1. What was the situation like before the start of the DMF?

There were indications from not replicated studies, that RF-EMF exposure might lead to genotoxic effects on DNA, or affect cellular metabolism, cell functions, stress response or the cellular ROS level.
There were indications from not replicated studies in vitro and in vivo that there may be adverse effects of RF-EMF on the blood brain barrier.
Reduction of melatonin synthesis by RF-EMF was discussed as a possible mechanism for adverse health effects.
No systematic research on a possible influence of weak RF fields on the visual system was performed earlier. Adverse effects of strong microwave exposure causing heating and cataract were established.
There were complaints from the public about hearing impairment due to electromagnetic fields, as well as few preliminary scientific publications showing possible physiological effects of RF fields on the acoustic system, which is the highest exposed organ during a phone call.
The pulsing or low frequency modulation of the RF signal caused public concern. The question, if pulsed signals of mobile communications can be demodulated as a result of nonlinearities e.g. in the cell membrane could only be answered with remaining uncertainty., although the biophysical research between 1970 and 1980 (e.g., by H.P. Schwan and K. Foster) suggested that a demodulation of RF fields with frequencies above 10 MHz should not be possible, since cell membranes are transparent to RF fields of these frequencies.Reasonable assumptions for the dielectric properties of subcellular compartments can not explain rectification effects in the upper MHz- and GHz-ranges. Rectification effects caused by nonlinear properties of membrane lipids or proteins can most probably be ruled out above some kHz.

2. What has been achieved by the projects? What are the lessons learned?

Physiological processes such as phagocytosis, cell proliferation, cell cycle, apoptosis, stress response or induction of superoxide radical anions and ROS in different immune relevant cell systems were not influenced by different mobile phone signals with intensities lower than international limit values. The results with experimental DTX Signal on ROS induction and protein expression are inconclusive. A difference in the exposure chambers (direction of air flow) and its possible impact on the results has to be clarified.
In vitro experiments using blood-brain barrier-models suggest that there may be effects on the pattern of gene-expression. *A*rrays have to be finally analysed, interpreted and relevant results have to be confirmed with RTPCR. Results from in vitro models have to be evaluated in context to results of ongoing in vivo studies. It should be clarified what kind of significance and what kind of effect can be found and verified with the methodology of gene arrays.
The hypothesis of RF induced inhibition of melatonin-synthesis can not be confirmed with this model. At present no further research was recommended.
According to first analysis, RF electromagnetic fields do not have an adverse effect on the neuronal network of the retina, but a detailed statistical analysis is still ongoing and final results have to be awaited. There are no indications, that retina and the visual system are impaired by weak RF fields below the limits. According to dosimetric studies (DMF Project, ARC Seibersdorf), the exposure of the retina with

GSM and UMTS signals during a phone call is rather low. Therefore, no further research on the visual system seems necessary.
According to first analysis, RF electromagnetic fields of mobile communications do not have an adverse effect on the sensitive electrophysiological response of inner hair cells of the cochlea, but a detailed statistical analysis is still ongoing and final results have to be awaited. These results are in accordance with the results of the international project GUARD which showed no influence of GSM signals on the hearing system – otoacoustic emissions of the outer hair cells and brainstem potentials – in volunteers and laboratory animals. A similar project on UMTS signal (EMFNEAR) is ongoing. Taken all these results together, there is no scientific rational to assume a health hazard to the hearing system from exposure to mobile telephone signals with intensities below the exposure limits. According to the complaints from the population, research on chronic effects (tinnitus) has been initiated, results from the ongoing project are expected at the October workshop.
Model calculations have shown, that the energy absorption in the cell membrane depends on the layered structure and the anisotropy within the membrane. The calculated absorbed energy based on an improved model was higher by a factor of up to 10 in comparison with calculations performed for homogeneous membranes. The calculations are now verified by measurements. The resulting temperature increase in the membrane will be very small, and there is no basis to anticipate health effects from this finding.

3. Where do we still have gaps?

The thermal sensitivity of biological systems should be known in more detail, to help separate "thermal" from "nonthermal" contributions to reported biological effects of RF fields.
Possible further research on the membrane of mitochondria and possible field effects on charge transport was discussed.
When modelling electrical interactions with cell membranes, membrane structure including membrane proteins should be taken into account to provide a more detailed picture of interaction mechanisms.
Electrophysiological studies and in vitro studies in general can investigate acute effects only. There are no indications for long term effects in retina, but tinnitus has to be studied in vivo. Results of the ongoing in vivo study have to be taken into account.
The slight but significant increase of the relative body weight of animals under exposure with GSM-900, SAR 0.4 W/kg, which was observed in one study, should be clarified. The possible effects of RF energy absorption on the metabolic rate of rodents, which can be anticipated on thermophysiological grounds, is the topic of an ongoing project, to the results of which should be taken into account in the interpretation of the study.
Physiological relevance of changes detected in screening arrays remain unclear and have to be supported/confirmed by in vivo results.
Screening arrays can not cover each time point and each SAR at the same time, “hypothesis driven” assays on the other hand can miss relevant targets. Results from different arrays on different levels (mRNA, proteins) have to be brought together (need of good data bases).
Although exposure systems have improved considerably, remaining technical problems need to be ruled out through an intense and open dialog between technical

and biological partners. It has to be clarified, to what extent biological findings in the experiments are due to inconsistencies and/or operating errors of the exposure setups.

4. *Can we define minimum standards for future work?*

Quality check of the exposure set-ups. Exposure systems have to be optimized for each individual project and in each case thoroughly validated. A continuous comprehensive support of the biologists by engineers (and vice versa!) is essential. Problems have to be mentioned and discussed openly.
Very sensitive methods, like shown here for electrophysiology in sensory systems, are recommended for investigation of acute effects..
All research has to be performed blinded, unblinding should occur after data evaluation, if possible.
Detailed statistical analyses should be performed by professional statisticians.
If possible, the power of each study has to be calculated and the number of experiments adjusted accordingly before the beginning of the study. To estimate the number of experiments guaranteeing a certain statistical power, a series of experiments has to be performed under the final measurement conditions, but without the EM field, in advance. Only by analysing the natural variation of the parameters of interest these calculations can be done. This should be part of any new study.
For each experiment incubator controls in addition to sham controls as well as positive controls should be carried in parallel, if possible.
Single array-experiments can only give very preliminary data and no further conclusions should be drawn from them, at least if results are not confirmed by a second method.
Data from screening techniques give valuable information if processed carefully but have to be confirmed by a second method (e.g. RTPCR).

5. Are there findings that have an impact on guidelines or on standard settings?

Not so far, but results of ongoing studies should be awaited.