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Chapter

«RISKS AND PROBLEMS OF 5G NETWORKS DEVELOPMENT IN RUSSIA AND IN THE WORLD»

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Risks and problems of 5G Networks development
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ABSTRACT

The development of 5G networks is one of the largest projects in the human civilization history. Moreover, this project was originally planned as international and covering the entire globe. During the implementation of most large projects modern science has developed a number of approaches. One of them is the project assessment based on the balance between costs, benefits and risks. The costs of many trillions of dollars for the "Development of 5G networks" project are already obvious. Dozens and even hundreds of articles in scientific journals and tabloid magazines and newspapers are devoted to the benefits of the project. The authors of the article describe the advantages and disadvantages of the 5G networks development. They offer their own classification of benefits for the 5G networks development and divide them into explicit, implicit and hidden. Moreover, the hidden advantages are apparently decisive. Special attention is paid to the potential capabilities of 5G networks to provide police functions, in particular, to ensure all issues of total surveillance of any person. The problem of risks associated with the project is covered very little. Although during the last years there appeared a number of articles that force us to consider carefully the problem of 5G networks risks, but the research on these risks is extremely insufficient. The latest scientific articles and reports made from 2020 to 2021, which deal with the adverse consequences of the 5G networks development, are analyzed in the article. A risk-cost-benefit analysis is carried out that allows concluding whether the 5G networks development is justified or not. The performed analysis raises doubts on the justification of spending trillions of rubles for the 5G networks development in the Russian Federation.

Keywords: smartphones, electromagnetic radiation, impact on human health, 5G networks.

CONTENT

And I brought you into a plentiful country, to eat the fruit thereof and the goodness thereof; but when ye entered, ye defiled my land, and made mine heritage an abomination.

[The Bible, *the Book of the Prophet Jeremiah*, Chapter 2].

1. INTRODUCTION

Communications were very important from the first steps of the human civilization development. But in the last century, after the invention of the telephone and the telegraph, their role has increased especially. Each new generation of network development created new opportunities, increased the speed of communications, expanded the scope of their application. Recent years have put the development of 5G networks on the agenda, because fundamentally new opportunities are associated with them. The development of 5G networks is one of the largest projects in the human civilization history. Moreover, this project was originally planned as international and covering the entire globe. Modern science has developed a number of approaches during the implementation of most large projects. One of them is the project assessment based on the balance between costs, benefits and risks. The costs of many trillions of dollars for the "Development of 5G networks" project are already obvious. Dozens and even hundreds of articles in scientific journals and tabloid magazines and newspapers are devoted to the benefits of the project. But the problem of risks associated with the project is covered very little. Although during the last years there appeared a number of articles that force us to consider the problem of 5G network risks carefully, but the research on these risks is extremely insufficient. Therefore, there is an urgent need to assess this project using the risk-cost-benefit analysis and to conclude what will be the consequences for the humanity and nature after the implementation of the 5G networks. Equally important

questions are: whether the benefits associated with the project are really worth expecting, who is going to receive these benefits and are the costs of this global project justified.

2. RETROSPECTIVE ANALYSIS OF THE 5G NETWORKS DEVELOPMENT AND THE IMPACT OF ELECTROMAGNETIC RADIATION

The development of communications since the dawn of civilization has played a major role, ensuring human safety above all. A number of archaic forms of communication have survived in the history of civilization. Some of them have remained only in legends, chronicles, historical films and science fiction stories, others still perform important functions of ensuring safety, maintaining order and providing communications in extreme conditions.

The archaic forms of communication are the following:

1) secret messenger/outrunner on foot, mounted or on ship;

2) pigeon mail;

3) owl mail (as shown in the Harry Potter films);

4) the system of signal fires and thick columns of smoke located on hills or towers; the smoke code had extensive capabilities - the Indians of North America could transmit various information giving the clouds of smoke a certain color and shape: warn of a military invasion, inform about the number of enemies and their location, ask for help;

5) tam-tams (drums), the relevance of which has not been lost in some West African tribes;

6) pipe, horn or hunting horn;

7) bell (in particular, an alarm bell);

8) the sounds transmitted by the rotation of a boomerang tied to a rope (as shown in the movie "Crocodile Dundee 2");

9) railway semaphore signal, which has not lost its relevance until now[1];

10) flag semaphore[2];

11) traffic light, which still plays an important role in traffic regulation[3].

All these archaic forms of communication began to gradually lose their meaning after the invention of the telegraph and the telephone. In the twentieth century all the benefits of telephone communications became apparent to all countries of the world.

A new era of telephony development began in the 1980s with the introduction of **1G** - the first generation of wireless cellular technology and mobile telecommunications, which allowed a single function of mobile calls. The features of 1G were the high cost of mobile phones, the high cost of mobile calls, a low level of communication security and a low transmission speed - up to 2.4 kbps, and the spectrum was limited from above by the frequency of 900 MHz.

In early 1990s there was a new leap in the development of communications - a completely new **2G** digital communication technology appeared. The features of the second generation of mobile network technologies were the transition of radio signals from analog to digital format, the emergence of communication channel encryption and the introduction of data transmission and reception - short text messages (SMS) and digital data (CSD). The transmission speed was originally up to 14.4 Kbps, but with the improvement of the technology to GPRS (**2.5G**) was boosted up to 115 (114) Kbps, and after the introduction of

[1] Railway semaphore signal is one of the earliest forms of fixed railway signals. This semaphore system involves signals that display their different indications to train drivers by changing the angle of inclination of a pivoted 'arm'. Semaphore signals were patented in the early 1840s by Joseph James Stevens, and soon became the most widely used form of mechanical signal.

[2] The Russian semaphore alphabet, which has survived to our time in the Navy, was developed in 1895 by Vice Admiral S.O. Makarov. The flag semaphore is intended for daytime communication. During good visibility the flag semaphore can be seen with the naked eye at a distance of up to 1.5 miles, using optical devices - up to 2.5 miles. The message transfer rate can be up to 100-110 characters per minute. Communication by them is carried out only by words, transmitted by letters. This is achieved due to the fact that each letter of the Russian alphabet has a certain conventional sign assigned to it. Each conventional sign is depicted by a *certain position of the hands with flags*. By sequentially displaying the characters of the letters in the order of their sequence the word is transmitted over a distance. This technology allows you to transfer any words and sentences.

[3] An optical device that provides light signals to regulate the traffic of automobile, rail, water and other vehicles, as well as pedestrians at pedestrian crossings.

EDGE technology (**2.75G**) the transmission speed already reached 384 Kbps, and the frequency range covered 850, 900, 1800 and 1900 MHz. The mobile Internet technology appeared at that moment.

The **3G** network was developed in 2001. This technology provides data transfer with a speed up to 2 Mbps. When upgraded to **3.5G**, the transfer rates could be from 3 to 14 Mbps. 3G technologies achieve better spectral efficiency over cellular broadband networks, allowing faster data rates and more services. The 3G network gave a push the development of the mobile Internet technology.

The **4G** network and its **LTE** modification have appeared since the 2010s. 4G has focused not so much on voice communication but on increasing the speed of data transfer. This technology provides data transfer rates up to 1 Gbps. LTE also supports seamless handovers for both voice and data to cell towers with older network technologies.

Mass adoption of **5G** networks is expected in 2022-23. These networks are expected to increase the peak speed up to 20 Gbps, increase the spectral efficiency in 5G networks by 2-5 times, increase energy efficiency by 2 orders of magnitude, increase the subscriber's available movement speed to 500 km/h, and increase the total number of connected devices to 1 million/km^2.

However, with the increased attention of both professionals and the public to the technical characteristics and capabilities of the next generation of mobile technologies, the question of the electromagnetic radiation impact on humans and the environment (associated with these technologies) was not raised practically, and no money was allocated for its study. It is possible that telecommunication companies, not interested in receiving negative information about their business, have a certain influence on this situation [Captured Agency, 2015].

In the meantime, the research on electromagnetic radiation (EMP) takes place independently of the mobile technology development. Scientists are primarily interested in electromagnetic fields associated with the physiological processes of living organisms (humans, plants, animals and bacteria), as well as the impact of external electromagnetic radiation on all biological objects. The impact of EMP on biological objects was studied a century ago, but only with the development of physical methods for measuring weak electromagnetic fields in the 1930-40s it became possible to identify many patterns of this impact. For a long time the impact of EMP on biological objects has been studied in the framework of biomagnetism and magnetobiology. Hundreds of articles, monographs, dissertations have been published in 1950-1970 (Kholodov points to more than 500 from two dozen countries of the world, including the USA, Canada, Finland, France, England, USSR, Italy, Czechoslovakia, Belgium, West Berlin, Japan, etc. - Kholodov et al., 1987). As a result, there has been accumulated extensive material that even very small impact of EMP on biological objects lead to very noticeable changes in their physiology, viability and many indicators of their state. This period of research has been well reflected in excellent reviews written by authoritative experts in this field of science activity (Biomagnetism and interdisciplinary approach, 1983; Hisako, 1986; Kholodov, 1970, 1982; Kholodov et al., 1987; Presman, 1968; Schmidt-Jedermann, 1984). The impact of EMP was studied on biological objects such as humans, animals, fish, plants and bacteria. Moreover, there has been emphasized a very high sensitivity of biological objects to EMP. For example, fish have up to 10^{-10} Tl, background brain activity has 10^{-12} Tl, retina has 10^{-13} Tl (Kholodov et al., 1987).

The research intensity on the EMP impact on biological objects, primarily on humans, has increased dramatically in the last decade. This is due to many factors, but two of them predominate: the explosive growth in the number of smartphones used by the population of all

ages and the abundant evidence of cancer cases, primarily the brain and breast cancer in users of these smartphones.

The situation is aggravated by the general crisis in the field of environmental safety [Kharchenko, 2014; Kharchenko, Dorokhina, 2016, 2017]. Numerous conferences and symposia are devoted to these problems (for example, 5th international symposium "Biophysical aspects of Complexity in Health and Disease." Milan, Italy, October 12th and 13th 2018 [Foletti, 2018]). Public speeches of famous scientists (for example, Dr. Devra Davis, Environmental Health Trust, and Dr. Martin Pall, professor at the University of Washington) and dozens of articles in reputable scientific journals pay attention to the problems. In particular, Dr. Martin Pall showed that there is a high sensitivity to electromagnetic fields in every cell of the human body, so that the force influencing on our cells has a huge impact on the biology of our body [Pall, 2015; 2016; 2018].

Many results of human exposure to EMP have been shown in the US Naval Medical Research Institute Reports [Naval Medical Research Institute Research Report, 1971, 1976], such as:

1) Various neurological/neuropsychiatric disorders, including changes in brain structure and functions, changes in various types of psychological responses, and behavior changes.

2) At least eight different endocrine (hormonal) effects.

3) Cardiac effects affecting the electrical control of the heart, including ECG changes causing arrhythmias that can be life-threatening.

4) Chromosomal breaks and other changes in the structure of chromosomes.

5) Histological changes in the testes.

6) Cell death (called apoptosis - part of the neurodegenerative process of the disease).

Other results of human exposure to EMP have been widely documented subsequently in the peer-reviewed scientific literature, in particular, such as:

7) Decreased male fertility, including decreased sperm quality and function, and decreased female fertility (less well understood).

8) Oxidative stress.

9) Changes in calcium fluxes and calcium signaling

10) Damage to cellular DNA.

11) Cancer that is most likely associated with these DNA changes [Baan et al., 2011].

12) Therapeutic effects, including stimulation of bone growth.

13) The occurrence of cataracts (previously it was believed that the source of cataracts is thermal, now it is known that this is not true).

14) Destruction of the blood-brain barrier.

15) Melatonin depletion and sleep disturbance.

In 2002, California conducted a survey that determined 7% of the population to be hypersensitive to EMP. For example, they have adverse reactions after several hours of continuous exposure to WiFi, cell towers or mobile phones. These reactions included headache, cognitive impairment, inability to sleep, inability to stay awake, tinnitus, depression or inability to concentrate. Estimates of hypersensitivity to EMP in Europe showed 3% in relation to this population.

Over the years since this study the EMP power has increased significantly and the percentage of hypersensitive people seems to have increased proportionally. This fact is confirmed by the significantly increased number of people susceptible to allergies. And since the technology allows radiation to penetrate any walls there is no safe refuge saving from it. In addition, there is very little oversight of the current EMP impact of 2G, 3G and 4G, and nobody is drafting laws to monitor or measure the health impact of 5G.

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Susan Foster from US Radiation Research Trust studied the carcinogenic impact of radio frequency radiation on firefighters [Foster, 2020]. Brain cancer is currently one of the most common cancers among US firefighters. She claims that cell towers made firefighters sick, impaired their ability to work and protect the public and even may have contributed to death. The study she organized was conducted on six California firefighters who were exposed to a cell tower at their fire station for five years. They all fell ill after the activation of the cell tower near their station, despite months of assurances from telecommunication company that there would be no any adverse consequences because of those towers. All six firefighters passed rigorous physical and cognitive exams before being hired by the fire department, but still experienced profound neurological symptoms after exposure to cell towers. The adverse reactions included (but were not limited to): headaches, extreme fatigue, sleep disturbance, depression, anxiety, unexplained anger and even sleep, similar to anesthetic (when men wake up for 911 calls “as if they were drugged”). All six firefighters had brain abnormalities on SPECT scans (single-photon emission computed tomography). Doctors discovered pervasive hyperexcitability of neurons, which made it clear that exposure to microwave radiation caused neurons to constantly work without rest. Cell towers were installed at two fire stations, where the firefighters had previously worked for 22 years without any signs of illness.

Three of the six firefighters were captains. The captain of each shift is responsible for making vital decisions for all firefighters and potential injured people. He orders the firefighters to enter the burning building and vice versa he orders them to get out before the roof can collapse. Damage to critical brain functions can cost firefighters their lives. Measurements of radiation from cell towers have shown that the radiation level is approximately 0.001 of the limit set by the FCC as safe. Therefore, there is an urgent need to

revise the existing EMP exposure standards to be based on the observed biological impact. And if firefighters, the strongest and most resilient among the population, experience symptoms that worsen their service due to severe headache, disorientation, sleep disturbances, cognitive impairment, delayed reaction time, lack of impulse control and mood swings, then the obvious question is arised: “A what about the rest of us?”

Canadian scientists have shown that people who used mobile phones for 558 hours a year or more have a more than doubled risk of cancer for glioma, meningioma, auditory neuroma, and parotid tumor [Momoli et al., 2017].

Many researches have shown that EMP affects health by a number of mechanisms including oxidative stress (antioxidants are able to protect against it), mitochondria damage, cell membrane damage [Benderitter et al., 2003], and the disruption of blood-brain barrier [Tang et al., 2015] (the blood-brain barrier protects the brain from the invasion of heterogenous substances and toxins; violation can lead to cerebral edema). Other mechanisms include narrowing of blood vessels and impaired blood flow in the brain, as well as triggering autoimmune reactions [Grigoriev et al., 2010a; 2010b; 2010c; Ivanov et al., 2010; Lyaginskaja et al., 2010]. A major exposure suppresses antioxidant defenses which increase vulnerability to future exposures and some people can no longer tolerate other forms of exposures after that.

Manufacturers' attitude

The mobile phone industry had little interest in the impact of its products on humans and kept silent about any evidence of such exposure. Despite much evidence of the contrary the manufacturers argue that radiation must be ionizing or heating in order to damage human health. They try to prove that the strength of electromagnetic fields in a cell is too weak to produce any biological impact. Public health has never been a concern for the mobile and

wireless devices manufacturers, as well as for tobacco manufacturers. They argued that any possible human exposure from using mobile phones would only be mild heat that the body can easily handle.

Therefore, the rules defining the safety limits established in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were based on the assumption that if electromagnetic radiation did not cause human tissue to overheat, then the human society was sufficiently protected. They believed that the impact on humans would cause the water to heat up inside the cellular tissues which would dissipate as heat in the worst case scenario (similar to what a microwave does, but at much lower energies). However, over the past 20 years, scientists have proven that the interaction between microwave energy and our tissues is much more subtle. There is growing evidence of non-thermal biological impact resulting from the interaction of body tissues with mobile phone radiation. In addition, the telecommunication companies have corrupted the agencies that are supposed to regulate them with bribes. The best example of this is that the FCC (US Federal Communications Commission), which regulates EMP in the United States, is dominated by companies that it must regulate. That's why there is no wonder that the companies continue to advertise their devices trying to convince buyers that the devices are within the safety guidelines set by the FCC [Captured Agency, 2015].

3. PECULIARITIES OF THE CURRENT STAGE OF 5G NETWORKS DEVELOPMENT

Individual scientists and entire medical associations have been actively discussing the introduction of a powerful new 5G network technology for the past 2-3 years. The technology

uses microwave wireless frequency of electromagnetic radiation (EMP), which has never been tested for its impact on public health or the environment. 5G is a new milestone in wireless cellular technology. 5G mobile networks are designed to deliver even faster Internet speed and enhance the capabilities of smart devices and machine-to-machine communications, giving the rise to the “Internet of Things” (IOT). 5G networks will be capable of transmitting large amounts of data over short distances.

Compared to existing cellular and WiFi networks that rely on microwaves using frequencies up to 6 gigahertz (GHz) 5G will use millimeter and submillimeter waves in higher frequency bands (30 GHz to 300 GHz). 5G technology will require many closely placed antennas for optimal functionality. Since millimeter and submillimeter waves have short wavelengths, it is difficult for them to pass through buildings or other obstacles, including foliage on trees and even rain. Therefore, 5G technology will require a dense network of millions of RF (radio frequency) antennas deployed next to every neighborhood in cities across the country. This will expose people to EMP in their homes, schools and businesses.

Upcoming high frequency 5G technologies pose an even greater biological threat than those we face today.

Several additional points can be highlighted and detailed:

1. Both physics and biology show that electromagnetic fields act primarily through the activation of calcium channels in the cells of our bodies. Functional disruption of calcium channels in cells produced by low-intensity electromagnetic fields lead to a wide range of biological changes and affect human health.

2. The DNA damage produced by these EMPs occurs in a man's sperm and can also occur in a woman's oocytes that result in a significant increase in the newborn child mutation. An increase in the mutation frequency by 2.5-3 times is believed to lead to extinction due to the accumulation of a large number of damaging mutations. Perhaps we have already passed

this level, and if so, then the future EMP exposure will lead to final extinction. Further increases in exposure will be more and more rapidly destructive.

3. Pulsed electromagnetic fields in most cases are more biologically active and therefore more hazardous than non-pulsed (constant) electromagnetic fields. All wireless communication devices communicate through ripples containing the reported information. All safety requirements for telecommunication industry are based on the heat-only theory, which was known to be false as early as 1971. And it was way before many thousands of additional studies that were published with a proof that the theory is false.

4. The industry is trying to master much higher frequencies because they allow much higher ripple and therefore bigger information flow. However, these higher ripple rates make the devices much more dangerous.

5. None of the wireless devices (cell towers, mobile phones, cordless phones, Wi-Fi routers, 5G phones) have ever been tested for biosecurity before they are exposed to irradiation of unsuspecting people [Karaboytcheva, 2020].

To assess the impact of magnetic fields on human health, first of all, it is necessary to distinguish between *magnetosensitivity* (initial short-term reactions that occur with a minimum duration of exposure) and *magnetosusceptibility* (long-term, sometimes irreversible reactions to cumulation). It can be considered proven that organisms are capable of reacting even to changes in the amplitude of the geomagnetic field, which are measured by fractions of oersted, and such reactions can be as an example of magnetic sensitivity. In addition, the systems approach shows that even the most insignificant impacts on the body lead to its change. Even the body is "microscopic". If these impacts are regularly repeated, then the changes in the organism are gradually intensified – it can be called “the accumulation of

response." Therefore, when smartphone manufacturers claim that one conversation on a mobile phone does not cause any negative impact on the body, then it is true. But the effect can accumulate and lead to brain cancer over time. This process depends on the power of the smartphone, the frequency and duration of its use, and to a large extent on the age of the user. The younger the body the more unstable are its structure and functions, the more easily they are exposed to changes, the more likely the occurrence of brain cancer and other disorders. And the fact that minimal impacts can lead to severe damage to human health has been known since ancient times.

The Chinese torture with drops of water falling on the head is widely known: a person was tied with shackles. The man was left alone with dropping water for a day. The effect was very striking. At first, an absolutely healthy person came into a state of anxiety, trying desperately to free himself from the shackles, then slowly he became numb, falling into unconsciousness. Each blow of the drop felt like a hammer blow, hitting his head and his brain. Soon the distraught prisoner was ready to confess to any crime. If the torture lasted long enough then the prisoner went crazy and even died. And if the drops of falling rain never led to health disorders and did not concern anybody, then absolutely everyone was afraid of torture with drops of water, which has a much stronger impact than torrential rain. And the impact of this torture can be easily explained by the cumulative effect and a change in the body's sensitivity to this effect. This is the systemic response of the body, requiring the use of systemic analysis [Kharchenko and Dorokhina, 2017].

This approach to the smartphone danger assessment (and indeed any new technology, including nanotechnology) implies special care when using mobile phones.

Many well-known scientists, such as Dr. Paul Ben Yishai (Ishai) of Ariel University, argue that a growing number of publications show that the 5G frequency band can have serious biological impact. So current efforts to accelerate 5G adoption should be postponed

until more research is carried out to assess the critical impact level on human health [Betzalel et al., 2017]. Situation is worsen by the fact that cell towers are usually located next to homes, schools, hospitals, grocery stores, playgrounds, and public places.

In 2014, a team from the UK University of Exeter published a report highlighting the impact of smartphones on the decline in sperm quality [Adams et al., 2014]. Their research is based on over 1,492 men from around the world. In 2017 representatives of the World Health Organization International Agency for Research on Cancer (WHO / IARC) publicly stated that the data obtained from the research are classified in group 1 (agents that are carcinogenic to humans) in accordance with scientific criteria.

EMP is regulated by the US Federal Communications Commission (FCC) in the United States. It is an independent government agency established, administered and authorized under the statutes of the US Congress. On June 20, 2016, then outgoing FCC Chairman Tom Wheeler announced that 5G is "redefining network connectivity for years to come" at the Washington Press Club. When asked by a Bloomberg reporter about possible impact on health, Chairman Wheeler replied that "The FCC didn't have time to study the health impacts because the infrastructure for 5G would generate tens of billions of dollars of income." When a new technology is viewed only as a source of money a big number of questions is raised. And no wonder that a whole waterfall of appeals from scientists, politicians and public figures flow to various US government agencies with demands to prohibit the creation of infrastructure for 5G until its impact on human health is thoroughly checked. This is especially true for the unborn, children, people with suppressed immunity, the infirm, the disabled and the elderly. EMP impact on the central nervous system (brain) and our immune system. These two systems interact much more than any other system. And thus, if one of them is adversely affected, then the other may be affected too.

Recently published research on the human exposure to EMP from the National Institute of Environmental Health Sciences (NIEHS) research program suggests that RF microwave radiation can be dangerous. The 10-year National Toxicology Program (NTP) studying the impact of mobile phone EMP on humans (worth $ 30 million) has confirmed that radiation from mobile phones increases the incidence of highly malignant very rare tumors: brain gliomas and cardiac schwannomas [NTP technical report, 2018 ; Smith-Roe et al., 2019]. The data obtained from the experiment are consistent with the studies carried out on humans which make clear an increase in the frequency of gliomas and acoustic neuromas (Schwann cells) among people exposed to smartphone radiation. In addition the NTP also reported that animals exposed to such EMP prenatally produced offspring with lower birth weights and direct genetic damage.

The Ramazzini Institute (Cancer Research Center) conducted a research similar to NTP studies in 2018. The difference was that radio frequency radiation was 1000 times less than NTP irradiation. The results of the research showed a significant reduction in litter weight. This confirmed the danger of even a low level EMP. Thus, even ordinary cordless phones, widespread in Russia, and even cellular communication antenna towers pose a threat [Falcioni et al., 2018].

4. WHAT IS EXPECTED FROM 5G NETWORKS?

5G is the fifth generation of wireless technology for transmitting information using electromagnetic radiation (EMP). This technology provides faster and higher bandwidth than previous generations allowing the transfer of massive amounts of data that will be used by new industrial projects. They include the Internet of Things (IoT), self-driving cars, faster video streaming, smart cities, smart roads, smart homes, airplanes, power grids, dams, augmented reality and others.

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First of all, let's define the place of 5G networks in the electromagnetic spectrum. While 4G networks occupy a range from 450 MHz to 2.7 GHz, then 5G networks occupy a range from 2.4 GHz to 300 GHz. Thus, 4G and 5G networks overlap over a significant frequency range.

The 5G networks are planned to include much higher frequencies of millimeter wave (MMW) that have never been used before by the internet and telecommunications technology. These waves do not pass through buildings well and spread over a short distance. If 4G networks can operate at a distance of up to 20 km from a telecommunication station, then 5G networks are limited to several tens of meters. Therefore, according to the industry data, 5G networks will require hundreds of thousands of new so-called "small cells" known as wireless telecommunication stations. In 2017, a number of telecommunication companies stated that 5G signals could travel 1,000 meters, although some experts believe that 5G will require cellular antennas at least every 100-200 meters. But already now there are cases of installing cellular antennas in some American and Canadian cities at a distance of about 30 meters.

The mobile device industry is pushing hard to equip lampposts and utility poles across the country (such as the United States) with **microwave antennas** emitting hazardous EMP next to our homes 24/7. The practice of installing 5G cellular antennas on lampposts has also been developed in Russian Federation where the usual distance between these lighting poles (for example, in Moscow on Kutuzovsky Prospekt) is from 30 to 60 meters. That is, the density cellular antennas emitters of the network will be many tens of times higher than the available density for 4G networks, and the magnitude of the effect of electromagnetic radiation from these 5G networks will be accordingly many times greater.

The Ministry of Telecom and Mass Communications of the Russian Federation issued order No. 923 “The Concept of adoption and development of 5G/IMT-2020 networks in the

Russian Federation" on December 27, 2019 [The concept, 2020]. This Concept sets out **almost all** the reasons for the 5G networks development in Russia in details. In particular, all the advantages of 5G networks are described from the position of ministry. Let's examine some of these "benefits".

If 4G networks are 10 times faster than 3G, then 5G networks are expected to be 1000 times faster than our current 4G LTE systems. However this does not prevent LTE from the development of new features and the expansion of existing functionality. However, 5G networks are much faster only under certain conditions - the presence of a large pool of frequencies, which is not currently available. Other issue is that high speed will be localized within a hundred meters from the telecommunication station. How much of a benefit will this be for the vast majority of the users? If in 4G networks a movie is downloaded in 1-2 minutes, then in 5G networks it will be in 20-30 seconds. Few users will be eager to pay extra money for this advantage. And the price of the new technology is estimated at 10 times more than the one from the existing 4G. If these advantages are focused on the industrial cluster, then there is a problem that we don't have such type of industry in Russia, and there is no reason to assume that it will appear in the near future.

The costs of 5G network infrastructure development are counted as many trillions of rubles. The 5G cell tower antennas will be complemented and integrated with **space communication systems**, which means the communication with satellites. **Thousands of new satellites** are planned to launch by 2020 to ensure that every inch of the planet is sufficiently irradiated to support ubiquitous high-speed wireless communications.

5G will significantly increase the emission of microwaves and millimeter waves in our environment. The technology will also use new frequencies that have not been tested by independent experts for their impact on humans.

Most of the advantages noted in the Concept (The Concept, table 1.1, pp. 15-18) can be achieved in 4G LTE networks (this is rightly noted in the Concept). This is true except the case that the number of devices will exceed 100,000 devices per km². However, there is no reason to believe that this amount will be exceeded in Russia in the near future (possibly in the next 100 years). The population density of Moscow, the largest city in the Russian Federation was 4,956.06 people/km² on January 1, 2020 [Website about countries, cities, population statistics of Russia, n.d.]. It is absolutely incredible to assume that this density will increase many times because it will require the birth of more than 7-10 children in all families or the possession of 20 smartphones by everyone.

The Concept considers the Internet of Things, augmented reality, virtual reality and machine-to-machine communication capabilities to be the main advantages of 5G networks adoption, as well as the introduction of the "smart home" and "smart city" concepts.

5. WHAT IS THE INTERNET OF THINGS?

The Internet of Things (IoT) is a technology able to connect all possible “things” (all machines, appliances, objects, devices, animals, insects and even our brain) to the Internet. In addition, the IoT will include **artificial intelligence** (AI), **augmented reality**, **virtual reality**, **robots**, **microchipped humans** and **augmented humans**.

Augmented reality (AR) is a service that is able to introduce additional auxiliary information into the perception field of any sensory data with the help of a computer in order to supplement information about the environment and improve the perception of information. For example, mixing real and fictional objects in films and computer games. This service is expected to be widespread in medicine, in the control of an aircraft, a tank, etc.

Augmented humans are people with some form of technology implanted or integrated into their biology to "improve" human characteristics, abilities, or capabilities.

IoT sensors and **surveillance cameras** will also be widespread in our society. The new cyber-physical systems of the Internet of Things will make all objects “smart”, because of the connection to the cloud. That will allow ubiquitous **machine-to-machine communication** (M2M) and **massive data collection**. The problem is that it will open us to **destructive cyberattacks** as well.

Some of the IoT products currently being manufactured include self-driving cars, clothing, toasters, and coffee makers. Even baby diapers and pacifiers are being made “smart”. There are “smart mattresses” (with infidelity detection systems), “smart toothbrushes” which record and notify how well you brush your teeth, tablets with Wi-Fi which share medical information with your doctor, and “smart toilets”. The IoT even includes sex bots, bluetooth tampons and baby capsules that mothers can insert to serenade their unborn child, and even “smart condoms” to measure effectiveness.

Every IoT “thing”, including robots, sensors, CCTV cameras and augmented reality will generate personal usage data that will be mined, stored and used by government, law enforcement, industry and hackers at their desicion.

Every IoT “thing” will increase our exposure to EMP which is known to negatively impact on both humans and wildlife.

Governments and companies are promoting the IoT as a panacea for all ills, although the IoT itself poses a threat. After studying this information, you can decide for yourself: are the benefits of 5G and IoT so great and do they outweigh the serious damage they cause. This will allow you to make a substantiated decision whether to buy 5G/IoT or not.

Let's highlight nine main ways with a help of which 5G and the IoT will cause serious damage to people, wildlife and our Earth.

1. **Health Damage** - numerous *independent* scientific studies have shown a serious threat to human health from microwave radiation.

2. **Personal privacy threat** - an invasion of our privacy as a result of our digital data collection and processing, often even without our consent.

3. **Cybersecurity threat** - the constantly increasing destructive cybersecurity risks.

4. **Environmental damage** - damage caused to wildlife - animals, plants, microorganisms, insects, in particular bees, butterflies and other pollinators.

5. **Power supply threats** - powering 5G networks will require millions of new telecommunication stations and many new interoperable devices increasing overall energy consumption. All the advances in energy efficiency will vanish because of a huge number of new devices.

6. **The threat to the human brain** both at the stage of its development and during its functioning includes various types of brain cancer, impairment of brain functional abilities and even its degradation, as well as the potential ability to control human behavior.

7. **The damage from e-waste** is the huge waste of the electronics industry that will be generated when every "thing" is connected to the internet.

8. **"Conflict resources" issue** - 5G and the IoT will significantly increase our dependence on "conflict resources" (tungsten, tantalum, tin and gold), the struggle for which has already resulted in the deaths of nearly 6 million people.

9. **Ethics issue** arising from the IoT. Ethical issues will require to consider new human rights laws and determine the attitude of people towards robots and artificial intelligence. The blurring of concepts such as human rights, intellectual property rights (in particular, those created by the computer) of everything that was once clearly delineated between technology and people.

In addition to this, almost all IoT tasks are achievable using 4G LTE networks, since the restrictive requirement for users with high mobility (from 10 km/h to 120 km/h) provides a data transfer rate of 100 Mbit/s (which is sufficient for self-driving cars), and for users with low mobility (up to 10 km/h) the transfer rate is from 1 Gbit/s (which is enough for all the needs of the "smart home" and the absolute majority of the needs of the "smart city". This means that the development of 4G LTE networks will allow completing all the tasks but will cost **thousands of times cheaper**. The forecasts of Russian population needs in 5G networks, presented in the Concept, do not stand up to criticism, especially against the background of forecasts of a reduction and impoverishment of the population. Forecast showing that the population is eager to pay much more for non-obvious advantages in the current conditions cannot be considered scientifically substantiated.

The only ***scientifically substantiated*** obvious advantages are noted in the last line of Table 1.1 of the Concept (The Concept, table 1.1, p. 18). These advantages are for the military. "This is ultra-high reliability and high speed radio connection, for remote control vehicles, in emergency situations, work in conditions of fast moving objects and the presence of obstacles." That can help to automate the control of supersonic missiles for which 5G networks are clearly needed. In addition to this opportunity the military expects many others from these networks.

6. WHAT IS THE MILITARY EXPECTING FROM 5G NETWORKS?

Currently, a number of companies in the world produce equipment for 5G mobile networks. Among them are Nokia, Samsung, Ericsson, but the largest manufacturer is the Chinese company Huawei. Therefore, the US administration sees the network equipment produced by Huawei as a threat to national security, even though there is no confirmation of the possibility of conducting secret surveillance through the 5G networks built by Huawei so

far. In addition, the military are worried about the question if the country's 5G network can be completely disabled by the enemy in case of war. However, one thing is clear: the 5G network can already be seen as a ***critical infrastructure*** worthy of protection even before it is built. This is so important because no country wants its telecommunications systems and its "Internet of Things" (planes, electrical grids, dams, etc) to be open to a remote enemy attack.

While earlier technologies have been upgraded to create more and more advanced smartphones, 5G is not only designed to improve their performance, but mainly to connect digital systems that need massive amounts of data in order to work automatically. The most important 5G applications will be for the military and not for civilian use. The opportunities offered by this new technology are explained by defense applications of 5G network technology which were presented by the Defense Science Council, a federal committee that provides scientific advice to the Pentagon. Military experts foresaw that the commercial 5G network, built and activated by private companies, would be used by the US military at a much lower cost than the cost in the situation when the network was built solely for military purposes.

So what kind of military revolution is 5G expected to bring around the world?

1) 5G could play a role in the adoption of ***hypersonic weapons***. Hypersonic weapons under development are able to travel at five times the speed of sound, fly at very high altitudes and follow unpredictable flight paths, easily bypassing existing missile defense systems. Therefore, it is very difficult to intercept them, but it is also very difficult to direct them. 5G will be part of hypersonic defense systems. An aircraft carrier, military base, or even a city will have less than a minute to react to an approaching hypersonic missile. Therefore, protection against hypersonic weapons will require incredible amounts of data obtained using artificial intelligence in real time on targets and trajectories.

2) 5G will enable "***smart" military bases***. The military believes that 5G is ideal for providing smart military bases and command posts because such network has a high transfer rate of large amounts of data, but a very short range. This will prevent the enemy from detecting it as 5G millimeter-wave signals do not travel far [5G for Warfighters, 2019].

3) 5G will make able to create a more powerful ***"combat network"*** as the low latency and high capacity of 5G will allow armies to exchange large amounts of data in real time. The data may include maps and photographs of battle scenarios, as well as computer simulations. The recent US Defense Innovation Board report makes a statement that "The true potential of 5G will lie in its impact on the combat network of the future" [Milo M. and Gilman L., 2019]. It is also stated that the network will increasingly include a large number of cheaper, more connected and more resilient systems to function in a rapidly evolving battlefield. An equally important fact that the network will improve situational awareness and decision-making as well as logistics and maintenance is described in the report.

4) 5G will enable multiple ***"portable combat devices"*** that will allow up to a million connected devices per square kilometer, such as sensors that collect and transmit data over the 5G network. If you strap a smartwatch and a bunch of biometric wearables to soldiers you can get vital statistics on them - geography, heart rate, blood pressure and fatigue. It is supposed to use augmented reality devices such as Google Glass, similar to those already used by pilots, but with real-time streaming data. So the fact is that information about what is happening on the battlefield will completely change using 5G.

5) The military is relying heavily on ***unmanned aerial vehicles*** or ***drones***. They are already actively used by the military, but they do not transmit or exchange information in real time using 4K video and other data with command and control centers and units on the battlefield. 5G enables 4K video transmission, object recognition, much faster data processing and the use of artificial intelligence to aid intelligence missions and provide army units with

information about what they are about to face [Pellerin, 2017]. 5G can also be used in more accurate and intelligent weapon targeting.

6) Currently, the US Army is already actively using ***non-lethal directed energy weapon***. The weapon is called *Active Denial System* (ADS) which is an active defensive response system used mostly for protecting the restricted area, perimeter security, crowd control (to disperse the crowd) and guarding the prisoners. ADS was developed by the US defense company Raytheon [DoD Non-Lethal Capabilities, 2019].

On June 21, 2010, Lt. Col. John Dorrian, spokesman for NATO Force Commander Gen. Stanley McChrystal, confirmed in an email to Wired Magazine correspondent Noah Shechtman that ADS had been deployed in Afghanistan. However, it was removed from service. A US Department of Defense spokesman stated that the ADS withdrawal from Afghanistan was unexpected, that it was a missed opportunity and that the non-lethality of the ADS system could prove useful in counterinsurgency operations where civilian casualty avoidance is essential to mission success [Active Denial System, nd]. A public demonstration of ADS to the media was held on March 9, 2012 at QUANTICO Marine Base, Virginia (USA). There the Marine Corps Commander General James F. Amos invited senior officers and media representatives to examine the new non-lethal weapon in action, as detailed by the official US Department of Defense source DVIDS [DVIDS, 2012].

The ADS directs a powerful 95 GHz wave beam, which corresponds to a wavelength of 3.2 mm, at the target. ADS is supposed to work on the same principle as a microwave oven, energizing water and fat molecules in the skin and instantly heating them using dielectric communication. One difference is that the microwave uses a much lower frequency of 2.45 GHz. The short millimeter waves used in ADS only penetrate the upper layers of the skin, with most of the energy absorbed within 0.4 mm, while microwaves penetrate about 17

mm into human tissue. Most humans reached their pain threshold within 3 seconds and no one could withstand the impact more than 5 seconds. Anyone unable to leave the target area (e.g. physically handicapped, infant, disabled, trapped, etc.) will continue to receive radiation until the operator turns off the beam. The US Air Force Special Operations Command experimented with the installation of ADS on the AC-130J Ghostrider attack helicopter, both to engage crowds and individuals.

Mark Steele says that "5G is powerful enough to kill babies in the womb. It has nothing to do with telecommunications for humans. 5G is a vehicle-to-vehicle connection for autonomous vehicles" [UK's First 5G Court Case and Mark Steele Won, 2020].

Thus, it becomes obvious that 5G networks are being developed in all countries largely at the expense of the state budget in order to reduce US government (especially the US Department of Defense) spending. So the main purpose of 5G development is to ensure the US national military interests and shift the burden of these expenses to developed countries government spending. And building a satellite communication system covering every square centimeter of the Earth's surface is worth hundreds of trillions of dollars. Thus, shifting these costs onto the budgets of all economically developed countries of the world can be considered the largest diplomatic victory for the United States, since the Pentagon will be the main beneficiary of the 5G networks development. The frequency bands planned for 5G were assigned mainly to the military, various special services, the Ministry of Emergencies and the police until now. And only the calculation of shifting the infrastructure development costs of 5G networks onto the shoulders of civilians forced the military to share their frequency range.

However, the question remains: how the development of 5G networks will affect the population of all countries of the world, especially the health of the population.

7. RISKS AND PROBLEMS ASSOSIATED WITH 5G NETWORKS

In October 2019, Joel M. Moskowitz, Ph.D. published an article in Scientific American titled “We have no reason to believe 5G is safe” [Moskowitz, 2019]. Hundreds of scientists from all over the world agree with his opinion. Why did they all come to the conclusion about the **danger of 5G networks**? Why do they consider deploying 5G infrastructure a **very unreasoned idea**? Because the analysis of the latest scientific articles and reports from 2020-2021 on the adverse consequences of the 5G networks development allows coming to this conclusion.

This research has been expanded significantly during the past decade. There are many facts in the literature indicating the ability of high-frequency (3 MHz - 300 GHz) electromagnetic fields to affect biological systems, interfering with some regulation and control processes. However, nowadays the mechanisms of EMP exposure to humans have not been sufficiently studied. In any case, its impact depends on the characteristics of the electromagnetic field, in particular, on the exposure time (chronic or acute), frequency and type of modulation. Much evidence has been obtained stating the impact of EMP in far-field conditions, leading to a decrease in the functionality of cells, in particular, the olfactory system, which are typical glial cells with stem cell characteristics. A decrease in the functionality of the olfactory system is an early sign of neurodegeneration.

The adoption of 5G networks has been hotly debated during the recent years, including the proximity of transmission towers to homes, schools and hospitals. These questions are especially interesting due to the fact that, for example, in Moscow (Russia) these towers are located in close proximity to schools, hospitals, grocery stores, playgrounds, and public places. And although in the United States these issues are the subject of heated public discussion, especially in the state of California, in Russia such discussions are practically

absent. And this is despite the proven fact that electromagnetic radiation has a negative impact not only on humans, but also on animals, plants and even the beneficial microflora of our intestines.

For more than 20 years commercial propaganda in the mobile device industry has argued that all evidence of EMP hazards is false. Research over the past 10 years clearly shows that we can debunk the claims of the telecommunication companies that there is no mechanism for the impact produced by these weak electromagnetic fields. Now there are thousands of studies proving the adverse health effect of EMP.

It is surprising that 5G has never been tested for its impact on public health or the environment. RF microwave radiation used in previously released mobile phones and other wireless devices was classified as a Potential Human Carcinogen (Group 2B) by the International Agency for Research on Cancer (WHO) in 2011 [IARC, 2011]. This radiation was named "probable carcinogen" by experts in 2015. A recent research carried out by the US National Institutes of Health has confirmed this finding. Research has also shown that exposure to radio frequency radiation can impair the normal development of the fetus's brain and impairment of learning, cardiac abnormalities and electrohypersensitivity. Famous individuals with recognized electrohypersensitivity include Gro Harlem Brundtland, former 3-time Prime Minister of Norway and former Director General of the World Health Organization; Matti Niemelä, former technical director of Nokia; as well as the wife of Frank Clegg, who previously headed Microsoft Canada.

Population groups that are most exposed to this type of radiation include pregnant women, children, people with implanted medical devices, people who are sensitive to electromagnetic radiation and the elderly. In addition, millimeter and submillimeter waves have unique impact on human health. The sweat ducts inside our skin, the largest organ in the human body, act as antennas in contact with electromagnetic waves. The waves penetrate

through 1-2 millimeters of human skin tissue and are also absorbed by the surface layers of the eye cornea.

Plants and animals also suffer from wireless radiation. Studies have shown that electromagnetic radiation from mobile phones damages trees [Waldmann-Selsam et al., 2016]. Some other researches have identified that RF radiation changes the composition and structure of plants [Halgamuge, 2017].

Many studies also point to wireless technology as a contributor to the decline in the populations of birds, frogs, bats and honey bees. Also, millimeter and submillimeter waves can make bacteria resistant to antibiotics. The proof is that one research analyzing the interaction of these waves with bacteria has shown that the waves can cause changes in bacteria's sensitivity to various biologically active chemicals, such as antibiotics. The research reports that there is a risk of the waves creating antibiotic resistance in bacteria that can cause a serious concern in the medical community [Soghomonyan et al., 2016].

The impact of 5G networks on human health

Currently there is no standard for 5G networks, but most likely it will be a combination of different frequencies and modulations. Hundreds of articles in peer-reviewed scientific journals indicate that current 2G, 3G and 4G wireless technologies, used by our mobile phones, computers, and wireless technologies, create radio frequency exposures that pose serious health threat to humans, animals and the environment. Scientists warn that there must be a human health impact research before the adoption of 5G networks to protect the public and the environment [International Appeal, n.d.].

Modern cellular and Wi-Fi networks use microwaves, a type of electromagnetic radiation that uses frequencies up to 6 GHz, to transmit voice or data wirelessly. However, 5G

applications will require the discovery of new spectrum bands in higher frequency bands above 6 GHz - to 300 GHz and beyond. That will be done using submillimeter and millimeter wavelengths to deliver ultra-high data rates in the same time frame compared to previous microwave deployments. Modern researches on wireless frequencies in the millimeter and submillimeter range confirm that these waves interact directly with human skin, in particular with the sweat glands, which act as an array of spiral antennas when exposed to these wavelengths [Parliamentary Assembly, 2011].

The fact that 5G is qualitatively and quantitatively different from 4G and all networks of previous generations can be especially emphasized. As was mentioned before, the rules defining the safety level of electromagnetic radiation were established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) on the assumption that if electromagnetic radiation does not cause human tissue to overheat, then humans and society will be protected. The Commission believed that exposure to humans in the worst case would cause the water to heat up inside the cellular tissue. ICNIRP considered that the heat would just dissipate, similar to the process in microwave, but at much lower energies.

There has been ample evidence of non-thermal biological effects resulting from the interaction of body tissues with radiation since the establishment of the ICNIRP rules in 1998. When an ordinary electromagnetic field affects the human body, it penetrates the tissues by about 15-20 mm and makes charges move and enhances the flow of all fluids: blood, lymph and intercellular fluid. But in the case of 5G, very short electromagnetic pulses act on the body, which transform the moving charges into small antennas, rearrange the electromagnetic field and send radiation deep into the body using all electrically conductive structures capable of carrying currents. Even the shallow penetration of 5G radiation poses a particular threat to the eyes and to the largest organ of the body - the skin. O. Gandhi stated that millimeter waves are strongly absorbed by the cornea and that ordinary clothing one millimeter thick

increases the absorption of energy by the skin due to resonance [Gandhi and Riazi, 1986]. In addition, 5G radiation damages the cardiovascular system, the immune system and leads to DNA damage. These facts forced 298,272 scientists and environment protection organizations from 214 countries to sign an appeal to the UN, WTO, EU, Council of Europe and the governments of all states to immediately stop the adoption of 5G wireless networks on Earth and in space [International Appeal, nd]. This appeal proves that the deployment of 5G is an experiment on humanity and the environment that is defined as a crime under international law.

8. ARE THE COSTS OF 5G DEVELOPMENT JUSTIFIED?

To make conclusions about the justification of 5G networks development a risk-cost-benefit analysis should be carried out. Two documents published by supporters of the 5G networks development in the Russian Federation will help in the analysis [The concept, 2020; Mechanik, 2020]. The documents summarize all the official facts about the main characteristics of 5G networks, their advantages, capabilities, limitations, development costs and much more. The first step is to analyze the obvious and hidden advantages and disadvantages of the 5G networks development, to compare them with other problems (with Russia as the example) and to compare the costs and prospects of solving these problems.

The classification presented in the article divides the advantages of the 5G networks development into ***explicit***, ***implicit*** and ***hidden***.

1. **The explicit advantages of 5G development**. An article in Expert journal [2] notes that 5G networks promise consumers three important things: high data transfer rates (1 Gbps on average, more than 10 Gbps at peak), guaranteed ultra-low latency of information transfer (1– 10 ms) in combination with ultra-reliable delivery and the ability to simultaneously

connect a huge number of devices (up to 1 million per 1 km^2 per one telecommunication station. As stated in the Concept (The concept, 2020, table.1.1, p. 15-18), in 4G LTE Advanced networks, the total bandwidth can be reached up to 100 Gbps/km^2 with a delay of up to 7 ms. Therefore it is necessary to clarify which cases require more bandwidth and lower latency. The author of the article in Expert journal explains what technologies require more reliability of 5G networks (this is missing in the Concept): "... **this is the so-called critical Internet of things, which includes devices that send very important information, the loss of which should not exceed 10^{-5}, and provide very low latency, no more than one millisecond**." This is a group of IoT devices that are associated with the management of some other devices. And such devices are no longer drones (for them it is superfluous), it is only necessary to control missiles, in particular (and especially) supersonic missiles.

As for the simultaneous connection of a huge number of devices, which is noted as the most important advantage of 5G networks, the number of devices in 4G LTE Advanced networks can connect up to 100,000 devices per sq. km. With the population density less than 5000 people/km² (01.01.2020) of the most densely populated place in the Russian Federation - the city of Moscow, it is difficult to imagine a situation with such a concentration of gadgets even in the capital, not to mention other territories of Russia. As it was mentioned before, such a density will require the birth of more than 7-10 children in all families or the possession of 20 smartphones by everyone.

Scenarios with an ultra-high concentration of IoT sensors in certain zones (production, infrastructure) [The concept, 2020] that will require the adoption of 5G networks in Russia seem unlikely. In some places, there are still pre-war or even pre-revolutionary equipment in use by the industry, and in many regions the condition of the roads is the same as it was before the revolution.

Remote control of production equipment and facilities, production management, transmission and consumption of electricity ("smart" networks) that require more reliability of 5G networks (as mentioned in the Concept) are possible to adopt using 4G LTE Advanced. The use of drones for surveillance and delivery, as well as partial automation of the transport system are also possible with 4G technology [The concept, 2020].

Thus, the explicit advantages of 5G development noted in Expert journal [Mechanik, 2020] are questionable even with a superficial analysis. There is a reason to believe that these advantages are not so obvious.

The author of the article in Expert journal comes to a conclusion that 4G is quite enough for ordinary users because this standard already allows you to watch streaming videos and play resource-intensive games without significant inconvenience. Viktor Zefirov, vice president of Zelax, concluded “From the point of view of a person with a smartphone or tablet, 4G or 5G makes little difference whether I download a movie in fifteen minutes or five” [Mechanik, 2020].

If the explicit advantages of 5G development apparently are not obvious, then the tricky question arises: why developed countries and their IT companies are so eager to develop 5G networks. This is clearly answered by the author of the article in Expert journal, who analyzed the results of a research conducted by Qualcomm Inc., a well-known developer and researcher of wireless communications. The answer is that the total economic effect of the 5G networks development around the world by 2035 is able to exceed $ 13 trillion. **This fight is for big money.** When that amount of money is at stake, then all other issues go into the background, including ethical issues, health issues, state interests, national values, etc.

2. **The implicit advantages of 5G development**. The implicit advantages of 5G development are those advantages that are not mentioned either in the Concept or in the

article in Expert journal, but which are partially described in our previous articles. These advantages may be decisive. It is about military advantages. Indeed, only 5G networks can provide both control of hypersonic missiles and the anti-missile defense against such type of weapon; only they will allow the creation of "***smart military bases***", a powerful "***combat network***", the use of numerous "***portable combat devices***" and much more.[4]

In any case, the implicit advantages of 5G development, noted in the article, seem to be obvious and undeniable even with a superficial analysis. The fact that with the huge benefit of the technology for the military this technology is intensively developed by the civilian services of the developed countries of the world is explained quite simply. For the military the costs of hundreds of trillions of dollars for the complete construction of the infrastructure for 5G network system are too high even for the United States. And when these expenses are distributed among all the developed countries of the world this is a great success for American diplomacy, which has achieved the protection of the US national military interests at someone else's expense.

3. **The hidden advantages of 5G development**. The hidden advantages of 5G development not mentioned either in the Concept or in the Expert journal article, but there is a significant probability that they are decisive. These advantages imply the capabilities of 5G networks that are already being used by the US Army as a "***new non-lethal weapon***". Such weapon has been used during counter-insurgency operations to prevent civilian casualties, to effectively disperse demonstrations, to defeat both crowds and individuals. But 5G devices will be equipped with multiple antennas organized into “phased array antennas” [De Grasse, 2016], collectively transmitting focused, laser-like beams that track each other.

When the system is fully deployed, the technology of 5G networks potentially has the ability to track the location of any person. And if there is a face recognition system and a

[4] More details can be found in the previous article: Kharchenko, S.G., Zhizhin, N.K. (2020b). “Fifth generation of wireless networks (5G): Problems and risks.” *Ecology and Industry of Russia*, vol. 24, no. 12, pp. 58–65. (In Russ.) Accessed June 25, 2021, from https://doi.org/10.18412/1816-0395-2020-12-58-65.

unified federal information register of the population, such technology will allow tracking any person anywhere on planet Earth. The technology allows even exposing humans to strongly focused beam which can even kill persons by "frying the brains." That is, 5G networks provide such a hidden advantage as police functions, in particular, they provide all issues of total surveillance of any person without the introduction of any chips. This advantage alone can justify the investment of any money.

China has already effectively tested these police functions during the coronavirus epidemic. Sergei Sobyanin in Moscow successfully proved that police functions can be successfully provided without the help of the 5G network, having collected more than 30 thousand fines from the population for violating self-isolation during the coronavirus epidemic (in particular, using a video surveillance system).

Adverse consequences of 5G development. In order to assess whether the development of 5G networks is justified it is necessary to consistently assess not only the advantages, but also the adverse consequences of the 5G networks development.

The adverse consequences of the 5G development (partially summarized in [Kharchenko, Zhizhin, 2021a, 2021b; Kharchenko, Zhizhin, 2020a, 2020b]) are still not so obvious for people and require more thorough research. However dozens and hundreds of scientific papers and expert conclusions already suggest that these consequences can be catastrophic and irreversible because they are global.

Susan Foster of the EM-Radiation Research Trust (USA) emphasized the important fact that there is no established safe level for 5G millimeter wave radiation, there have been no tests of 5G 24/7 exposure to animals and humans and there is no health and safety

department at the FCC, but still human health and safety has been entrusted to FCC [Foster, 2020; Karaboytcheva, 2020].

A recent report by Dr Shirin Joseph of the US Radiation Research Foundation, released on August 28, 2020, noted that 5G is likely to do more damage than all its predecessors [Analysis of 5G and Its Implications in the UK, 2020]. The report argues that real negative nonthermal biological effects arise directly from low levels of electromagnetic radiation, that are orders of magnitude below the current safety limits, set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). And as it was proven by many studies, the ICNIRP norms are deeply erroneous. In fact the ICNIRP safety guidelines are false because negative nonthermal biological effects occur about 100,000 times below current acceptable levels. These principles ignore many important indicators of EMP, such as biological heterogeneity, the pulsed nature of EMP, complex sinusoidal dose-response curves and many others. Such indicators cause adverse effects like oxidative stress, free radical damage, increased intracellular calcium levels causing chronic effects, damage to cellular DNA, decreased adaptive immune responses and even complete dysregulation of the immune system. Cardiac effects include tachycardia, bradycardia, arrhythmias and ventricular defects. Effects on brain include neurological/neuropsychiatric effects, sleep disturbance and impairment of memory, motor skills, attention and cognitive functions. Other effects include cancer (initiation, development and progression), pathological damage to several organs (for example, liver, kidneys, uterus, bladder, testicles), microelement disorders in tissues, damage to the eyeball, decreased fertility, hormonal dysregulation and other damage.

Moreover, EMP emitted from 2G-4G is already causing these non-thermal, negative biological effects at levels 1000 times lower than those established by ICNIRP as safe, so 5G will not be safer. The level of EMP emitted from 5G facilities is 150,000 times higher than its

maximum for 2G-4G (acceptable ICNIRP levels). Overall conclusion from Dr Shirin Joseph's report is: "We are guinea pigs in this experiment and are exposed without any safety tests."

In the scientific research of Naren and the others [Naren et al., 2020] it is emphasized that if 5G networks are deployed without careful analysis of the expected exposure levels, then almost all people in the coverage area could be exposed to hazardous levels of power flux density, the consequences of which in the near future could be disastrous.

To make a conclusion about the justification of the 5G networks development it is necessary to carry out an uncertainty analysis, which includes a risk-cost-benefit analysis.

The methodology of this analysis requires answering a number of questions. The questions are analyzed below.

1) *What is the nature of the risks* associated with the exposure to EMP? How serious are their potential consequences? Are they reversible?

2) *What is the probability of each person being exposed to EMP* at a given point of space? How does the hazardous exposure cumulate over time? Is the exposure once in a short period of time, in multiple episodes, or could it be chronic over a longer period of time?

3) *How strong is the hazardous effect?* What is the relationship of exposure or "dose" to response?

4) *How is the hazardous exposure distributed?* In particular, which groups receive a disproportionately high proportion of hazardous exposure?

5) *What is the sensitivity of different social groups to hazardous exposure?* What is the appropriate damage assessment for highly sensitive groups of people that are exposed to hazardous exposures? What are these population groups (for example, babies, children, pregnant and lactating women, retirees, etc.), where are they located, and what part of the total risk are they exposed to?

6) *How do existing hazardous exposures interact with exposures to other hazards?* Sometimes one exposure can make people more sensitive to another hazard. It is called a synergistic effect. But sometimes exposure to one hazard can even reduce sensitivity to another - blocking exposure. What is known about such effects?

7) *What is the quality of the hazard?* What organs and tissues are affected by this hazard, can people reduce or eliminate the impact on them (and what is the cost)? Many of these questions about risk have not been answered yet. The world scientific community is urging governments of all countries to stop adopting 5G networks until all these questions are answered.

However, it is also necessary to answer questions about the benefits of 5G networks adoption, in particular:

8) *What are the benefits of a 5G network? Who benefits, and in what ways?*

9) *How many people are benefiting? How long do benefits last?*

10) *Which groups receive a disproportionate share of the benefits?*

11) *What is the probability that the projected benefits will actually result from the activity in question? What uncertainties might intervene to prevent those benefits from being obtained? What is the probability of these uncertain events? Which part of the population will benefit, and which will be the risks from the adoption of 5G; how likely are the benefits/risks to occur and what circumstances may prevent this?*

There is no information required to assess the risks and benefits of 5G adoption. Experts debate the accuracy or reliability of the data that is available. This data is insufficient to confidently extrapolate an estimate of the risks (or benefits) for the entire population. However, only a complete analysis of the risks and possible benefits can provide an answer to the question of the justification for the 5G networks development.

Risks and problems of 5G Networks development
in Russia and in the world

At the moment, it is quite obvious that the main benefit from the adoption of 5G networks will be received by telecommunications companies, telecommunication equipment manufacturers - all those who have created and will create the infrastructure for 5G networks. In 2019, the Ministry of Industry and Trade of Russia considered the allocation of about 28 billion rubles (about 379 million dollars) for the next 5 years, which were going to be divided among the program participants - the state corporations Rostec and Skoltech.

The number of benefiting is a maximum of a million people (the number of all employees of IT companies), while the owners of these companies (usually living abroad) receive a disproportionate share of the benefits. Thus, a significant part of the money received will be deposited in foreign banks. It is also necessary to remember about significant percentage of corruption kickbacks (taking into account the domestic experience of Olympic construction projects, the construction of the Vostochny cosmodrome and other large projects).

An important issue is that **even if the advantages of the 5G networks development were obvious and achievable** and the disadvantages are insignificant, can the costs of solving this problem be considered a priority over the solution of other long-standing problems of the state? That major problems include depopulation, deterioration of health, medicine, education and living standards of citizens, an increase in retirement age. The problems are worsen by the facts that the state cannot allocate several billion rubles to provide wheelchairs for disabled people [Report, 2020], and the Accounts Chamber revealed that “on January 1, 2019, 14% of the 116,865 buildings, in which medical care is provided, were in emergency condition, 30.5% had no plumbing, 52.1% had no hot water supply, 41.1% had no central heating, 35% had no sewerage and in 47% there was no accessibility for the disabled

and other low-mobility groups" [Bulletin, 2020]. In such conditions the relevance of IoT with its "smart" coffee makers and condoms is highly questionable.

All the state problems listed above require significantly less public investment than the development of 5G networks. The state's desire to solve these problems is written in the Constitution, therefore doubts arise whether we can consider the costs of trillions of rubles (in the future) justified for the development of 5G networks in such conditions.

The analysis that was carried out in the article casts doubt on the justification of spending trillions of rubles for the development of 5G networks in the Russian Federation.

But in addition to monetary assessments there are also moral ones, based on moral and ethical principles developed by the entire history of modern civilization and enshrined in a number of international rules.

The Nuremberg code (1949) [The Nuremberg code, 1949] is applied to all human experimentation, thus the adoption of 5G with a new, higher exposure to RF EMP is also included. According to this code, all such experiments must be based on previous knowledge (eg, expectations derived from experiments on animals) that justify the experiment (art. 3). «No experiment should be conducted, *where there is an a priori reason to believe that death or disabling injury will occur;* except, perhaps, those experiments where the experimental physicians also serve as subjects.» (art. 5). Already published scientific studies show that there is "*a priori reason to believe*" that there is a real threat to human health from the 5G technology.

In 2005, the EU (UNESCO) adopted ***The Precautionary Principle***, which declares that *when human activities may cause morally unacceptable damage to the environment, human, animal or plant health, that is scientifically substantiated but uncertain, measures should be carries out to prevent or mitigate this damage* [Communication from the Commission on the precautionary principle, 2000; The Precautionary Principle, 2005].

Resolution 1815 of Council of Europe in 2011 stated [Parliamentary Assembly, 2011], that the potential hazards of electromagnetic fields and their effect on the environment require to: «…*take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumours».* The Assembly *strongly recommends* to *«apply ALARA principles* (ALARA – as low as reasonably achievable, which means *reducing risk to a reasonably achievable level, with economic and social factors taken into account), covering both thermal effects and the athermic or biological effects of electromagnetic emissions or radiation»; and to «improve risk-assessment standards and quality*». Such recommendations mean, that if it is not possible to establish the degree of risk of exposure to EMP on the population and the environment with sufficient certainty, the ALARA principle should always be applied.

It is impossible not to quote a few powerful arguments from the 5G Appeal (2021).

1. The European Environment Agency (EEA) is warning for ”Radiation risk from everyday devices” in spite of the radiation being below the WHO/ICNIRP standards. EEA also concludes: ”There are many examples of the failure to use the precautionary principle in the past, which have *resulted in serious and often irreversible damage to health and environments* … harmful exposures can be widespread before there is both ‘convincing’ evidence of harm from long-term exposures, and biological understanding [mechanism] of how that harm is caused.” (5G Appeal, 2021).

2. The current ICNIRP «safety guidelines» are obsolete. All proofs of harm mentioned above arise although the radiation is below the ICNIRP «safety guidelines». Therefore new safety standards are necessary. The reason for the misleading guidelines is that «conflict of interest of ICNIRP members due to their *relationships with telecommunications or electric*

companies undermine the impartiality that should govern the regulation of Public Exposure Standards for non-ionizing radiation…To evaluate cancer risks it is necessary to include scientists with competence in medicine, especially oncology.» (5G Appeal, 2021).

3. The current ICNIRP/WHO guidelines for EMF are based on the obsolete hypothesis that ”The critical effect of RF-EMF exposure relevant to human health and safety is heating of exposed tissue.” However, scientists have proven that many different kinds of *illnesses and harms are* caused without heating (”non-thermal effect”) at radiation levels well below ICNIRP guidelines. (5G Appeal, 2021).

The traditional Russian question, from which everything begins and ends: what to do? Is there a protection from 5G radiation? First of all, everyone should pay attention to the appeal of scientists around the world, which says that “If the telecommunications industry's plans for 5G come to fruition, no person, no animal, no bird, no insect and no plant on Earth will be able to avoid exposure, 24 hours a day, 365 days a year, to levels of RF radiation that are tens to hundreds of times greater than what exists today, without any possibility of escape anywhere on the planet. These 5G plans threaten to provoke serious, irreversible effects on humans and permanent damage to all of the Earth’s ecosystems” [International Appeal, (nd)].

Therefore, parliamentarians should immediately discuss the possibilities of legislative restrictions on the 5G networks deployment. The government and big business should decide whether they are going to continue to live on this planet, in this country, to raise children and grandchildren here, or if they intend to spend the rest of their lives in protected bunkers, where their children and grandchildren will observe life through a window or through a computer display.

9. CONCLUSION

In 2015, 225 independent health scientists from 41 countries, who have published a total of more than 2,000 papers on the health impact of EMP, signed a petition to the United Nations and Member States stating that current EMP safety guidelines are inadequate because they do not account for non-thermal effects. On July 23rd, 2021, there are 298,272 signatories from 214 nations and territories.

Results of a successful struggle. Dr. Devra Davis, President of the Environmental Health Trust, analyzed the actions of governments in several countries to counter the dangerous impact of EMP. In California (USA), firefighters lobbied for their safety and successfully received exemption from the installation of cell towers on their territory for health reasons. In India, the Indian Supreme Court upheld the decision of the Rajasthan High Court to remove all cell towers from the vicinity of schools, hospitals and playgrounds due to life-threatening radiation. In Chile, the Antenna Law (2012) prohibits the installation of a telecommunication antenna/tower in “sensitive areas” [International Policy Briefing, 2016]. In Estonia, an appeal on the introduction of a moratorium on the deployment of the fifth generation of 5G wireless communications was signed by 1,122 subjects, forcing a hearing in the Social Affairs Commission and the Environment Commission of Estonian Parliament on June 4, 2019. At these hearings, it was confirmed that the 5G network is technically different from the previous generations. The new technology use complex beam transmissions in both directions - from the telecommunication station to the handset and vice versa. Although the fields are highly focused by the beams, they change rapidly over time and with movement and thus are unpredictable [Hardell, 2019; 2020].

Many of the scientific findings presented at these parliamentary hearings deserve close attention. In particular, it is shown that decision-makers act and base their decisions on expert

opinions that do not have proper scientific justification. And these biased and distorted expert opinions are applied in the legislation. These expert opinions include: 1) misinformed and misleading expert claims about the fact that 5G are “nothing new”, which is not true as 5G will deploy beam-forwarding technology, much wider bandwidth and millimeter waves; 2) “5G is safe”, although the vast scientific researches on EMP make the opposite conclusion; 3) many expert opinions from the experts that have little or no experience in studying the health effects of EMP; most experts who had real experience in studying the impact of EMP on health opposed the adoption of 5G pending proper research on their safety to human health [Hardell, 2019; 2020].

Today, most inhabitants of the Earth believe that a person needs wireless communication like air, and that various gadgets are more tools of entertainment than just means of communication. In particular, social networks have practically supplanted live communication not only among young people, but even among pensioners. The opinion of a significant number of people is "today it is simply impossible to survive without gadgets". However, researches over the past 20 years make the opposite conclusion - with the current trends in the impact of wireless communications on human health the future generation is not destined to survive. And society must urgently put the need to identify “how safe is microwave radiation?” on the agenda.

The fact that extremely low exposure to radiation (0.001 of the safe standard established by the FCC) leads to serious consequences can be explained by the fact that the effect of exposure can accumulate over time, and the body's sensitivity changes with each new exposure to the body. This is due to the systemic response of the body to any external influence [Kharchenko, Dorokhina, 2017].

The EU published an “In-Depth Analysis on 5G Adoption” with recommendations in April, 2019 [Blackman and Forge, 2019]. The main idea of this analysis is that 5G is a more

complex project than previous wireless technologies, and “should be seen as a long-term project to solve technical problems” and widespread use in business. Although 5G technical standards have not yet been approved and their health impacts have not been adequately identified, the EU, the US, China and other countries are already planning to be the first in the deployment of a working commercial network.

The original specifications for the 5G network standard made by ETSI/3GPP SDO were released in 2017. But the rest of this first 5G standard, 3GPP Release 15, appeared in September 2018. It supports 28 GHz mm wave spectrum and MIMO antenna array technologies. It means that 2019 was a key year for working standards, starting with ETSI/3GPP endorsed by the ITU, where 5G was called International Mobile Telecommunications 2020 (IMT-2020).

This document received surprisingly little media attention, was not discussed by politicians and parliamentarians, as well as by officials in different countries, that set guidelines for the adoption of 5G. Most governments and policymakers base their opinions on the facts that are long-obsolete and disproven by hundreds of papers and, in addition, do not seem to be aware of the technical aspects of 5G, which differ from the networks of previous generations.

In September 2017, a large group of scientists and doctors from more than 40 countries (on May 5, 2021 there are already 417 scientists) signed the 5G Appeal to the EU [5G Appeal, 2021], which urges the EU to stop the adoption of 5G immediately due to serious potential consequences for human health and demanded a moratorium on 5G adoption until the conducting the analysis of risks. In September 2017, the Appeal was presented to the European Commission. Most scientists who signed this petition have done significant

research on this subject. On the contrary, the 13 ICNIRP commission members (who approved the adoption) have not carried out any research.

5G will significantly increase exposure to radio frequency electromagnetic fields over 2G, 3G, 4G and WiFi fields. EMP emitted from 5G has been proven to be a hazard to humans and the environment. The appeal notes that with "the ever increasing use of wireless technology", no one can escape exposure. Because in addition to the increased number of 5G transmitters (even inside homes, shops and hospitals), it is estimated that "10 to 20 billion connections" (to refrigerators, washing machines, CCTV cameras, self-driving cars and buses, etc.) will be the part of Internet of Things. The effects of exposure include an increased risk of cancer, cellular stress, an increase in harmful free radicals, genetic damage, structural and functional changes in the reproductive system, learning and memory deficits, neurological disorders, and negative effects on a person's overall well-being. The damage extends far beyond the human race, creating a damaging impact on both plants and animals and bacteria, including vital human microflora that provides immunity and the digestive process.

The Appeal was also signed by several Russian scientists, but the domestic media paid little attention to this problem. Only a few articles are trying to draw attention to the impending threat [Kharchenko, Zhizhin, 2020a; 2020b; 2021a; 2021b]. However, the Appeal had no impact on the adoption of 5G technology so far [Panel for the Future of Science and Technology - Workshop on 5G, 2020].

During the recent years, individual scientists and entire medical associations have been actively discussing the adoption of a new wireless cellular technology - the 5G network. The technology has never been tested for its effects on human health or the environment. All manufacturers declare the complete safety of these devices for health, although every year more and more authoritative scientists declare the opposite. Currently, there is practically no supervision over the current exposure to EMP of 2G, 3G and 4G in all countries of the world.

No one is developing laws to control or assess the impact of 5G on public health [Karaboytcheva, 2020]. The same conclusions were made at the meeting of the STOA group of experts by the European Parliament commission on December 7, 2020 [Panel for the Future of Science and Technology - Workshop on 5G, 2020]. In particular, it was concluded that assessment of the risk of exposure to electromagnetic fields on health and the environment that was carried out by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) is not reliable enough and cannot be used to develop protection policy. And the ICNIRP recommended exposure limits for electromagnetic fields, which are based primarily on the short-term effects of tissue heating, are not protective enough to avoid damage from lower, longer-term exposures that are below the ICNIRP limits. Thus, in the **absence of reliable data** allowing the use of 5G networks without damage to human health, the adoption of these networks must be suspended until the results of the necessary research are obtained.

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