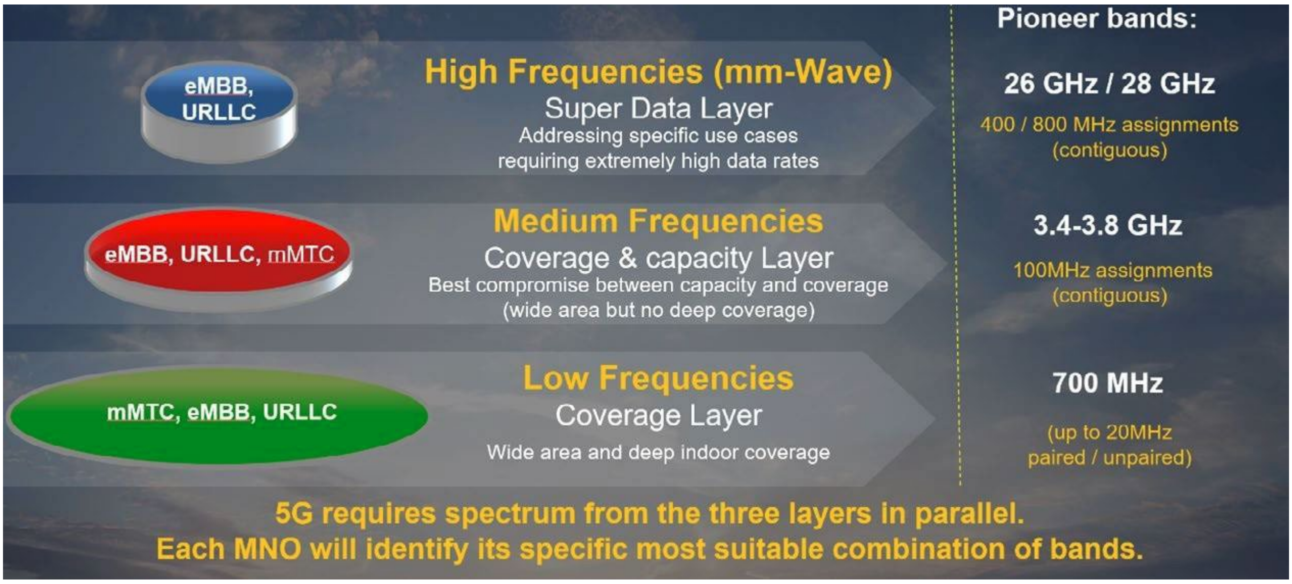
In a traditional antenna system, the power is radiated in a wide range according to the established spatial characteristics. The area in which users may be located is predefined.

In the 5G active antenna from Massive MIMO, power is radiated in specific directions, focused on individual users or their groups, rarely located in the service area. The power radiation directions can change almost automatically to focus on mobile users and reduce interference to others.



ORGANIZATION OF THE ALLOCATION AND FREQUENCY USING SYSTEM

Ensuring the high capacity of the 5G network, which is necessary to meet the promises of ITU (International Telecommunication Union), requires the use of wide radio channels. Currently used radio bands, mostly below 3 GHz are in use already, which is why RSPG (Radio Spectrum Policy Group) advising the European Commission has identified 3.4 - 3.8 GHz and 26 GHz (24.25 - 27.5 GHz) bands next to the band 700 MHz (so-called Second Digital Dividend) as a pioneer in the implementation of 5G in Europe. Mature 5G networks will use multiple bands simultaneously, including bands that are currently used by mobile cellular network systems (including 1800 MHz, 2100 MHz, 2600 MHz. The latter are distributed in the auction with the 800 MHz band).



However, in the initial phase of 5G implementation, pioneer bands will be used, including in particular the C band, ie 3.4 - 3.6 GHz, in asymmetrical arrangement using time slots (TDD - Time Division Duplex). The vital aspect when dividing the C band between operators is the allocation of appropriately wide channels (preferably 100 MHz for each operator) and defining national licenses for a relatively long period (min. 15 years), which should guarantee profitability and predictability of 5G network investment. Furthermore, it is important to synchronize the band, namely to ensure that 5G operators with adjoining band allocations will use the band for transmission of "to" and "from" the network (uplink, downlink) at the same time. In the case of lack of such synchronization, there will be significant interference that will force the use of guard bands at the band allocation boundary.

BAND REQUIREMENTS

The number of base stations for building the 5G network is a key factor in the cost of construction.

LOCATION OF TRANSMISSION AND RECEPTION SYSTEMS

The maximum use of current base stations to build a 5G network is a key factor in the cost of building a radio network. In typical scenarios for the use of a cellular network, the number of base stations is determined by capacity requirements (downlink direction) in urban areas and the minimum signal strength (uplink direction) in non-urban areas with low traffic load. From the point of view of cell capacity, operators decide on the minimum data rate that the network user receives at the cell border. Based on this assumption, operators define the number of base stations needed to cover a given area with a guaranteed data speed. Operators having a wide frequency band at their disposal, eg 100 MHz in the C band (ie 3.4 - 3.8 GHz), can guarantee better signal quality than operators with poorer frequency resources, eg 60 MHz. For example, to guarantee the same network capacity, an operator with a 60 MHz channel would have to increase the number of base stations by 64% compared to the situation as if operating at 100 MHz, Table X below.

Channel width in the C band (3.4-3.8 GHz)	Cell Range (km)	Cell Coverage (km2)	Number of base stations	Increase in base stations' no.
100 MHz	0,19	0.070395	14	Reference level
60 MHz	0,15	0.043875	23	+64%

However, in the uplink direction, the cell range can be significantly improved by using special active antennas consisting of many antenna elements and technology that allows the use of a lower band for uplink transmission when the range on the C band drops to a low level. The basic principle of radio wave propagation is greater attenuation of the environment at higher frequency waves. Therefore, cell coverage can be improved towards uplink when changing to a lower band (e.g. 1800 MHz) if the range in the C band falls below a certain threshold. The technology is called *uplink-dowlink decoupling*.

Using all available technologies and having a relatively wide channel (90 MHz in the C band), the first commercial 5G operator in the world - LGU+ in South Korea, provided continuous 5G coverage in the C band using existing LTE base stations (so-called 1: 1 co- coverage).

An important aspect when building a cellular network, in particular 5G, is to ensure a good signal level and therefore data speed in indoor locations. It is estimated that currently almost 80% of traffic in cellular networks is generated from inside buildings, and it is expected that in the following years this value will increase.

PLANNING 4G NETWORK INTEGRATION PROCESS WITH 5G AND EVOLUTION IN 5G

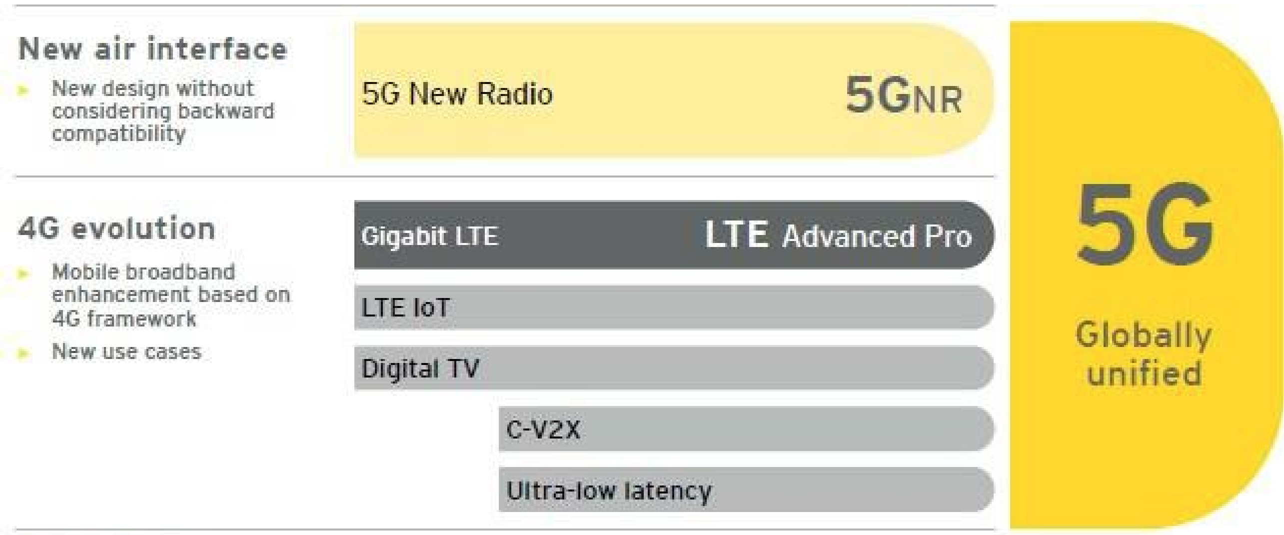
1. Diversity of area

Due to the very high level of advancement of Polish LTE networks in the context of the percentage coverage of the country, the 4G layer will be the basis for upcoming 5G networks. Of course, to be able to talk about 5G implementation, there must be frequencies available to operators. In the first phase of implementation, we assume that operators will focus on the 3.4 - 3.8 GHz band, which provides 5G network capacity and will be the main driving force behind the perception of 5G technology by the end user. Thus, the 5G network in this scenario will appear as island type of coverage, which will grow over time in the country, as it did before when implementing 4G technology.

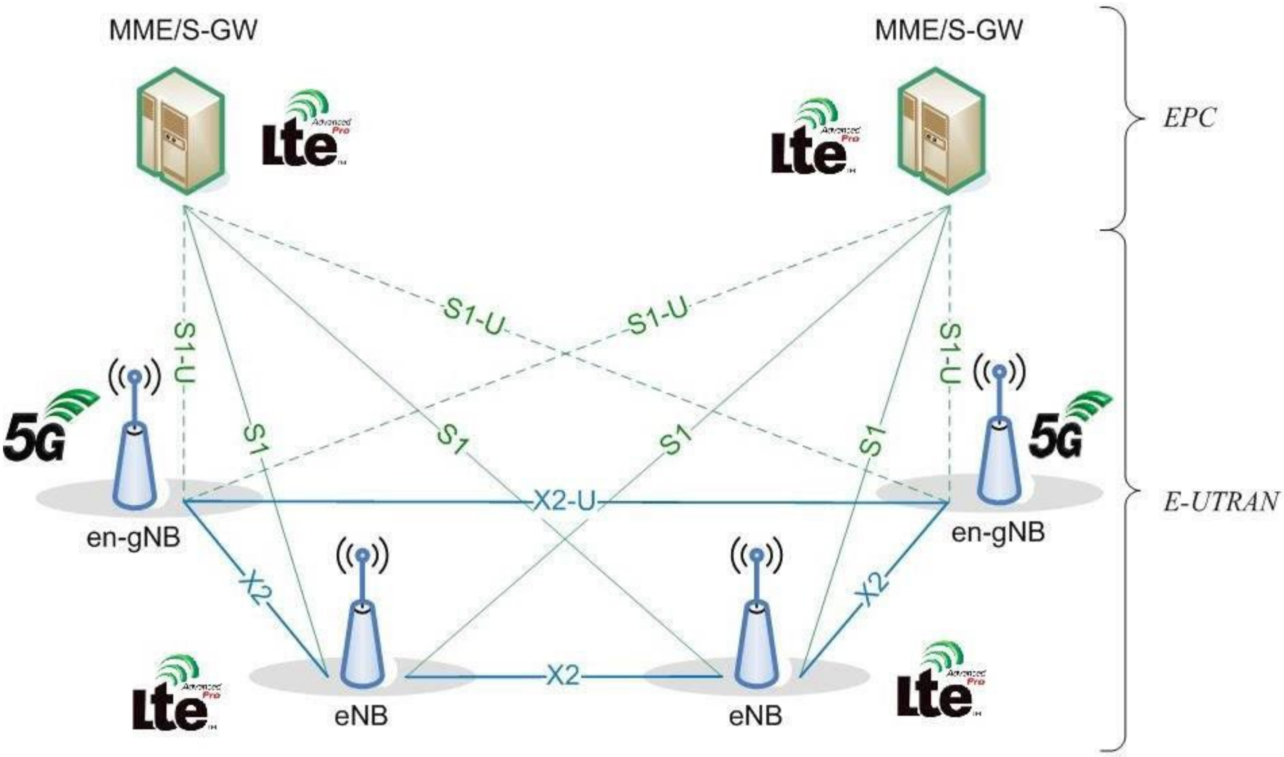
However, it would be optimal if with the implementation of 5G on the C-band layer frequencies in the 700 MHz band appeared. This is crucial in the context of indoor building coverage, where the signal is

desired and expected by users, but the C-band layer cannot provide it. This is due to physical constraints, since high frequencies poorly penetrate obstacles, and in the case of 3.4-3.8 GHz, in practice they are stopped by the first obstacle, which often is just a wall of the building. Range inside buildings can also be provided through dedicated installations, however, such solutions are dedicated to public places (stadiums, hospitals, stations, airports) and buildings intended for office purposes, where the developer himself repeatedly strives for the presence of such an installation. In the context of a mass client, such systems are too expensive in the context of mass implementation.

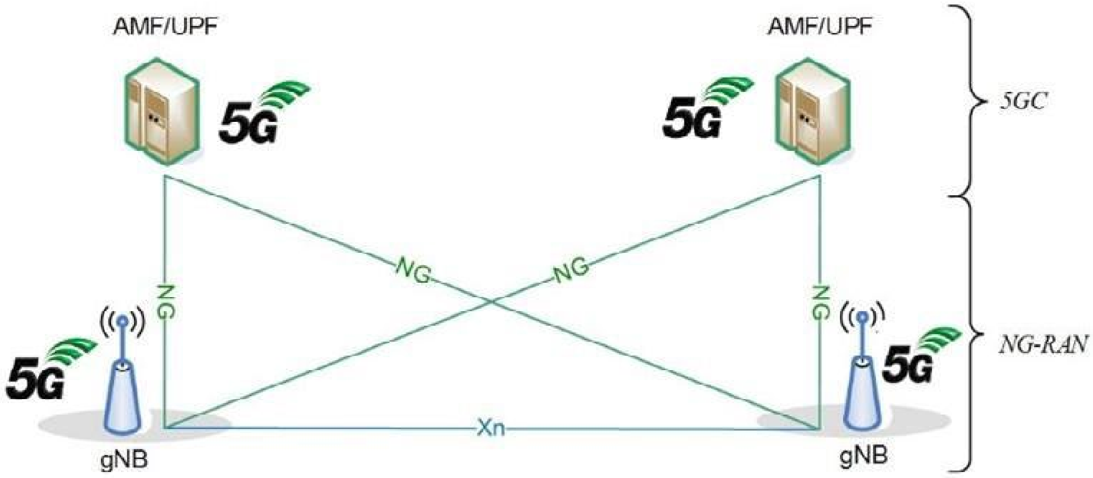
There is also another important reason why 5G networks will be based on 4G technology. In the first phase, most operators are preparing to implement the NSA (Non-Standalone) architecture, which in practice means the use in the core network (CORE) of solutions based on 4G technology. Signalling will be handled through a 4G layer and customer data will be sent at high speed with a 5G radio interface (NR - New Radio). This basic requirement forces the operators to use the 5G network in some way overlaying the 4G layer.



Source: Qualcomm



Architecture of 5G Non-stand-alone (NSA) network standard



Architecture of 5G Stand-Alone (SA) network standard

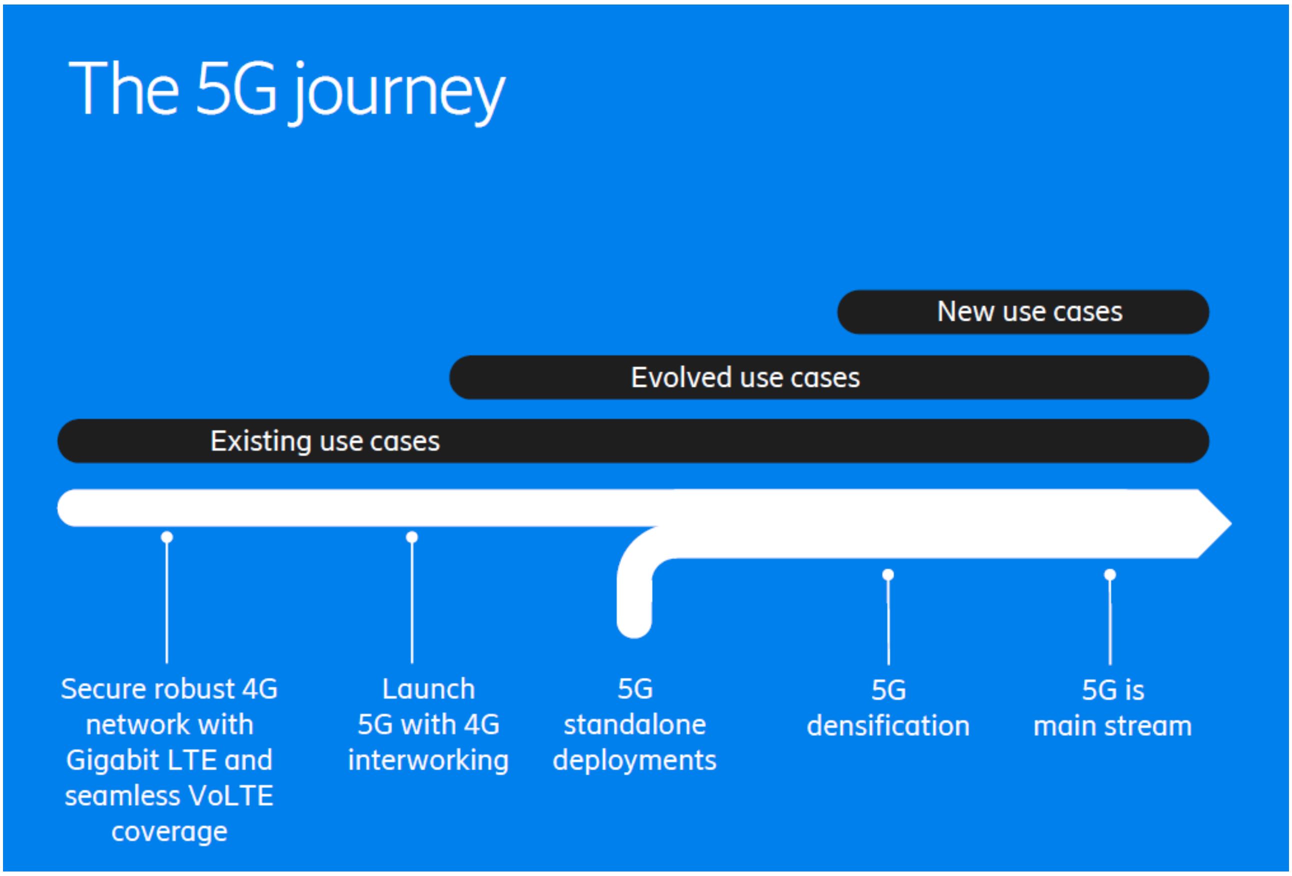
This is not the only reason. While in the context of the use of 64T64R or 32T32R Active Antennas, the outdoor range at the C-band frequency will be similar to the LTE 1800 signal level towards Downlink (to the client), the Uplink (from the client) range and Bit rate is quite limited as the distance from the antenna function. Therefore, it is necessary to support the previous generation on the Uplink link through so-called dual connectivity to use the LTE interface if data cannot be sent up via the 5G technology.

2. Folliwng the supply (quality and quantity).

Putting aside specialized applications such as the construction of a dedicated indoor building installation in selected buildings and very fast 5G connectivity in geographically dedicated areas using millimeter waves (26 GHz), the rate of development of capacitive and geographical coverage with a 5G signal will directly result from users' needs, availability of innovations and differentiating the layer of radio access services, and penetration of terminal equipment indirectly dependent on the price of such devices. While in the context of 4G technology the rate of adoption was, to put it mildly, not the smoothest, the qualitative leap from 4G to 5G technology is so significant that this process can be even twice as fast - at least these are market expectations on a global scale.

At first, 5G will be offered to business customers around their headquarters and for typically dedicated applications. Secondly, 5G technology will be targeted at residents of large cities, who also in the area of residence will require network parameters similar to those used in the office environment. The next stage will be to provide domestic coverage with 5G technology, but it should be remembered that frequencies in the 700 MHz range and dedicated 5G resources covering 30 MHz will be insufficient in terms of capacity and the provision of services with very high bit rate. There are two ways to solve this dilemma. One, by absorbing other frequency bands such as 800 MHz or 900 MHz for the 5G technology, with the 800 MHz layer being the last step of this transformation, due to the dedicated nature of 4G services and the relatively low penetration of devices supporting low bandwidth in the initial phase of technology implementation 5G. From the point of view of services requiring quite high bit rates, as in the case of the "entertainment" segment for autonomous cars, the 700 MHz layer will be insufficient for such applications. Therefore, on major road and rail routes it will be necessary to use dedicated solutions based on a dense network of base stations in the C-band band, or even dedicated solutions based on mmWave (26 GHz), which should be integrated in the latest generation of vehicles at the planning stage. . However, we are not talking here about V2X connectivity (V2V and V2I). However, this approach generates significant costs and may be cost-inefficient when implemented by a single operator.

At the current stage, market expectation is estimated for the coexistence of 4G and 5G networks over the next decade, and depending on the pace of popularizing 5G technology, the gradual blanking of 3G and then 2G technology. As prices of 5G supporting devices decrease and their saturation increases on the market, it will be possible to consider switching to SA (Standalone) architecture, where the 5G layer will gain its dedicated core network (CORE) fully independent of the 4G layer.



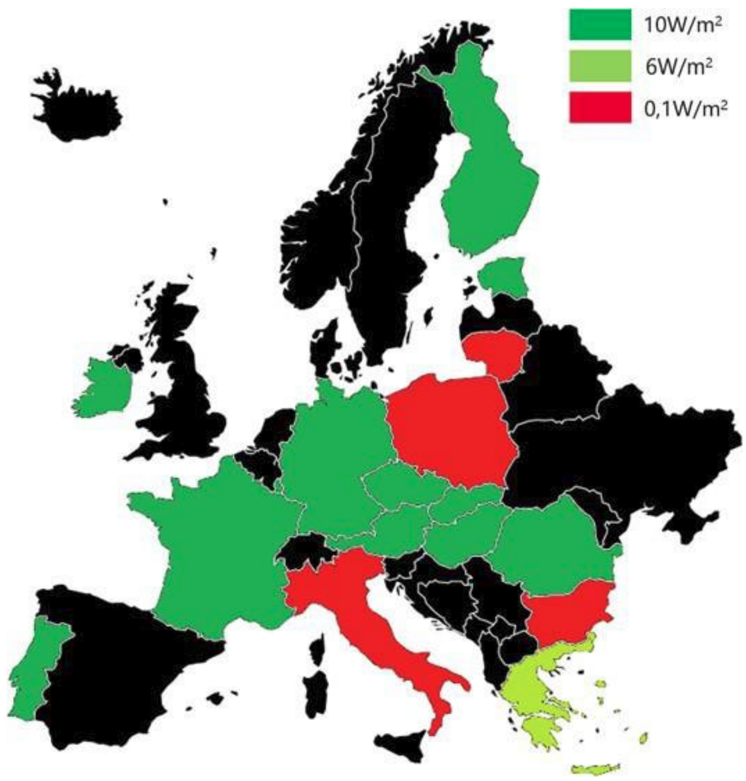
In the meantime, other very important development directions may have a significant impact on the final technological appearance of future 5G networks. On the one hand, further progress of virtualization and transfer of many functionalities to the cloud, separation of core functions dedicated to voice connections, fast data transmission, IoT solutions and dedicated professional solutions taking into account the requirements of uRLLC and the associated quality guarantee, will further strengthen the virtualization trend by placing dedicated capacity and computing power per each of these solutions, which at this stage is called "network slicing" - network layering. At the same time, at this stage, we separate the main functionalities of the 5G network for reliability reasons of the network itself, while ultimately there will be layering from the application (application) point of view and related requirements for network parameters, as well as the cost incurred by the customer for meeting the requirements dedicated to him.

3. Rationalization of improvement costs

Rationalizing the costs of transformation is a very complex issue from the point of view of the entire telecommunications ecosystem. The main implementation costs result from the costs of obtaining frequencies at which it will be possible to build the 5G network. While the market average says that these costs should be lower than with 4G implementation, because otherwise license costs will far outweigh the costs of technical network construction, and this is already putting the industry "on its head", in practice the importance of this future technology on selected markets is so important that it entails little rational investment decisions, especially in the context of the overall cost of implementation. Such situations are often inspected by governments, which finance pro-social policy with such means, for which at the end they will pay the society with a high price of services or low quality of services. However, such examples also in Europe can already be pointed out - so far the record holders in the amounts quoted are

Italy and now Germany, where operators want to allocate on the frequency of around EUR 6 billion. For comparison, when implementing 4G technology in Poland, it was said that about one billion PLN was needed to build a quite sensible network for a single operator. Thus, it is clear that these proportions, even taking into account slightly different realities of markets settling in euros, are not reflected in logic. That is why so many voices saying that 5G frequencies should be distributed in Poland in the form of a tender, not an auction. The previous auction for 4G frequencies placed Poland among the top paying countries for 4G frequencies in comparison to the whole of Europe, taking into account the cost of MHz per capita and inadequate to purchasing power. Of course, the reasons for this were various, including government needs and errors in bidding documentation intentionally left in the documentation despite numerous environmental comments. Clearly, these records supported price increases for these radio bands. As you can see, the end justifies the means. A further approach of this type will distort the process of implementing 5G technology, delay its start, and thus exclude Poland from the group of States that add value to the information society, putting society in the position of consumers of foreign technical and technological thought.

Operators on the Polish market are closely monitoring the actions of state offices regarding the frequency availability schedule, the abolition of investment barriers and the expected change in PEM (electromagnetic field) limits, which in Poland do not correspond to European reality, as can be seen in the graphic below.



Any money saved on imposition to the state for frequencies dedicated to the construction of 5G technology can be directly invested in 5G infrastructure, which in the medium and long term will provide the Citizens much more benefit from the wide accessibility than the unique character available to a few due to geographical availability as well as economic availability.

Operators are the most appropriate entities to control the geographical development of 5G technology, colliding on the one hand the needs of clients and entrepreneurs in time with healthy market competition.

PERMISSIBLE LEVEL OF ELECTROMAGNETIC FIELD (PEM) AS ONE OF THE KEY ELEMENTS FOR SUCCESSFUL 5G IMPLEMENTATION

The new 5G network topology based on dense networks using pico cells, also raises new legal challenges. Due to the use of higher frequencies by 5G networks, pico and micro cells will have a small range. This means that they will have to be distributed more densely, which means closer to people. Currently, such installations are not possible due to the current electromagnetic field (PEM) limits. It is therefore not possible to implement the 5G network concept. What's more, in public space it is often noted that the permissible levels are raised, suggesting that 5G stations should be up to 100 times more powerful. Nothing could be further from the truth. Changes in permissible levels will allow placing antennas closer to people, while maintaining the same power level in the transmitter.

It should therefore be emphasized that the current acceptable levels of electromagnetic field (PEM) are one of the main restrictions on the way to implementing 5G networks in Poland. Their current levels may result in the need to launch a large number of new broadcasting stations, duplicating the one that already exists and which would significantly increase investment costs than in the case of increased PEM standards. The problem of PEM standards does not apply only to antenna installations installed close to people in pico cells. The current PEM standards cause difficulties in the construction of 4G networks. Due to the high levels of PEM in urban areas, a significant increase in radio systems at current base stations could exceed statutory standards. As a consequence, as noted by the Institute of Communications, we are threatened by online blackout related to overloading of mobile networks[1].

In Poland, the current acceptable power density of the electromagnetic field is 0.1 W/m^2, and the intensity of the electromagnetic field cannot be more than 7 V/m^2. This means that the permissible power density of the electromagnetic field in Poland represents only 1% of the value resulting from the recommendations of the World Health Organization and ICNIRP[2].

Organization	Permissible electromagnetic field strengths	Permissible electromagnetic field density
Poland	7 V/m	0,1 W/m2
European Union	41,3 V/m	4,5 W/m2
World Health Organization	61 V/m	10 W/m2

Polish acceptable levels were established in 1984 on the basis of standards developed in the Soviet Union. Despite the passage of so many years, they have not been constantly updated. In turn, the admissible levels set by the European Union or WHO were established in 1998 and were similarly confirmed by studies in 2009.

As the BCG[3] consulting company pointed out in its report, the result of acceptable PEM levels will be low efficiency in the use of radio spectrum. In practice, this means that the frequencies acquired for the implementation of the 5G network will be used only partially and in the auction process will be valued by operators below the values found in other countries. Such levels also cause difficulties in the management and construction of the network, which translates into less optimal locations for 5G stations.

Another negative consequence of the applicable PEMs is also the poorer radio coverage of already

1 https://www.il-pib.pl/pl/aktualnosci/biezace-wydarzenia/1559-mobilny-internet-raport
2 BCG Report, "Impact of Power Density Limits (PDL) on wireless connectivity: are Poland facing delays in 5G development?", July 2018
3 Raport BCG, „Wpływ limitów gęstości mocy (PDL – Power Density Limits) na łączność bezprzewodową: czy Polsce grożą opóźnienia w rozwoju 5G?", Lipiec 2018

built cellular base stations, as well as the limited possibilities of sharing infrastructure and masts, and the need to build an increased number of stations in comparison.

According to Haitong Bank's estimates, the average cost of building a base station is around PLN 300,000. The construction of a thousand base stations would cost around PLN 300 million, and doubling the current number of base stations around PLN 2.5-3 billion[4]. In turn, the Ministry of Digitization indicates that if the permissible PEM levels remain unchanged, to ensure proper the capacity of the cellular network, due to the growing traffic generated by users, the number of base stations will have to be increased more than 7 times.

STATE OF KNOWLEDGE ABOUT HARMFULNESS OF ELECTROMAGNETIC FIELD

Talking about harmonizing PEM standards to the values recommended by WHO and ICNIRP, it is worth discussing the state of research on the harmfulness of PEM. The International Agency for Research on Cancer (IARC) is a cancer agency at the World Health Organization (WHO). Since 1971, IARC has been running a program in which expert groups examine whether certain things are carcinogenic. IARC has already analyzed over 900 factors. This group includes factors such as asbestos, benzene, formaldehyde, alcoholic beverages, coffee, hair dyes, paracetamol, talc or electromagnetic fields generated by power lines, and shift work disrupting natural sleep cycles. By performing the IARC analysis, it determines the risk of carcinogenicity of the examined factors as: certain (1), probable (2A), possible (2B), not classifiable (3) or improbable (4). In May 2011, the agency classified the electromagnetic field generated by radio frequencies as potentially carcinogenic to humans (2B) due to the increased risk of glioma, a malignant type of brain cancer associated with the use of cell phones. In summary, IARC wrote:

"The evidence has been critically reviewed and the overall assessment states that it is too limited for cordless phone users to assess the risk of glioblastoma and neuroblastoma, and that it is inappropriate to draw conclusions about other types of cancer. Evidence from the analysis of the occupational and environmental exposure described above was similarly inadequate".[5]

A few years later, the World Health Organization updated the study on electromagnetic fields and public health with reference to the IARC Classification. The WHO position can be summarized as follows:

"The potential health effects of contact with various types of radiation from the entire spectrum of electromagnetic waves, including cell phones and base stations, have been and are the subject of comprehensive research. All previous analyzes have shown that radiation exposure within the PEM radiation limits set by ICNIRP in 1998 and maintained in 2019, covering the entire frequency spectrum, i.e. 0-300 GHz, does not cause any known adverse health effects.

However, there are still unexplored aspects in this area and they need to be supplemented before the final health risk assessment is issued.[6] "[..]" Despite extensive research, no evidence has yet been found that low level electromagnetic radiation exposure has any harmful effect on human health."

It is also worth looking at the results of research of other agencies and scientific institutions that studied the subject of PEM, such as the Centers for Disease Control (CDC), the Federal Communications Commission (FCC), the Food Administration and the Food and Drug Administration and the National Cancer Institute, and they all agree. According to the CDC: "We currently don't have scientific knowledge to link health problems to the use of cell phones. Scientific research is only being used to determine whether mobile phones can affect health." FCC says the same: "To date, there is no scientific

4 https://www.money.pl/gielda/wiadomosci/artykul/haitong-bank-aukcja-5g-w-polsce-nie,213,0,2424533.html, Dostęp 12.06.2019

5 http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

6 http://www.who.int/peh-emf/research/en/

evidence that the use of cell phones can cause cancer or other health effects, including headaches, dizziness and memory loss."

In conclusion, we have no convincing evidence that telephones are harmful to us.

REAL SOURCES OF SOCIAL FEARS AND THE NECESSITY TO LIMIT SOCIAL HARMFUL ACTIONS

One of the main sources of drugs in the field of PEM is deliberate misinformation. In Poland, materials prepared by the international community are distributed, aimed at delaying the implementation of modern networks and thus contributing to GDP growth and quality of life. Materials with "lethal 5G technology" are distributed, causing "birds falling", increasing radiation power 100 times, threatening us to build public space with a forest of large antennas or finally about grilling our brains due to the fact that the 5G network uses the same frequencies every microwave oven.

The second source of drugs is fear of a new one. The situation with 5G networks resembles the construction of a sewage system in Warsaw in 1897 or the construction of an electricity network in London in 1880. New situations generate similar suspicion, as it was already in history. Small groups of opponents are created that do not relate to science and the world of physics.

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