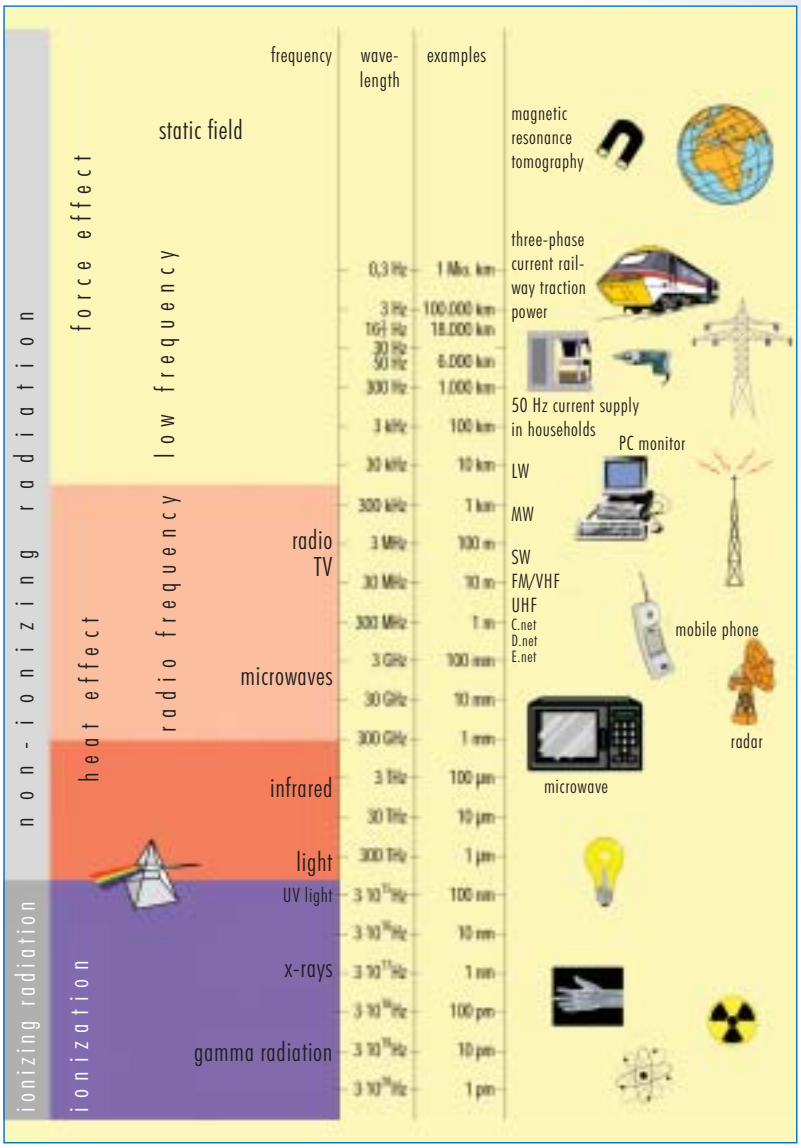
The future
Expected developments the wireless

by Fritz Jörn

“Communcation is fine. In contrast to energy, it can only trigger processes, it is not the force behind them. It is just its lack of energy that makes communcation transmittable, without objectification – just like thoughts. For our modern society this means that communication loves radio. And rightly so: There are not many reasons left against free-space communication; certainly not at their origin or target. What developments can be expected? Will radio and waves continue to “pollute” our private and public spheres? What is it we will have to pepare for?”



# of airwaves: in spectrum

Radio transmission capacity drastically increases, but not so-called emission

Wireless communications has a very long histroy. Agamemnon sent the message of Troia's fall already in 1148 B.C. by open fires. The light signals were seen at a distance of 450 km[1] throughout the Aegeis. Other milestones were: In late 1901, Guglielmo Marconi[2] sends a radio message from Europe to America. Since 1987, we can legally buy cordless phones, which in the meantime have replaced the conventional phone even in the country homes of our grandparents. Of course, cordless phones are operated by radio. Authentic public mobile radio is used more often in Germany than fixed network telephony since the turn of the millenium – an unprecedented victory of radio technology, which is visible even to the not so technology-attracted parts of the population when looking at the transmission masts. Television becomes digital terrestrial[3] again through DVB-T. Even meals are warmed up in the microwave by radiation instead of in circulating air ovens. Thermometers are operated by radio, bus tickets can be bought via mobile phone short messages – there are countless examples. Wireless and free is just more attractive than chained and bound. Moreover, there is our all-encompassing addiction to news, to communication and entertainment, both on the road and at home.

Without much effort, this well-known scenario allows to draw plausible prognoses about the future of radio technology. As you will see, they mainly refer to the increasing data traffic and only marginally to conventional mobile speech telephony.

With regard to mobile radio, the UMTS[4] frequencies, bought for much money at auction, will be increasingly used, at the latest with the increase in consumers demand the next economic upturn will bring. Mobile radio operators hope for new applications such as visual telephony, mobile video conferencing, television broadcasts and music clip downloads. Operation of mobile radio is virtually limited to its actual use – phones on stand-by do not send radio signals, or very rarely resp. on a low level[5]. This means that only increased mobile radio use leads to an increase in radiation. If radio waves were visible, one would become aware of this development, like a city that wakes up in the evening and in the night increasingly filled with life and light: Light is simply growing and this is, overall, less irritating personally than increased noise. One can close one's eyes; if one is blinded, one can avert one's eyes. But back to radio waves: They cannot not be sensed at all[6]. So let's leave the populist debate over electrosmog behind and, instead, deal with the fields of application of wireless transmissions.

Let us first take a closer look at frequencies and modulations. The electromagnetic spectrum that can be used for radio transmissions has already been fully assigned, from the long wave – still used by a few older radio stations for the transmission of similarly lengthy old-fashioned and boring parliamentary debates – to radio broadcasting and television, as well as microwaves used in ovens and between transmission masts. Due to the lack of spectrum, higher

and higher frequencies are used. However, their advantage is that high frequencies allow transmitting relatively more messages than low frequencies (thus, one single television channel with a bandwidth of 6 to 8 MHz[7] would be 50 times larger than the entire 135 kHz long-wave band). High frequencies, i.e. short waves[8], however, are characterized by the fact that they do not spread out widely and do not easily bend around an obstacle. They can therefore be used only in the proximity of the transmitter, preferably at direct visual contact between transmitter and receiver. This requires a relatively large number of UMTS mobile radio cells – with a frequency of about 2 GHz[9], the wavelengths are around exceed 15 cm. Laypersons know radio frequencies mostly from FM, ultrashort wave radio, where transmitters send around the clock, using a few hundred Watt up to hundreds of kilowatt (kW)[10] each. The radio signals of analog television are even stronger – a powerful transmitter can reach up to 500 kW[11]. But when looking at other, less popular bands, which also are strictly regulated, one can see that, for the most time, they are not used, e.g. military frequencies, fire brigades or mobile radio. As transmitters may not interfere with each other, the required spatial safety distance adds to this. Put more simply: The sea of radio waves lies tranquil but for a few churning areas.

Modulation, i.e. the specific change of the sinusoidal wave, is required to transmit a signal, a message. Techniques range from the simple analog amplitude modulation of the medium wave, decoded by a simple rectifier diode (detector), to the ultra-modern emerging digital HSDPA modulation[12] in the UMTS network. Mathematical demands grow with increasing computerization and decoding capacities of transmitters, and mainly also receivers (e.g. mobile phones). As a consequence, increasingly more data can be transmitted more economically. This development in data transmission could be observed by laypersons for phones. While better modems („modulators-demodulators“) transmitted 300 bit per second (b/s) in the early eighties, later 64 kbit/s via ISDN[13], DSL[14] connections today reach 1000, even 5000 kbit/s. With regard to future development it can be noted that increasingly more data can be transmitted via the same cable or radio bandwidth, thanks to steady improvement of modulation techniques. But this does not suffice to counterbalance the overall increase in data volumes. In comparison: Digital image compression density is increasingly higher, thanks to JPG[15], but the number of digital images is growing and growing ... Future actual growth will take place in the airwaves[16], in the area of *digital data transmission* via radio, i.e. in the nearfield, due to the lack of other than very short wavelengths, etc., i.e. in apartments, offices, in public squares, hotels, etc. Remote mountain forests e.g. will not be affected ... How come? Where do all the data come from? Here is the prognosis:

The number of broadband Internet connections will strongly increase. There are a about six million high-speed connections[17] in Germany. With a little more than 7 broadband connections per 100 inhabitants, Germany thus is lower middle – logically so, but regrettable all the same. In countries like the United States of America[18] or South Korea[19] with as much as 25 broadband connections per 100 inhabitants, there is a surge in demand for bandwidth – regardless of actual use or usefulness. One may suspect: In times of speed limits on highways, as fuel gets more and more expensive, people want to have at least speedy internet access.

Although these large bandwidths are provided by (phone) wire or (television) cable – and rarely, but expensively, by UMTS end distribution is wireless and cost-free. First a kind of private sub-distribution to storeys or parts of the building is conceivable; either by a conventional „Ethernet“[20] interfaces, i.e. by a wired resp. coaxial cable network (LAN: Local Area Network), or, modulated, via the in-house power supply net. This is called PLC, Power Line Connection. Radiation is generated – some more than by shielded coaxial cables, but considerably less than by trans-

missions operated by radio. But this only irritates radio amateurs[21]. In Germany, PLC has very few fans, in spite of many attempts to introduce it.

For data, a development analogous to that of household phones is predicted. Where in former times there was one phone in the hall or in the living room, later on wired phones in the bedroom and, very soon, also cordless phones were added. The connection between the phone outlet resp. the source of data and the „user", the PC or notebook, or, in the future, the television set, is comfortably wireless. WLAN technique (wireless LAN) has been established in the free 2.4 GHz ISM[22] band, according to the 802.11 standard, also called Wi-Fi or „hotspot". So-called servers or routers, data distributors for connection with DSL or cable modems, for the most part are offered and sold as radio devices. There will be a situation similar to that of cordless phones: there will be more and more of them.

Omissive lines in residences are generally more attractive, of course. There are increasingly more wireless connections between television sets (e.g. for viewing videos) or acoustic sets (e.g. Dolby Surround) with numerous speakers distributed in the room. Wireless headphones are not only used by considerate fans of classical music, they also serve as a tool for cordless phoning via the PC, as „headsets" with inbuilt microphone – radio also in the other direction. Video surveillance systems will not only increase in the public spheres, but, unfortunately, also in our private lives. What could be simpler than connecting the first few meters wirelessly? Even babies nowadays call their parents from the crib by wireless devices. From their birth, a cordless baby phone monitors them. Mobile phones are equipped with walkie-talkie functions, called push-to-talk, so that, with one push of the button, an entire group of friends can be reached - wirelessly, of course. In the more narrow close-up range, Bluetooth radio[23] will connect devices, even if the present standard still suffers from a lack of speed for larger data volumes.

Radio using high frequencies in the nearfield will accompany us also when leaving home. Very soon, our surroundings will be fully covered by privately used WLANs or publicly operated „hotspots". In Bonn, there are already trams with internal hotspots for passengers with laptops[24]. Despite the now quite absurd ban of mobile phones, airplanes, in the business class, are routinely equipped with wireless WLAN (and will not crash because of that ...). The Deutsche Lufthansa uses radio on its transatlantic flights already since the beginning of 2003[25].

Occasionally, Bluetooth, known as a radio interface between mobile phone and headset, is used similarly to WLAN. While the usual „small" Bluetooth[26] with power levels of a milliwatt at best reaches as far as ten meters (just the right distance for connecting small cordless devices) and is correspondingly low in effectivity, „strong" Bluetooth, as WLAN, uses the technical possibilites of the ISM band, sending with up to 100 mW. These connections virtually replace WLAN links with slightly changed protocol characteristics. (Applications are again DSL to laptop, e.g. by AVM with their popluar „blueFritz!"[27] connections, or wireless analog modems – e.g. the small typhoon[28] – and similar devices.)

Another small radio standard has to be mentioned: UWB or ultra-wideband, according to IEEE 802.15.3a, for short-distance wireless networks[29]. In America, this is called WPAN, Wireless Personal Area Network. UWB is said to allow a good broadband wireless data transmission over short distances with very small transmission power levels and very short pulses, operating on several parallel frequencies, i.e. it competes in speed with Bluetooth. Originally, the technique was used by the military, because it can scarcely be traced back. However, there is presently a dispute over the standard between the chip manufacturer Freescale[30] and a consortium around Intel. Later on, UWB shall be the basis of Wireless USB (WUSB), which shall transmit data with 480 Mbit/s over up to 10 m. Theoretically, UWB bandwidth is very large, up to 10

Gbit/s. However, UWB nowadays uses frequencies of 3.1 to 10.1 GHz[31], with minimum power, but in frequency bands already assigned and regulated. In short: In most cases, even approval is lacking.

A new standard for "small" radio signals has just been completed, "ZigBee"[32], or more precisely, IEEE[33] 802.15.4[34] resp. 802.15 TG4[35]. Domestic appliances that do not communicate much, such as washing machines or thermometers, the doorbell etc., shall be connected with very small radio power levels. Through deliberate limitation to very slow transmission – i.e. to small data volumes – power and bandwith consumption are kept low. Even if there should be many devices equipped with ZigBee soon, the increase in radio traffic will be relatively low.

After the debacle with the auctioned UMTS radio frequencies[36], large service providers are not very motivated to pursue new radio adventures. An exception may be the former

C-Net[37], which could be a wonderful range for radio transmission, mainly of data, as frequencies are not as wretchedly high as those of GSM[38] and UMTS networks. To this end, the company Flarion has even proposed an own fast-working transmission protocol, Flash-OFDM[39]. Flash stands for „Fast Low-Latency Access with Seamless Handoff"[40], and OFDM for Orthogonal Frequency Divison Multiplexing. Whatever: We have to wait and see what will come of this. Before data traffic can take place, "regulators"[41] will have to allocate the respective frequencies, they have to be licensed, a network – rather wide-meshed, thanks to the relatively long wavelengths – has to be implemented, receivers have to be made available, to say nothing of the required consumers demand ...

A similar fate may await the "wide-traffic WLAN", WiMAX[42] (IEEE 802.16) that, compared to the much used WLAN 802.11, offers spectacular ranges of up to 50 km and transmission rates of up to 70 Mbit/s, but also needs frequencies that have to be allocated by the regulatory authorities, and new networks. Neither Flash-OFDM nor WiMAX can be operated in the

generally allocated license-free ISM band, due to the power limit of 100 mW[43].

So first there will be an increase in radio operations in highly computerized areas, in the popular license-free ISM band (2400 to 2483.5 MHz)[44], until – yes, until devices there will begin to interfere with each other. The usual way out, namely to simply raise power levels in order to overcome competitors, is not permitted here. Thus, a maximum level will be reached, and the effective coverage of individual transmissions will suffer. The different modulation techniques will then compete. The emerging overall "impact" of our environment– if we want to see electromagnetic fields as such (not "perceive", because that is impossible) – will be limited, despite wireless data transmissions.

Dipl. Ing. Fritz Jörn, journalist, Bonn

Footnotes

[1] http://www.joern.de/handypc/handypctext.htm#hist
[2] http://de.wikipedia.org/wiki/Guglielmo_Marconi
[3] DVB-T: Digital Video Broadcasting Terrestrial
[4] UMTS: Universal Mobile Communications System
[5] http://www.ralf-woelfle.de/elektrosmog/technik/mobil_2.htm
[6] the author denies that there is anything like "electrosensitivity"
[7] the long-wave range normally used for radio broadcasting is between 148.5 and 283.5 kHz (according to http://de.wikipedia.org/wiki/Langwelle)
[8] wavelength "Lambda, calculation" = 300,000 km/s/f, and frequency f=300,000 km/s/. 300,000 km/s is the light velocity.
[9] lower band (mobile to stationary) 1920 to 1980 MHz, upper band (stationary to mobile) 2110 to 2170 MHz (http://www.joern.de/esmog/esmog.htm#frequenzen)
[10] http://www.senderfotos.de/nieders.htm
[11] http://www.zdf.de/ZDFde/inhalt/21/0,1872,2004693,00.html "... basic network transmitters (transmitters with power levels between 20 and 500 kW)" ... „In Germany, 51 channels with a bandwidth of 7 MHz in the VHF- resp. with 8 MHz in the UHF range are used for conventional terrestrial television broadcasting.
http://www.joern.de/esmog/esmog.htm#leistungen
[12] HSDPA: High-Speed Downlink Packet Access, adaptive (AMC, Adaptive Modulation Coding) QPSK and 16-QAM modulation (QPSK: Quadrature Phase-Shift Keying, QAM: Quadrature Amplitude Modulation)
[13] ISDN: Integrated Services Digital Network
[14] DSL: Digital Suscriber Line
[15] JPG: named after the Joint Photograph Experts Group
[16] In the 19th century, a mysterious "ether was considered the transmission medium for electromagnetic waves (in technical terminology: "airwaves"). It was thought to be impossible that, bodyless, they travel in free space, see http://de.wikipedia.org/wiki/Michelson-Morley-Experiment
[17] state at the end of 2004 http://www.btd.de/schlagzeilen.php. At the end of 2003, Germany had approx. 82,536,700 inhabitants (http://www.destatis.de/basis/d/bevoe/bevoetab4.htm). Result: 7.3 broadband connections / 100 inhabitants.
[18] In America, there are much more cable than DSL connections for broadband Internet access. At the end of 2003, 16.4 million out of 28.2 million broadband connections were via television cable, and only 9.5 million via phone wires[19]. Germany has much to catch up in this respect; there is only half the number of broadband connections, compared to America.
[19] 25 broadband connections per 100 inhabitants (http://www.netzwelt.de/news/69355-suedkorea-ist-breitbandweltmeister.html), http://www.heise.de/newsticker/meldung/40363
[20] http://de.wikipedia.org/wiki/Ethernet
[21] www.darc.de/aktuell/voinfo/vinf05003.pdf
[22] ISM: originally for the free use of "industrial, scientific, medical", i.e. for interferential transmitters such as microwave ovens
[23] according to Harald Blåtand (Blauzahn, circa 1000)
[24] http://www.teltarif.de/arch/2005/kw05/s16110.html
[25] http://www.teltarif.de/arch/2002/kw19/s7885.html

[26] Bluetooth power levels

power level in Watt	1 mW	2.5 mW	100 mW
power level in decibel	0 dBm=»dB0«	4 dBm	20 dBm
maximum coverage	3 to 10 m	20 m	circa 100 m
used as	cable substitute "on the body"	rarely used	BlueFRITZ!

[27] http://www.avm.de/de/Produkte/index.html
[28] http://www.joern.de/Bluemodem.pdf
[29] http://www.heise.de/tp/r4/artikel/17/17270/1.html
[30] http://www.wirtschaftsblatt.at/cgi-bin/page.pl?id=390902, http://www.heise.de/newsticker/meldung/56542, http://www.zdnet.de/news/tkomm/0,39023151,39125836,00.htm
[31] http://www.windowsitpro.com/Windows/Article/ArticleID/40394/40394.html
[32] The name ZigBee (zig-zag and bee) is said to be derived from the dance bees perform to signal their comrades where worthwhile prey is found (http://www.eduvinet.de/mallig/bio/7insekt/7btanz1.htm)
[33] IEEE: Institute of Electrical and Electronics Engineers.
[34] http://www.corscience.de/zigbee.html
[35] http://www.ieee802.org/15/pub/TG4.html, http://standards.ieee.org/getieee802/802.15.html, fact sheet lecture ETH http://www.vs.inf.ethz.ch/edu/SS2004/DS/slides/09_zigbee.pdf
[36] "After almost three weeks of auction, D1 and D2, E-Plus, VIAG Interkom, Quam and Mobilcom each paid eight billion euros for their ticket to future mobile busines." http://www.faz.net/s/Rub4C34FD0B1A7E46B88B0653D6358499FF/Doc~ED2D3D4D1250644CDB2B7E416C01AF86B~ATpl~Ecommon~Scontent.html
[37] C-Net: 450 to 455.74 MHz, and 460 to 465.74 MHz
[38] GSM: Global Mobile Communications Systems; formerly Groupe Spéciale Mobile
[39] http://www.flarion.com/products/flash_ofdm.asp: "The OFDM physical Layer creates a robust multiple access technology to deal with the impairments and uncertainties of the wireless channel. FLASH-OFDM goes further, dividing the available radio spectrum into a number of equally spaced and orthogonal tones and using fast frequency hopping across those tones to become a spread spectrum cellular technology. Spread spectrum allows the data to be packetized and spread out over a wide range of bandwidth, then re-assembled into its original message. Because of this, FLASH-OFDM supports a larger number of users and transmissions, and is highly secure." http://www.inside-handy.de/news/1933.html
[40] http://www.flarion.com/about/faq.asp, http://www.enorgis.com/mor20040911.htm
[41] Regulatory Authority for Telecommunications and Posts http://www.regtp.de/
[42] http://de.wikipedia.org/wiki/Wimax with interesting details on the German development
[43] http://www.wissensnetz.de/lexikon/wiki,index,goto,WLan.html
[44] http://de.wikipedia.org/wiki/ISM-Band