European Cooperation in the field of Scientific and Technical Research
- COST -

Brussels, 22 November 2013

COST 049/13

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action BM1309: European network for innovative uses of EMFs in biomedical applications (EMF-MED)

Delegations will find attached the Memorandum of Understanding for COST Action BM1309 as approved by the COST Committee of Senior Officials (CSO) at its 188th meeting on 14 November 2013.

MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action BM1309
EUROPEAN NETWORK FOR INNOVATIVE USES OF EMFS IN BIOMEDICAL APPLICATIONS (EMF-MED)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4114/13 "COST Action Management" and document COST 4112/13 "Rules for Participation in and Implementation of COST Activities" , or in any new document amending or replacing them, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to build an interdisciplinary European network for innovative uses of electromagnetic fields (EMFs) in biomedical applications.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 92 million in 2013 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of section *2. Changes to a COST Action* in the document COST 4114/13.

A. ABSTRACT AND KEYWORDS

The Action will provide a cooperative framework to support the research on beneficial biological effects of non-ionizing electromagnetic fields (EMFs) and their use in biomedical applications. Research on biological effects of EMFs has traditionally focused on health risks. Inspired by promising recent studies on useful biomedical EMF interactions and applications, this Action will focus on beneficial effects, aiming for breakthrough results, new discoveries and innovative biomedical technologies. The Action will provide a better understanding of underlying physical and biological interaction mechanisms, related to both cancer and non-cancer applications, filling the gaps in the present state of knowledge. Ultimately, the Action will aim to contribute to development and optimization of innovative EMF-based medical devices and procedures, which will be safer, more efficient and less invasive. Interdisciplinarity of the proposed topic and significance of the expected outcomes require a concerted research network at the European level.
Keywords: beneficial effects of EMFs, biomedical applications of EMFs, cancer and non-cancer interactions, EMF stimulation of cells and tissues, measurements and in silico tools for EMF dosimetry

B. BACKGROUND

B.1 General background

The human body is intrinsically and essentially an electrical object, based on complex electrical functionalities. Possibilities for interactions between electromagnetic fields (EMFs) and the human body are numerous, ranging from ions and polarized molecules at the subcellular level to cellular electrical phenomena and tissue-level electrophysiology. However, not all known processes are fully understood, and more processes remain to be discovered.

The last few decades of research on the harmful effects of EMFs have brought some interactions to light, and several potentially harmful effects have been used in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines as rationale for limiting human exposure to EMFs. These refer to thermal effects of high-level radiofrequency (RF) EMFs ("high-level" referring to the magnitudes above the limits for safe human exposure), and electrical stimulation effects of high-level low frequency (LF) EMFs, e.g. the direct stimulation of nerve and muscle tissue, and the induction of retinal phosphenes. Such effects are called short-term effects, because the effects occur instantaneously, lasting just as long as the exposure itself. These effects have

thresholds below which they do not occur, and can therefore be avoided by complying with appropriate exposure limits.

However, in the last few years, some interesting scientific results have emerged, regarding the biological effects of EMFs occurring at levels well below (i.e. complying with) the exposure limits (therefore addressed here as "low-level" EMFs). Interaction mechanisms and health implications are still not understood. Some findings suggest a potential for long-term biological effects, and some suggest possibilities for usable beneficial and health promoting uses and applications.

Understanding these effects is getting more important as the exposure to "low-level" EMFs from a raising number of different appliances is drastically increasing, in the general population as well as by occupationally exposed workers. Research on these "low-level" effects, particularly the long-term effects, is declared necessary (and practically mandated) by the newest legislative document of the EU: Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields), OJ L 179, 29/06/2013, p. 1–21 (hereafter referred to as “EMF Directive").

On the other hand, the vast range of possibilities for interactions between EMFs and the human body raises a question whether currently unexplained or even unknown interaction mechanisms may be used for the benefit of human health. Some recently discovered potentially beneficial interactions are under investigation in various contexts, e.g. EMF-based cancer treatment, EMF exposure/stimulation of excitable tissues and cells for neurological, neurodegenerative and psychiatric disorders, as well as EMF exposure/stimulation of non-excitable tissues in tissue healing, growth, or regeneration applications. Such mechanisms could be harnessed and employed in biomedical applications for the benefit of human health.

The aspiration to use electricity and magnetism for beneficial medical applications is not new – in fact, it is as old as the study of electricity itself. However, to be able to find, investigate, and make use of certain beneficial effects of EMFs, a whole set of pre-conditions have to be met: the extensive knowledge of life sciences – primarily medicine, biology, and biophysics, aided by modern methodology in molecular biology, chemistry and physics research, and on top of that, engineering apparatus in electrical engineering and bioelectromagnetics, consisting of modern technologies, measurement methods and instruments, computational simulation methods combined with sufficient computational power and accurate physiological models. All these should provide the scientific basis for design and development of new healthcare technologies for routine applications, as well as for assessment of such technologies. At the moment, only several applications are being or have been approved as medical devices, but there is still much room for

improvement and optimisation. Now is the time when the above pre-conditions are getting adequate to approach this research topic systematically, and exactly this will be achieved through this Action. Some of these pre-conditions have been addressed and at least partially met in recent decades of research on harmful effects of EMFs to humans, e.g. through the COST Action BM0704 "Emerging EMF Technologies and Health Risk Management". Extensive expertise and several applicable methodologies are thus already at hand to the EMF community. However, that knowledge and methodology will now be applied to investigations of the shifted (or even opposing) paradigm – beneficial effects and innovative uses of EMFs in biomedical applications. Such innovative EMF-based biomedical applications could give a significant boost to the current healthcare systems, by providing cost-effective therapeutic or diagnostic alternatives, revolutionizing the way we see medical treatment today.

B.2 Current state of knowledge

In the last two decades, research on EMF interactions with the human body has been performed predominantly with the objective to assess the harmful effects, i.e. health risks of exposure to EMFs. Experiments, analyses, and studies have been designed and performed according to this objective, and several past COST Actions, including the recently completed BM0704, have been devoted to the topic of health risk and its management. On the other hand, beneficial effects of EMFs have a great potential for research and innovation, but have not so far been included in previous COST Actions dealing with biological effects of EMFs. However, last year, this subject created an extensive demand for a new Action that would focus exactly on the beneficial health effects of EMFs. This shift of focus (with respect to most other EMF projects and studies) could lead to breakthrough results, and to a deeper understanding of the biological interactions of EMFs (especially low-level EMFs and long-term effects) with the human body, as a basis for innovative medical procedures. The new Action will form a new, previously non-existing network; relying on the expertise already available in the European EMF community, with outreach to the researchers studying the beneficial applications, who have not been previously involved in past Actions on EMFs.

To illustrate the scientific potential and current state of knowledge, a selection of several important recent studies, possibly leading to innovative biomedical applications of EMFs, are outlined here: cancer cell proliferation is inhibited when treated with very low levels of EMFs of specific carrier and/or modulation frequency; electrical and electromagnetic stimulation can be successfully used for treatment of insomnia, pain management, tissue regeneration, and wound healing; novel

exposure systems are being devised for the study of EMF effects on cell cultures and on the central nervous system; novel realistic multiphysics in-silico models and simulation methods are being developed to better understand the biological processes and EMF interactions; procedures of transcranial electric and magnetic stimulation are being analyzed and optimized by simulations using realistic anatomical models. In addition, novel EMF-based biomedical applications are being increasingly investigated, such as: minimally invasive microwave ablation therapy; hyperthermia; magnetic drug targeting; biomedical telemetry based on wearable, implantable and ingestible antennas; non-invasive monitoring of vital signs; radio-frequency identification (RFID) systems in healthcare, etc.

B.3 Reasons for the Action

In the last few years, some interesting scientific results regarding the biological effects of EMFs have emerged, that are still not well understood. Some of these effects occur at low levels of EMF, well below (i.e. complying with) the exposure limits, suggesting the potential for long-term biological effects, and some suggest possibilities for usable beneficial and health promoting uses and applications. At the same time, novel EMF-based systems for therapy, monitoring, diagnosis, etc. have started to prove their benefit for human health, and promise much more innovative applications in the future. The promising topics leading to envisaged applications are outlined in section B.2, whereas the objectives and means to achieve them are detailed in sections C.2 and C.3. Therefore, this is an ideal time to launch a COST Action as a cooperative framework to support interdisciplinary research in the area of innovative uses of EMFs in biomedical applications. This COST Action will be the very first scientific initiative in the world to systematically approach the topic of beneficial effects of EMFs, using triple synergy: synergy of disciplines, synergy of dispersed resources, and synergy of stakeholders.

The synergy of disciplines, required to fully understand and exploit the underlying phenomena of biological interactions with EMFs, will be achieved by bringing researchers from several disciplines (biomedicine, biology, physics, electrical engineering, computational life sciences, etc.) to work from different directions together in a single program. This will provide the strongest environment for intense in-depth scientific discussions, "out-of-the-box" thinking, and ultimately will boost progress in understanding of potential biological effects.

Many researchers who study the beneficial applications were not involved in previous Actions on EMFs. They are dispersed across Europe and wider, and it is thus an absolute priority to connect all these otherwise dispersed groups from different countries into a concerted research network, to

achieve synergy of dispersed resources.
The synergy of stakeholders (researchers, health care institutions, industry, various policy makers and others listed in section C.5) is required to ensure application-oriented activities, putting the accumulated knowledge to use. In this way, the Action will result with solid grounds for development, design, production, introduction and assessment of EMF-based biomedical technology to make the translation of research from the experimental bench to the patient's bedside possible, ultimately producing economic and societal outcomes and impacts.
The results of this Action will be crucial for future legislation, standardization and policy-making, as well as for the future collaborative research initiatives, e.g. through Horizon 2020. Connecting the research in this domain with adequate applications and technology development will facilitate founding of new knowledge-intensive start-up small and medium enterprises (SMEs) to the profit of European economy. Hence, this Action is aimed both at European societal/economic needs, and at scientific/technological advance. The COST Action is an optimal framework for this purpose, and the best choice to maximize the benefit-to-cost ratio for the invested budget.

B.4 Complementarity with other research programmes

The Action aims to foster and inspire other types of subsequent collaborative interdisciplinary research projects on this topic, as well as innovative projects in technological development, fulfilling one of the COST functions as a generator of initiatives in the Framework Programmes, e.g. Horizon 2020, and as a potential source of industrial applications, e.g. in EUREKA.
Links will be established to research groups in other parts of the world where similar topics are being studied, where important experiments and investigations are already being performed. Links will additionally be established to other research initiatives focused on EMFs (which all, by rule, address EMF-related health risks and safety aspects), in order to sustain exchange of information on EMF-based technologies and EMF exposure assessment, as well as complementarity and synergy with such initiatives.
COST Action TD1104 - European network for development of electroporation-based technologies and treatments - is an ongoing project that deals with the application of electroporation (the process of permeabilizing cell membranes by applying external electric fields) in several application areas. Besides working groups on food processing, pharmaceuticals, biomass processing and environmental applications, there is also a working group on medical applications. Although electroporation as a procedure is not envisaged as a topic in this Action, links with TD1104 will be established for exchange of potentially complementary information surrounding this procedure,

with TD1104 Chair supporting this Action as participant.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The aim of the Action is to build an interdisciplinary European network for innovative uses of EMFs in biomedical applications.

C.2 Objectives

The Action objectives are to:
1. build the capacity for scientific networking and research on the topic of innovative and beneficial uses of EMFs in biomedical applications within Europe, increasing the number of highly trained and qualified researchers, pooling the relevant knowledge and research facilities, and establishing collaborations that will result in new research initiatives;
2. achieve a better understanding of EMF interactions with the human body at the molecular, cellular, tissue and system level, and the resulting health impacts;
3. provide a sound scientific basis for better understanding of the existing and the introduction and development of innovative applications of EMFs in medicine;
4. develop appropriate computational and measurement tools for EMF dosimetry as well as optimal exposure and application setups;
5. enable Early-Stage Researchers (ESRs) to gain knowledge and training in this promising field, and maintain the gender balance;
6. promote and/or establish new links with industrial partners, by converging academic and industrial research – resulting in possible new commercial applications, increasing the number of academic partners collaborating with industrial partners;
7. provide inputs and recommendations for Health Technology Assessment (HTA) for commercial applications and for adequate policies, evaluation, monitoring and vigilance systems;
8. strengthen the position of EU in this field with respect to the rest of the world.
Achievement of the objectives will be carefully monitored and evaluated using quantitative indicators, i.e. number of:
- active participants from COST countries (objectives 1, 7, 8);
- active participants from non-COST countries (objectives 1, 7, 8);
- ESRs involved (objectives 1, 5);

- number of men and women involved (objectives 1, 5);
- companies involved or interested in the Action (especially innovative SMEs) (objectives 1, 3, 6, 7, 8);
- organized networking events (meetings, workshops etc.) (objective 1);
- completed Short-Term Scientific Missions (STSMs) (objectives 1, 5);
- Training School attendees (objectives 1, 5);
- studies undertaken by the participants, and specifically, undertaken in collaboration of different participating groups (objectives 1, 6);
- scientific publications authored during the course of the Action, and specifically, co-authored in collaboration of different participating groups (objectives 1, 2, 3, 4);
- reports and publications disseminated by the Action (objectives 1, 6, 7);
- researchers visiting other research groups and laboratories (objective 1);
- theses (especially PhDs) achieved on the Action topics (objectives 1, 5);
- subsequent initiatives for collaborative research (objectives 1, 6, 8);
- contacts and queries received from outside of the Action, and specifically, from outside of Europe (objectives 1, 6, 8).

More indicators may be devised in the course of Action.

The initial values of these indicators at the start of the Action will be noted and used as reference values for subsequent evaluation. The indicators will then be continuously monitored by the Steering Group (SG) and the Management Committee (MC) (their roles explained in section E.1). Relevant data on the said indicators will be collected by the SG, using queries, questionnaires and other communications, with the help of Dissemination Manager and ESR/STSM/Training Coordinator (their roles also explained in section E.1). The SG will provide detailed reports on the state of quantitative indicators for the MC analysis and discussion, as agenda item for each MC meeting. MC will thus evaluate the achievement of objectives, and, based on that, discuss and plan the future Action activities. If needed, measures for improvements will be adopted by the MC and executed by SG. In between the MC meetings, the SG will continuously and proactively work on the improvement of said indicators through its regular activities, fostering dissemination, training, communication and collaboration between participants and stakeholders, involving the whole MC whenever necessary.

Formal evaluations of the Action progress will be done yearly by the MC. Positive evaluation from the MC will be based on the continuous rise of the quantitative indicators with respect to each previous year (in accordance with the milestones defined in section E.1).

C.3 How networking within the Action will yield the objectives?

The expected objectives will be achieved through the following means of networking:
- forming a European network of research groups (joined by key experts from non-member countries) working on relevant topics;
- concerting the activities of individual research groups, while tasking and focusing their research according to the Action objectives;
- structuring the Action activities into Working Groups devoted to interdisciplinary approaches to major topics and applications;
- jointly analyzing the research results and strategically guiding further research through Management Committee (MC) and Working Group (WG) meetings, workshops, and other types of conferencing;
- fostering the formation of new European and other research initiatives and new research groups, to study relevant topics that are highly prospective, yet currently insufficiently addressed in the EU with respect to the rest of the world;
- fostering the involvement and training of ESRs to ensure a sound basis for further research in these important topics;
- fostering the cooperation that will lead to joint participation in European and other international research initiatives;
- disseminating information, involving SMEs and all other relevant stakeholders in the activities, either as participants, or as target audience for the dissemination of results.

C.4 Potential impact of the Action

The Action will help to make the translation of research from the experimental bench to the patient's bedside; creating innovative EMF-based applications in medicine, resulting in improved, optimized, safer, more efficient and less invasive health care for citizens in Europe and worldwide. A short list of potential applications includes: cancer treatment, pain management, tissue regeneration, drug-delivery systems, targeted personalized medical procedures, physiological parameter monitoring using EMF-based technologies, etc. Consequently, the impact of the Action is very wide, affecting not only each field of this interdisciplinary topic and the associated technologies, but also the fundamental quality of human life. The translation of the results will be enabled through dissemination to the key stakeholders, i.e. target groups specified in section C.5. These are already represented in the proposal by the Action participants, thus ensuring the Action

visibility and the width of its impact.
The Action will help to build research and innovation capacities in the field of EMF-based biomedical applications, leading to the formation of subsequent targeted R&D projects, primarily within the framework of Horizon 2020, but also through worldwide cooperation.
Finally, the Action is ambitious and set up to generate, or at least provoke breakthrough discoveries and innovations, especially considering that the concerted and systematic research on the biological interactions with EMFs could reveal previously unknown or unforeseen interaction mechanisms. Such outcome would maximize the impact of the Action, leading to new concepts and products.
By investigating interaction mechanisms, the Action can lead to better understanding of biological effects of EMFs in general – particularly the long-term effects, the topic specifically emphasized in the recently adopted EMF Directive. From historical experience, it is clear that harmful and beneficial effects of an agent are often relying on the same biological mechanisms. The accumulated results will thus have a considerable impact on policy making, strategic decisions and possibly even the legislation.

C.5 Target groups/end users

The end users of the results will be:
- researchers, engineers, and other experts in R&D sector of EMF-based biomedical technologies;
- Early-Stage Researchers and students (especially PhD students) in the related fields;
- health care institutions and medical practitioners, who apply the EMF-based medical devices in clinical settings;
- industry, especially SMEs in the field of biomedical technology, both new start-ups and established enterprises, aiming to improve their products;
- government and administration bodies during legislative procedures, policy making or when making strategic decisions regarding EMF-related applications and issues;
- international organizations, bodies, agencies, societies, and other policy makers in need of scientific knowledge, or when considering scientific facts in the related fields;
- standardization bodies and technical committees when preparing relevant technical standards;
- ultimately and most important: the general public, receiving better health care based on innovative, efficient and less invasive EMF-based biomedical technologies.

The proposal was prepared by an interdisciplinary group of people covering all listed stakeholders, including renowned researchers who have been involved in the work of the related standardization bodies, national and international technical committees, organizations, agencies, societies, etc.

Many of them are involved in legislative procedures at the national level, and some are involved at the EU level. Several participants are closely involved in R&D activities of SMEs in the field of biomedical technology. Several researchers are active in clinical settings, either as medical practitioners, or as clinical experimenters. Early-Stage Researchers and PhD students are also present in the group. In addition to incorporating the target group representatives in the list of participants, care will be taken to disseminate the relevant information and results to each of the target groups, as described in section H.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The scientific programme will focus on the following research topics, and each topic will be addressed using interdisciplinary approach:

Topic 1. EMF-based cancer interactions, treatment and related applications

This topic covers the research on treatment and diagnosis of cancer using EMFs and/or EMF-based technologies.

Special interest will be in the treatment and diagnosis of cancer using low-level EMFs - an emerging methodology with a breakthrough potential, which so far lacks a sound scientific foundation, although clinical trials have shown promising results. Therefore, a wide range of interdisciplinary and multilevel studies are needed.

Clinical evidence suggests that low-level EMFs having certain frequencies within the radiofrequency (RF) range of the spectrum may have anti-tumour effects without causing hyperthermia in patients with breast cancer, hepatocellular carcinoma (HCC), ovarian cancer, thyroid cancer and glioblastoma multiforme. It has been shown that the growth of certain types of cancer cells, namely HCC and breast cancer, was significantly decreased when exposed to amplitude-modulated (AM) EMFs, having carrier frequency in the RF range, and modulation frequency specific to the type of cancer. Growth rate of certain tumour cell lines was reduced with respect to the normal cells, when exposed to tumour-specific modulation frequencies. Subsequent clinical investigations reported benefits from using the specific AM EMFs to treat advanced HCC, stabilising the disease and producing partial responses. Other studies demonstrated that low-intensity non-modulated alternating electric fields, in the intermediate frequency range (100–300 kHz), delivered by means of insulated electrodes, have a profound inhibitory effect on the growth rate of a variety of human and rodent tumour cell lines. These findings demonstrate the potential applicability of the low-level EMFs as a novel therapeutic modality for malignant tumours. The

NovoTTF-100A technology applies alternating electric fields by means of electrodes placed on the skin overlying tumour-harbouring body parts, and was the first EMF device of its kind approved by the US FDA in March 2011, following promising results of a Phase 3 trial for the treatment of recurrent glioblastoma, indicating efficacy similar to the standard-of-care chemotherapy regimen but with fewer side effects. The portable TheraBionic treatment modality, which uses amplitude-modulated EMF having RF carrier frequency, demonstrated therapeutic efficacy in a Phase 1/2 Study in patients with unresectable hepatocellular carcinoma, with a response rate nearly four times higher than treatment with sorafenib, the most commonly used treatment for patients with advanced hepatocellular carcinoma. It is important to emphasize that these interactions occur at the non-thermal level of applied EMFs, well under the ICNIRP limits for harmful exposure. However, there are evident gaps in knowledge that limit the applicability of this treatment. To improve the knowledge linked to cancer treatment and diagnosis based on EMFs, the modifications undergone by cells and tissues due to the interaction with low-levels EMFs will be investigated with the aim of evidencing the EMFs characteristics linked to morphological or other cells modifications. These data will be useful for developing the scientific rationale of treatments based on low level EMFs. The discovered interactions of EMFs with tumour tissues and cells raise questions whether similar underlying mechanisms could be used for cancer diagnosis. One group of investigators reported a phenomenon of “tumour-specific frequency signature” identified in patients with primary malignancies from the same tissue of origin, and lacking in patients without malignancy. Other modalities for EMF-based cancer diagnosis include the use of impedance tomography and radar-like applications where backscattering is used to identify tumour locations. Other approaches use targeted (functionalized) nanoparticles (e.g., magnetic) that can be subsequently imaged using EMFs. Magnetoencephalography (MEG) is a non-invasive modality used to differentiate among neoplastic tissue types in the brain, with the potential to be used in combination with CT or MRI. A modality called TRIMprob has shown sensitivity and specificity in the diagnosis of prostate and rectal cancer by exploiting differences in tissue resonance between neoplastic and normal tissue. Thus, optimization of EMF diagnostic modalities to complement current screening methods may lead to improve diagnosis accuracy.

High-level EMF treatments can be based on: strong heating that directly leads to macroscopically apparent tissue changes (such as tumour coagulation); moderate heating that interferes with the immune system, perfusion and related oxygenation, genetic activity, protein expression, and DNA damage/repair; membrane permeabilization; the use of magnetic nanoparticles that translate applied EMF fields into deposited energy and temperature activated liposomes for targeted drug delivery. Particularly in the case of moderate heating treatment (e.g., hyperthermia), the mechanisms,

expected outcomes, and optimal administration and control are poorly understood. Cancer treatment applications with high-level EMFs, as hyperthermia and radiofrequency (RF)/microwave (MW) thermal ablation, still present challenging aspects for the clinical practice. In particular, thermal ablation is a technique that has remarkably developed in the last years, showing many promising advantages for local treatment of soft-tissue pathologies as tumours, and offering the possibility of treating relative large tissue areas with minimally invasive applicators. The implementation of treatment planning procedures for the clinical practice requires the development of patient-specific simulation models, exploiting the availability of high-resolution digital models (e.g. from MR or CT scanners) and automated tools for the EM model generation. However there are several open issues to be investigated, with particular reference to the changes in the dielectric, thermal and morphologic properties of tissues due to the very high temperatures reached during an EMF-based ablation treatment. Deeper understanding of these phenomena could allow the development of optimised ablation antennas and of predictive tools for personalised treatment planning in clinical practice.

Topic 2. EMF-based non-cancer interactions and applications

This topic includes applications and procedures based on applying EMFs to tissues and cells, causing interactions that produce direct effects of such stimulation. These can be both short-term and long-term in nature. Health promoting effects can be produced in both excitable and non-excitable tissues and cells, by applying EMFs having specific controlled parameters. Envisaged applications and procedures include: electrical and magnetic stimulation of central and peripheral nervous system; minimally invasive stimulation for promoting pain treatment, treatment of chronic (non-healing) wounds, treatment of neurological disorders (dystonia, Parkinson, Alzheimer, depression, etc.); EMF-induced/promoted bone healing, healing or growing tissue, tissue regeneration, etc. Large amount of concerted research efforts is needed in this area. Many observed interactions have not yet been fully understood, and there are still more to be discovered. The parameters of the applied EMFs and the associated effects have yet to be determined or optimized to maximize the benefits of such procedures. Ultimately, the accumulated knowledge will help in developing or optimizing the associated biomedical applications.

EMF interactions with excitable tissues can interfere with signalling activity. While some interactions are unintended (e.g., nerve stimulation by gradient field in MRI), EMF may be applied specifically to achieve beneficial effects, e.g., to induce, suppress, or synchronize (across neurons) spiking and signal propagation. Examples include deep brain stimulation with implanted electrodes, e.g., to manage chronic pain, tremor, dystonia, or Parkinson’s disease; magnetic stimulation; and neuroprosthetics. The latter uses external or implanted electrodes to replace lost sensory

functionality – e.g., retinal, vestibular, cochlear prostheses for blindness, balance loss, and hearing deficiencies, respectively – or motor action, e.g., to overcome paralysis. Simulating such applications – to develop and optimize devices, improve mechanistic understanding, or assess risk – requires the integration of dynamic neuron models in anatomical models, and coupling of EM and neuron simulations.

Transcranial magnetic stimulation (TMS) and transcranial electric stimulation (such as transcranial direct current stimulation tDCS, or transcranial alternating current stimulation tACS) are techniques for non-invasive application of magnetic and electrical stimuli to induce electrical currents in brain tissue, modulating neuronal activity in the brain. The two principal stimulation techniques induce changes in cortical excitability that outlast the duration of the stimulation itself, thus underscoring the potential of the techniques for therapeutic treatment of neurological and psychiatric diseases (e.g. depression, epilepsy). This has opened up new opportunities for therapy and rehabilitation following stroke and other brain injuries, for producing analgesic effects in pain syndromes and for curbing the progression of psychiatric and neurodegenerative disorders (e.g. Alzheimer's, Parkinson's disease), thus reducing personal, economic, and social burden. Notwithstanding these practical benefits, these stimulation techniques remain under-investigated in many clinical conditions, mainly because disease-specific best-practice protocols are still lacking and technical limitations restrict the focality, depth and predictability of the site of activation. Insights on mechanisms between exogenous stimuli and neural tissues mediating its therapeutic benefits, and the neurodegenerative diseases that are its targets, will offer exciting new vistas for neuroscience. Progress in these techniques requires modelling of brain electromagnetic and neurological properties, development of technology and applications, and close cooperation between research, clinical and technological partners.

With respect to non-excitable tissues, the biological effects of low-intensity and low-frequency EMFs for therapeutic purposes (healing applications, fractures and non-union consolidation, osteonecrosis) present a significant socio-economic interest. However, the selection of electrical or electromagnetic stimulation patterns is empirical, and the electrical parameters acting on the cellular mechanism and the metabolic pathways involved in reception, transcription and response to pulsed EMF are still unknown. The scientific knowledge and the techniques in molecular biology evolved significantly over the past ten years and a better understanding of the cellular mechanism involved in the electric and/or magnetic stimulation will give a scientific base to the treatment. The better knowledge of the cellular mechanism and the identification of effective electric characteristics will allow improving the existing electric patterns often established empirically in the early indication. The better correlation between specific electrical characteristics and the cellular response will

improve both the efficacy and the specificity of the effects, thus providing to the surgeons a more obvious positive relation between the treatment and its result.

In addition to the direct effects of EMFs on tissues and cells, this topic also refers to the biomedical procedures, applications, and technologies that are essentially and functionally based on EMFs. Use of EMFs, as the common feature of such applications, implicates the use of the same methodology of research, especially in terms of EMF dosimetry that is a common feature for all topics in this Action. The non-exhaustive list includes: wearable/implantable/ingestible radio-sensors for body-centric applications, autonomous body sensors, room temperature magnetic sensors for medical uses, RFID/Short-Range-Device/other wireless EMF-based technologies related to medical telemetry and other medical uses, radar systems for remote monitoring of human physiologic parameters, magnetic drug targeting, diagnosis through magnetic beads, etc.

Topic 3. EMF dosimetry - in silico tools and measurements

EMF dosimetry is an essential part of all scientific studies on EMF biological and health effects. Underlying physical, technical, and relevant biological (tissue) parameters must be properly understood and controlled during experimental investigations, and, consequently, during medical procedures. This topic provides the technical support to topics 1 and 2.

Computational tools in EMF dosimetry have previously concentrated on modelling and simulations on the macroscopic level. This is still essential for all parts of the experimental and application system design, thus the computational analyses will be applied to the EMF generating devices, EM wave propagation through various media, and EMF distribution in various media, especially in the targeted tissue. However, research topics 1 and 2 require accurate characterization of the interactions of EMF with non-isotropic tissue models embedded in complex anatomies at all levels. This includes: 1) EMF macro-dosimetry, i.e., thorough understanding and control of the induced fields at the macroscopic level; 2) EMF micro-dosimetry, i.e., the development of simulation models to describe the induced-field distribution at the subcellular level, thereby enabling the studying of interaction mechanisms of EMF with the biology; 3) neural tissue models, i.e., models for studying the coupling of the externally applied or induced fields with the non-isotropic neuron network. Accordingly, this topic includes both the development of novel and improvement of currently available tools for in silico studies of biological interactions with EMFs. In silico models require accurate characterization of tissues with respect to their dielectric parameters. Considering the shortcomings of the present databases, regarding their validity with respect to frequency and temperature range, proper tissue- and application-specific values have yet to be obtained experimentally. Thus, this topic includes the development of measurement instrumentation, methods, and procedures, for validation of the predicted theoretical or in silico values, and for

obtaining the accurate input parameters needed for theoretical or numerical analyses.
EMF macro-dosimetry can now exploit both numerical and experimental tools, providing accurate information on the distribution of the EMF induced in the biological target. Experimental dosimetry is a necessary tool for validating numerical codes, as well as for testing EM exposure systems and EM applicators under reference conditions. Numerical dosimetry, once validated, allows performing thorough investigations on induced field distribution in complex targets (e.g. by exploiting the availability of high-resolution digital anatomical models). Therefore, EMF macro-dosimetry can be considered as a necessary and powerful tool throughout the research topics defined in this proposal.
The tools to be developed or adapted from existing ones include:
- Validated multi-physics, multi-scale simulation tools optimized for simulations involving living tissue: These tools must be able to integrate physiology and biology on many levels (organism, systems, organs, tissues, cells, subcellular structures, biomolecules), their interactions, and the coupling with EMFs. To handle the necessary complexity, the underlying solvers – EM, neural- and molecular-dynamics, etc. – must be efficient, high-performance-computing enabled, and optimized for the needs of computational life sciences (i.e., with support for anatomical models, living tissue, and inclusion of biological measurement information).
- Dosimetric measurement equipment: The equipment is needed to perform accurate macro- and micro-scale measurements to characterize treatment and exposure equipment. Such measurements are also critical for the validation of simulation tools and models.
- Functionalized anatomical models: In view of the important impact of the inhomogeneity (on many scales) of the human body on the local EM field strengths and induced effects, detailed anatomical models are crucial for assessment of exposure in regards to personalized treatment, equipment development, or mechanism exploration. In the case of personalized treatment, it can even be necessary to generate patient-specific models that are enriched with tissue parameters (dielectric properties and perfusion information, potentially personalized) and functionalized, e.g., with integration of dynamical neuron models, vasculature and thermoregulation information, and tissue growth/damage models.
- Exposure equipment: This equipment is required to generate well-controlled conditions for experiments. Exposure can target humans, animals, and tissue or cell cultures. Tight control over the frequency, waveform, field strength, deposited energy, and temperature is crucial.

Technology assessment, policies, evaluation and monitoring of health impacts

Achievements in the topics 1-3 should increase our general knowledge in this field, but also lead to commercial EMF medical applications. Therefore, in parallel to pure research on the focused topics,

corresponding framework for adequate policies, methods for evaluation and monitoring of health impacts, risk-benefits and cost-effectiveness analysis as inputs for Health Technology Assessment (HTA) should be elaborated. An optimal framework should be envisaged enabling high degree of freedom for development of cost-effective technologies and competitive industries, but at the same time offering adequate protection to patients and other users of the new technologies. This aspect will be integrated in the activity of each of the three WGs that will reflect research topics 1-3, and will be addressed in the stage of technological implementation of the research results.

D.2 Scientific work plan methods and means

The scientific programme will encompass the research on EMF interactions at molecular, cellular, tissue, and system level, putting to use the theoretical and practical interdisciplinary knowledge of medicine, biology, electromagnetism, engineering, and related fields. Under the umbrella of the Action, the concerted research will synergize the results of theoretical, in silico, in vitro, animal, and clinical studies. The Management Committee will guide and manage the Action to maintain the focus and ensure the synergy among different fields and different levels of research. This will maximize the outcomes, creating the space and opportunities for novel and significant findings. The Action aims to find new beneficial effects, understand the nature of interactions, harness the effects, devise the optimally designed devices and systems, and implement them in innovative EMF-based biomedical applications. The Action also aims to foster the development of novel EMF-based biomedical applications, not necessarily based on the direct interactions of EMFs, however using EMFs as their crucial feature. The currently available EMF-related biomedical applications will also benefit from the systematic approach of this Action, and from the knowledge on EMFs, interactions, setups and dosimetry, accumulated in this Action.

The Action will make the best use and will build upon the data on the EMF interactions collected in previous EMF research projects. The research will also benefit from the access to established measurement and exposure setups used in previous EMF studies, and the related knowhow.

The extensive existing knowledge base on EMF-related health risks will also help identify and prevent the potential health risks of EMF exposure arising from EMF-based biomedical applications and procedures. These risks, if existing, can be regarded as side-effects, and must be properly analyzed as such; however they are not in the primary focus of the Action.

The technologies in electrical engineering and electromagnetics are essential for the success of the Action. These are associated with all topics, and cover: stimulation/exposure devices and systems including applicators (EMF generating devices, antennas, electrodes, etc.); measurement

technologies; modelling and simulation tools for both dosimetry and biological effects/interactions; wireless technologies (especially regarding topic 2); and others as deemed necessary. The required expertise will be provided by participating researchers educated in electrical engineering, most of whom are experienced in interdisciplinary research, and familiar with biomedicine.

The work will be structured through working groups, reflecting the topics described in section D.1, as follows:

WG1 – Cancer EMF interactions and applications

WG2 – Non-cancer EMF interactions and applications

WG3 – EMF dosimetry - in silico tools & measurements

The Working Groups will ensure that the initially dispersed research focuses on the given topics, thus achieving objectives that by far exceed the significance of individual results. This synergy will be accomplished under the careful guidance of the Management Committee, and the Working Group leaders. As the purpose of WG3 is to provide services to other two WGs, it may be regarded as a horizontal Working Group. The work plan is also open to other cross-group tasks, as required during the course of the Action.

In order to focus the work and be more efficient, a working plan will be specified and subsequently updated by defining a number of sub-topical working modules. These will be established at the first WG meetings, examples could include: cancer treatment with amplitude modulated EMFs; optimization of high-level EMF cancer treatment; tissue healing using low frequency EMFs; functionalized computational anatomical models for personalized EMF treatment, and many others. Each working module will be approached by interdisciplinary way covering the complete progress from biomedical research (WG 1 and 2), via instrumentation (WG 3) to applications, policies etc. Particular attention will be given to participation of ESRs from different disciplines in each working module. In this way they will learn to build the interdisciplinary approach around their principal discipline. In each working module appropriate number of STSMs will be defined.

STSMs and Training Schools

The Action will strongly encourage STSMs, as an important mean of achieving the scientific objectives. The additional benefits include:

- strengthening the cooperation between the research groups,
- increasing the overall mobility,
- benefits for ESRs undertaking STSMs, in terms of personal training and international cooperation.

Training Schools will be targeted to train researchers, especially ESRs (both already participating in the Action and the new ones), in disciplines complementary to their basic training. In this way, ESRs will be encouraged to become interdisciplinary personalities, capable of understanding more

than one aspect of a biomedical topic. Training Schools topics could include e.g.: cell anatomy and electrophysiology (targeted audience: engineering fields); selected topics in electromagnetics (targeted audience: biology, medicine); in silico studies i.e. modelling and simulation of EMF interactions with biological tissues (targeted audience: all) etc. Topics will be decided upon reviewing the needs, means and logistics, and the first one will therefore be organized in the year 2 of the Action. A minimum of three Training Schools is foreseen. A larger number is expected, as possibilities will be investigated to provide particular trainings in cooperation with relevant organizations, associations, and societies.

E. ORGANISATION

E.1 Coordination and organisation

The Action will be managed, supervised and coordinated by the Management Committee (MC), in accordance with the "Rules and Procedures for Implementing COST Actions". The MC will meet twice a year, with online collaboration in between meetings. In addition, the Steering Group (SG) will be formed, consisting of the MC Chair, Vice-Chair, and the leaders of the Working Groups described in section E.2. The main role of the SG will be to assist the MC by taking over the continuous tasks of communication, monitoring, data collection, materials preparation, dissemination coordination, and similar, upon decision of the MC. The main tasks of the SG will be: to monitor the Action activities and quantitative indicators (listed in section C.2) and pass the relevant information to the MC, to prepare the materials for the MC, to suggest activities to the MC, to organize the agendas of meetings, workshops, and any other such events, and to coordinate the activities of the Working Groups and facilitate efficient communication among them. The SG activities will be managed by the MC Chair. The SG will work closely and meet with the ESR/STSM/Training Coordinator (ESTC) and the Dissemination Manager (DM). The SG will meet at least three times a year (in person or online), or when deemed necessary, with continuous online collaboration in between meetings. Additional parties, in addition to ESTC and DM, may be invited to a SG meeting, if needed for efficient steering work. The SG will also help to collect and prepare the dissemination materials envisaged by the dissemination plan in section H.
The MC will continuously monitor and evaluate the Action progress and achievements at each MC meeting and formally on a yearly basis, in accordance with the milestones given below, using the quantitative indicators and procedures given in section C.2. Positive yearly evaluation from the MC will be based on the continuous rise of the quantitative indicators with respect to each previous year. This data will be prepared for the MC by the SG. For that purpose, WG leaders, ESTC and

DM will prepare progress reports for each SG meeting. SG will thus monitor the Action's progress towards the MoU objectives, and pass all the relevant information to the MC for formal evaluation and adoption of corrective measures if needed (at regular MC meetings or electronically if urgent corrective measures are needed).

Action website, serving both as a dissemination channel and as an organizational feature of the network, will be set up, maintained, and updated according to the dissemination plan, described in detail in section H.3. Considering the ambitious dissemination plan elaborated in section H., a dedicated person will be appointed as a DM. The main role of the DM is to assist the SG by taking over the tasks such as:

- to set-up and update the Action website;
- to edit the Action newsletter;
- to prepare and publish the materials provided by MC Chair, WG leaders, SG, or MC, according to the dissemination plan;
- to monitor the dissemination activities and published information relevant to the Action, and to pass that information to the SG.

The Action will strongly encourage STSMs, trying to keep their number over the recommended minimum of four STSMs per year. As they are particularly intended for young researchers, this activity will overlap with the activity of training and involvement of ESRs explained in sections D.2 and E.4. Therefore, a dedicated person will be appointed as ESR/STSM/Training Coordinator (ESTC), with the primary role to coordinate and take over the tasks of administering: measures for involving as many ESRs as possible into the Action; STSMs in general; STSMs as a form of training of young researchers; organization of Training Schools and other training events, having in mind the gender balance throughout its activities. ESTC will monitor the indicators associated to ESRs, STSMs and training, and pass that information to the SG.

The Action will strongly encourage new research studies on the Action topics, especially collaborative studies of the participating research groups. Furthermore, the Action will strongly encourage publication of scientific papers in peer-reviewed journals, as the ultimate scientific output of the concerted research, especially in co-authorship of the participating research groups. In order to foster ESR involvement, collaborations and paper publishing, the MC will look into the possibility of devising an award system and the associated criteria for awarding the activities that are important for achievement of Action objectives, on a yearly basis. Possible examples are: ESR award based on STSM activity, scientific paper award based on collaboration and co-authorship, large collaboration award based on number of research groups involved, etc. The award system would not be based on competitiveness, but on the fulfilment of criteria which would emphasize

COST goals, as well as the goals of the Action.
The envisaged Action budget and activities refer only to coordination and networking, while the research is carried out in and financed by the participating countries. All the parties carrying out research possess the infrastructure and national funding required for the research to be concerted through this network. This COST Action will concert such research using means and activities described in section C.3.
Milestones (to be used for self-evaluation):
- Month 1: 1st MC meeting, management and organizational structure established.
- Month 3: Website set up.
- Month 12: Accomplishing yearly meeting activities given in the Timetable (section F) followed by the increase of quantitative indicators described in section C.2 with respect to their initial values (successful completion of year 1).
- Month 24, Month 36: Accomplishing yearly meeting activities given in the Timetable (section F) followed by the increase of quantitative indicators described in section C.2 with respect to each previous year (successful completion of years 2 and 3).
- Month 48: Accomplishing yearly meeting activities given in the Timetable (section F) followed by the increase of quantitative indicators described in section C.2 with respect to year 3, and publishing the final publication - an edited book or report summarizing Action achievements and accumulated knowledge on beneficial uses of EMFs in biomedical applications (successful completion of the Action).

E.2 Working Groups

The structure of this COST Action will reflect both the strategic directions of research and the interdisciplinarity of the Action. The work will be structured through Working Groups (WGs), reflecting the topics 1, 2 and 3 described in D.1, as follows:
WG1 – Cancer EMF interactions and applications
WG2 – Non-cancer EMF interactions and applications
WG3 – EMF dosimetry - in silico tools & measurements
WG1 and WG2 are topic-based, application-oriented, interdisciplinary working groups. This means that, at each WG meeting on a certain topic, each expert will contribute with his/her proficiency and discipline-specific complementary knowledge, research methods and resources. This will maximize the synergistic effects, essential for breakthroughs in any of these topics. Hence, this COST Action avoids the division of working groups by discipline. WG3 is a horizontal WG that provides the

necessary technical and physical support to WG1 and WG2.
The framework is both focused and flexible, at the same time. It highlights the topics of utmost novelty and importance (e.g. cancer treatment, EMF stimulation of tissues), while providing space for structuring the work further into sub-topical working modules. The Action is open to cross-group tasks, if required by a specific problem or topic. Each WG will meet twice a year, with online collaboration in between meetings, and additional focused workshops depending on developments.

E.3 Liaison and interaction with other research programmes

COST Action TD1104 Working Groups WG1 "Basic Mechanisms of Electroporation and Modeling" and WG3 "Medical Applications" may be of interest regarding research methodology and results. Link is already established to the projects' management, as TD1104 Chair is on the list of experts supporting this proposal, and will therefore act as liaison. Joint meetings or seminars are not anticipated at this moment, such possibility will be considered in the course of the Action.

E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve Early-Stage Researchers. This item will also be placed as a standard item on all MC agendas.
For both issues, the Action has plans for achieving and maintaining proper involvement and balance.

Overall monitoring

Number of ESRs, as well as gender balance in the MC, WGs and involved groups, will be monitored by surveys, conducted by the SG and reported to the MC at each MC meeting, for discussion and evaluation. As the starting point for continuous monitoring, proposal preparation included the first survey of ESRs and gender balance across the involved groups. Considering that the majority of the listed participants are in fact group leaders or representatives, the ESR involvement and gender balance refer not only to the listed experts, but to the overall number of involved researchers. The survey asked for: the total number of researchers or associates in an individual research group, whose activities are (or will be) connected to the Action topics; number of ESRs, men and women out of the previously given total number. This helped to get a broader perspective on ESR involvement and gender balance in the Action.

ESRs

Since this is a highly interdisciplinary Action, ESRs will be trained to become interdisciplinary personalities, i.e. to gain additional expertise in complementary disciplines. ESRs will have priority when approving STSM and Training School grants, and they will be encouraged to apply for the COST Conference Grants. This will be administered by the ESTC. Networking events will have time slots or other types of events dedicated specifically to ESRs (such as ESR poster sessions with brief oral presentations of their work), where they will be encouraged to present their results, interact with each other and with experienced researchers in a less formal form, or propose new ideas to be considered by the Action. Experienced researchers will be made aware of the need to act as mentors. Finally, as an innovative measure described also in section E.1, the MC will consider establishing the yearly ESR award, awarded to ESRs according to the criteria to be decided by the MC. This will lead to capacity building in terms of proper interdisciplinary training and ESR involvement.

To attract new ESRs, Action information leaflet and Action newsletter subscription will be continuously offered to the graduate and postgraduate students enrolled to relevant courses throughout the network of participating universities. The DM and ESTC will make sure that the materials include data on available researcher positions, PhD grants and associated jobs in the field of biomedical EMF applications (collected continuously throughout the EMF-MED network). This will lead to capacity building in terms of number of young researchers entering this field.

Gender balance

Considering that this is an interdisciplinary Action composed of life sciences mixed with engineering, it is expected that different disciplines involved in the Action will be differently dominated – some by women, and some by men. Consequently, it is expected that this could yield an appropriate overall gender balance in the Action. This will be observed again at the beginning of the Action, and carefully monitored later on. Thanks to broad interdisciplinarity, Action will have a unique opportunity for an additional innovative measure for achieving the gender balance: to foster cross-discipline involvement of the less-represented gender, using STSMs and Training Schools as appropriate mechanisms. For example, cross-discipline training of female ESRs or students coming from a life-science background would be fostered in traditionally male-dominated engineering disciplines, and vice-versa. This will be managed by the SG with the help of ESTC, and reported to the MC.

F. TIMETABLE

The duration of this Action will be four years. The activities are scheduled as follows:

Activity	Year 1	Year 2	Year 3	Year 4
Kick-off meeting	x			
Website set up	x			
MC Meetings	x x	x x	x x	x x
WG Meetings	x x	x x	x x	x x
Workshops	x	x	x	x
Training Schools		x	x	x
STSMs	> 4 per year	> 4 per year	> 4 per year	> 4 per year
Newsletter	monthly	monthly	monthly	monthly
Reports and evaluation	x	x	x	x
Final publication				x

The Action will start by kick-off meeting, immediately establishing the WGs and the working plan. The kick-off meeting will be followed by two MC and WG meetings per year. Working modules will be specified at first WG and MC meetings, and subsequently updated. Other priorities for the start include: appointing the WG leaders, ESTC and DM; setting up the Action website; establishing Action visibility; planning for inclusion of ESRs. The Action will proceed with the yearly number of activities and events given in the Timetable, steering the activities according to evaluation of achieved objectives, and other relevant developments. The end of the Action (especially last two trimesters of year 4) will be reserved for wrapping up the achievements, particularly in respect of recommendations for policies, further research and technology developments and assuring a roadmap for sustainability after the end of the Action, all summarized in the final publication. Website maintenance and updating, dissemination activities, and STSMs will be organized continuously throughout the course of the Action.

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, BE, BG, CH, DE, EL, ES, FI, FR, HR, HU, IL, IT, LT, MK, MT, NL, PL, RO, RS, SE, SI, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 92 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

The target audiences for dissemination include:

1. Action participants;
2. researchers (including engineers and other experts in R&D), research institutes and universities (including associated ESRs);
3. health care institutions and medical practitioners;
4. companies (especially SMEs) in the field of biomedical technology;
5. international organizations, bodies, agencies and societies;
6. standardization bodies and technical committees (international, national and EU level); 7. government and administration bodies (both at national and EU level);
8. general public.

H.2 What?

Dissemination means and methods with respect to the target audiences (all audiences unless specified):

A. presentation of the Action: facts, objectives, joining the Action, opportunities for cooperation and training within the Action

B. presentations at conferences, workshops and other events, also in forms of papers and posters

C. scientific papers and reviews published in peer-reviewed journals

D. reports: Action activity reports, final publication (edited book or report), STSM reports, state-of-the-art reports, publication databases, research finding reports, case study reports, etc., and their short versions publishable in the Action newsletter

E. position papers and presentations for policy makers and regulatory bodies (target audiences: 3, 4, 5, 6, 7 from section H.1)

F. guidelines and manuals related to EMF-based biomedical technology introduction and usage, including effectiveness and risk assessment criteria (target audiences: 3, 4, 5, 6, 7 from section H.1)

G. non-technical press releases (target audiences: all except researchers and Action participants)

H. password-protected working documents and other documents pertinent to the Action, such as Action reports and WG reports (target audience: Action participants)

Information will be disseminated to an extent compatible with adequate intellectual and/or

industrial property rights, copyrights and confidentiality safeguards.

H.3 How?

The activities will be managed by the appointed Dissemination Manager (DM), under the guidance of SG and MC, as explained in section E.1.
Action newsletter, as the forefront vehicle for targeted outreach with updated Action information in a compact form, will be distributed to a subscription-based mailing list, and published on the web site. The newsletter will be published at the very start of the Action for the purpose of outreach, and then monthly. This frequency will keep its format brief (1 or 2 pages), informative, and easy to edit and publish, while maintaining continuous awareness among the subscribers. It will offer news, announcements and short information, such as short versions of STSM reports and other documents, short info on: research findings, Action activities, cooperation possibilities, complementary research and networking initiatives etc., while pointing to the Action web site for more comprehensive material. Subscription will be offered openly on the web site, and by e-mail to the targeted audiences.
Action web site, as the main storage of all information, will be set up immediately with all readily available information. After the initial set up, it will be maintained and kept up-to-date, by continuously posting all relevant information about the Action: Action facts and associated documents, MC and WGs member lists with participants' affiliations and associated links, WGs descriptions, Action presentation material, Action contact information, news, events announcements, information on cooperation and training opportunities, public documents section (presentations, reports, press releases, publicly available publication etc.), password-protected documents section for Action participants, list of publications published in the course of Action, list of relevant publications and literature beyond the Action, etc. To establish and maintain visibility, the site will be immediately reported to the major search engines.
Targeted e-mail correspondence will be used for the monthly distribution of the Action newsletter and other short informative announcements, as well as for drawing traffic to the Action website. Initial mailing list will consist of the researchers interested or working in this topic. E-mail announcements will then be sent to the contact e-mails of relevant institutions, reaching out for their interested members. The mailing list will then be updated on the opt-in/opt-out basis.
Action management and participants will promote the Action by attendance and participation in various events, conferences, workshops etc. The Action facts, activities and results will be presented using specially designed and updated Action poster and Action information leaflets.

Action information leaflet and Action newsletter subscription will be continuously offered to the graduate and postgraduate students enrolled to relevant courses throughout the established network of participating universities, in order to attract new ESRs. The DM and ESTC will make sure that the materials include data on available researcher positions, PhD grants and associated jobs in the field of biomedical EMF applications (collected continuously throughout the EMF-MED network).
Targeted correspondence will be used for communication with interested individual stakeholders (target audiences 3, 4, 5, 6), e.g. for distributing individual items of specific interest to the stakeholder.
MC and WG meetings, workshops, joint conferences and other events will be organized by the Action, according to the timetable given in section F, subject to change in response to the developments in the course of Action. These networking channels will serve as dissemination channels for all means of dissemination listed in section H.2. In order to increase the outreach, whenever possible, conferences and information-sharing meetings will be held jointly with other major conferences organized by international organizations, bodies, agencies and societies.
The research results and findings will be published as peer-reviewed journal papers, being the most important scientific outputs of the Action. Since these publications are the ultimate output of the research thoroughly concerted by the Action, their number and significance will be carefully monitored and evaluated (as described in section C.2).
Final publication will be aimed to be published as an edited book on beneficial uses of EMFs in biomedical applications.
Press releases will be issued to the media: at the beginning of the Action, as announcement, or in conjunction with major events organized by the Action, and to announce major findings during the course of the Action. Action facts and announcements will also be communicated through relevant society newsletters and magazines, to make an outreach towards potential stakeholders.
The dissemination plan may be adjusted in response to the developments and progress of the Action. Specifically, if monitoring and evaluation (described in section C.2) show weaknesses in certain indicators, SG and MC will steer the dissemination activities to correct the observed deficiency.