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Fifth International
of the European

This year, the Fifth International Congress of the European BioElectromagnetics Association (EBEA) took place at the Marina Congress Center, Helsinki, Finland. From 6-8 September, 290 scientists from 32 countries met to discuss potential biological effects of electromagnetic fields and to exchange their knowledge. The EBEA succeeded in organising a congress with participants from the United States and Japan. Further, many scientists from Russia, Ukraine and the Baltic countries took part in the event, certainly because of its close geographic proximity.

In 5 plenary sessions, 10 lecture sessions with 67 single lectures, and 70 poster presentations, researchers introduced current research developments and research results. As usual, the congress presented a number of keynote lectures on international research, plenary survey lectures, short lectures, and posters. Topics ranged from biological effects on single cells and tissues (in vitro studies), animal tests (in vivo studies), experiments on humans, epidemiological studies, and medical applications.

A special section presented new concepts concerning the interaction mechanisms of electromagnetic fields. Aspects of radiation protection were dealt with in the section "Risk evaluation and communication." Technological problems were discussed in the section on dosimetry and dosimetrically controlled exposure systems, as well as in the section on wireless telecommunication. As a matter of fact, contributions covered the whole frequency range up to 60-GHz microwaves including strong static magnetic fields.

Plenary sessions

Congress events began with experts presenting information on international large-scale projects, such as the EMF Project of the World Health Organisation (WHO). Dr Mike Repacholi, departing chairman of the EMF Project, introduced his successor, Dr Leeka Kheifets. In his report with the title "Protection of the public from electromagnetic fields," Repacholi admitted the occurrence of a considerable delay of the schedule of the international project on EMF. Until now, the experimental standards required as a basis for the evaluation of scientific studies could not be established. Thus, evaluation of scientific publications on research results in the area of radio frequencies will be delayed by at least two years.

Repacholi then reported on the current state of the WHO project spanning the years 1996 to 2006. In his speech, he emphasized that performing a scientifically valid assessment of potential health risks caused by electromagnetic fields as planned by the WHO is a highly ambitious undertaking.

Congress

BioElectromagnetics Association (EBEA) 2001

In Repacholi's opinion, electromagnetic compatibility is developing more and more into a political issue. Ultimately, the political system is responsible for health protection. Science can only provide special knowledge on which legal precautionary measures are based. Particularly noteworthy was his warning against introducing additional precautionary values thus undermining limit values recommended by the ICNIRP and confirmed by the WHO. At the same time he pleaded for an intensified communication with the public to achieve a greater degree of acceptance of the scientific data.

Until now, the "precautionary principle" has been applied only to environmental issues. The WHO was asked to examine whether this principle also can be applied to health aspects in connection with electromagnetic fields. Hence, it was necessary to discuss when and under what conditions this principle may be applicable to health issues and whether it is in accord with basic scientific findings. The commentary published by the European Commission in February 2000 has proved to be quite useful concerning the assessment of the "precautionary principle."

Repacholi put special emphasis on the "limit value discussion." In his view, a combination of scientifically-validated limit values and voluntary precautionary measures is an appropriate way to reduce exposure arising from electromagnetic fields. However, according to Repacholi, an arbitrary adoption of additional "safety factors" into limit value setting, solely for the sake of being cautious, is wrong: "By this we undermine the scientific basis for setting limit values wasting hundreds of millions dollars which have been spent for scientific efforts." Here, Repacholi took a firm stand. But he also came out in favour of extending public involvement in the assessment of health risks. By establishing an improved communication about risk assessment and providing more precise information, the public should able to have more involvement in the corresponding decision-making. Public trust in science and in the individual countries' governments needs to be able to grow.

Dr Alastair McKinley gave a survey of the activities of the International Commission of Non-Ionizing Radiation Protection (ICNIRP) during the last ten years. He particularly emphasized the guidelines developed by the ICNIRP in 1998 supported by the WHO, which serve today as a basis for limit value setting in many European countries.

Dr Elizabeth Cardis, chairwoman of the International Agency for Research on Cancer (IARC), presented the INTERPHONE study with fourteen participating countries. The aim of the project is to gain knowledge of the impact of electromagnetic fields caused by mobile phones on the occurrence of certain tumour types through population studies.

As a first step, project designers made investigations meant to prove that in principle it is possible to start an epidemiological study on this issue which will lead to significant results. In recent years, observations showed that the INTERPHONE study certainly is feasible concerning conception, methodology and its objective, since cellular phones in the last five years have been widely enough distributed in the population to perform an assessment of health risks caused by the use of mobile phones. Even less-frequently-occurring effects can be measured.

At present, the main focus lies upon mobile phone dosimetry. In this context, Dr Cardis suggested the use of software modified devices (software-modified phones, SMP) being specially developed by some manufacturers. These mobile phones can store parameters, such as initial power or call duration, and send them to scientific data bases. The SMP are given for a month to participants to record a representative and practical impression of the mobile phone user's pattern of telephone use.

There will also be a delay concerning the INTERPHONE study. Dr Cardis pointed to the fact that IARC will not comment on possible connections between radio waves and tumour frequency before the INTERPHONE study is finished. Thus, the IARC will not issue a statement in 2004, as previously planned, but in 2006. First results on this were presented by Adroino et al. in the section "Epidemiology and experiments in test persons."

A similar topic, the feasibility of reliable epidemiological studies on possible effects of mobile phoning, was addressed by staff members of the Finnish Cancer Registry, of the National Authority for Radiation Protection, and of the Finnish Institute of Occupational Health (Auvinen, Hietanen, Luukkonen, Koskela). A study is

planned based upon the more than 500,000 mobile phone users registered in Finland. Should there actually be an increase of brain tumour incidence, a significance factor of more than 1.4 would be sufficient to give proof of an association. However, to give proof of field-induced salivary gland cancer the rate would have to lie above 2.8 to be statistically significant. Such considerations surely are affected by a recently published Danish study (Johansen, C., Boice, J.D., McLaughlin, J.K., and Olsen, J.H., Cellular telephones and cancer - A nationwide cohort study in Denmark, National Cancer Institute 93 (2001), 203-207). More detailed information on these programmes was given in the two lectures of Auvinen et al. held in the section "Epidemiology and experiments in test persons."

Dr Shoogo Uneo from the University of Tokyo reported on new developments in the area of human cognition and memory capacity. During an experiment, test persons had to distinguish between simple drawings, rotation-symmetrical and mirror-image presentations. Moreover, participants were challenged concerning three-dimensional thinking; they had to rotate illustrations in their mind's eye and analyse them. The distribution of activity in three brain areas was recorded (in the parietal area, the rear temporal area, and in the supplementary motor area). Results demonstrated differences between the activity in the rear left temporal area and the left parietal area at processing more complex illustrations.

Further, Ueno referred to the results of a study in rats. Here, the effects of an electromagnetic field at a frequency of 1.439 MHz on the memory of rats were examined. The specific absorption rate (SAR) for the brain was at most 7.4 W/kg. At an antenna power of 6 W the average whole-body SAR was 1.4 W/kg. The rats had to perform orientation and memory tasks within a T-maze. Ueno and colleagues could not detect any alteration of memory capacity or permeability of the blood-brain barrier caused by field exposure. From his results Ueno concluded that the use of mobile phones for humans is safe.

Dr. Lluis Mir of the CNRS Institute Villejuif, France, presented methods for therapeutical use of electro-permeabilisation. According to Mir, both electro-chemotherapy and non-viral gene transfer are two of several applications that will be of great importance in near future. Electro-permeabilisation means that cell membranes are made permeable by electrical impulses over a short-time period of a few hundred microseconds. This fast permeability alteration suffices to bring active substances into living cells. For example, for tumour treatment, bleomycin, presently one of the most effective tumour-inhibiting bindings, is transferred into tumour cells by electro-permeabilisation. An input of 500 bleomycin molecules suffices to kill a tumour cell. Several clinical studies have shown that electro-chemotherapy can be successfully applied to humans. To this end, bleomycin or cisplatinum have been introduced into several different tumour types.

Dr Mir also anticipated therapeutic progress through use of the second practical application of electro-permeabilisation. DNA electro-transfer could develop into an important tool of gene therapy. On one hand, the electrical pulses lead to cell membrane permeabilisation; on the other hand they improve the interaction between extracellular DNA and cell membrane, thereby promoting absorption of the external DNA by the cell. The applied field has a further positive effect. As DNA molecules are electrically charged, they are accelerated within the electric field thus supporting external molecule implantation into the target cell. The electrical impulses of DNA electro-transfer of about 20 milliseconds are significantly longer than those applied during electro-chemotherapy. The electrical field strength of 200-250 V/m is rather weak.

Until now, DNA electro-transfer has been successfully performed in mice, rats and primates. This method could become an alternative to viral gene transfer. Genes at electrically-injected DNA molecules were expressed in muscle cells over several months. Meanwhile, DNA electro-transfer can be controlled precisely enough by the applied impulses to draw reliable conclusions on the subsequent gene expression. For a long time this had not been possible for technical reasons.

In vitro experiments

The contributions on in vitro experiments in part were quite inconsistent. Partially, this had to do with the fact that "preliminary results" were presented. This rating is very important for assessing and evaluating the studies presented and should have been added to the title of the respective contributions. Several authors truthfully mentioned this aspect in their paper; in some cases, however, the "preliminary" character became obvious only at closer inspection of the applied methods or of statistical data. In this way often interim results or information is given that only later on - mostly unnoticed by the public - are fully confirmed or disproved.

After having published several of his own contributions on the effects of pulsed fields on animal cells, Pakhomov et al.

during this conference dealt with the question of whether the SAR value of short-time field pulses (9.3 GHz, 0.5 μs) is equivalent to that measured at continuous field exposure. The process engineering applied during these experiments was noteworthy. The growth of yeast cells suspended in a gel was examined. Because of the limited penetration depth of the RF field into this gel block, the cell behaviour at different SAR values could be examined by a single test. After 6 hours the block, which was heated from the outside up to 25° C, was cut into slices of 2 mm thickness each. Within these slices the SAR value varied between 0.6 mW/kg and 3.2 kW/kg depending on the slice's position. As the slices were differently heated (measured by thermistors), tests showed the typical temperature behaviour of cell division. However, even at the most intensive exposure no specific field effects could be found. Pulsed fields showed the same behaviour as continuous fields.

Other studies on the impact of 900-MHz fields on yeast cells were presented by posters of Campanella et al. and of Markkanen et al. The first study was able to find effects on cell breathing intensity at a power flux density of about 38 W/m², though it remains doubtful whether this was not simply caused by the heating of the sample. The Finnish study compared a special thermosensitive yeast stem (cdc48) to wild type (Kgy417). The effect of the field (0.6 W/kg) and the effects of UV radiation on colony formation and apoptosis were examined. Seemingly, UV radiation intensifies the field effect; however, the experiments still have to be replicated.

A Finnish group (Jeszczanski et al.) reported an increase of protein phosphorilisation, an expression of the heat shock protein Hsp27 and other proteins after a 1-hour exposure of human epithel cell cultures (EA.hy926) to a 900-MHz GSM field with intensities of 1.8-2.5 W/kg. Unfortunately, no information was given on a critical evaluation of the applied genetic engineering methods and statistical data processing.

Also "preliminary" - as already stated in the title - were the results presented by a French group (Lagroye et al.) on the impact of a GSM 900-field on the nitric oxide development in micorglia cells. The slight inductions of a nitric oxidase found after a 48-hour exposure (0.6 W/kg) could be seen as evidence for a protective mechanism against cancer induction.

According to experts, the approach of a Spanish group (Lederer et al.) of conducting experiments with 0.1 mT LF magnetic fields (8.3 and 217 Hz), as a contribution to the research into the impact of modulated and/or pulsed GSM fields, is unconvincing. The group - having published studies on static and low-frequency field effects on quite different objects - detected effects in the low-frequency range on the bioelectric activity of neurons. However, the authors completely misjudged the biophysical basis of these effects. In any case, a connection with GSM fields can not be derived from this. Several contributions referred to the much-discussed effects of radio-frequency fields on the enzyme ornithine decarboxylase (ODC), a key enzyme of the polyamin biosynthesis. After the American group of L. Cress and R. Owen found no effect on ODC activity in mouse lymphocytes (L929) in the LF range (Cress, L.W. et al., Carcinogenesis 20, 1999, 1025-1030), it presented equally negative results after exposure of the same cells to the TDMA regime (835 MHz, 1-15 W/kg). A second poster from the same group (Anderson et al.) showed that no alterations of the ODC activity in the brain of pregnant Fischer-344 rats and their offspring occurred after 4-days' exposure (1.62 GHz, 1.6-5 W/kg, 2 h/d) either. A Finnish group (Ruotsalainen et al.) even found a 40%-decrease of the ODC activity in the range of 900 MHz (0.3-0.5 W/kg, 2.8 to 24 hours) in the same cells as Cress et al. compared to control cells. These data combined with the many data given by recent literature seem to disprove the (alleged) ODC effect repeatedly claimed by Litovitz.

In this context, the evidence for a high-temperature sensitivity of this system given by the group around Cress et al. is important. These results also contradict the results found by Litovitz in the early nineties. He observed a distinct increase of ODC activity in mammalian cells after field exposure. He then selected an amplitude-modulated field with a frequency of 835 MHz. SAR values with 2.5 W/kg were significantly higher than during the previous experiments of Ruotsalainen. According to Ruotsalainen's interpretation of the results, electromagnetic fields can have effects on cells also at significantly smaller SAR values.

The group of D'Ambrosio from Italy presented a poster on the induction of micronuclei, an indicator of possible alterations within the genome of the cells. This group had earlier reported such effects (D'Ambrosio, G. et al., Electromagnetobiology 14, 1995, 157-164) pointing to potential uncontrollable temperature rises as a cause of the effects (LaCara, F. et al., Bioelectromagnetics 20, 1999, 172-176). Meanwhile, a publication of the group is in preparation claiming a positive finding which however is disproved by the poster presented during the conference. Obviously, during experiments described in the publication local SAR values about 5 W/kg with corresponding heating occurred. If such heating is avoided (GSM 1.748 GHz, 2W/kg, 15 min.), no effect occurs in human lymphocytes.

Some contributions dealt with frequencies above the range being of interest for mobile radio: a Russian group (Ogay and Novoselova) recently having reported on field effects in the range from 8.15 to 18 GHz (Fesenko, E.E. et al., Bioelectrochem. Bioenergetics 49, 1999, 29-35; Novoselova, E.G. et al., Bioelectrochem. Bioenergetics 49, 1999, 37-41) presented a poster pointing to effects of fields in this frequency range (1W/cm²) on the immune

system of ground squirrels in different phases of hibernation.

Following published data concerning the 50-Hz range (Shckorbatov, Y.G. et al., Bioelectromagnetics 22, 2001, 106-111), a group from Ukraine extended its study to the range between 18.75 GHz to 37.5 GHz. The electrophoretic mobility of epithelial cell nuclei was measured. It is doubtful whether results measured by such non-specific methods actually allow one to assume the existence of functional alterations of the cell nucleus.

An Armenian group (Trchounian) reported on effects of microwaves (53.5 to 68 MHz) on bacteria growth. Here, a thermal effect can not be excluded.

Dr. Leszczynski from Finland spoke about signal transfer path and stress mechanism activation in exposed cells. According to his results, exposure of human endothelian cells to a 900-MHz GSM signal led to alterations of signal transfer and stress response. Leszczynski's working group found a significantly increased protein phosphorilisation within exposed cells, and interpreted this as evidence for signal path activation.

The heat shock protein HSP 27 was more strongly phosporilised in 1-h exposed cells than in non-exposed cells. In cells exposed for several hours the effect was not observed. However, Leszczynski emphasized that this phenomenon of phosphorilisation and ensuing dephosphorilisation is typical for HSP 27, also occurring during other stress responses. The working group concluded that though electromagnetic fields can trigger stress responses in cells, this is no evidence for health effects.

Van der Plas and colleagues examined the interaction between magnetic fields of high-voltage transmission lines and incidence rates of childhood leukemia in the Netherlands. According to their results, at most one of the 110 cases of childhood leukemia annually occurring in the Netherlands can be explained by exposure to magnetic fields of high-voltage transmission lines. In the opinion of the authors, there is no evidence at all for any causal association, or for any biological mechanism.

As part of the lectures on in vitro studies, Dr Pakhomov from San Antonio, U.S.A., presented an interesting set-up for cell field exposure. His working group embedded yeast cells in a plastic cuvette filled with agarosis gel. During field exposure, a series of decreasing SAR values runs along the longitudinal axis of the receptacle. This test set-up allows the quick examination of effects at cells which are exposed to a wide range of SAR values. At a frequency of 10 GHz the specific absorption rate decreases by a factor of two with each mm distance to the electromagnetic field source. Across the whole length of the measurement cuvette there is a factor of significantly more than one million beween maximum and minimum SAR value. In experiments, for example SAR gradients between 3 W per g and 1 W per g were produced. After field exposure the gel can be cut into thin slices for examining the embedded cells. The authors refer to the temperature rise in the cuvettes during field exposure. Nevertheless, according to the authors, different exposure types, for example exposure to pulsed and to continuous fields, should be comparable, since temperature distribution also is comparable between experiments.

In vivo studies

This section was introduced by a survey lecture of Murphy et al. on recent studies on mm-waves (30 to 300 GHz). Here, the emphasis lies on the temperature effects on the skin. The lowest sensitivity threshold for this effect is the heating of the skin by 0.1° C caused by a 10-min. exposure to 94 GHz with a power flux density of 4.5 mW/cm^2. The pain threshold in the same frequency range was determined to correspond to an exposure of 1250 mW/cm^2, leading to a heating of the skin by about 9.9° C. For the cornea, a limit value of

about 5 W/cm² for acute damage has been found. No cancer-initiating or cancer-promoting effect has yet been confirmed.

A French group (Mausset et al.) presented combined neurohistochemical and biobehavioural studies in rats on effects of strong 900-MHz fields (4 and 32 W/kg). Whereas no significant impact on the locomotive behaviour of rats could be found, there were effects on the activity of different neurotransmitters for as short a duration of 15-min. field exposure with 4 W/kg. These results, too, were marked as "preliminary."

An unexpected clinical application was recommended by a Russian group (Sinotova et al.) claiming to have found proof that a long-term (1.5 hours per day, 30 days) field exposure of mice to 8.15 to 18 GHz (0.3 W/cm²) strengthens their immune system. The number of macrophages as well as that of T-lymphocytes significantly increased. Also the activity of the tumour necrosis factor and of interleucin (IL-3) increased. The authors recommend long-term exposure to radiation as a preventive treatment against infections. Therefore, a second report of this group (Glushkova et al.) followed in the section on medical applications (a surprising new aspect of the discussion on "electrosmog"!). However, during the same session South African scientists (deJager et al.) reported opposite effects. They found a decrease of the number of lymphocytes in mice after 14-weeks' exposure to 50-MHz magnetic fields stochastically varying between 0.5 and 77 T.

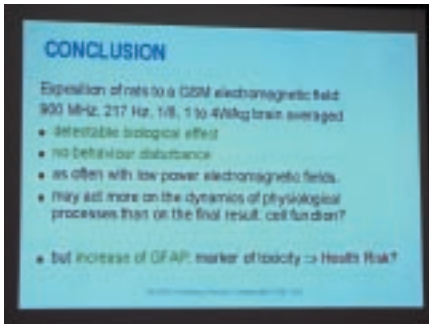
Studies on the highly-controversial impact of RF fields (900-MHz GSM pulses) on the blood-brain barrier were presented in the lecture of von Töre et al. Normal rats were compared with rats suffering from an infection of the dura mater.

Although after field exposure (2 W/kg average whole-body SAR, 20 W/kg in the dura mater, 2-hours' exposure) the passage of plasma protein in the infected rats was stronger then that for normal animals, distinct traces of the passage of plasma protein could also be found in the normal animals. The tests will be continued applying decreased field intensities. A Japanese group (Nagawa et al.) that recently published a study on the same topic (Tsurita, G., Bioelectromagnetics 21, 2000, 364-371) arrived at opposite results. The scientists could not find any effect of this type in rats after exposure at 1.439 GHz, 0.99 and/or 4 W/kg, 1 hour/day for 2 to 4 weeks.

Similar to an earlier published test (Heikkinen, P. et al., Intern. J. Radiat. Biol. 77, 2001, 483-495), a Finnish group (Kumlin et al.) reported on experiments that provided no confirmation that 50-Hz magnetic fields promote cancer induced by ionising radiation (in this case UV radiation).

Prof. Adlkofer spoke about a new project (REFLEX) - an association of twelve laboratories - mainly dealing with possible effects of weak fields both of the LF and the RF ranges. Some first results still have to be replicated.

A number of further animal tests were illustrated by posters. Yamaguchi et al. demonstrated that irradiation of the brain with 7.4 W/kg (at 1.439 GHz) showed no effect on the memory of rats in behavioural experiments. The same result was found by B. Cobb and E. Adair after field exposure of rats to 500-pps pulses of an average dose of 0.6 W/kg. Thus, they explicitly disproved the study of Lai (Lai, H. et al., Bioelectromagnetics 15, 1994, 95-104). Three posters of Hungarian groups (Salamon et al. and two posters of Kubinyi et al.) reported on experiments on the impact of GSM fields on melatonin and other enzyme alterations in rats which showed no effects. The Polish group of Szmigielski (Reijt et al.) presented an analysis of the breeding behaviour of great tits and bluetits near a radar station, however, without providing convincing data.



Interaction mechanisms

Though this session consisted of eight contributions, there was no substantial new knowledge in this area. Professor Martin Blank again presented his theory on possible effects of electron conductivity in macromolecules, ignoring the available critical reviews of his publications. In a second lecture, he elucidated the possible consequences of this model for genetic engineering. The Italian group of D'Inzeo (Ramundo-Orlando) also presented two lectures. The main focus of the first one was on the role of connexin, a protein which is responsible for creating gap junctions, the connecting channels between the cells. The second lecture demonstrated a calculation using the Italian computer program, which has often been demonstrated. All this is known and has already been presented at various other conferences; thus, the group did not provide any new knowledge for use in the current discussion.

A poster of French et al. dealt with an interesting question: "Can low-energy radio-frequency (non-thermal) fields (by activating heat shock proteins) initiate induced cancer?" It was a follow-up to a recently published study (Laurence, J.A. et al., J. Theoret. Biology 206, 2000, 291-298) dealing with the issue as to how proteins can be heated under conditions not leading to a temperature rise of the whole system. This hypothesis must be verified by experiments.

Epidemiology and tests in participants

On epidemiology, there were no new knowledge and data given. As mentioned above, two of the seven lectures held in this section presented details of the IN-

Table: Distribution of lectures and posters among topic areas; EBEA Congress 2001

Topic	number of lectures	number of posters
Session Interaction Mechanisms	8	3
Session Exposure Assessment	6	4
Session Wireless Telecommunication	5	5
Session Epidemiological and Human Studies	6	8
Session Risk Assessment and Communication	5	5
Session in vivo Studies	8	18
Session in vitro Studies	6	16
Session Dosimetry I und II	14	9
Session Medical Applications	5	4

TERPHONE project (Adoino et al.) as well as on the planned Finnish study (Auvinen et al.). Hakansson et al. reported on a study, until now still not evaluated, on an association of occupational exposure to fields of extremely low frequency with mortality rate and diseases of the cardiovascular and circulatory system. A Polish study of the Szmigielski group (Sobisczewski et al.) presented tests in 115 field-exposed workers after several years of employment. The workers subjectively complained of dysregulations of the heart function that could not be determined objectively, i.e. clinically confirmed.

Three further contributions dealt with tests of participants. A group from the Technical University Tallin reported in a lecture and a poster (Lass et al.) on tests of participants' being exposed to a 450-MHz field modulated at 7 Hz (no SAR value given). The aim of the tests was to determine to what extent vigilance and short-time memory would be affected. However, the scientists could not find significant differences from control participants.

Three further contributions dealt with a possible impact of electromagnetic fields on the cardiovascular and the circulatory system. In their lecture, Mann and Röschke presented the impact of a 900-MHz GSM field on heart rate during different sleep phases. The significance of the impact found is not very high. Obviously, individual conditions play a huge part. A Finnish group (Tahvanainen et al.) dealt with the question whether RF fields affect heart rate and blood pressure of healthy participants. Over 35 min. they exposed participants to 900 and/or 1800 MHz (no SAR values given). ECG, arterial blood pressure, respiration, ear temperature, and intrathoracal pressure were measured. However, no effects were found in any of the 11 participants.

Resumé

To the most part, the results presented and discussed during the Fifth Congress of the European BioElectromagnetics Association gave no proof of any effect of electromagnetic fields on biological systems. Thus, an association between health risks and daily exposure to electromagnetic fields could not be confirmed on the basis of the new scientific data.

Dr. Gerd Friedrich, managing director of the Research Association for Radio Applications (Forschungsgemeinschaft Funk e.V.)