European Cooperation in Science and Technology - COST -

Secretariat

Brussels, 4 July 2012

COST 4141/12

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action MP1201: Nanoscale Superconductivity: Novel Functionalities through Optimized Confinement of Condensate and Fields (NanoSC -COST)

Delegations will find attached the Memorandum of Understanding for COST Action as approved by the COST Committee of Senior Officials (CSO) at its 185th meeting on 6 June 2012.

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

COST Action MP1201
NANOSCALE SUPERCONDUCTIVITY: NOVEL FUNCTIONALITIES THROUGH OPTIMIZED CONFINEMENT OF CONDENSATE AND FIELDS (NANOSC -COST)

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 4154/11 "Rules and Procedures for Implementing COST Actions", or in any new document amending or replacing it, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to streamline science and technology in the field of superconductivity and to contribute to the development of novel applications of nanostructured superconductors beneficial to European industry and society.

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 68 million in 2012 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 Chapter V of the document referred to in Point 1 above.

A. ABSTRACT AND KEYWORDS

The world has just celebrated the 100 years of discovery of superconductivity by Kamerlingh Onnes. Superconducting materials are of special interest in the XXI century since they provide new energy saving solutions for electricity grids, transport, metrology, information/communication technologies, and healthcare. This COST Action will coordinate and strengthen scientific and technological collaboration in the field of superconductivity in Europe through a variety of organizational tools, assuring leadership in this field. It will cover fundamental issues as well as explore possible novel applications important for European industries. This Action will also contribute to innovation-based growth in the field of superconductivity aimed at overcoming the existing bottlenecks for widespread industrial applications of nanostructured superconducting materials. The key novel approach here is to exploit recent spectacular progress in design and fabrication of nanostructured superconductors, in order to develop and implement such flux and condensate confinement patterns, which not only substantially improve the superconducting critical parameters, but also lead to novel functionalities of these nanopatterned materials. Due to the advanced dedicated modern technologies needed to produce nanostructured superconductors, international and interdisciplinary collaboration is essential for a successful implementation of the objectives for the NanoSC-COST Action.
Keywords: Superconductivity, Nanostructuring, Vortex matter, Superconductor/Ferromagnet Hybrids, Josephson junctions and qubits.

B. BACKGROUND

B.1 General background

The key technologies of the XXI century have been recently identified: energy, transport, nanotechnology, information/communication technology, health care, and environment. For several of them, superconductivity is of special interest, since it deals with the dissipationless flow of charged particles thus enabling superior performance needed for new energy saving technologies of the future.

Due to the ever-growing applicability of superconductors, the development of new superconductors with strongly enhanced critical parameters is a fundamental challenge. The critical parameters, defining the perspectives for practical applications of superconductors, are the critical temperature T_c, the magnetic fields H_c or H_{c2} and the current density J_c. J_c and H_{c2} can be enhanced by optimizing the confinement of fluxons with the help of nanoengineered pinning centers. The most difficult problem, however, is to enhance T_c. To address these challenging problems and to enable emerging technologies, new superconducting materials with a superior performance can be developed by manipulating the appropriate "elementary building blocks" through nanostructuring. For superconductivity, such "elementary blocks" are Cooper pairs and fluxons.

This brings us to the ***main scientific objective of this Action***:

"to investigate the effect of the nanoscale confinement of the Cooper pairs and flux on superconductivity and flux behaviour in order to enhance the superconducting critical parameters (critical current, field and temperature), through nanostructuring thus enabling novel functionalities and new applications of the superconducting materials."

Along the line of the main research strategy, the scientific activities in the framework of this NanoSC-COST Action will be ***focused on the following topics***:

- Individual superconducting nanostructures and in particular, the relation between their quantized states and T_c's.
- Interface superconductivity and electrical field effects in ultrathin layered and gated structures and devices
- Application of nanomodulated templates originally developed for fluxon confinement in superconductors for making new photonic metamaterials
- Fluxonics devices based on vortex manipulation, Josephson junctions and arrays
- Nanopatterned superconductors (SC) and superconductor-based hybrids (triplet superconductivity and proximity effects, SC/ferro, SC/insulator, SC/metal hybrids)
- New superconducting devices

- Nanostructured multiband superconductors
- Novel nanoscale mechanisms for superconductivity (theory)
- Power applications of nanostructured superconductors and new fabrication techniques
- Enhancing direct visualization techniques

Why do superconductors play such an important role in nanosciences?

Because they provide a unique opportunity to use quantum-mechanical principles to obtain superconducting properties, needed for applications, by designing and implementing such nanoscale confinement of the Cooper pairs and flux which control these properties via the quantum laws ("quantum design").

The COST Action will result in a true multidisciplinary international effort aimed at ***overcoming the fragmentation*** of the efforts in our quest for achieving novel functionalities of nanostructured superconductors through the optimization of the flux and condensate confinement. This ***COST Action will lead to***: (i) more focussed and productive international collaborations, (ii) developing a common knowledge basis among the different participating research groups, (iii) training students and young researchers, (iv) improving the knowledge transfer from fundamental research to applications. The format of the COST Action provides an optimal platform for strengthening and consolidating international collaboration and networking in the dynamic and strategically important field of nanoscale superconductivity. The deliverables and milestones are specified in section F. (Timetable).

B.2 Current state of knowledge

Summary of the previous research in the field of the COST Action:

Last year, the scientific community celebrated the 100 years of the discovery of superconductivity by H. Kamerlingh Onnes. Rarely any research topic has been awarded so many Nobel Prizes as superconductivity (no less than five): (i) Heike Kamerlingh Onnes -1913, (ii) John Bardeen, Leon N. Cooper, and J. Robert Schrieffer -1972 for the BCS-theory, (iii) Leo Esaki, Ivar Giaever, and Brian D. Josephson -1973 for the discovery of tunneling phenomena, (iv) Georg Bednorz and Alex K. Müller -1987 for discovery of high temperature superconductivity and finally (v) Alexei A. Abrikosov, Vitaly L. Ginzburg, and Anthony J. Leggett -2003 for pioneering contributions to the theory of superconductors and superfluids.

After a century of intense efforts worldwide, scientists have recently evidenced new and most remarkable developments in fundamental research in superconductivity. These developments can be categorized schematically into the following four groups:

1. "No taboo" developments:

- Fe (ferromagnet) under pressure becomes superconducting (note that normally ferromagnetism and superconductivity are two antagonistic phenomena)
- Interface between two insulators can be superconducting, i.e. by bringing together two certainly non-superconducting and even insulating blocks the interface area can become superconducting
- Strong local electrical fields can increase superconducting critical temperature, especially in sandwiches built up from ultrathin superconducting and ferroelectric layers
- Magnetic field can enhance superconductivity, while normally it is expected to suppress it - field induced superconductivity has been discovered in Chevrel phases and Super/Ferro hybrids
- A few atoms clusters, with a cluster size much less than the coherence length, are superconducting, contrary to conventional superconductivity theory

2. Great breakthroughs in material science of superconductors:

- discovery & spectacular progress in fabrication of new oxide superconductors
- discovery of new ferropnictide superconductors
- discovery of superconductivity in organic superconductors, MgB_2, boron-doped diamond

3. Successful design and fabrication of various superconductor-based devices for quantum computing

4. Spectacular technological developments in fabrication of superconducting wires, tapes and coils

For all these developments, the understanding and the application of an appropriate nanoscale flux and condensate confinement has been playing a crucial role.

Relevant research within the EU Framework Programmes and other EU fora, comparison of EU research with that in other parts of the World:

Strategic importance of fundamental and applied research in the field of superconductivity is reflected in numerous, well defined projects within the EU Framework Programmes and other EU fora, targeting narrowly defined specific subjects (see the list below). None of them is focused on nanoscale confinement of condensate and flux and its exploitation for achieving desired properties and functionalities of nanostructured superconductors. This COST Action is relevant to various existing, narrowly focussed EU grants (see below) as an important integration instrument serving to a broader scientific community working on ***Nanoscale Superconductivity***.

1. Engineering and Physical Sciences Research Council (EPSRC) Materials Programme (programme in FP7 -UK)

2. Light Element Molecular Superconductivity: An Interdisciplinary Approach (LEMSUPER), UK, Proj. Ref: 283214, Prog. Acronym: FP7-NMP, Prog. Subarea: Fundamental properties of novel superconducting materials (coordinated call with Japan)
3. Exploring the potential of Iron-based Superconductors (SUPER-IRON), ITALY, Proj. Ref: 283204, Prog. Acronym: FP7-NMP, Prog. Subarea: Fundamental properties of novel superconducting materials (coordinated call with Japan)
4. Mathematical problems in superconductivity and bose-Einstein condensation (CONDMATH), DENMARK, Proj. Ref: 202859, Prog. Acronym: FP7-IDEAS, Prog. Subarea: ERC Starting Grant - Condensed matter physics
5. Scanning Nano-SQUID on a tip (NANOSQUID), ISRAEL, Proj. Ref: 226246, Prog. Acronym: FP7-IDEAS, Prog. Subarea: ERC Starting Grant - Condensed matter physics
6. Understanding high-temperature superconductivity from the foundations: Superconductivity as a cure of bad metallic behaviour (SUPERBAD), ITALY, Proj. Ref: 240524, Prog. Acronym: FP7-IDEAS, Prog. Subarea: ERC Starting Grant - Condensed matter physics
7. Search for novel mechanisms to increase the critical temperature of a superconductor (NANOHIGHTC), PORTUGAL, Proj. Ref: 268172, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: International Re-integration Grants (IRG)
8. Iron-based superconductivity: Fermi Surface and superconducting gap anisotropy (FESUME), UNITED KINGDOM, Proj. Ref: 273105, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: Marie Curie Action: "International Outgoing Fellowships for Career Development"
9. Organometallic Palladium(III) Polymer and Copolymer Assemblies for Superconductivity (PALLAS), FRANCE, Proj. Ref: 274975, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: Marie Curie Action: "International Outgoing Fellowships for Career Development"
10. Superconductivity in quantum-size regime (SCQSR), FRANCE, Proj. Ref: 235486, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: Marie Curie Action: "Intra-European Fellowships for Career Development"

11. New Century of Superconductivity: Ideas, Materials, Technologies (SIMTECH), ITALY, Proj. Ref: 246937, Prog. Acronym: FP7-PEOPLE, Prog. Subarea : Marie Curie International Research Staff Exchange Scheme (IRSES)
12. First-principles modelling of electron-phonon anisotropy (ELE-PH-ANT) in low-dimensional superconductors (ELEPHANT), UNITED KINGDOM, Proj. Ref: 252586, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: Marie Curie: "Promoting science"
13. UNCONVENTIONAL SUPERCONDUCTORS: FROM SYNTHESIS TO UNDERSTANDING (USSU), FRANCE, Proj. Ref: 273572, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: Marie-Curie Action: "Intra-European fellowships for career development"
14. Spin triplet proximity effect and spin-injection in High Tc superconductor/ferromagnetic hybrids (PIXIE), FRANCE, Proj. Ref: 275045, Prog. Acronym: FP7-PEOPLE, Prog. Subarea: Marie-Curie Action: "Intra-European fellowships for career development"

Scientific Innovation of the Action

The research in the framework of this Action will reveal the fundamental relations between quantized confined states in nano-superconductors and their physical properties, which will be used for enhancing dramatically the critical parameters (critical current, fields and temperature) of nanostructured superconductors (thin films and bulk materials) and for developing their novel applications.

The current Action is aiming at the control and manipulation of these critical parameters through nanostructuring. Recent spectacular progress in nanosciences has demonstrated that electrical, magnetic and optical properties of various condensed matter systems can be controlled practically at will and new functionalities can be created by designing and implementing the proper nanoscale confinement patterns for charges, spins and photons, respectively. ***The modern nano-revolution is actually aimed at controlling and mastering the nanoscale confinement for developing new properties and creating novel functionalities***.

Designing specific material properties through the application of quantum mechanical principles is "quantum design" – a key idea in nanoscience. Superconductors, with their inherent quantum coherence over even macroscopic scale, not to mention nanoscale, are in that respect superior to semiconducting or normal metallic nanomaterials, where quantum coherence is much more difficult to achieve. ***In that respect nanostructured superconductors is the best choice for the demonstration of applicability of quantum design to tailor specific properties of nanomaterials***.

Like for a particle in a box, properties of the confined condensate in nanostructured superconductors can be tuned using quantum laws. In contrast to the classical approach, which relied upon the search for new bulk materials each time a specific combination of their physical properties was required; nanosciences rely upon the ***modification of the properties of the same material through its nanostructuring and the optimization of the confinement potential and topology***. Controlling the vortex behaviour and creating a guided vortex motion via nanoengineering of arrays of pinning sites or channels in the superconductor, makes it possible to develop new devices like micronet superconducting transistors, vortex lenses, switches, pumps, etc. This paves the way for designing new generation of fluxonics devices based on the controlled behaviour of vortices (fluxons). ***The charge and the spin of electron form the core of electronics and spintronics, respectively. In the same way mastering fluxon behaviour in nanostructured superconductors creates unique new possibilities to develop the basics of fluxonics***.

The main lines of the scientific innovations of this Action are linked to:

- Novel nanostructured superconductors
- New mechanisms for enhancing critical parameter space through nanostructuring
- New fluxonics devices
- New nanostructured superconducting materials for power applications
- New superconducting electronic devices

B.3 Reasons for the Action

Reasons for cooperation

Due to the advanced dedicated technologies needed to produce nanostructured superconductors, international and interdisciplinary collaboration is essential. Dual focussed ion beams systems, electron beam writers/lithography, high quality self-organized template etching, in combination with thin-film deposition technologies, are normally required, but they are complex and expensive techniques. Measurement techniques for quantum information processing also require expertise and knowledge only available in a few laboratories. Sharing equipment and training schemes on a European scale is therefore one of the key issues for this COST Action. To realize this, this Action will initiate a new "European virtual institute" consisting out of a pan-European set of real laboratories distributed over the participating COST countries/parties, allowing mutual access.

Due to many possible combinations of nanostructured materials and individual nanostructures, a coordinated approach in exploring new superconductors and nanoassemblies is furthermore of utmost importance. Besides this, the field of nanosuperconductors evolves fast and regular meetings for scientific discussions and research organization in the form of schools, conferences, and focused workshops are needed at the European scale.

Targeted European Needs

The main issues addressed by this COST-Action target the fundamental science and technology which have the potential to meet specific essential economic and societal needs: self-healing power grids, plasma confinement by superconducting magnets, medical sciences (enhanced Magnetic Resonance Imaging -MRI), purification, reduction of energy consumption, superconducting generators (for wind power harvesting), transport via levitating vehicles, fundamental elements for quantum computing, etc.

The potential economical and societal needs are clearly limited to the scientific and technological advances aimed at developing new superconducting materials and devices based on the optimized nanoscale confinement of the condensate and flux. Such materials will have tailored improved superconducting critical parameters and novel functionalities.

Due to a broader national basis, the research groups in the US, China and Japan suffer less from fragmentation than the European research groups in the field of superconductivity. The Action networking activity, will therefore generate benefits for the European fundamental and applied research, and will be crucial for enhancing its leading role. New international collaborations will be initialized by this Action. More efficient use of existing experimental and computational facilities of the participating countries will be enabled via the "European virtual institute"

Generally, individual research activities face substantial limitations due to missing equipment for the practical realization of certain important experiments. These limits will be mostly overcome by enhancing cooperation and stimulating scientific exchange in this Action.

As one of the main results of this Action, the COST countries will certainly benefit from:

i) the development of new superconducting nanostructured materials with higher critical parameters enabling superior performance
ii) design, testing and implementation of new fluxonics devices based on nanoscale control of fluxons
iii) design, testing and implementation of superconducting electronic devices

COST-Action outcomes

- Increased number of joint publications (growing with 10 % each year)
- Enhanced collaboration output (measured via specific interaction parameters like the number of exchanges, join Ph.D. promotorships, lecturer exchanges. The deliverables for these outcomes are quantified in section D.2)
- More efficient and complementary use of existing and future set-ups, equipment in the laboratories of each participating team/country via the "European virtual institute" (ten major setups per year will be used for this)
- Improved training and researchers exchange (deliverables are quantified in section D.2)

B.4 Complementarity with other research programmes

Relation to other COST Actions

The COST Action is to some limited extent related to other COST Actions (see list below), but at the same time NanoSC-COST clearly defines new strategically important targets of very high relevance for the European society.

MP0701 Composites with Novel Functional and Structural Properties by Nanoscale Materials
MP0803 Plasmonic Components and Devices
MP0901 Designing Novel Materials for Nanodevices: from Theory to Practice (NanoTP)
MP1006 FPQP – Fundamental Problems in Quantum Physics
MP0702 Towards Functional Sub-Wavelength Photonic Structures

What is essential at this stage is a cooperation-based progress towards joining and optimizing the European research efforts in the framework of a multilateral Action, taking into account the whole set of requirements to the development of well-defined novel superconducting materials and nanostructured superconductors. The only way to ensure that the parameters and nanostructuring of these novel superconducting structures can fulfil the requirements of practical applications is to exploit interdisciplinary boundaries and generate ideas and results covering the full chain of materials development, from design to fabrication, to analysis, testing, and device integration.

This Action does not rival any research carried out in het framework of the FP and other EU programmes but rather represents a crucial complementary Action needed for the development of novel superconducting nanostructured materials.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The main objective of the Action is to streamline science and technology in the field of superconductivity and to contribute to the development of novel applications of nanostructured superconductors beneficial to European industry and society. The Action will create a strong network of teams and institutions working in the field of nanoscale superconductivity and nanopatterned superconducting materials. It will encourage and stimulate the efficient use of joint resources and exchange of researchers in this scientific field. The Action will link academic institutions with small and middle-sized Enterprises (SMEs) and other industries throughout Europe. The Action will have a scientific impact at many different levels (see objectives below). A further benefit will be in technology dissemination among the end users and facilitation of joint academic-industrial projects to target specific industrial problems and applications. The aim of the Action is also to enhance various training activities, by fostering personnel secondment and the search for common objectives. Finally, the Action will broaden the scope of education programs on superconductivity by encouraging the study, and providing specific training courses and interdisciplinary programs at the interface between exact and material sciences

C.2 Objectives

The following objectives can be put forward:

- Coordinating research efforts for real breakthroughs in the field of superconductivity and fluxonics; rationalizing European research on superconductivity with particular emphasis on nanostructures; establishing a Pan-European and multidisciplinary research and communication platform that can develop the Science & Technology potential of nanostructured superconductors
- Overcoming existing fragmentation of research efforts at the European level, avoiding expensive duplication of research efforts, at the same time promoting European cross fertilization.
- Sharing equipment on a broad European base via a new “European Virtual Institute”

- Strengthening competitiveness of the European industry and SME’s
- Establishing training and Short Term Scientific Missions (STSMs) for scientists and students
- Enhancing multidisciplinary and international collaborations, with well-defined criteria for collaboration
- Attracting young scientists (ESR’s) and students to this domain of research, promotion of women’s participation
- Providing a meeting forum through organization of dedicated schools, conferences and workshops
- Developing and maintaining a Web site, allowing other interested countries/parties to join this COST Action
- Achievement of a common understanding at the European level of requirements of superconductors in view of transport and energy applications and feasibility via the use of nanostructuring. A road map for the development of new materials and technologies will be drawn, representing a European alternative to the targets currently released by the US Department of Energy. This will strengthen the European position in the research and development superconducting wires for power applications (generators, motors).

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

The ***aim of this Action*** is to enhance links and coordination between top quality nationally funded programs on fundamental and applied research on nanostructured superconductors in order to avoid costly duplication and improve complementarities on the European scale. It is of vital relevance for this Action to face and tackle one of the key problems of our modern society, which is the existing gap between academic science and industry. Along these lines, the Action will be providing an important link between research in superconductivity and its industrial applications by including specialists from industry for task oriented discussions and counselling. In that regard, the majority of the Action constituting partners have the necessary experience, since they form already part of national networks linking, to some extent, research and industry, and thus providing a connection between science and technology.

The final goal of the Action is to integrate new partners, from COST countries, coming from top-quality research institutes, universities and industry.

The objectives of the Action will be achieved through networking possibilities offered by COST. It is worth noting that one strong characteristic of this Action is the high professional level and complementarities of its 74 forming partners from 17 COST countries. All the integrating partners possess a firmly established experience over the years on specific subjects of superconductivity in advanced nanostructured materials, covering its key theoretical, experimental and practical aspects. Additionally, their research activities are supported by national funding.

We present a list of particular items that will be used to achieve the formulated ***objectives of the Action***:

- To facilitate the management and improve the quality, profile and industrial relevance of European research in superconductivity and advanced nanostructured materials, through organization of meetings, workshops and schools, which will also involve the participation of industry representatives.
- Through a series of yearly peer reviews and subsequent reports, the achievements of the Action and its individual partners will be evaluated. The purpose of these reviews is the optimization of the individual research lines and the network management.
- The Action will coordinate the dissemination channels towards academia, industry and general public.
- The Action will strongly support the gender parity in the participating teams.
- The support of Early Stage Researchers (ESRs) for their rapid integration and sustained involvement in the existing community, aiming to ensure their contribution to the Action activities in a respective equal manner
- The Action will coordinate the sharing of ideas and facilities between the different constituting partners and will promote ground-breaking and pragmatic joint research efforts across the community.
- To provide the highest benefits from the different and complementary expertise of the different members, the Action envisions the Short Term Scientific Missions (STSM). Their goal is to team up research groups within the Action to tackle particular scientific problems.

C.4 Potential impact of the Action

Expected scientific impact:

The expected scientific impact is based on the development of new nanoscale confinement realizations for condensate and flux in various nanopatterned superconductors and superconductor-based hybrid nanostructures. These realizations will eventually provide new properties and functionalities of superconducting materials needed for different applications. Nanoscale confinement phenomena for superconducting condensate can be also mapped on other quantum systems such as Bose-Einstein Condensates, ultra-cold trapped atoms, superfluids. For these quantum systems, the main findings of the COST Action, based on the concept of "quantum design" of important new properties, are directly applicable. In a broader scientific context, the COST Action will generate important new knowledge and added value for quantum matter in general. New findings in the field of electron response of arrays of nanosuperconductors are very important also for the fields of plasmonics and nanophotonics.

Scientific & technological benefits.

The key energy saving technologies in the XXI century will be strongly linked to novel applications of various superconducting materials and devices. Non-dissipative current flow in superconductors and their ideal diamagnetism are extremely valuable assets for developing such technologies. It should be made clear that the superconducting technology is at present not the most economical technology overall, but for some applications, this technology becomes quite competitive (self-healing grids) and in some particular cases even superior to the classic, existing technologies (medium sized engines and generators). Recent successful realizations of superconducting qubits will pave the way for the development of essential elements for quantum computing. Ultrasensitive devices based on new nanostructured superconductors and fluxonics elements will certainly be beneficiary for device applications and metrology.

Societal benefits.

We will establish an actively working network providing training excellence at all levels (PhD, Post-Doc, junior researcher) in a range of technical skills that are essential for this Action. These include training in nanoscale sample design and fabrication, physical measurements and computational modeling skills as well as advanced theoretical analysis. For the European countries this project contributes to maintaining leadership in high technology applications of novel superconducting nanomaterials.

This COST Action is aimed at forming a "critical mass" needed for outstanding R&D and innovation-based growth in the field of Nanostructured Superconductors. It gives also a possibility to the involved new Members States and emerging countries to become an attractive and highly performing partner in the ERA, and will support the participation to future EU integrated projects of researchers from this Action's network.

This Action will contribute to the development of European human potential and economic growth since the researchers will participate in top trans-national teams, attend and organize workshops, thus benefiting from training and know-how exchange. Early stage researchers and female researchers will be encouraged to take leading roles at all levels of involvement within this Action, and special attention will be given to the selection of the WG Leaders and Steering Group members, in order to create an age and gender balanced team (election process by the Management Committee -MC).

This Action addresses strategically important and innovative topic of nanostructured superconducting materials, the effective use of which will sustain in medium-long terms the economies of European countries with evident benefits for environment and society.

The connections towards the industrial system and the chances of technological transfer will be enhanced by the multilateral trans-national research and dissemination framework provided by this Action. The development of new nanostructured superconductors, towards which the Action's research network is aimed, clearly would have an important impact on large companies that can sustain significant R&D investments, like the ones involved in energy production / distribution and electronics.

Moreover, the development of new technologies related to this field would be of high relevance to Small and Medium Enterprises (SMEs) as well, that could get involved in the design and production of special components related to probing superconductivity at the nanoscale, etc.

C.5 Target groups/end users

The major purpose of the Action is to provide an European level framework for networking and fluent cooperation between academic scientists and the industry sector. Ultimately the Action will provide to potential users novel superconducting materials for electronics and energy efficient power applications. The Action will cover necessities which current technology cannot yet achieve, and also replace, where appropriate, materials in current technology by more efficient and more effective superconducting materials.

In this context the Action differentiates various target groups and end users.

- As a first target group, ESRs will be encouraged to join international research networks to cultivate their originality and to motivate their professional career. Ultimately this will lead to better opportunities for employment in novel technologies. In this sector, the Action foresees, wherever possible, practical support for female ESRs to project their professional growth.
- Another relevant target group is the general public who will profit from dissemination activities such as an open access website covering the Action activities. In that regard, the Action will try to identify new possible audiences, and to analyse which are the concerns of the potential public. The Action will provide them with clear information on superconducting based technology and its benefits and improvements on power applications and electronic devices.
- The governments and the general public represent a target for the superconducting technology being addressed by this Action. Superconducting power applications can contribute to reduce the effects of global and local climate change due to high efficiency-low pollution energy generation (and transport) capabilities via superconducting materials. Therefore, this Action will provide to governments and general public a comprehensive and realistic dissemination (life cycle analysis) of the superconducting technology advantages.

- A first level user exploiting the results from this Action will be industrial companies in the fields of energy, electronic devices and detectors. The adequate, comprehensive and targeted dissemination to SMEs of the new technological outputs from the Action will enhance their capacity to assimilate these new technologies into their production and business market. This will outline possible paths to transform industry from a resource-intensive to a knowledge-intensive business which would increase the competitiveness of European industry.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The national research efforts that have to be coordinated in this COST Action are focused on ***modification of the properties*** of the same material ***through its nanostructuring*** and the ***optimization of the condensate and flux confinement*** that represent the backbone of this Action.

Research tasks to be coordinated by the Action

Like for a particle in a box in quantum mechanics, properties of the confined condensate in nanostructured superconductors, individual nanostructures, and other superconductor-based nanosystems and devices can be designed using quantum laws ("***quantum design***"). In contrast to the classical approach, however, which relied upon the search for new bulk materials each time a specific combination of their physical properties was required; nanosciences rely upon the ***modification of the properties of the same material through its nanostructuring providing the optimization of the flux and condensate confinement potential and topology***. Controlling the vortex behaviour and creating a guided vortex motion via nanoengineering of arrays of pinning sites or channels in the superconductor, makes it possible to develop new devices like micronet superconducting transistors, vortex lenses, switches, pumps, phase shifters for quantum computing, etc. This paves the way for designing new generation of superconducting devices based on the controlled behaviour of vortices (fluxons). ***The charge and the spin of electron form the core of electronics and spintronics, respectively. In the same way mastering fluxon behaviour in nanostructured superconductors creates unique new possibilities to develop the basics of fluxonics.***

Importantly, developing and applying systematically principles of "quantum design" of superconducting critical parameters will bridge the "paradigm gap" from superconductors by serendipity to superconductors by design. This is certainly a ground-breaking challenge in basic science with potentially very high impact for technology.

The Action will consider the following classes of superconducting nanostructures, superconductor-based hybrid and fluxonics nanosystems:

- **Individual superconducting nanostructures and in particular the relation between their quantized states and Tc's.**

This part of the COST Action deals with the most challenging objective: to reveal the evolution of the superconducting gap and critical temperature Tc at the nanoscale thus bridging continuously the gap between atomic and bulk behaviour of the matter by using nanograins of tuneable sizes d. Problems of fundamental importance and of ground-breaking nature will be addressed here concerning the evolution of the superconducting state:

- ***Critical dimension dc for the appearance of superconductivity***
- ***Dependence of Tc and the gap on d and geometry (3D, 2D and 1D nanostructures)***
- ***Possibility of having in nanograins critical temperature exceeding that of the bulk material***
- ***Applicability of Matthias rule at the nanoscale***
- ***Possible correlations between quantized conductance and quantized Tc***

The research along these lines would have a huge potential to change the whole research landscape in superconductivity and to modify drastically conventional approach to the problem of increasing Tc.

- **Interface superconductivity and electrical field effects in ultrathin layered and gated structures and devices**

Highly mobile electron system can be induced at the interface between insulating oxides such as LaAlO3 and SrTiO3 and others, or between insulating and metallic oxides. This unlocks the door to study novel artificial 2D interface matter that is often not stable as a 3D bulk phase. In particular, there exists a unique new opportunity to modulate electrostatically different types of correlated electrons at the interface thus achieving new functionality of the interface layer—including superconductivity and colossal magnetoresistance. These novel interfaces have potential applications through the nanoscale control of electric fields and they also offer the opportunity to study quantum phenomena in reduced dimensions, like ground states where superconductivity coexists with ferromagnetism.

Broad spectrum of tailored electrodes /interfaces and different realizations of nanoscale strong local electrical fields will be used:

- ***Interface between two insulators (I1/I2)***
- ***Gate-like nanosystems for tailoring Tc***
- ***Sandwiches with ultrathin superconducting, normal metallic and insulating layers (S-I-S, S-M-S, etc.)***

- **Application of nanomodulated templates originally developed for fluxon confinement in superconductors for making new photonic metamaterials**

Nanoscale interconnecting photonics elements on chip are urgently needed to provide much faster operating speeds. Remarkably, nanoscale metallic nanomodulated films/nanostructures can combine the better of the two worlds: surface plasmons in these films can very efficiently enable light propagation, together with the still efficient electrical conductivity. The metallic film undergoes after nanostructuring a very unusual metamorphose: if bulk metal is a good conductor of electrical current and a strong absorber of light, the nanostructured metallic film can “conduct” both electricity and light. In other words, ***photonics based on plasmonics can lead to a very efficient synergy between electronics and photonics at the nanoscale, thus providing a much higher operating speed***.

The methodology successfully used for controlling the confinement phenomena in nanosuperconductors will be systematically applied to investigate plasmons/photons confinement effects in plasmonics nanostructures and metamaterials. Taking the advantage of this interdisciplinary approach the ***optical confinement and plasmonic behaviour in individual nanocells (normal metallic, magnetic, superconducting, semiconducting and hybrid) and in metamaterials formed by the arrays of these nanocells will be investigated for achieving new optical properties***:

- ***Broadening the negative magnetic permeability range***
- ***Achieving a low absorption limit by using superconducting metamaterials at sub-gap frequencies***
- ***Studying Fano resonances in superconducting metamaterials and extraordinary transmission in such structure***
- ***Enhancing non-linear optical properties by using broken symmetry nanocells and their arrays***

- Fluxonics devices based on vortex manipulation, Josephson junctions and arrays

Recently, the focus of the fluxonics research has turned to studies of fluxon dynamics and vortex motion. The control of moving vortices can be achieved by creating artificial pinning landscapes or changing the size or shape of superconductors. The main emphasis of this part of our research is to develop novel nanoscale fluxonics devices with a wide range of applications. The following important issues will be addressed:

- ***Achieving vortex control, needed for fluxonics devices, by guiding and manipulating vortices with pre-designed nano-engineered non-magnetic and magnetic templates***
  • Development of magnetic templates for inducing guided vortex motion and tunable vortex diode effects
- ***Investigation of quantum disordered state of the Josephson junctions as a novel form of Bose metal state in 2D***
- ***Design and studies of parametric μ-wave emitters and amplifiers***

- **Nanopatterned superconductors (SC) and superconductor-based hybrids (triplet superconductivity and proximity effects, SC/ferro, SC/insulator, SC/metal hybrids**

The interplay of the superconducting and magnetic properties in unusual settings (***SC/ferro, SC/insulator, SC/metal hybrids***) is expected to lead to novel effects. For example, a triplet proximity effect may be generated – now due to the variation of the exchange field in time, in contrast to the conventional space variation. Generation, imaging and control of novel coherent electronic states in nanoscale Ferromagnet/Superconductor Hybrids and Devices will be addressed.

We will target the following research topics:

- ***Generation of spin triplet pairs at superconductor/ ferromagnet interfaces***
- ***Development of the theory of proximity effects in S/F hybrid, including the full theory based on numerical calculations of the Bogoliubov de Gennes equations in nanometre scale geometries***
- ***Current carrying Andreev bound states in a Superconductor-Ferromagnet proximity system. These edge currents are very similar in origin to the edge states in topological insulator***
- ***Dynamics effects in superconductor/ferromagnet hybrids***

- **New superconducting devices**

Presently, the most successful, practical application of nanostructured superconductors is the superconducting single-photon detector (SSPD) developed in 2001 by the groups of Gol'tsman and Sobolewski. The SSPDs have already been demonstrated to be the fastest and most-sensitive optical and near-infrared photon counters and started to play a leading role in such applications as fiber-based quantum communications, optical information processing, free-space satellite communications, or medical diagnostics.

The current COST Action will address the following novel device applications of nanosuperconductors:

- ***Superconducting single-photon detectors***
- ***Devices for quantum information processing (qubits, etc.)***
- ***Superconducting phase shifters for quantum computing***

- **Nanostructured multiband superconductors**

The classification of superconductors between type-1 and type-2 has been recently challenged when considering a multicomponent superconductor, i.e. consisting of two coupled condensates. In these materials the flux distributes unevenly combining bundles of vortices, as in type-2 materials, separated by vortex-free regions as in type-1 superconductors, due to competing vortex-vortex long range attraction and short range repulsion. Vortex states similar to those predicted theoretically have been only just experimentally observed in a clean prototypical two band superconductor MgB2. This new type of superconductivity was coined type-1.5. Type-1.5 superconductivity, if combined with mesoscopic nanostructures, opens remarkable new possibilities, both for fundamental research and applications.

Among the new research topics, the focus will be on:

- ***Semi-Meissner effect***
- ***The violation of the London law and Onsager-Feynman quantizatio***
- ***Noncomposite vortices***
- ***Intrinsic Josephson effect***
- ***Analogy with two-condensate Bose systems and superfluid metallic hydrogen***

- **Novel nanoscale mechanisms for superconductivity (theory)**

Theory and modelling is essential for understanding current experimental data and predicting new phenomena in nanosuperconductors and artificial nanoscale systems In the framework of the current COST Action the focus of these activities will be on:

- ***High Temperature Superconductors (HTSC) and its pairing glue***
- ***Interplay of superconductivity (SC) and (self-)ordering of charge and spin***
- ***Triplet SC in S/F hybrid***
- ***Multiband superconductors***
- ***Symmetry breaking and non-centrosymmetric superconducting crystals***
- ***Analogy between nanoscale superconductivity and confined ulta-cold atoms condensates***

- Power application of nanostructured superconductors and new fabrication techniques

Important recent achievements in the fabrication of bulk superconducting materials will be further advanced by developing new methods for making novel superconducting materials for power applications. The following realizations for large scale application possibility will be targeted:

- ***Superconducting wires***
- ***Magnet Design***
- ***Self-healing superconducting grids and windmill engines***

New fabrication techniques providing for these applications superconducting materials with state of the art critical parameters will be exploited:

- ***Physical Vapour Deposition (PVD) and Chemical Solution Deposition (CSD) for production of HTSC cuprates***
- ***Electrodeposition of type II SC and exfoliation techniques***
- ***Sol-gel pyrolyse and Inkjet printing***
- ***Coated conductors***
- ***Focussed Ion Beam (FIB) + Masked Ion Beam Structuring (MIBS)***

- **Enhancing Direct Visualization Techniques**

In this topic we will focus on the local visualization of the (dynamical) vortex patterns using a wide variety of techniques: ***scanning Hall probe microscopy (SHPM), magnetic camera (MagCam), scanning tunneling microscopy (STM), low temperature magnetic force microscope (LT-MFM) and scanning SQUI D (*****superconducting quantum interference device*****) microscopy***.

In the last decades an enormous effort was put towards the development and improvement of the aforementioned techniques, making them important new tools in research on superconductivity. The continuous strive to improve these systems will be prolonged in the coming years and the available know how will be used to investigate static vortex patterns in new superconducting materials (e.g. Iron pnictides) and new superconducting phenomena (e.g. 1.5-superconductivity). Another branch of superconductivity research, which could benefit strongly from these techniques, is the design of new “fluxonics” devices based on vortex manipulation. A time resolved visualization of vortices will allow us to monitor fluxonics devices at work and study their performance in a wide variety of external conditions (applied magnetic field, temperature, etc.).

The study of the above topics, will require the use of the most modern and performing analytical tools that often require specialized structures for optimum running. These instruments will be made pan-European accessible thanks to this collaborative COST action.

The human and technical means to achieve the objectives will be considered by the participating research teams, taking at present more than 70 teams, with an average of 5 people per team, leading to more than 350 researchers, spread over 17 COST countries, capable of executing the scientific and technological challenges in this area.

(Work plan in section D2.)

D.2 Scientific work plan methods and means

The main purpose of this COST Action is to bring into efficient contact the scientific teams active in the field of nanostructured superconductors in order to achieve the synergies required for the development of materials with improved performances. To implement that, the Action will be organized via 4+1 WGs that will focus on the most important issues in this COST Action. Four of the WGs are scientific or technological, whereas WG5 is the workgroup controlling this COST Action.

The WGs will aim to activate and to coordinate the consequent synergy on the following subjects:

WG 1: Design and fabrication of new superconducting nanostructures

- Thin layered (hybrid) superconductors for nanostructuring via top-down and bottom-up techniques
- Methods for introducing nanosized pinning centers in bulk materials, tapes and wires
- Fabrication techniques scalable towards industrial production
- Fluxonics devices
- Superconducting devices

WG2: Characterisation

- Integrated response techniques (magnetization, transport, heat capacity, …)
- Vortex visualization techniques with nanoscale resolution
- Nanoscale mapping of the superconducting condensate distribution and superconducting tunnelling
- Structural characterization
- Thermodynamic properties
- Microwave, millimetre and sub-millimetre spectroscopy

WG3: Modeling tools

- Molecular dynamics, Monte-Carlo simulations
- Numerical solution of Ginzburg-Landau equations (static and time dependent), Bogolyubov-de Gennes formalism

WG4: SME's/Industry relations - demonstrator devices

- Single photon detectors
- Fluxonics lenses
- Efficient pinning centers in pyrolitic HTSC tapes
- Superconducting tapes for power applications
- Superconducting quantum interference devices
- Quantum standard of electric current

WG5: coordination, dissemination & teaching-actions (see section E)

This COST action will have the following deliverables (D):

- Web site
- Social network group (Linkedin)
- 2 Schools (theory/exercises/experiments)
- 2 Conferences
- 2-4 Exploratory/strategic workshops
- Training/exchange scheme for young scientists
- Exchange of Lecturers (10/yr)
- Personnel secondments with SME/ industry (2/yr)
- Distributed European laboratory ("Virtual institute") for the production and characterization of nanostructured superconductors
- Joint publications and supervision of PhD theses

Scientific programme and innovation

The main scientific objective of this COST Action is:

"to optimize the effects of nanomodulated electric and magnetic fields on nanoscale confinement of the Cooper pairs and flux in order to enhance the superconducting critical parameters (T_c, H_{c2} and J_c) and to enable new applications of the superconducting materials"

The most important scientific deliverables of this COST Action will be newly developed and successfully tested nanoconfinement patterns providing superior superconducting critical parameters. This research will reveal the fundamental relations between quantized confined states in nano-superconductors and their physical properties, which will be used for enhancing dramatically the critical parameters (J_c, H_{c2} and T_c) of nanostructured superconductors and for developing their novel applications. The current Action is aiming at the control and manipulation of these parameters through nanostructuring. Recent spectacular progress in nanosciences has demonstrated that electrical, magnetic and optical properties of various condensed matter systems can be controlled practically at will and new functionalities can be created by designing and implementing the proper nanoscale confinement patterns for charges, spins and photons, respectively. The modern nanorevolution is actually aimed at controlling and mastering the nanoscale confinement for developing new properties and creating novel functionalities.

E. ORGANISATION

E.1 Coordination and organisation

Management and organisation of the Action

The Management Committee (MC) and the organization of the Action are conceived according to the "Rules and Procedure for Implementing COST Actions". The COST Action will have the following directions of coordination: management, networking, dissemination activities, ESRs and gender related activities and the "Virtual European Institute".

The MC is responsible for the overall direction of the COST Action. Its role is to ensure that the Action goals and milestones are fulfilled in due time, and to oversee that networking and collaboration between the partners in the Action is fluent, promoting new joint studies, researchers mobility through STSM and organization of workshops and conferences. The MC will be responsible also to select and assign coordinators to Working Groups (WG). The MC will meet every 6 months and in addition will regularly exchange information via e-mail and web conferences. The MC will also be responsible for the management of the COST Action budget, reviewing applications for membership of the program and preparing reports to the COST central administration.

A Steering Group (SG) of the MC will be formed. The SG will be composed by the Chair and Vice Chair of the Action, the WG, the gender parity, the ESR and the dissemination, STSM and virtual institute coordinators. Its role will be the management and decision taking regarding Intellectual Property Rights (IRP) and information dissemination issues. The SG will allow for agreements to be reached between the partners in IRP matters based on the evaluation of their individual contributions. In addition to the monitoring role of the SG, participants will provide the periodic progress reports of any advances in their areas which could lead to industrial commercialization. The SG will set clear milestones and will prepare the documents for the MC meetings.

Finally, all participants will take part in WGs according to their field of expertise or interest. Task and subtask coordinators may also be selected from the participants in each WG.

Organisation of the network:

- Participating countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Italy, Norway, Poland, Sweden, Slovakia, Spain, Switzerland, The Netherlands, United Kingdom
- The MC will be conceived according to the “rules and procedures for implementing COST Actions”)

- The MC will appoint a Steering Group (SG), led by a Chair and seconded by a Vice-Chair
- Each WG (5 in total) will have a WG leader (elected by the MC)
- The WG leader for WG5 (COST-Action manager) will lead a team of 6 task-coordinators, coordinating the tasks of:

    - Organization of Schools, Conferences and Workshops [coordinator will change for each event]
    - Dissemination
    - Gender balance
    - Early Stage researchers
    - Short term scientific missions
    - Virtual Institute (pan-European access to facilities)

The research is carried out in and financed by the participating countries, while COST provides the necessary co-ordination.

An Action specific website will be developed, integrating all activities within this COST Action.

E.2 Working Groups

The WGs will aim to activate the scientific debate and the consequent synergy on the following subjects:

-WG 1: Design and fabrication of new SC nanostructures
-WG2: Characterization
-WG3: Modeling tools
-WG4: SME's/Industry relations - demonstrator devices
-WG5: coordination, dissemination & teaching-actions

Organization of the workgroups:

Each workgroup will have a leader, who will coordinate the activities of the WG. She/He will make sure that the scientific programmes will be carried out in close cooperation with the other WGs and strong overlap between the members of these groups is expected in all fields of interest. Working Group coordinators will be elected at the kick-off meeting. WG5 will have besides the overall manager also a team of six coordinators for well-defined tasks as there are ESRs, Gender balance, STSM exchanges, the Virtual institute, dissemination activities and organization of schools, conferences and workshops (coordinator will vary according to the specifics of each organization).

There will be a strong synergy between WG1, WG2 and WG3, since design is based on theoretical knowledge (WG3), fabrication (WG1) and Characterization (WG2) are strongly dependent on each other. Other important workgroup collaborations are between ESR think tank and WG4 which is involved in the relations with industry.

Each WG leader will have as main tasks to:

1. participate in the meetings of the SG;
2. plan the appropriate scientific meetings;
3. coordinate and monitor the WG activities in order to meet the objectives that are defined in the scientific program;
4. promote the set-up of joint research (e.g. making use of STSMs);
5. promote the writing of common publications;
6. report the WG progress to the MC and SG.
7. participate in the Virtual pan-European facility

The scientific program running within each WG is described in Section D2.

E.3 Liaison and interaction with other research programmes

This Action will have a strong interaction with other European National and International research Programmes (see B4). The main topic of liaison and interaction will be on the Actions agenda and will accordingly be considered by the MC. It should be pointed out, that this Action is an "open" Action, and as such, NanoSC-COST can accepted further interested parties.

The visibility of the COST Action and the dissemination of its scientific output can only benefit from a strong interaction with other COST Actions and European and international research programs. This will be done by joined organization of training schools and workshops, in which experts of both programs will be invited to contribute. In this case, the merged expertise will increase the level and impact of the organized events. In addition, COST Action members will be actuated to participate in events organized by other programs. Finally, international experts, active within related programs, will be invited at MC and WG meetings to provide useful input on the scientific strategy followed by the COST 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 considerable involvement of early-stage researchers. This item will also be placed as a standard item on all MC agendas.

Gender balance

At this point, unfortunately, a clear gender imbalance is present in the scientific community working in the field of superconductivity. Unavoidably, this is reflected in the list of experts suggested in this COST Action. Taking the whole situation into account, the main objective will be to tackle vigorously the present imbalance from the bottom up. All participating members will be asked to engage as soon as possible female researchers in their country for participation in all activities undertaken during the COST Action.

This should lead to a gradual decrease of the gender imbalance and, ultimately, would shape a more balanced gender future in the field of superconductivity. The COST Action will be closely monitoring the situation with the gender balance, and will be revising the composition of the participating teams on a regular basis. Within WG5, a special coordinator (female) for gender balance issues will be appointed.

Involvement of early stage researchers

As stated in the COST strategy (June 2011) one of the key features is "providing network opportunities for early career investigators (ECI or ESR)". This key feature will be implemented in the COST Action in several directions, with the ultimate goal to have ESRs involved in both the daily organization of the Action program and the long term planning of the Action strategy. Several concrete actions are given below:

- Short research visits and conference grants will be opened for ESRs in order to give them the opportunity to come in to contact with experts around Europe and establish a long-standing network inside the COST Action.
- Training schools will be organized giving ESRs the opportunity to gain expertise on the variety of topics engaged within this project.
- An incentive will be given to ESRs to actively participate in the organization of conferences and workshops.
- ESRs, with a strong expertise in one or more topics of the COST Action, will be consulted to improve and strengthen the research strategy.
- Secondment towards international universities and industry

F. TIMETABLE

The Action will last for four years.

Due to the nature of the COST framework of collaboration, the re-adjustment of the activities may become necessary and corresponding changes are subject to approval by the MC.

Scientific exchange program, information exchange and dissemination activities will go on at all times during the course of the Action.

A tentative Timetable is given below. Actions' Milestones are grouped under "M:" and Deliverables under "D:" Each year (Yr) is split into 3 trimesters (T1-T3).

Yr	T1	T2	T3
1	M: Kick-Off meeting D: Definition of MC / SG and coordinators for ESR, gender, dissemination	D: Web site on-line with opening "Virtual Institute" M: Kick off meeting - Think Tanks on WG4, gender balance, ESRs, dissemination - WG1 – WG2 – WG3	D: **School -I-** D: 1st Evaluation and Activity Report, work plan Yr 2.
2	M: MC /SG/WGs meetings D: Liaison with Industry:WG4 D: Specialized **workshop** by WG1.	M: meeting Think Tanks on WG4, gender balance, ESRs, dissemination	D: **Conference** D: 2nd Evaluation and Activity Report, work plan Yr. 3.
3	M: MC /SG /WGs meetings D: Liaison with - industry:WG4 - other programmes: WG5	M: meeting Think Tanks on WG4, gender balance, ESRs, dissemination	D: **School -II-** D: 3th Evaluation and Activity Report, work plan Yr 4.
4	M: MC /SG /WGs meetings D: Liaison with - industry:WG4 - other programmes: WG5 D: Specialized **workshop** by WG1-WG2-WG3.	M: meeting Think Tanks on WG4, gender balance, ESRs, dissemination D: Strategy for the Action follow up	D: **Conference**; D: Final Evaluation and Activity Report

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, BE, CH, CZ, DE, DK, EE, ES, FI, FR, IT, NL, NO, PL, SE, SK, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 68 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 promise of nanoscale fabrication, characterization, and simulation for advancing the fundamental science of superconductivity and rational design of functional superconducting materials for a myriad of applications like next-generation grid technology, quantum computing, detectors, motors, transportation, magnets, plasma confinement in nuclear fusion...has never been higher. Nevertheless, it should be made clear that the superconducting technology is at present not the most economical technology overall, but for some applications, this technology becomes quite competitive (self-healing grids) and in some particular cases even superior to the classic, existing technologies (medium sized engines and generators). There is a strong sense of optimism and awareness of the opportunity that spans the superconducting community in the basic and applied sciences. Nonetheless, the rapid advances that have been occurring the last decade in superconductivity might be vulnerable to inaccurate public perception.

Addressing this issue inappropriately could lead to opposition to the technology and potentially could cause costly delays and enforced changes to proposed initiatives. This is especially true for power applications and electronics, where superconductivity has to compete with two well established technologies, copper and silicon. Commercialization of the technology cannot be successful until the reliability and long term economical savings of the superconducting technology are demonstrated to a broader public. In addition superconductors can bring many other economic and environmental advantages. To achieve wide public acceptance of superconducting technologies usage, it is necessary to address different key audiences, identifying and analysing their concerns and providing them with due information that improves their understanding of these new technological systems.

Taking into account the size of the Actions related issues, it is likely that the target audience for dissemination will be a large one, from academic scientists, to scientists and technologists working in materials science on development and application of materials, students, industry, thematic international organizations (e.g. implementation and operation of renewable energy –wind-, regulation of energy production and supply, Electronics, …), other COST Actions, European-, national- and regional-level Research Policy decision-makers, National and European Funding Agencies including the European Commission DG RTD Research and other European organizations (e.g. EUREKA)

H.2 What?

The dissemination plan includes a wide variety of actions addressing experts in the field, industry and the general public. A brief summary of all the undertaken activities is given below:

- A website will be developed and launched as a communication platform towards the general public and between all the members of the COST Action. All participating members will have access to a restricted area in which confidential information can be shared. The Virtual European Institute will be accessible via this web site.

- A Social Network Group (on Linkedin), allowing members of this Action to communicate and allowing proliferation over the web towards a broader the scientific/industrial community.
- A mailing list will be created to inform and update all participants on the progress and upcoming events inside the COST Action.
- Two schools will be organized to transfer knowledge among the various experts inside the COST Action and towards ESRs and industry.
- At regular intervals conferences, workshops and seminaries will be organized within the COST Action.
- The members of the COST Action will actively contribute to other national and international conferences.
- Publication of scientific results in peer-reviewed scientific and technical journals.
- Non-technical publications for a broader audience.

H.3 How?

A crucial role in the dissemination plan is given to the website, which will be the connection towards both researchers (internal and external), the general public and industry. Highlights of achievements within the COST Action, will be summarized in laymen terms, with additional links to inform researchers more deeply about the on-going research. In addition, a passport protected platform will be constructed, on which annual reports of the COST Action will be published. This platform will allow researchers to post internal reports and trigger an active collaboration with other groups. The website will also be used to announce conferences, workshops and training schools. A job site will also be available on which all participating groups can put open vacancies and invite young researchers for short stays abroad.

Planned conferences and workshops will be held on a regular basis allowing researchers inside the COST Action to present and discuss their most important achievements. These events give researchers the opportunity to interact and discuss on-going research more directly. In order to enhance the impact of the organized events, companies and leading experts from around the world will be invited to actively participate.

Addressing the international research community will be done via publications in peer-reviewed journals. Research between partners is strongly encouraged in the COST Action and achieved results will be presented in joint publications with a clear reference in the acknowledgements to the COST Action. In addition, researchers inside the COST Action will be financially supported to present results in conferences and workshops around the world. On the level of organization strong contacts will be made with other National-European, European and non-European scientific organizations to allow researchers outside the COST Action to participate in our events and vice versa.

The training schools will be the ideal platform to transfer the obtained knowhow to young researchers and learn more about the research network available within the COST Action. This will be achieved by inviting top researchers active in the COST Action.

Finally, the general audience will be informed about novel applications of superconductors, emerging via the COST Action, using all available channels: website, publications in press, television and radio.