The Times of Scaremongering

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Can the 5G technology affect your health?

We are told that we live in the Information Age. However it looks more like a Disinformation Age. As put by William Casey (CIA Director 1981-1987): *We'll know our disinformation program is complete when everything the American public believes is false!*

For some 30 years we are being told that we are going to be cooked alive because of climate change which we have been causing. Yet after the year 2000 the global mean temperature has been rising at less than one third of the rate predicted by most computer models. Those of us old enough may remember that back in the 1970s the temperatures have dropped by almost 0.5°C from 1950, so climatologists were warning us of a new imminent ice age in the next 50 years. In 2005 we were told that in 10 years our children will not know what snow is. However, in Spring of 2020 we had heavy snowing in North America, Central and East Europe, and South Australia. Weather is not climate, of course, but it was yet another failed prediction nevertheless.

Some say that artificial intelligence will save the world, others say that it will destroy us. Yet we still do not have any proof for the existence of natural intelligence. On the contrary, each time we turn on our computers we get evidence of a questionable level of intelligence of computer programmers.

The downward trend of human intelligence seems to be a wider phenomenon. The quality of school programs is generally declining, mainly as a consequence of dogmatic and *ex cathedra* type of teaching, rather than promoting understanding and cohesive approach to acquiring knowledge.

A quick glance over the titles in the press or electronic news media reveals increasing fears of technology advancement, fears of the influence of fertilizers and genetic modifications in agriculture and additives in food production, fears of influence on the environment, fears of vaccination and pharmaceutical products, and fears of both left and right wing totalitarianism.

There is even a minority who believe that we are in a deep trouble because of too much democracy. Yet I cannot remember the times when we have had too much democracy during the last 65 years, or at any times before. There were revolutions promising us democracy, but all turned up to be hard or harder dictatorships.

And now we are endangered by a virus, that tiny cluster of proteins which does nothing else but uses our cells to multiply and propagate its own RNA. A serious situation, indeed, and those who were unlucky are not just statistically dead, they are truly 100% dead. The rest of us are influenced more by the fear of a possible infection, than the infection itself. The consequences of too lately imposed and thus unnecessarily strict countermeasures will be felt for many years to come and in all sectors, not just the public health, but mainly financial, in form of a significant increase of the national debt and inflation, both caused by government money printing to restart the economy, which those same governments have shut down in panic.

As if that were not enough, there are people who believe that the outbreak of this new virus is the consequence of a strike back by Nature, which is punishing us for all the pollution, not least the electromagnetic pollution caused by the latest 5G communications technology implementation.

In short, it can be said that we live in the times of scaremongering.

Here I want to speak about this latest widely trumpeted but actually imaginary danger from electromagnetic radiation emitted by the new fifth generation communication technology, popularly known as 5G. This network will host mobile phones at first, and all sorts of other devices later, all operating at higher carrier frequencies than the current (3G, 4G) devices in order to achieve wider bandwidth, more channels, and faster data transfer rates. But because of the frequencies involved there is a rising concern about a possible influence on human health, ranging from headache to cancer. Similar warnings have appeared before, accusing everything from electrical power lines, radio and TV transmitters, color TV sets, radars, as well as every previous mobile phone generation, and the media did their best to inflate those warnings to absurdity, because their impact and selling is increased by bad news far more than by good news. Now, at the start of implementation of the new technology, we are witnessing a highly intensified media campaign against it, while correct technical, scientific and medical information is scarce and left in the background.

Therefore I find it necessary to offer a few bits of information which I miss in all the publications. I am of course well aware that few people will believe any of it, in spite of a clear scientific explanation and explicitly stated empirically well established numbers, most people will dismiss it as pure propaganda. Yet it is quite easy to differentiate between scientifically correct information and pure scaremongering: in the first case you are flooded with boring numerical data and physical processes, while in the second case reporting numbers is generally avoided, instead expressions of high emotional impact are rather used, but when numbers are reported, mostly very big numbers are shown without comparison to other data, with the sole intention to look more scary.

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Mobilnik ne povzroča raka

Dolgotrajna uporaba prenosnih telefonov ne povečuje tveganja za nastanek rakavih možganskih tumorjev, ugotavlja največja tovrstna raziskava danskih znanstvenikov. Agencija za raziskave raka pri Svetovni zdravstveni organizaciji je maja letos ocenila, da uporaba prenosnih telefonov morda lahko povzroča raka. Vendar ugotovitve danske študije, v kateri so 18 let spremljali zdravstveno stanje več kot 350.000 uporabnikov prenosne telefonije, tega ne potrjujejo. Njeni rezultati namreč kažejo, da povezava med dolgotrajno uporabo prenosnega telefona – celo več kot 13 let – in rakavimi možganskimi tumorji ne obstaja. **STA**

Fig.1: There is an intensive negative campaign on the internet (left), while occasional reports of studies that find no particular danger are very brief and often found in the last pages of a newspaper (on the right is an example from a Slovenian journal Delo, Oct. 22Nd, 2011, page 32, titled *Mobile phones do not cause cancer*).

To a majority of people the term 'radiation' immediately triggers memories of nuclear bombs exploding above Hiroshima and Nagasaki in 1945, followed by the three greatest nuclear power plant incidents (Three Mile Island in 1979, Chernobyl in 1986, Fukushima in 2011). Further associations go to all electrical and electronic networks and devices, from power lines, transformer stations, medical diagnostic equipment, as well as other sources, like granite pavements, the Sun, even industrially processed food. Yet most people have no idea of the actual radiation levels, let alone about the various types of radiation, or the health danger they may present. Neither do they know what are the natural levels, the accepted safety limits, or what are the biological effects, when there are some at all. Such a situation is the result of media mostly talking about radiation as being a great danger, with little or no actual data.
In order to be able to compare the electromagnetic radiation and its effects to other types of radiation, we need to first review some basic facts about radiation in general.

We usually sort radiation by its physical effects on matter. **Ionizing radiation** has enough energy to induce electric charge to neutral atoms. This occurs mostly when one or more electrons are accelerated out of their orbitals, which changes the chemical activity of that atom. However, if the radiation energy is very high, the atomic nucleus can also be changed, possibly becoming unstable, with a wide range of probability of decay by emitting particles or electromagnetic radiation. In contrast, **non-ionizing radiation** does not have enough energy to induce electric charge; it can only activate thermal (vibration or rotation) excitation of molecules.

In biological matter, a single such event is not fatal, and not even dangerous, since metabolic processes constantly change molecular bonds between atoms, some molecules are disassembled, and others are assembled, and these processes rely on changing the energy of electrons in outer orbitals. However if the intensity of radiation is high, and many ionizing events occur in a short time, the metabolic processes may not be able to cope with too much charge created, and individual cells, or organs, or entire organisms may suffer considerable damage.

In complex organisms a molecular damage in a single cell is not dangerous, since metabolic processes constantly transform molecules from one type to another more appropriate for the organism, either as building blocks, energy storage and retrieve, or intercellular signaling. Problems arise only if the intensity (either the rate, the energy, or both) of the ionizing radiation is high and many molecules are damaged in a short period.

The greatest damage occurs if the genetic material (DNA) in the cell nucleus is changed or broken. But even in such cases there are many self correcting mechanisms which are capable to repair most of the damage. When repair is not possible, a cell either becomes dysfunctional, or dies, or, if it starts to produce incompatible proteins, the cells in its surroundings can force it into apoptosis, a programmed cell death, the cell membrane breaks and the cytoplasm flows into the intercellular space where macrophages consume the remains or disassemble the complex molecules into simple forms that can be reused.

A particularly sensitive moment for DNA damage is during mitosis, when a cell divides. The DNA is then also divided into single strands, and ribosomes rebuild the complementary strands in each divided part later. If the DNA is changed during division, the ribosomes have no means to determine what was the original genome sequence, and the damage is permanent. But even so, if the damage is serious, the cell becomes dysfunctional, or dies, and is again consumed by macrophages. Only if the damage is small and does not inhibit normal cell metabolism can this damage propagate by subsequent division to many similarly changed cells. And if the damage occurs at the p53 gene, the function of which is to control the cell division rate, the cell will divide fast and in an uncontrolled manner, growing into tumors, which can again be benign or malign. Malign tumors are usually referred to as cancer. However not all cancers are lethal, in fact most are curable if detected at an early stage of development.

As can be understood from this short review, life is not as fragile and sensitive as we often assume. There are thousands of self-repairing and protecting mechanisms, so it is in fact quite resilient. If that were not so, life on Earth would probably not evolve at all, because of the very hostile natural environment everywhere, except maybe in some rare calm oases with perfect conditions, and during extended periods of low cosmic radiation.

Statistically about ten million genetic changes occur daily in each kilogram of a human body mass. Approximately one third of those can be attributed to the natural background radiation, one third is attributed to the functioning of bacteria and viruses in our body, and the remaining third is a consequence of random transcription errors and cellular metabolism. Successful correction of these changes is the essential function of each cell. Of course, with aging, all cellular functions slowly decline, and this error correction capability becomes less efficient. Because of that, in elderly population the probability of degenerative and genetic diseases, including cancer, increases with age.

Returning to radiation properties, we differentiate the radiation in form of **emitted elementary particles** from the radiation in form of **electromagnetic waves**. In case of particles, we differentiate between alpha (helium nuclei) and beta (electrons) radiation, which are emitted by radioactive materials, as well as individual protons and neutrons from cosmic sources. Ionizing electromagnetic radiation is often referred to as gamma radiation, but the spectrum is broad, ranging from ultraviolet, X-ray (Röntgen), to gamma radiation (extremely high frequencies), and these are emitted by radioactive decaying materials and by cosmic sources.

Alpha radiation has the lowest penetration depth, it can be stopped by a sheet of paper, or the surface of human skin. Damage occurs only if alpha emitting material is imported into the digestion or respiratory tract (remember for example the tragic case of the Russian agent Litvinenko in 2006). Beta radiation penetrates deeper, but can be stopped by a relatively thin sheet of metal. Gamma radiation has the deepest penetration range, it can be stopped only by a very thick concrete block. The thickness and the composition of the material also plays a role, for example at low energies (low frequency) gamma rays can be stopped by thick glass with high density of lead (Pb), as has been done in older cathode ray tubes of color TVs and computer monitors in order to prevent the so called *bremssthrallung* radiation emitted by the beam of electrons slowing down when hitting the screen.

We are most exposed to proton and neutron radiation during high altitude intercontinental flights. Several such flights can be compared by dose to a single medical X-ray exposure. Otherwise, high energy protons collide with air molecules already at high altitudes, whereupon showers of secondary particles are emitted, mostly as muon pairs, but also electron-positron pairs and gamma rays. Thus most of the energy is dissipated before this secondary radiation reaches the ground.

Serious damage is generated also by neutrons. Because they have no electric charge, they can penetrate deeply into the body and into the atomic nuclei, however the probability of a nucleus absorbing a neutron depends on kinetic energy, the greatest probability occurs at middle energies (middle particle speed), at low and high speeds the absorption probability is somewhat lower.

We express the dose of exposure in physical units of absorbed energy within a unit of mass of the body exposed to radiation. In the metric (SI) system the units are Joules per kilogram (J/kg). However the impact to biological material differs for different types of radiation and the type of tissue affected. Because of that, the unit Sievert (Sv) is used (named after a Swedish medical physicist to acknowledge his work on radiation dose measurement and the biological effects of radiation, Rolf Maximilian Sievert, 1896–1966), where an additional weighting factor is included for each type of radiation, as well as each type of body tissue, in order to account for different bio-sensitivity. In this way the effective dose is made comparable for risk assessment. For example, the highest susceptibility factors apply for eyes and gonads (about 4 times higher), while for radiation types factors of up to 20 times higher are assigned to neutron radiation at energy around 1 MeV.

The average yearly dose from natural background radiation amounts to one thousandth of a Sv, or 1 mSv/year. For those categories of the population exposed to additional radiation because of their professional activity, 50 mSv/year is set as a safe limit. However, the same dose received over a shorter period represents a proportionally greater risk. For a dose of about 5 Sv received within a short time there is a 50% probability that such a dose can be lethal. A similar dose (1 Sv) received over a working lifetime represents the maximum allowable dose for astronauts. For comparison purposes, a dose received by eating a single banana is about 60 nSv (60 billionth of a Sv), caused by radioisotopes of potassium and carbon, ^{40}K and ^{14}C, which are present in small quantities everywhere in nature.

For biological effects of radiation in form of particles the risk assessment is often performed using the linear, no threshold (LNT) model, where it is supposed that each particle represents a risk (thus there is no low level safety threshold), and the risk is cumulative and linearly proportional to the acquired dose. However this model is questionable. Many researches have reported examples where a part of population lives in area of substantially higher radiation (because of geological properties of the local ground), but the incidence of cancer and other genetics related diseases is comparable to the rest of the population in low exposure areas. A known example is the Iranian region of Ramsar, where the inhabitants are exposed to yearly doses up to 250 times higher than normal because of radon gas, ^{222}Rn, a decay product of radium, ^{226}Ra, emanating from the ground. This indicates that low level radiation exposure requires further research to understand why such differences occur.

Regarding electromagnetic radiation, the mentioned LNT model does not apply, because there is a well defined threshold below which this type of radiation does not have any effect except thermal. For bio-material this threshold equals about 4 eV (electron-Volt is the energy that an electron acquires when accelerated by a tension of 1 V). Physicists often use such units in order to avoid writing awkward exponential numbers, but here we cannot avoid it, because we need to put the appropriate energies and radiation doses on equal footage. To convert the energy of 1 eV to Joule units we have to multiply it by the electron charge, $q_e = 1.6\times10^{-19}$ As (Ampere-second). The resulting energy (work) is $W = 1.6\times10^{-19}$ VAs, where VA is the Watt, W, and Ws is the Joule, J. Therefore the 4 eV threshols equals $W = 6.4\times10^{-19}$ J. This is a very small amount of energy.

We need another two important physical relations, the Planck-Einstein equation for the enery of a photon (which is the quantum of electromagnetic radiation) as a function of radiation frequency, and the relation of the propagation speed of light to the frequency and its wavelength. The energy of a photon is determined by the product of the Planck action constant, $h = 6.63\times10^{-34}$ Js, and the frequency (the number of waves per second, 1/s, or Hertz, Hz), so $W = hf$. The electromagnetic radiation propagates at the speed of light, $c = 299792458$ m/s, or approximately 3×10^8 m/s, and this speed is equal to the product of the frequency f and the wavelength λ: $c = f\lambda$. With these relations we can determine the frequency of the electromagnetic radiation energy and its wavelength.

We obtain the frequency of the 6.4×10^{-19} J energy threshold by dividing it by the Planck constant h: $f = W/h$, so we have $f = 6.4\times10^{-19}$ J / 6.63×10^{-34} Js = 965×10^{12} Hz. Then, by dividing the speed of light c by the obtained frequency we get the associated wavelength: $\lambda = c/f$, or numerically 3×10^8 m/s / 965×10^{12} Hz = 310×10^{-9} m, or 310 nm.

The wavelength of 310 nm belongs to the ultraviolet range (UV, from 100 to 390 nm). The effect of UV radiation is known to everybody who has been exposed to direct sunlight in summer for too long without protective cream, before developing more skin pigmentation: the skin is burned and is peeling off. But if we are exposed to sunlight behind a glass window, our skin will not burn and no melanin pigment will be created, because glass is not transparent for UV radiation.

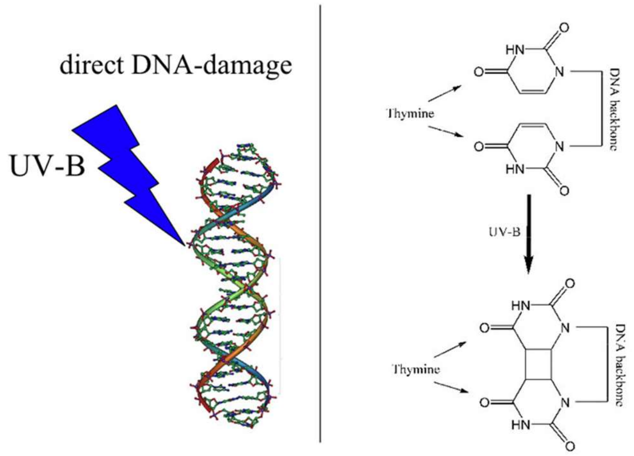

Fig.2: An example of DNA damage by UVB radiation. The double bonds of two adjacent bases (thymine molecules) are modified and the bases bond to each other. The photon energy needed for this damage is about 4 eV.

We can use the above relations to find the energy of the mobile phone antenna radiation of the existing 4G and the future 5G types. The current frequency bands used are between 0.8–1.8 GHz, or of the order of magnitude of 10^9 Hz. This relates to the wavelength of about 0.3 m, and the appropriate energy is about 6.6×10^{-25} J. By comparing this with the 4 eV threshold, or 6.4×10^{-19} J, we see that this energy is about one million times lower than the energy required for the skin damage by UV radiation.

The new generation of devices, 5G, will be using the frequency range at about 5 GHz at first, but will later be gradually upgraded to use probably up to 30 GHz. Yet this is still 30 000 times lower than what is the lowest requirement for biological damage. Therefore the frequencies used by 5G will not be able to cause cancer, and neither is the current technology.

Some simple statistics confirms this statement. Before 1990, the number of people professionally exposed to higher electromagnetic radiation levels was probably less than half a million. Today, the number of people employing mobile phones has risen to 4 billion, or about 10 000 times higher. If there were any chances of this radiation influencing our health, it should have shown up already. But the average incidence of cancer (of all types) has increased only slightly, and even that increase can be attributed to better diagnostic techniques and early discovery of diseases.

Are there any other influences of electromagnetic radiation below the ionization threshold other than thermal? So far, our experience with radio and TV high power emitters, radars, and similar installations indicate that only thermal effects can be expected. This means only molecular vibrations and rotations are excited. We know that a microwave oven, which operates at frequencies of about 1 GHz, can cook food (evaporate chemically unbounded water, with a consequent coagulation of proteins), but for that we need a power of some 800 W. However, even much higher radiation power at these frequencies will not change any chemical bond.

In comparison with the microwave oven, the power in the antenna of a mobile phone is some 1000 times lower. Mobile phones radiate some 0.5 W, and that only during calls; when the connection is established, the power usually drops to 0.2W or less, depending on the distance from the base station and possibly some dense concrete or metal obstacles in the pathway. Some people complain that after a prolonged conversation their ear becomes noticeably warmer. But if they would cover their ear by only a palm of their hand, the ear temperature would increase some 4-5°C more than when covered by a mobile phone.

Fig.3: Examples of base station antenna systems of new generation. During the transition period both old and new systems will be operating alongside each other.

There were examples of older high power radio transmitters of 100 000 W and more, with a large fence protected area around the antenna, but this protection was more intended for preventing the high power cables from accidental damage. There were rare cases of workers making repairs nearby, who reported headaches and similar short duration problems after the work. However such transmitters were never built close to a populated area. Those were extremely high power transmitters, of which very few remain in operation today. Because the field strength falls off with the square of the distance from the antenna, the inhabitants living close to those transmitters were never at risk. For example, at 100 m distance from the antenna the field strength is 100 times lower than at 10 m, at 1 km it is reduced by 10 000 times, and at 10 km it is 1 000 000 times lower.

It must be emphasized that many biological processes benefit from exposure to radiation of some specific wavelength range, like sunlight, and a few other narrow wavelength ranges, which are used for therapeutic purposes. Besides the mentioned melanin production, the production of vitamin D is also activated by UV radiation. Some skin diseases (psoriasis, etc.) are being successfully treated by UVB radiation, substantially reducing the symptoms. Similarly, neonatal jaundice cases are routinely treated by blue light (430 nm, ~3 eV), which causes isomerization (change of shape) of the bilirubin molecules. Bilirubin has two light sensitive bonds, which are twisted when activated by blue light, so that one of the hydrogen atoms inside the molecule becomes exposed, making the molecule hydrophilic (solvable in water), and consequently excreted from the body more easily.

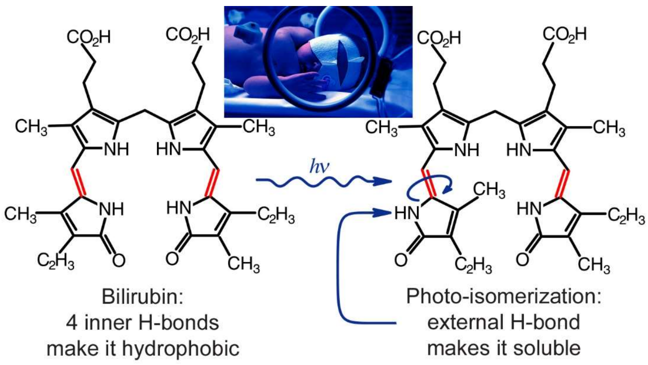

Fig.4: Neonatal jaundice phototherapy using blue light.

Red and near infrared light (630–1250 nm, 2–1 eV) can enhance chronic would healing by activating the mitochondrial trans-membrane enzymes (cytochrome C oxidase) to produce more adenosine three-phosphate (ATP), which is both an energy storage molecule, making energy available to other processes, and a signaling molecule. Fibroblasts and mastocytes production is also promoted. Most of such processes can occur only in the presence of light activated enzymes which catalyze the processes, rather than by direct light activation. Below about 1 eV no enzyme activation is possible, therefore the influence of electromagnetic radiation is only thermal (inducing vibrations of molecular bonds or molecular rotation).

In case of 5G mobile phones and other devices using the same frequency band for communication, the higher frequency of radiation requires direct visibility between the transmitting and the receiving antenna. Even tree leaves can attenuate the signal so much to prevent reliable detection. Therefore the technology requires a much higher density of base stations, especially in densely populated areas. Because of the higher density and shorter distances the power required for communication can be greatly reduced, down to 0.05 W or less, both in the base stations and the mobile phones. Users of 5G network will benefit from this, not only because of much higher data transmission rates and much larger number of channels, but also because of lower power consumption and much longer lasting batteries for a single charging.

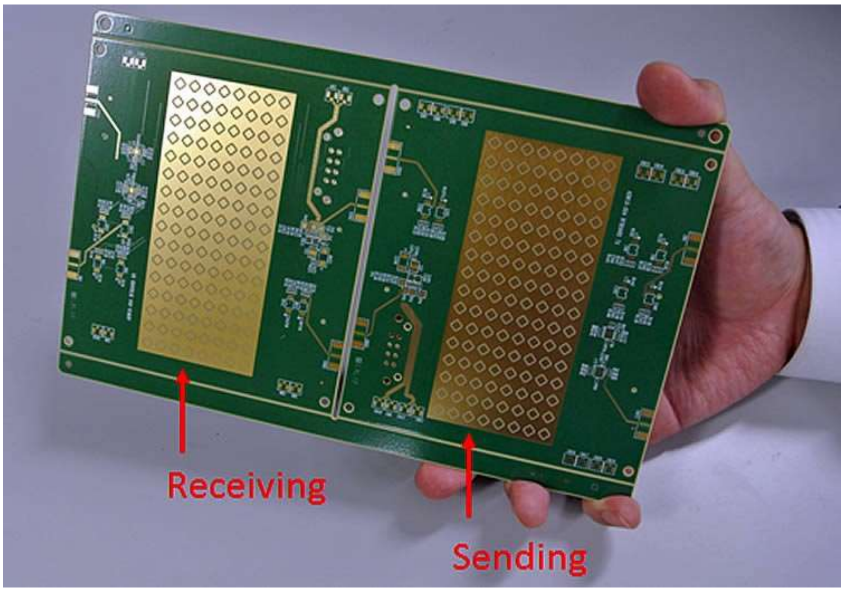

Fig.5: An example of the antenna system of the 5G base station (by Fujitsu).

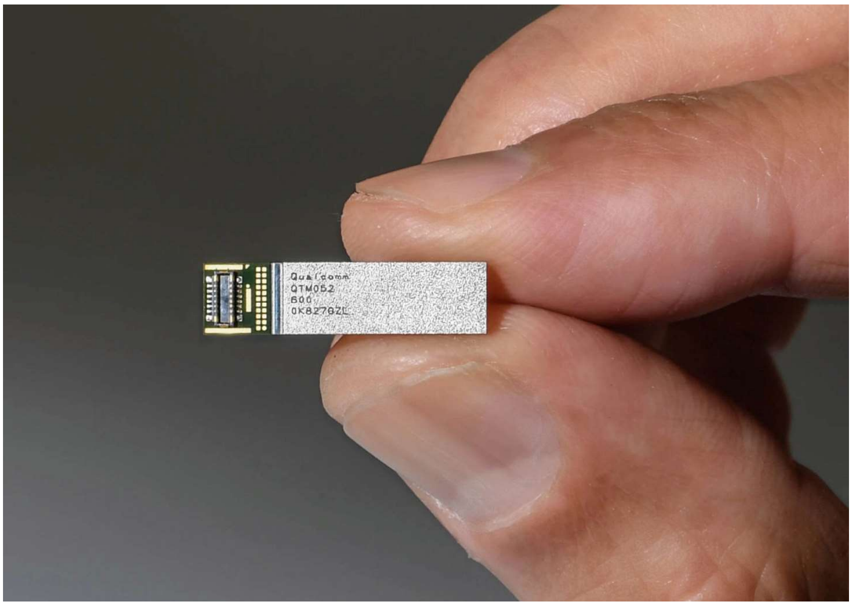

Fig.6: An example of the antenna system of the 5G mobile phone (by Qualcomm).

There are nevertheless some undesirable consequences, though not health related. One is the enhanced possibility of following the whereabouts of the users, meaning that whenever you pass near a shoe shop you will receive an advertisement for shoes. This will certainly be a nuisance to some, and a useful feature for others. In any case, implementation of such features is a matter of law regulations on which a wider consensus still has to be reached. Misuse of such features, in the sense of being followed by state security agencies, are possible already with the existing technology by reading our GPS location, either in real time or afterwards by examining the base station data, so there will be nothing new here. This is possible to prevent only by taking out the battery from the mobile phone, but few will be prepared to do so because of the need to be accessed by family members and friends at any time. Some will even welcome the tracking feature in order to be readily found in case of accidents or health related emergency. Yet criminals will still be able to avoid being followed by either disabling the GPS in their phones or by manipulating the user related data in several other ways. The most simple way is to ask somebody else for a favor to use his phone for an urget call, with the excuse that you forgot to charge your phone and your battery is now empty. So the state agencies will be able to track only the honest citizens and those naive ones who think they are safe, which makes the usefulness of tracking very limited.

Another and probably greater danger is for the wallets of less prudent users, who will use the high data transfer rates more often than they do now, especially during the first months as they will be eager to explore the new user experience offered by faster system response and faster downloads of very large files, such as movies or games. Unless, of course, the mobile service prices would be lower, which will probably be the case later, but not initially when the system is introduced.

To conclude, any concern for health risks caused by the use of 5G technology is unjustified.

On Wikipedia pages we find that Slovenia is currently the only state that has temporarily stopped all 5G upgrades. Several other states have slowed down the implementation mainly to prevent access to their communications market to the Chinese Huawei company and give time to their own service providers to develop. United Kingdom is the only one that cancelled all previous contracts with Huawei, preventing them from setting up their network there. The motivation is purely political, and not because of any health related concern. The Slovenian case is particularly interesting, since the motivation was certainly not to gain a better negotiation position with respect to Huawei, rather it was more because of a traditional restraint of the Slovenian politics in regard to radical technology changes and innovations, a consequence of the dominantly social and humanistic educational provenience of the Slovenian political elite. Which is why their actions are often guided by the precautionary principle: wait until changes are first tested by others (typically the Germans). Which is also why Slovenia lags behind the developed countries much more than it should.