**European Cooperation in Science and Technology - COST -**

**Secretariat**
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**Brussels, 8 December 2011**

**COST 4185/11**

**MEMORANDUM OF UNDERSTANDING**

Subject : Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action TD1105: European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability - EuNetAir

Delegations will find attached the Memorandum of Understanding for COST Action as approved by the COST Committee of Senior Officials (CSO) at its 183rd meeting on 30 November 2011.

**MEMORANDUM OF UNDERSTANDING**

**For the implementation of a European Concerted Research Action designated as**

**COST Action TD1105**
**EUROPEAN NETWORK ON NEW SENSING TECHNOLOGIES FOR AIR-POLLUTION CONTROL AND ENVIRONMENTAL SUSTAINABILITY - EUNETAIR**

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 develop new sensing technologies for Air Quality Control at integrated and multidisciplinary scale by coordinated research on nanomaterials, sensor-systems, air-quality modelling and standardised methods for supporting environmental sustainability with a special focus on Small and Medium Enterprises.

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 2011 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

This Action will focus on a new detection paradigm based on sensing technologies at low cost for Air Quality Control (AQC) and set up an interdisciplinary top-level coordinated network to define innovative approaches in sensor nanomaterials, gas sensors and devices, wireless sensor-systems, distributed computing, methods, models, standards and protocols for environmental sustainability within the European Research Area (ERA). The state-of-the-art research on innovative sensing technologies for AQC based on advanced chemical sensors and sensor-systems at low-cost, including functional materials and nanotechnologies for eco-sustainability applications, the outdoor/indoor environment control, olfactometry, air-quality modelling, chemical weather forecasting, and related standardisation methods is performed already at the international level, but still needs serious coordination efforts to boost new sensing paradigms for research and innovation. Only a close multidisciplinary cooperation will ensure cleaner air in Europe as well as reduced negative effects on human health for future generations in smart cities, efficient management of green buildings at low $CO_2$ emissions, and sustainable economic development. The objective of the Action is to create a cooperative network to explore new sensing technologies for low-cost air-pollution control through field studies and laboratory experiments, to transfer the results into preventive real-time control practices and to move towards global sustainability via monitoring climate change and outdoor/indoor energy efficiency. Establishment of such a network, involving COST country participants as well as non-COST key-experts, will enable Europe to develop world capabilities in urban sensor technology based on cost-effective nanomaterials, to form a critical mass of researchers suitable for cooperation in science and technology, to give training and education, to coordinate outstanding R&D, to promote innovation towards industry, and to support policy-makers.

**Keywords**: sensor functional materials, nanomaterials and sensing nanostructures, gas sensors and wireless sensor-systems with distributed computing, air quality control/monitoring and environmental measurements/modelling, protocols and standardisation methods for environmental sustainability and chemical weather forecasting.

## B. BACKGROUND

### B.1 General background

Since air pollution was identified to affect human health the World Health Organization (WHO) introduced air quality management and control actions to protect all people against health risks from air pollutants ($NO_x$, CO, $SO_2$, $O_3$, BTEX, PAH, $PM_{10}$, $PM_{2.5}$, $PM_1$). In the 1970's United Nations Environment Programme (UNEP) and WHO established a global programme on air quality monitoring (UNEP/WHO/GEMS/Air) to assist countries in monitoring air pollution to improve the utilization of data for health risk assessment and to promote the exchange of information. Since 1990, the WHO European Centre for Environment and Health took over the responsibility for the programme Air Quality and Health for Europe. Problems in the comparability of air quality data have been identified within Europe. Thus, WHO recommended quality assurance and control (QA/QC) activities to harmonise air quality measurements and data. JRC Ispra (Italy), Institute for Environment and Sustainability, was nominated as responsible institution in the EU in order to fulfill the QA/QC requirements within the implementation of the EC air quality directives. Current legislation, e.g. the Ozone daughter directive 2002/3/EC (European Parliament, 2002), requires informing the public on AQ, assessing air pollutant concentrations throughout the whole territory of Member States and indicating exceedances of limit and target values, forecasting potential exceedances and assessing possible emergency measures to abate exceedances. For this purpose modeling tools must be used in parallel with and together with air pollution measurements. The goals of reliable air quality forecasts are the efficient control and protection of population exposure as well as possible emission abatement measures. Furthermore, the implementation of the European Union framework directive on air quality (96/62/EC) and their daughter directives requires an extensive assessment of air quality in the EU member states. A new European Directive 2008/50/EC on *ambient air quality and cleaner air for Europe* has been defined.

Air-Quality Control (AQC) is currently realized by continuous and discontinuous methods to be carried out with automated, semi-automated, and/or manual devices (chemical monitors, sampling, analysis) to check calibration procedures and standards. Such analysis equipment is very expensive, and therefore no dense network of air monitoring nodes could be used if reliable devices at low cost are not employed. To do this, new sensing technologies such as cost-effective micro-sensors based on gas-sensitive nanomaterials could be used for monitoring of ambient air, rural or remote sites, traffic on road network in smart cities. They offer the opportunities for real-time mapping of air pollution by connecting several sensors through wireless networks or GSM. This is critical for validation of dispersion models of air-pollutants and evaluation of exposure of population. Collaborative networking and European transnational network within European Research Area (ERA) is a valid tool for approaching new challenges on improving sensor technologies by optimizing the preparation of sensors materials, identifying sensing mechanisms involved in gas detection with development of simplified models for controlled gas mixtures and ambient conditions, comparing in field the sensor responses against measurements of reference methods and sensor calibration. Hence, new air-pollutant sensors based on nanomaterials with functional properties are required at low-cost for a distributed air quality remote control in real scenario. The main purpose of this Action is to provide a discussion forum where outstanding scientists can jointly analyze the state-of-the-art and can define coordinated actions able to overtake the current limits, mainly taking advantages of the largely unexplored properties of nanomaterials for gas sensors, consolidated wireless technology, air-quality modelling and chemical weather forecasting, harmonisation of environmental measurements. The Action aims at networking top-level scientists in complementary skills such as sensor materials, nanotechnology, devices, sensor-systems, wireless technology, modelling and distributed computing, environmental measurements and protocols, air-pollution modelling, chemical weather forecasting, standards and methods.

This COST Action seems to be the best approach to coordinate, streamline, integrate and harmonise the interaction between material scientists, environmental modellers, chemists, computing engineers, end-users, stakeholders for a wide international community to address the following scientific issues:

- study of gas sensing mechanisms into materials;
- study of new gas sensors based on functional nanomaterials;

- study of new transducers for chemical sensors;
- study of new sensor-systems at low cost and low power consumption;
- development of portable and wireless sensor-systems for AQC;
- development of air-quality modelling and chemical weather forecasting;
- implementation of experimental campaigns for validation in-field at outdoor and indoor level;
- development of standards, methods and protocols for AQC based on low-cost sensors;
- harmonisation of environmental measurements.

The mentioned topics are properly addressed by a COST Action because of the following reasons:

- A COST Action with its inter-governmental character is best tool suited for harmonisation of activities in the field of new sensing technologies for AQC as well as for knowledge transfer between intra-COST countries with different level of technology capability. Moreover, COST allows the participation of leading non-COST countries involved in the Action.
- COST framework offers the optimal framework to coordinate high-level R&D to strengthen capacity building of cost-effective new sensing technologies for AQC in the ERA.
- This COST Action will stimulate European cooperation in science and technology in the field of new sensing technologies for AQC including air-quality modelling and forecasting, environmental measurements and standards, distributed computing engineering and models development. Each country will develop its own solutions to address the problems within nationally funded research and projects. Capacity building, knowledge transfer and networking with other COST countries are of highest priority and can be managed by the flexibility of a COST Action.
- This COST Action intends to create a network which will set up the basis for future more specific European projects within FP7 and beyond.

Combining multidisciplinary competences in science and technology (S&T), the COST Action generates a critical mass useful for outstanding R&D and innovation-based growth in ERA in the AQC, supporting the development of advanced sensor materials, improved cost-effective sensor-systems and environmental protection/sustainability. This Action will contribute to the development of European human potential stimulated by top-leading transnational teams. The outcome of this COST Action will include the advantages and benefits of:

- fostering international collaborations in science and technology for AQC;
- providing better knowledge of interactions between air-pollutants and sensor-materials;
- creating possibilities for exchange of knowledge between materials scientists, physicists, engineers, nanotechnologists, chemists working in AQC with environmental engineers, forecasting/computing engineers, industry and decision makers;
- training students and early stage researchers;
- providing arguments for discussion with governmental organisations, environmental agencies, stakeholders, to set priorities on venture-capital and funding of environmental research and AQC with a new paradigm of low-cost sensing measurements by pre-standardised protocols/methods;
- facilitating the innovation by transfer of knowledge from basic research to applications and AQC industry;
- contributing to establish suggestions in the guidelines for outdoor/indoor AQC.

In summary, the present Action is meant to offer an important contribution for a smooth implementation of new sensing technologies at low-cost for AQC, based on functional nanomaterials and wireless distributed network, to develop portable sensing technologies in green cities and indoor/outdoor energy efficiency in our society by giving a major impulse for future activities of research and innovation in the field at European level. Networking is of crucial importance, because all the techniques, methods and approaches needed in this Action are unlikely to be available in a single country.

## B.2 Current state of knowledge

The search for materials, which can meet both the specifications of continuous and ubiquitous environmental monitoring and the industrial demands for device integration, is pushing the development of new low-dimensional nanostructured materials. Successful synthesis of low-dimensional materials includes graphene-based and metal-oxide-based nanostructures *[A. Kolmakov Ann. Rev. Mater. Res. (review). 34:151–80, 2004], [F. Netzner and co-workers, J. Vac. Sci. Technol. B 28, Jan/Feb 2010]*.

Although carbon nanotubes (CNTs), nanohorns (CNHs) and graphene sheets (GSs) have been identified as promising candidate materials for future sensing devices (e.g. able to detect traces of pollutants even when operated at room temperature), graphene based materials face big challenges before the much-anticipated breakthroughs associated with the use of such materials can be realized. Namely, the production of high quantities of high quality raw materials with uniform structure and properties and their optimal integration in actual devices are the two most important issues to be solved.

Nanotubular, nanocolumnar or nanowire oxides as gas sensitive material are rapidly developing, since they offer the potential for massively increased specific surface area and precise surface composition control (e.g. via wet chemistry routes). However, for these materials to come of age requires a step-change in the knowledge for avoiding grain boundary poisoning in polycrystalline metal oxides (limits their repeatability and long-term stability due to slow recovery) and better controlling electrical contacts between the electrodes and the nanostructures.

In a real environment many gases can be present simultaneously and currently available gas sensors are not selective enough to unambiguously respond to a given target gas. Improved selectivity is needed for quantitative multi-gas analysers to be developed. In that sense, arrays of different low dimensional nanostructures can be used as active layers providing high active surface area. However, their assembly and integration needs to be compatible with modern Complementary Metal-Oxide-Semiconductor (CMOS) processing as Si-based CMOS devices will be required to interface and process information generated. Once more, there is a need for developing advanced techniques of assembling and integrating nanostructured materials into functional devices.

EuNetAir will address the existing challenges by focusing on the development of easily-scalable, fabrication methods that enable the optimal integration of low-dimensional nanostructures in functional sensing devices. As a result, it will boost the development of a wide spectrum of environmental analysers (e.g. from sensing nodes with communication capabilities to desktop handheld units). Additionally, EuNetAir will address the need for developing protocols and standards for the new generation of low-cost environmental analysers.

Regular environmental monitoring of gaseous air pollutants in Europe is currently carried out within dedicated networks governed by the regulations of the EU directive 2008/50/EC (mainly for urban environments) and the Convention on Long Range Transport of Air Pollutants (CLRTAP) and its European Monitoring and Evaluation Programme (EMEP, mainly addressing the regional background). Neither of these networks makes currently use of micro-sensors, if existent, for the detection of gaseous or particulate pollutants on a regular basis. For the sites operated under the auspices of the EU directive, reference methods are fixed in corresponding EN standards for most of the regulated pollutants, comprising e.g. continuous monitors based on chemiluminescence, fluorescence and photometry. Where no EN standards exist Member States are free to choose an appropriate method, if possible based on recommendations from CEN Technical Reports or EMEP standard operation procedures (SOPs). In the EMEP framework manual methods are preferred (except for ozone) combining a suitable time averaging sampling method (based on impregnated filters or denuders) with laboratory based chemical analysis.

Aside of these regularly operated public monitoring networks air quality monitoring plays a major role in epidemiological research on the health effects of air pollutants. Pollutant concentrations are used to calculate population exposures and doses. Short-term effect studies need time-resolved concentration data and hence frequently make use of measurements carried out in the public air quality networks (e.g. in course of the APHEA and APHEA-II projects).

However, studies with focus on personal exposure in various micro-environments [e.g. the EU funded project EXPOLIS] need to apply small, portable instruments. Except for carbon monoxide, which was measured by a continuously operated personal monitor, mostly passive or active integrative samplers (diffusion tubes, adsorptive cartridges) have been used. Passive samplers were also used in a recent study investigating commuter's exposure to nitrogen dioxide *[Bean, T., Carslaw, N., Ashmore, M., Gillah, A. and Parkinson, C.: How does exposure to nitrogen dioxide compare between on-road and off-road cycle routes? J. Environ. Monit. 13 (2011),1039-1045]* while for particulate pollutants continuous monitors (e.g. handheld particle number counters) or black carbon monitors could be used *[Zuurbier, M.; Hoek, G.; Oldenwening, M.; Meliefste, K.; van den Hazel, P.; Brunekreef, B.: Respiratory Effects of Commuters' Exposure to Air Pollution in Traffic. Epidemiology 22 (2011) 219-227]*.

Recently, portable instruments based on differential optical absorbance spectroscopy (DOAS) have been developed which allow simultaneous measurements of several gaseous pollutants *[Richards, M., Mobile multi-species trace vapour sensors for Localised Pollution Monitoring & Mapping. Presentation at AAMG-RSC Conference 2010]* and have the potential to produce e.g. real-time pollution maps along polluted roads.

While already frequently applied in occupational safety, the use of miniaturized solid-state sensors for ambient air pollution control is still limited to research projects, mainly because of their comparatively high detection limits *[Gerboles M., Sensors for monitoring regulated Compounds. Presentation at AAMG-RSC Conference 2010]*. Nevertheless, some pilot projects have been launched in the recent years promoting the application of small microsensors for ambient air quality monitoring within diffuse sensor networks, as e.g. the MESSAGE project (UK, http://research.cs.ncl.ac.uk/message/) and the Suiss OpenSense project [*OpenSense: Open sensor networks for air quality monitoring, http://www.nano-tera.ch/projects/401.php*].

Similar activities also exist in other parts of the world, like the United States [*CommonSense project* *http://www.communitysensing.org/index.php*], Japan [*Tsujitaa, W., Yoshinoa, A., Ishidab, H. and Moriizumi, T.: Gas sensor network for air-pollution monitoring, Sensors and Actuators, B Chemical 2 (2005) 304-311*], China [*Gi Heung Choi, Gi Sang Choi, Joo Hyoung Jang: A framework for wireless sensor network in web-based monitoring and control of indoor air quality (IAQ) in subway stations. 2009 2nd IEEE International Conference on Computer Science and Information Technology, Beijing, China*] and South-Korea [*Seong Kyun Oh, Young Tae Byun, Seok Lee, Hyung Seok Kim: Multi-sensor system for air quality monitoring in building and surroundings, Proceedings of the 2010 International Conference on Information and Communication Technology Convergence (ICTC), 455-456*]. AirMonTech, a recently started FP7-Coordination Action, seeks for new online monitoring devices and strategies for urban areas.

EuNetAir will extend on the recommendation from AirMonTech with specific view for non-urban areas. First evaluations of sensors, their compound specific sensitivity and cross sensitivity will be conducted. Recommendations of their use linked to specific measurement strategies will be developed and a research map developed.

**B.3 Reasons for the Action**

Air pollution control and environmental sustainability are a key to sustaining and improving the level of health within Europea and worldwide. Today, many people are exposed to a wide variety of pollutants from combustion processes or a wide range of chemicals, which have a considerable impact on the health, when considering acute poisoning as well as long term effects like asthma, allergies or cancer caused by airborne pollutants. In addition, due to the increased importance of energy consumption, monitoring of indoor air quality will become hugely important when buildings and homes are becoming more and more airtight to reduce the energy consumption due to heating and air conditioning.

The current state-of-the-art shows that research addressing innovative sensing technologies for Air Quality Control based on advanced chemical sensors and low-cost sensor systems, including functional materials and nanotechnologies for eco-sustainability applications, the outdoor/indoor environment control, olfactometry, and related standardisation methods is already performed at the European and international level, but still needs serious efforts for coordination to boost new sensing paradigms for research and innovation. Only a close multidisciplinary cooperation will ensure cleaner air in Europe and reduce negative effects on human health for future generations as well as sustainable economic development.

The objective of the Action is to create a cooperative network to explore new sensing technologies for low-cost air pollution control and monitoring through field studies and laboratory experiments, to transfer the results into preventive real-time control practices and to move towards global sustainability via monitoring climate change. Envisaged applications include, but are not limited to:

- distributed air quality monitoring stations in cities, e.g. ozone, particulate matter and relevant hazardous chemicals, allowing early warning of citizens and counter measures, i.e. reduction of traffic in smart cities;
- indoor air quality monitors, e.g. $CO_2$ and hazardous VOC (volatile organic compounds, e.g. benzene, formaldehyde etc.) to optimize ventilation strategies top reduce cost and health effects ("sick building syndrome") simultaneously in green buildings;
- improved sensors for monitoring and controlling combustion processes, not only in cars but also in heaters, lawnmowers and leaf blowers, which already today dominate the level of pollution in rural areas;
- enhanced cost-effective handled-sensors for odour monitoring in sensitive sites (e.g., urban wastes, sewages, landfill gas locations, composting houses, etc.) to prevent risks on public health also in schools, hospitals, public offices, including residential and commercial areas;
- exact measurement of air pollution in distributed networks in the general environment to monitor climate change and effects of new legislation to improve the environment.

These examples show that the proposed Action addresses European economic and societal needs and will simultaneously lead to scientific and technological advance improving the competitiveness of European industry in this area, which is of increasing importance worldwide.

This Action is a Trans Domain Proposal related to three Domains such as Materials, Physics and Nanosciences (MPNS), Chemistry and Molecular Sciences and Technologies (CMST), and Earth System Science and Environmental Management (ESSEM).

The research spectrum of this Action covers several COST domains such as materials and nano-technologies, chemistry and molecular sciences, environmental control/management. Air quality control and environmental sustainability requires multidisciplinary skills from physics, chemistry, nanotechnologies and materials science for basic understanding of processes and interactions as well as engineering, electronics, environmental sciences and management for implementation of these basic technologies into applications.

The research related to the Action requires reciprocal interaction between the various COST domains due to the multidisciplinary approach proposed: understanding the fundamental sensing mechanisms between various relevant chemicals and sensing layers will allow novel designs of sensing materials as well as engineering of cost-effective sensor systems. Advanced functionalities such as intelligent signal processing and wireless communications will provide the basis for distributed environmental monitoring and indoor/outdoor air quality control, allowing improved air pollution modelling, which will then in turn provide in depth understanding of the effects of air pollutants. Finally, protocols and standardisation methods for a new paradigm of low-cost environmental sensing can be developed on these fundamentals. The scientific approach including concepts and methods is drawn from all involved COST domains. In fact, materials science, nanotechnology, sensor chemistry, systems engineering and environmental science are topics with a strong interdisciplinary, cross-border character and thus require the adaptation and integration of highly-specialized scientific and technical know-how from the listed domains.

**B.4 Complementarity with other research programmes**

The challenges, objectives and outcomes of this Action are directly linked to the topics of various current national programmes, and to the Joint Technology Initiatives (JTI) on Miniaturized Sensors (AIRWISE) devoted to hardware development of wireless sensor network nodes for operation in airborne environment but not including chemical sensors or environmental applications.

Additionally, AIRWISE JTI is focused on the transfer and market of the mature technologies, while this Action deals with mid-term R&D on new sensing technologies for AQC including functional nanomaterials. The current COST Action ES0602 “Towards a European Network on Chemical Weather Forecasting and Information Systems” and other COST Action ES1004 “European framework for online integrated air quality and meteorology modelling” are focused on forecasting and air-quality modelling only without a massive study of new environmental technologies based on functional nanomaterials. Additionally, COST Action MP0701 “Composites with novel functional and structural properties by nanoscale materials” is close to the end of activities with major focus on study of nanocomposites for multiple applications in various industrial sectors but not environmental monitoring. Also, the ongoing COST Action MP0901 “Designing novel materials for nanodevices: from theory to practice” focuses on nanoscale materials of high technological relevance. Another COST Action 2100 “Pervasive mobile and ambient wireless communications” deals with the development of the paradigms of pervasive wireless communications without focusing on air quality control applications. These mentioned Actions are not rivals to this Action since its core issue is an integrated solution of new sensing technologies for cost-effective AQC based on functional nanomaterials, including air-pollution modelling and forecasting, wireless sensors network and distributed computing. Some FP6-FP7 projects deal with sensor nanomaterials and gas devices (NANOS4, S3, ORAMA, NANO2HYBRIDS), and with AQC by harmonisation of environmental data and development of environmental technologies and modelling (MEGAPOLI, CITYZEN, HITEA, PEGASOS, OFFICAIR, AQUILA, AIRMONTECH). However, they deal with specific questions or tackle the problem from a particular point of view. It is extremely necessary to initiate a cooperation of European research efforts in an integrated approach from technologies, models, computing and communications.

Furthermore, European Science Foundation (ESF) has funded EuroBioSAS focused on Bio-inspired engineering of sensors, actuators and systems. Additionally, ongoing Eureka projects of related items are 896 IPAS, 2624 EUROSENS, 5839 FOGS. These Eureka projects are at a limited number of participating EU Countries and restricted typologies of gas sensors and transducers. GOSPEL devoted to European Network of Excellence in Artificial Olfaction provides significant progress towards the commercial application of chemical sensors but different from focused air pollution monitoring. Also, FLEXSMELL is a network for initial training funded under PEOPLE Marie Curie Action aiming at the design, investigation and realization of printed chemical sensing systems on flexible plastic substrates for wireless compatible applications in several fields ranging from logistic to food security. Teaching and training strategies will be implemented to prepare the next generation of scientists in this strategic research area. The application is different from this Action, but some technologies developed in FLEXSMELL could be useful for air pollution control. Then, other efforts towards the opening of a new sensing paradigm based on low-cost gas sensors for AQC are strongly necessary for wide and integrated approach. This is the motivation for Action that will advance knowledge in AQC by new sensing technologies, while networking and coordination will provide conditions for development of sensor materials and innovative low-cost sensors. Hence, it is imperative to coordinate European research in this area to guarantee AQC. Finally, this COST Action is not duplicating the aims of above all-mentioned projects, but focusing on the European framework, networking and capacity-building activities. This Action is essential to the development of a new sensing paradigm at low-cost for AQC in an integrated approach including technologies, nanomaterials, models, methods, computing, wireless communication. Section E.3 will give further information how the interaction with the complementary projects will be achieved.

## C. OBJECTIVES AND BENEFITS

### C.1 Aim

The aim of the Action is to form a European-wide science and technology knowledge platform by a multidisciplinary coordinated network at international level on the new sensing technologies for Air Quality Control including sensor nanomaterials, portable wireless sensor-systems and distributed computing, air-quality modeling and chemical weather forecasting, standards, methods and protocols for environmental measurements in order to advance R&D and innovation in the European green-economy by strengthening the sustainable development in smart cities, outdoor air-pollution control and indoor energy efficiency in buildings and to foster the technology transfer of the new sensing paradigm of the cost-effective chemical sensors in the European countries with a special focus on SMEs.

### C.2 Objectives

With the participation of researchers and industry, as primary objective, the Action will develop a transnational network of multidisciplinary expertise in AQC from COST and non-COST countries, to investigate novel sensors and deployment technologies for environmental monitoring.

The main objectives of the Action are listed, but not limited to:

- to establish a Pan-European multidisciplinary R&D platform on new sensing paradigm for AQC contributing to sustainable development, green-economy and social welfare;
- to create collaborative research teams in the ERA on the new sensing technologies for AQC in an integrated approach to avoid fragmentation of the research efforts;
- to train early stage researchers (ESR) and new young scientists in the field for supporting competitiveness of European industry by qualified human potential;
- to promote gender balance and involvement of ESR in AQC;
- to disseminate R&D results on AQC towards industry community and policy makers as well as general public and high schools.

The secondary objectives, across the 4 Working Groups of the Action, are:

- to provide a platform between scientists in the field of materials, nanotechnology and sensor-systems and other scientists such as environmental protection engineers, public agencies managers, stakeholders, decision-makers, aiming to improve best practices in AQC and explore the potential role of new generation of low-cost sensing devices;
- to investigate sensing mechanisms of functional nano-materials for gas measurement and identification of the best available nano-materials, proving concepts and harmonising pre-standardised methods; based on available datasets from partners;
- to assess degradation rates and lifetime of sensor elements in defined environmental conditions and evaluate interactions of sensitive materials with outdoor/indoor pollutants; based on datasets from ongoing and historical field deployments of low cost sensors;
- to investigate the best available technology for sensor deployment, communication, power supply and data storage, analysis and display;
- to monitor real-world environmental conditions with experimental campaigns to assess composition of indoor air (buildings: house and office) and outdoor air (urban areas and industrial sites) and to investigate how such data can be utilised in air pollution modelling;
- to approach standardisation of methods for air quality measurements e.g. harmonisation of test procedures, chemical analyses, post processing, protocols etc.;
- to disseminate knowledge on functional materials and sensor-systems for AQC;
- to aid better focusing of Europe's resources by coordinated efforts in AQC and environmental sustainability to strengthen Europe's competitiveness and scientific excellence improving capacity building and networking to tackle global challenges in a big market in the mid-long term.

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

The networking is one of the most important keys to success of the objectives defined in this Action and detailed above. The backbone of the Action covers expertise on all key aspects from theory to experimental and practical aspects of science and technology development in the field of AQC. The interdisciplinary character of scientists implicated in this Action, the complementary technologies and methodologies implemented, the high diversity of investigated materials and the spread of scientific knowledge involved are crucial parameters to yield the ambitious objectives.

Beyond the objectives, the networking is a real opportunity to constitute scientific, technologic and management platforms devoted to the control of air quality and environmental sustainability unrestricted at the national scale but extended to Europe and more. The scientific dynamics, the information transfers, the sharing of skills and knowledge as well as the development of innovations between these platforms will be ensured by human mobility made possible by such a COST Action.

The networking, strengthened by the organization of working groups and workshops, will initiate new scientific collaborations between partners and will lead to new scientific programs whose equipments may be acquired by other financial supports that will contribute to yield the objectives of this Action.

More precisely, the networking for the development of new sensing technologies for AQC at the European level is relevant and strategic:

1. to successfully achieve the objectives previously described in section C.2 by means of:

- the development of a multidisciplinary network of physicists, chemists, physico-chemists, electronics, nano-technologists, specialists of materials, environment, metrology and management;
- the relevance, the expertise and the international renown of each partner implicated;
- synergies leading to work prospects and collective thought focused on the realization of innovative sensitive materials and high-efficient sensing devices. Such collective work will be initiated during workshop and strengthened by early-stage researcher exchanges;
- a global approach on sensing microsystems and their applications (materials, transducers, technology, working conditions, methodologies, models, protocols) leading to simultaneous and synergic optimizations of all the parameters to reach the best performances.

2. to federate human and material resources essential to the project accomplishment. This will give each partner the opportunity:

- to have access to at least 5 new European technological platforms (synthesis, characterization, design, development, experiments under gas), whatever materials, gases and transducers investigated in this Action;
- to perform measurement campaigns in real conditions (in indoor or outdoor conditions, in occupational or non-occupational context, in industrial or urban environment) in various European towns thanks to the strong collaborations with National networks of air quality monitoring and environmental agencies (e.g., AtMO in France, ARPA-Puglia air-stations network in Italy, air quality research network CSIC in Spain, Environmental Agency in Lithuania, Meteorological Services in Hungary, etc.) previously initiated by some Action partners or directly involved as active partners in the Action;
- to contribute to a better modelling of pollutant dispersion at the European scale (and more) by the achievement of a large database on pollution which will be available to environment protection engineers;
- to react quickly and more efficiently to economic, social and medical needs related to air quality control, the networking providing a wide range of technical solutions to suit to each requirement;
- to promote the pooling of scientific knowledge and skills by means of the manpower mobility (Short Term Scientific Missions) as encouraged by COST Action.

The deliverables of the Action are cooperative activities, workshops, conferences, exchanges, mobility. Briefly, areas of cooperation include:

- Workshops on sensor materials and nanotechnologies, sensor-systems for AQC, environmental measurements, air-pollution modelling, chemical weather forecasting, distributed computing, wireless sensor networks, protocols and pre-standardisation organization of open conferences to improve knowledge transfer and dissemination;
- Schools on sensor materials, technologies, processes, methods, modelling, forecasting, applications, environmental certification and validation, project management;

- International Early Stage Researchers exchange and Scientists Mobility (Short Term Scientific Missions) between partners involved in Action and non-COST partnership at incoming and outcoming level;
- New collaborative research actions and research projects providing synergies between partners capabilities;
- Participation in Conferences, Short Courses, Mutual Publications, Reports, White Papers, Position Papers, etc.;
- Outreach activities and enforcement of the gender agenda;
- Coordinated Dissemination of the networking activities towards Academia, Industry and General Public.

The final goal is to produce a supporting tool for a broader S&T community, enabling cross-interaction between researchers, specialists, industrial partners working in the sensing technologies and environmental modelling and measurements. Strong impact is expected by a regular sharing of experts from different related fields and AQC strategies to support a sustainable development and green-economy in Europe.

**C.4 Potential impact of the Action**

The Action will constitute an important element in cross-discipline coordination of research and application studies related to densely distributed air quality monitoring. The comprehensive reviews of achievements and existing gaps, advantages and shortcomings (both within each research area and across their inter-connections) will lead to a better understanding of a variety of processes determining the critical technical, economical and societal aspects for the development of widely distributed gas sensing systems for air quality monitoring. It will also highlight the existing gaps in knowledge and help identify the most important areas for future developments in low-cost, low-power wireless micro gas sensors. This is critical for validation of dispersion models of air-pollutants and evaluation of exposure of population.

European integrated nano gas sensors framework and strategy will be elaborated in this Action. Establishment of such a network will enable Europe to develop world capabilities in urban sensor technology based on cost-effective nanomaterials and contribute to form a critical mass of researchers suitable for cooperation in science and technology, including training and education, to coordinate outstanding R&D and promote innovation towards industry, and support policy-makers.

In summary, the Action will have a major impact at different levels: scientific, technological and societal.

Direct outcomes from the Action will include benefits for:

1. Sensing technologies for low-cost air-pollution control through field studies and laboratory experiments;
2. Identification of sensing mechanisms involved in nanomaterials with development of simplified models for controlled gas mixtures and ambient conditions;
3. Increase knowledge on largely unexplored properties of nanomaterials for gas sensors;
4. Improvement of the sensor technologies by optimizing the preparation of sensors materials;
5. Harmonisation of environmental measurements and protocols, standards and methods for calibration and measurements;
6. Experimental datasets will enable different groups to evaluate their models and practical results within a coordinated effort.

Outcome from the Action will also include benefits for scientific community via:

1. Better integration of researches across different areas of sensing systems for air quality control;
2. Linking developments aiming at mutual enrichment and cross-validation;
3. Identifying important areas for future research;
4. Providing a flexible forum for planning future activities.

Specific scientific impacts of the Action will include:

1. A list of strengths and weaknesses of the existing knowledge-base;
2. Established/strengthened communications between different research fields involved;
3. Established/strengthened connections with end users and beneficiaries of distributed air quality sensors technology;
4. A mid-to-long-term common research agenda for the future.

Besides, benefits for society will include the following:

1. Sensing technologies such as cost-effective micro-sensors based on gas-sensitive nanomaterials for monitoring of ambient air, rural or remote sites, traffic on road network in smart cities;
2. Improved air-quality modelling and chemical weather forecasting;
3. Real-time mapping of air pollution by connecting several sensors through wireless networks or GSM;
4. Transfer of results into preventive real-time control practises and global sustainability for monitoring climate changes and outdoor/indoor energy efficiency.

Finally, the development of the new sensing technologies for AQC would be of high relevance to Small and Medium Enterprises (SMEs) that could get involved in the design and production of related special demonstrators, sensor-systems and advanced devices or development of higher technology products for large markets.

**C.5 Target groups/end users**

The COST Action will improve the scientific and practical knowledge on low cost sensing device, such as chemical gas sensors, in relevant areas of concern currently and in the future (e.g., outdoor and indoor air control, health, material labelling, building energy efficiency, air-pollution modelling and forecasting, smart cities, etc.). Inevitably, these results interest different categories of end-users and stakeholders (i.e., environmental agencies, decision makers, industries, laboratories, governmental organisations, public managers, authorities). This Action will provide an enhanced framework for cooperation of researchers, industrial partners and users of innovative solutions for AQC. In this context, the Action identifies different target groups and end users.

First of all, ESRs will be involved in an international research framework that will stimulate their creativity and professional growth, also increasing their employment opportunities in novel AQC technologies. This Action will be a practical support to build a successful career with gender balance. Various stakeholders and end-users will exploit the expected results by typical initiatives of new enterprises based on research-results and knowledge with young scientists and early stage researchers involved.. This Action objectives require that the environmental consulting laboratories are able to measure easily, without a high level of skill, air pollutants using cheap sensing systems. But today, they actually need to use expensive equipment to obtain reliable and accurate results and consequently the real time control in the field is usually not performed by private laboratories. A new technology, the Electronic Nose, is very promising for the control of air pollutants and in particular for the off-odours monitoring. But even if this technology corresponds to the needs of the end-users, the chemical sensors used in this device have several limitations such as high detection limits, water sensitivity, low selectivity and a poor reproducibility. Thus, there is really a need to improve these chemical sensors. A collaboration of end-users and scientists would have the power to merge the requests of each actor.

One spin-off of this Action, will be confronted with the difficulty to monitor odorous pollution and is waiting for information and innovation in the field of low cost and effective gas sensors. There is also a need of standardisation in the air pollutants metrology. Again, the odour field is a good illustration. Excepting the European standard EN 13725 (determination of the odour concentration), there are no certified rules to measure an odour in the environment. The laboratories and the consulting companies have no references, no obligations to proceed using a standard methodology and it induces an unfair competition. A further spin-off is expected to develop environmental services for SMEs. Particularly, odour control at sensitive places (i.e., wastes site, sewages, garbages, landfill gas locations, composting houses) is performed by olfactometry method with a trained panel of assessors. This activity of environmental services is expected to be nationally funded by private SMEs, public agencies and local governmental authorities.

Moreover, a network of spin-offs on AQC from COST area will be linked and some European spin-offs are expected to be involved in the Action. This will be very useful to boost the exploitation of the research results and to promote technology transfer towards new business models based on green economy and environmental sustainability for a sustainable development in Europe.

The field of indoor air pollution also needs quality assurance and control. At this moment, a European group (CEN/TC 351 Construction Products - Assessment of Release of Dangerous Substances) is working to elaborate a labelling procedure for the construction products. A big challenge to elaborate a label is to harmonize the procedure to measure the release of pollutants by materials everywhere in Europe. A Belgian project on this topic, (HEMICPD, ended last year) had the goal to give the first guidelines to harmonise the procedure in Belgian. A private research institute (with contributing members are the more than 65000 Belgian construction companies: general contractors, carpenters, glaziers, plumbers, roofers, floorers, plasterers, painters, etc... most of which are SMEs) and an independent research organisation have worked in collaboration on this project supported by the Belgian science policy. This project reveals that harmonisation of governmental schemes to assess volatile organic emissions is necessary to obtain transparency. It also highlights that the different limit values in different countries is a difficult problem to solve.

The importance of the quantification procedure on the emission results has also been demonstrated by experimental results. In addition to the labelling procedure and its control, a new concern is the aeration and the air quality of passive and in-wood buildings. The aeration control needs an efficient servitude to the air quality with new sensing systems integrating low cost gas sensors. A new trend is the development of wallpapers that clean the indoor air thanks to active molecules “sprayed” on the surface of the papers. To control the efficiency of this material and to reactivate its cleaning properties, small gas sensor devices located in or on the material are demanded by the producers. The new chemical sensors and new chemical sensing platforms into products - that are systems rather than sensors - are bringing new assets to the European industry such as the opportunity to develop and market a complete new series of products for the existing applications and also the opportunity to open up new application fields for the environmental sustainability and green economy.

Additionally, an important target group will be the general public. The Action will be directed at the general public by providing access to its dedicated website displaying its activities as well as the long-term implications and consequences of its research concerning AQC and sustainable development. In addition, it will include a strong communication to evaluate the public concerns about environmental nanotechnology and cost-effective AQC. Open public ways will be used to raise awareness of nanoscience for AQC and green economy. In fact, the global public is increasingly aware of, and concerned about the effects of climate change on Earth from the global to local scale. Therefore, the implementation of low-cost gas sensor networks for AQC as a possible solution to mitigate climate change, reduce the negative effects on public health and support environmental sustainability is crucial. Also, the policy-makers represent a key target for future success of the new sensing technologies for cost-effective AQC and environmental sustainability.

Finally, end users will be different industries as well as the society (consumers). The dissemination of AQC solutions towards SMEs will strengthen their capacity to develop and use these new sensing technologies in their businesses. The appropriate dissemination of R&D results upon coordinated strategy of the Action will improve competitiveness of the European industries and will provide knowledge-intensive businesses.

In summary, the potential target groups are:

- Utilities (environmental managers and AQC operators);
- National, municipal and private chemical weather forecasting services and environmental services;
- SMEs working in the field of AQC;
- Universities and Research Institutes;
- Investors;
- Authorities.

From the end users point of view, the whole EU population will benefit from the AQC, which will contribute to reduce the impacts of climate change and to promote environmental sustainability.

## D. SCIENTIFIC PROGRAMME

### D.1 Scientific focus

This COST Action focuses on the new sensing technologies for low-cost AQC. This is of strategic importance for the development of European industrial capability in environmental sustainability and green-economy, and to protect the public health. In the past, noticeable scientific efforts have been realized to develop functional materials and devices for AQC, air-pollution modelling and chemical forecasting, but developed nanosensors for cost-effective AQC have not yet commercialized. The national research projects in this field have to be coordinated in this Action aiming to share roadmaps and common purposes. In fact, the national efforts, coherently with the research projects worldwide, are considered more promising for the technological applications in a global scenario at an international level.

The Action will coordinate different research tasks to achieve the objectives described in section C. The workplan is organized in four complementary Working Groups (WGs), each devoted to a progressive development of synthesis, characterization, integration, prototyping, proof-of-concepts, modelling, measurements, methods, standards and application aspects. The four WGs with the specific objectives are:

- WG1: Sensor materials and nanotechnology

- WG2: Sensors, devices and sensor-systems for AQC
- WG3: Environmental measurements and air-pollution modelling
- WG4: Protocols and standardisation methods

Initially, this Action will focus on the study of sensor nanomaterials and nanotechnologies exhibiting unique properties in terms of chemical and thermal stability, high sensitivity, selectivity. Nanosize effects of functional materials will be explored for integration in gas sensors at low power consumption. Furthermore, specific nanostructures with tailored sensing properties will be developed for gas sensors and sensor-systems with advanced functionalities. Enhanced microsensors and nanosensors with functional nanomaterials will be studied in sensor networks at distributed deployment with high spatial and temporal resolution and wireless communications of data. Improved air-pollution models based on real-time datasets from deployed sensor networks will provide high-resolution mapping of air-pollutants to provide accurate chemical weather forecasting and air-pollution modelling. Long-term experimental campaigns of portable sensor systems by environmental measurements in field are expected to assess the huge potential of the new sensing technologies for cost-effective AQC. Taking into account the mentioned issues and cited in section B, the Action will focus on the following fields:

State of the Art

A state-oftheart report dedicated to past and present research activities in different countries of COST-area and participating non-COST countries will be established. The report will cover briefly the following aspects:

- currently sensing technologies applied to AQC for the different forecasts horizons, strengths and weaknesses;
- similarities and differences between the sensor nanomaterials for cost-effective gas sensors and sensor-systems with advanced functionalities including distributed computing;
- uncertainty of the chemical weather forecasting and air-pollution modelling, also depending on the specific region and hot-spots;
- use of real-time measurement data with cost-effective gas sensors, especially networked wireless sensing systems with multivariate intelligence;

- evaluate the strengths, weaknesses and limits of different portable gas sensor systems and instruments by means of environmental measurements with medium-long term experimental campaigns, and state-of-art of the current protocols and standardized methods related to the gas sensors and nanosensors;
- definition of the needs of the AQC industry and management plans with definition of targeted business-plans;
- expected economic benefit of improved sensing technologies for AQC and environmental sustainability.

The goal is to publish the satate-of-the-art report through an official body (e.g. publication series of EU, annals of Research Institutes, specialized magazines) in order to give a higher relevance and audience to the document and therewith promote a wider dissemination.

Sensor materials and nanotechnology

It will coordinate transnational innovative research on gas-sensitive materials for air-pollutants detection at high performance, including nanostructured materials (e.g., carbon nanomaterials, metal-oxides, supramolecular films, polymers, advanced nanostructures, etc.). These materials will be integrated into devices and gas sensors for air-quality control. The gas sensing properties of the nanomaterials will be studied with emphasis at functionalizations and surface modifications with nanocatalysts and foreign functional materials to enhance the gas adsorption and thus the gas sensitivity. The stability and selectivity of the gas sensor nanomaterials will be addressed as well. These depicted main research tasks will be studied via qualified manpower of the COST Action partners and investigated by their existing operational systems:

- growth facilities of materials and nanostructures by Physical Vapour Deposition (PVD) technologies (magnetron sputtering, thermal evaporation, electron-beam evaporation, etc.) and Chemical Vapor Deposition (CVD) technologies (radio-frequency plasma enhanced CVD, high-temperature ovens, reactive ion etching, etc.), and preparation of molecular films (Langmuir-Blodgett technique, spray-coating, etc.);

- materials characterization: Transmission Electron Microscopy (TEM), Field-Effect Scanning Electron Microscopy (FE-SEM), X-ray Photoelectron Spectroscopy (XPS), X-ray Diffraction (XRD), Atomic Force Microscopy (AFM), other advanced facilities for microanalytical, structural and surface analysis.

Sensors, devices and sensor-systems for AQC

It will concentrate on research for design, fabrication, testing and functional characterization of new cost-effective sensor-systems at level of proof-of-concept for enhanced air-pollutants detection up to trace levels by means of laboratory experiments and in field campaigns. Advanced transducers (chemoresistors, electrochemical, Field Effect Transistor (FET), Surface Acoustic Wave (SAW), Quartz Crystal Microbalance (QCM), optical fibers, Micro-Electro-Mechanical-Systems (MEMS), Nano-Electro-Mechanical-Systems (NEMS), cantilevers, hybrid transducers, etc.) will be employed for high-performance environmental sensors with new functionalities of advanced electronic interfaces and wireless communications at low-power consumption. Smart devices with pattern recognition algorithms and artificial neural networks will be designed and developed. Microsensors and nanosensors at low-cost and low-power consumption are expected to be integrated in a distributed wireless sensor network at high spatial resolution with distributed computing in the multiple nodes for accurate measure of concentration of air-pollutants in real scenario. The usage of fully autonomous systems for gas sensing becomes a challenge from technological point of view as well as for budgetary reasons. These depicted main research tasks will be studied via qualified manpower of the COST Action partners and investigated by their existing operational systems:

- Gas-management system for laboratory tests of gas sensors upon controlled multicomponent gas mixtures;
- Air quality gas analysers: $CO_2$, $H_2O$, NO, $NO_2$, $NO_x$, $SO_2$, $H_2S$, VOCs, PM, PAH, etc.;
- Manipulators of nanomaterials and processing such as Focus Ion Beam (FIB);
- Sensor/Device analyzers: network analyzers, spectrum analyzers, multimeters, electronic analyzers, S-parameter set test, oscilloscopes, digital analyzers, etc.;

- Distributed computing workstations: artificial intelligence algorithms, pattern recognition, neural networks, electronic circuit simulation, wireless communication suites, sensor network designer, ad-hoc firmware, ad-hoc software, etc.

Environmental measurements and air-pollution modelling

It will initiate and coordinate a European measure program including studies on innovative, continuous and automated environmental measurement and on air-pollution ($NO_x$, CO, $SO_2$, $CO_2$, $O_3$, BTEX, PAH, $PM_{10}$, $PM_{2.5}$, $PM_1$, etc.) modelling in specific hot-spot and large areas located in COST countries. Harmonised air pollution monitoring in Europe will be addressed such as:

- air quality research in urban, industrial, rural and remote sites, including assessing of air quality plans;
- Air quality monitoring of new pollutants to evaluate if these can be standardized in environmental norms;
- Development of particle measurement techniques and personal samplers. Particle and aerosol characterization;
- Inter-compare new instruments with classical ones. Interpret indoor and outdoor variability of levels of air-pollutants;
- Exposure assessments;
- Assessment of abatement strategies;
- Modelling of air pollution;
- Development and/or assessment of environmental emergency response systems (severe events, floods, transboundry radioactive pollution);
- Chemical weather forecasting;
- Assimilation of pollution data in integrated systems for monitoring and management of air quality;
- Assimilation of remote data in air pollution modelling.

These depicted main research tasks will be studied via qualified manpower of the COST Action partners and investigated by their existing operational systems such as:

- Air quality monitoring laboratories;
- Field stations for air quality research;
- Field sampling sites;
- Calibration facilities for aerosol equipment;
- Geochemical laboratories for analysis of air samples;
- Software for chemical weather forecasting and air-pollution modelling;
- Telecommunication hub of World Meteorological Organization.

Protocols and standardisation methods

It will deal with procedures, protocols and pre-standardised methods for low-cost sensor-systems applied to AQC. These include:

- Performance of partner-developed and available sensors/instruments for measuring air-pollutants (regulated in Air Quality Directive 2008/50/EC);
- Study and assessment of protocols and methods devoted to low-cost gas sensors for AQC with definitions of guidelines for standards;
- Air-quality case-studies;
- Benchmarking with official methods;
- Round-robin of procedures and tests for AQC sensors;
- Reference-materials for AQC;
- Assessment of gas sensors in well-characterized (industrial and natural) environmental situations;
- Indoor air quality monitoring;
- Assessment of physical and chemical characterization of nanomaterials and ambient particles;
- Assessment of measurement and exposure metrics in view of future use in ambient air quality assessment.

Originality of this COST Action consists in the definition of a new measuring paradigm of air-pollution real-time pre-standardised control based on a new generation of low-cost ubiquitous smart microsensors integrating functional nanomaterials for a distributed map of urban air-pollution at high-resolution. Actually, the AQC sensors are not yet standardized in certified procedures of measurements and protocols. Currently, AQC is performed by standardised, expensive and bulky analyzers. These depicted main research tasks will be studied via qualified manpower of the COST Action partners and investigated by their existing operational systems such as:

- Air quality analysis laboratories: mass spectrometers (MS), gas-chromatography (GC), infrared (IR), visible (VIS), ultraviolet (UV) spectrophotometry, thermal desorption systems, cooled (cryogenic) injection systems, etc.;
- Volatile organic compounds (VOCs) and particulate matter (PM) samplers;
- Calibration facilities for gas sensors, samplers and air-quality instruments;
- Particle sampling and measurement techniques (airborne): SMPS, FMPS, ESP, APS, TEOM, AMS, NSAM, minidisc, etc.;
- Particle analysis techniques: TXRF, SEM-EDX, HRSEM, EPR.

Networking

From the beginning of the Action, a strong effort will be put on the establishment of a top-level interdisciplinary collaboration between science, technology and industry. A trans-national community will drive the development of new sensing technologies for AQC by means of coordinated and networked activities. This will essentially contribute to clarify the needs of the AQC industry and the possibilities and limits of the chemical weather forecasting and air-pollution modelling. All workshops as well as Short Term Scientific Missions (STSMs) and training schools will strongly focus on this goal, especially to include early-stage researchers in the process. At the same time, the AQC communities will be brought together in order to launch an intense capacity building according to a flexible and open framework. Finally, the knowledge transfer from advanced to technologically less advanced countries in that field will be emphasized. The dissemination of the results at international and national conferences, workshops and training schools will be a valuable tool to support enhanced collaboration between science and industry.

Such work requires flexible and dynamic consortium, such as a COST concerted Action, which can easily incorporate new participants with specific contributions and network capabilities. This work will be carried out by COST Action partnership in co-financed manner by current nationally-funded and newly-submitted international/European/national research projects.

Potential

Even if the main emphasis is still to provide new sensing technologies for cost-effective AQC, including air-pollution modeling and forecasting, significant progress in this area may lead both to a widening of the application sectors and to a technological fertilization in other fields such as energy efficiency, energy harvesting, security, safety, aeronautics, automotive, transportation, sustainable mobility, food quality, automation, industrial process control. Flexible workplan with open possibilities will provide a good opportunity to include additional perspective activities not foreseen during the preparation of the proposal. This open scheme of the Action is at high added value for advancements in science and cooperation in technology more than planned activities in the workplan. Partners of this Action can bring to the discovery of new sensing technologies for low-cost AQC by a leading expertise in the multidisciplinary fields and by a great availability of synthesis facilities, nanomaterial growth systems, processes and technologies, novel analytical equipments and materials/devices characterization tools coupled to experimental, computational and modeling activities. This integrated approach of technologies, communications, information, forecasting and modeling will assure optimal support for the success of the Action.

**D.2 Scientific work plan methods and means**

This Action will achieve its scientific objectives through 4 inter-related Work-Packages identified in the Working Groups (WGs). These groups are responsible for carrying out the scientific tasks listed in the section D1. To this purpose the Action will be initially focused on the key-aspects in the development roadmap. The four WGs will aim to activate the scientific debate and the consequent synergy on the listed topics:

- WG1: Sensor materials and nanotechnology
- WG2: Sensors, devices and sensor-systems for AQC

- WG3: Environmental measurements and air-pollution modelling
- WG4: Protocols and standardisation methods

WG1: Sensor materials and nanotechnology

Gas sensors have been extensively used to detect and monitor a wide variety of volatile and other radical gases. In particular, gas sensors have a huge variety of applications such as environmental quality control, public safety issues, medical applications, automotive applications, air conditioning system setups in aircrafts, spacecrafts, vehicles, houses, etc. According to a recent industrial market report, in the USA the demand for sensors raised with an average annual growth rate (AAGR) of 4.6% from $6.1 billion in 2004 to $7.6 billion in 2009.

New classes of Nanostructured Materials are very promising for gas sensing: Semiconducting metal oxides (MOs), carbon-nanomaterials (i.e., carbon nanotubes, nanowalls, graphene, etc.), conducting polymers, nanocomposites. Semiconducting metal oxides (MOs) such as $SnO_2$, $TiO_2$, $InO_x$ and ZnO are used for gas sensing applications due to the sensitivity of their electrical conductivity to the ambient gas composition, which arises from charge transfer interactions with reactive gases such as $O_2$, $NO_x$, CO, hydrocarbons (HC), volatile organic compounds (VOC) and ozone ($O_3$). Ozone is a strong multi-purpose oxidizing gas which plays a fundamental role to the formation of photo-chemical smog in urban polluted areas. It may also be met in a wide field of industrial and agriculture applications. Ozone, in concentrations over the 40 ppb threshold, is known to be harmful to the human body according to existing USA (FDA) and EU standards. Thus a big thrust, for the development of gas sensors, driven by the need to enhance radical gases, including ozone, and trace element detection limits for security and environmental reasons, emerged. The sensitivity and response time of MOs based ozone sensor films strongly depend on the porosity of the material type. In addition, the grain size of the polycrystalline MO film has also a noticeable effect on its gas sensing properties. However, the gas sensing mechanism of polycrystalline MOs films is partially understood and the effect of grain size on the gas sensitivity in the limit of grains requires further clarification.

In the present COST Action, the WP1 efforts will be on Sensor materials and nanotechnology including advances and recent trends to develop and utilize sensors fabricated mainly by MOs polycrystalline films utilizing among other, two of the most intensively studied techniques, i.e. Aerosol Spray Pyrolysis (ASP) and DC magnetron sputtering. The influence of the grain size and the surface morphology from films obtained by the above different depositions techniques, achieving sensing responses of the order of a few parts per billion for gases such as ozone at room temperature, will be emphasized. Study of the sensitivity of MO films to additional harmful gases ($NO_2$, $H_2$ and vapors of acetone) will provide a guide for further material and device development either onto glass and Si or on flexible (PET/PEN substrates. Involving the successful application of flexible substrates may lead to simpler, faster and inexpensive fabrication techniques targeting novel roll-to-roll and printed processing applications with obvious advantages over conventional ceramic or silicon-based technologies. Sensor responses will be studied by applying conventional conductometric techniques or specific low to medium frequency Surface Acoustic Wave (SAW) devices which have shown high sensitivity towards electrical perturbations caused by the gas interaction at their active surface. Other advanced transducers (MEMS, NEMS, cantilevers, optical fibers, Field Effect Transistor (FET), electrochemical devices, etc.) will be studied as well.

Another important class of sensor materials to be considered in the research activities are carbon-based nanomaterials, including nanotubes, nanowalls, advanced nanostructures, nanoparticles. These nanomaterials can be synthesized by means of cost-effective methods with Chemical Vapor Deposition (CVD) technologies at single-wall or multi-wall format but not yet by controlled processing. These carbon-based nanomaterials are very sensitive to different air-pollutants even at room temperature for developing wireless gas-sensors at low-power consumption. Also, functionalizations with metal nanoclusters and surface-modifications of carbon nanomaterials are very challenging for addressing high sensitivity and broad selectivity.

WG1 Workplan Objectives will include:

- Protocols for synthesis of gas-sensitive nanomaterials;
- Protocols for synthesis of functionalized nanostructures for enhanced gas detection at part-per-billion (ppb) level, stability and selectivity;
- Report on nanomaterials characterization for AQC gas sensors;

- Protocols for integration of nanomaterials into micromachined devices and gas sensors;
- Protocols for development of gas nanosensors, microsensors and sensors-array.

WG1 Deliverables:

- Overview of the current state-of-the-art on gas sensor materials and advanced nanostructures;
- Recommendations for gas-sensitive nanomaterials priorities and strategies;
- Recommendations for nanotechnologies and nanomaterials management;
- Guidelines for an open framework on nanomaterials and new sensing technologies for AQC.

WG2: Sensors, devices and sensor-systems for AQC

The low-cost and ubiquitous measurement of air quality is essential for the health and well-being of EU citizens. Today air quality is generally monitored in the process industries, such as the petrochemical industry, or in city centres where pollution is an issue. The most common sensors are electrochemical for high concentrations of redox gases (oxygen, methane, etc.), optical for high concentrations of gases ($CO_2$, $H_2$) or metal oxide for low concentrations of toxic gases (CO, $NH_3$, $NO_x$). However, in the future we need to measure these gases at many more locations and at a much lower cost. The average price of a gas sensor today is €25 - and this does not include the interface circuitry, read-out electronics or packaging. This Actions aims to utilize pioneering research into low cost SOI CMOS based devices for low power gas and temperature sensing. Devices have been developed based on existing metal oxide materials and new on-chip nanomaterials such as nanowires and nanotubes to make low-cost, low-power devices at the full wafer level in a tungtsen CMOS process. The same patented technology is being used in IR gas sensors with a new SOI based product launched in June 2011 at the Sensor + Test Fair (Nurnberg). Further developments are needed to address the issues of AQC and in particular the reliability of the sensors, ultralow power consumption and wireless interfaces to control systems. Our approach is to look at thermally modulated polymer devices for low power detection of VOCs and to consider smarter interface circuitry. By smart design of CMOS devices, the Action hopes to initiate a new generation of devices for AQC systems.

The development of nanosensors and nanotransducers for portable gas sensor systems, miniaturised systems and microsystems will be addressed by:

- the implementation of full microsystem compatible technology for developing sensors based on the use of nanomaterials and their performances and characteristics with transducer principles controlled at the nanoscale level;
- the feasibility analysis of the implemented nanosensors considering response level, stability, selectivity and response times as well as their robustness as elements of heterogeneous integrated microsystems;
- the exploration of the power consumption requirements and capabilities range for the implemented nanosensors and elements for portable gas sensor systems and fully autonomous systems.

Moreover, zero emission buildings, related to high energy efficiency building concept, need to include air quality control inside the buildings and to give feedback on this information to have the most efficient management of the building from energy consumption and $CO_2$ emission point of views. Heating, ventilation and conditioned air need for supplying adequate comfort are determinants in the composition and specifications of air (e.g., humidity, temperature, CO, $NO_x$, $CO_2$, as well as some other targeted VOC's such as $O_3$ depending on the used technology). Likewise, the smart cities or green cities depend on information about the air quality. For security air quality must be easily monitored in industrial zones. Finally, in all of these cases, the use of fully autonomous systems for gas sensing becomes a challenge from a technology point of view as well as for budgetary reasons.

A wide possibility of transducers for AQC gas sensors will be studied and developed by the COST Action research-platform such as Micro-Electro-Mechanical-Systems (MEMS), Nano-Electro-Mechanical-Systems (NEMS), cantilevers, optical fibers, Field Effect Transistor (FET), electrochemical devices, chemoresistors, hybrid transducers, etc.

WG2 Workplan Objectives will include:

- Protocols for fabrication of gas sensors;

- Protocols for integration of nanostructures and nanomaterials into AQC gas sensors;
- Protocols for design and implementation of new transducers for AQC gas sensors;
- Report on device characterization for AQC gas sensors;
- Report/Protocols for integration of portable gas sensor-systems for AQC;
- Report on integrated intelligence of AQC gas sensors and distributed computing;
- Protocols for development of wireless sensors network for AQC;
- Report on IP Rights of gas nanosensors for AQC.

WG2 Deliverables:

- Overview of the current state-of-the-art on gas nanosensors;
- Recommendations for AQC gas sensors priorities and strategies;
- Recommendations for portable AQC gas sensor-systems management ;
- Recommendations for AQC wireless sensor networks management;
- Guidelines for an open framework on new sensing wireless technologies for AQC.

WG3: Environmental measurements and air-pollution modelling

Environmental measurements of PM and air-pollution

Current urban air quality monitoring networks across Europe are based on reliable and state-of-the-art measuring technologies. However, the data produced by the different networks are in strong need of harmonisation, if comparability between European regions is to be achieved. Efforts should be made to improve measurement data quality, as well as to develop and test new low-cost technologies which will allow for their widespread use across Europe.

For most regulated pollutants a reference measurement method has been prescribed by European Directives, with standardized methods being currently available for $SO_2$, $NO_2$, $NO_x$, $O_3$, Pb, Cd, As, Ni, $PM_{10}$, $PM_{2.5}$, benzene, and CO. Reference method automatic analysers are available for gaseous pollutants CO, $SO_2$, $NO_2/NO_x$, benzene and $O_3$. The reference methods for all other regulated compounds are non-automated, manual methods (e.g., $PM_{10}$). In addition to the well-known reference methods for each of the pollutants above, new monitoring techniques are currently being developed based on alternative strategies, such as passive sampling by dosimetry, wireless sensor networks, portable samplers (as opposed to fixed-site monitoring stations), assessment of indoor environment air quality, or personal exposure sampling. These new strategies are mostly based on a new sensing paradigm focused on low-cost sensors for air quality control. In order to meet the needs of these new air quality monitoring approaches, new measurement and analytical techniques need to be developed and tested. In a second stage, the new instruments and sensors should be subject to inter-comparison exercises which will guarantee the comparability of their results with regard to the reference methods currently in force. Such instrument tests and inter-comparison exercises should be carried out on a European-scale in order to ensure the validity of the new air quality monitoring strategies in different European regions.

Air quality modeling

The Air Quality (AQ) is a key element for the well-being and quality of life of European citizens. According to the World Health Organization, air pollution severely affects the health of European citizens (WHO, 2000, 2004): between 2.5 and 11% of the total number of annual deaths are due to air pollution. There is increasing evidence for adverse effects of air pollution on both the respiratory and the cardiovascular system as a result of both acute and chronic exposure. In particular, a significant reduction of life expectancy by a year or more is assumed to be linked to long-term exposure to high air concentrations of particulate matter (PM). There is considerable concern about impaired and detrimental air quality conditions over many areas in Europe, especially in urbanized areas, in spite of about 30 years of legislation and emission reduction. Current legislation, e.g. the Ozone daughter directive 2002/3/EC (European Parliament, 2002), requires informing the public on AQ, assessing air pollutant concentrations throughout the whole territory of Member States and indicating exceedances of limit and target values, forecasting potential exceedances and assessing possible emergency measures to abate exceedances. For this purpose, modeling tools must be used in parallel to and together with air pollution measurements.

Reliable air quality forecasts aim at the efficient control and protection of population exposure as well as possible emission abatement measures.

Air dispersion modeling has been an effective tool to assess the environmental impact of human activities on air quality already at the early planning stage. Environmental assessments during planning stage are required by the EU directive 85/337/EEC. Only models can give detailed information on the distribution of pollutants with high spatial and temporal resolution, while they allow the decision-makers to devise a range of scenarios, in which the various processes determining the environmental impact can be easily simulated and changed. Furthermore, the implementation of the European Union framework directive on air quality (2008/50/EC) and their daughter directives requires an extensive assessment of air quality in the EU member states. One of the required tools is air-quality models for assessing regional and urban air quality. There is a fundamental need for the all countries to build upon the experiences of each other according to the requirements in the framework directive, and to harmonize the development and use of models in several respects.

Lately, integrated air quality monitoring and forecast systems for a specific region was developed assimilating the ambient pollutant concentrations or any other air quality indexes delivered by in-situ networks of sensors and remote platforms (satellites, lidars etc.) on the base of up-to-science meteorological, emission and chemical transport models. Such systems can be used in different modes:

- planning or “preparedness” mode - mainly for optimal distribution of the sensor’s networks;
- off-line or “recovery” mode - simulation of critical pollution episodes combining model output and measured data in the frame of different scenarios or long-term integration for Risk Assessment purposes;
- on-line or “operational (fast decision)” mode - forecast of pollution levels with or without assimilation of the measured concentrations;
- inverse mode - use of on-line measurements for determining of unknown sources of pollution. Usually special versions of dispersion models have been elaborated for this purpose.

Such systems are supposed to give operational response to the releases of harmful gases in the atmosphere (as a result of normal industrial activity or industrial accident) for specific regions and they would be used for solving different tasks, mainly:

- perform accurate and reliable risk analysis and assessment for selected region or "hot spot";
- provide the local authorities (and the international community) with short-term regional and local scale forecast of the propagation of harmful air pollutants;
- perform, in an off-line mode, a more detailed and comprehensive analysis of the possible longer-term impacts on the environment and human health including assessment of the climate change impact on air quality;
- At a warning signal from the measuring network, by using inverse modeling and the functions of influence techniques, to detect (if not known) the harmful release location and evaluate the nature and the amount of the released harmful gases.

In the last years, the concept of "chemical weather" arises and in many countries respective forecast systems are being developed along with the usual meteorological weather forecasts. Respective systems were developed in many European countries. As long as air pollution easily crosses national borders, it would be cost-effective and beneficial for citizens, society and decision-makers that national chemical weather forecast and information systems would be networked across Europe. For this purpose, COST Action ES0602 Towards a European Network on Chemical Weather Forecasting and Information Systems - http://www.chemicalweather.eu/ - aimed at providing a forum for harmonizing, standardizing and benchmarking approaches and practices in data exchange and multi-model capabilities for air quality forecast and (near) real-time information systems in Europe. It examined existing and work out new solutions for integrating the development efforts at national and international levels and served as a platform for the information exchange between the meteorological services, environmental agencies, and international initiatives. The achievements of COST Action ES0602 are very important for this COST Action and must be assimilated and intensively used.

WG3 Workplan Objectives will include:

- Assessment of environmental measurements long-term campaigns by AQC gas sensors at laboratory experiments level;
- Assessment of environmental measurements in field by AQC gas sensor-systems in the air-quality stations;
- Assessment of air-quality modelling with data assimilation from integrated AQC gas sensors;
- Report on chemical weather forecasting at global area and hot-spot case-studies;
- Evaluation of integrated air quality plans and strategies: role of low-cost AQC gas sensors;
- Assessment of clean technologies and environmental management systems reducing the emission of air-pollutants, green-houses, particulate matter, aerosol, nanoparticles, etc.;
- Assessment of new sensing technologies, including AQC gas sensors and wireless sensors network, for environmental management;
- Report on harmonisation of environmental measurements in EU-zone and non-COST areas;
- Report on IP Rights of air-quality modelling and chemical weather forecasting.

WG3 Deliverables:

- Recommendations for laboratory and field experiments for evaluation of low-cost AQC gas sensors performance;
- Recommendations for research and development needs to improve cost-effective AQC gas sensors to be integrated in air-quality models and chemical weather forecasting;
- Recommendations for short-term operational developments and AQC gas sensors priorities and strategies in the air-quality plans;
- Recommendations for improving portable AQC gas sensor-systems in integrated models for mid- and long-term applications;
- Overview of the current state-of-the-art on air-quality modelling and chemical weather forecasting;
- Guidelines for management of new AQC sensing wireless technologies.

WG4: Protocols and standardisation methods

Quality assurance and quality control (QA/QC) for European air quality measurement data may only be achieved by means of the implementation and harmonisation of instrument testing and standard operation procedures, as well as of equivalence testing procedures (for real-time automatic monitors for pollutants regulated in the Air Quality directive). These are currently in place for regulated compounds ($SO_2$, $NO_2$, NOx, $O_3$, Pb, Cd, As, Ni, $PM_{10}$, $PM_{2.5}$, benzene, and CO). However, efforts should be dedicated to achieve this level of QA/QC for emerging air quality monitoring instruments and sensors. Once tests and inter-comparison exercises have been fulfilled, and data quality ensured, detailed and specific standard operating procedures need to be devised for each sensor/instrument, with the aim to guarantee that operational procedures will be comparable across networks. This will be a pre-requisite to consider the implementation of the new air quality monitoring strategies in near future air quality research programmes in the EU Member States.

During the lifetime of this Action, the WG4 activities aim to standardize the methods in sensing measurements and harmonise test procedures, chemical analyses, protocols and prevention to monitor air quality (in particular particulate matter, organic volatile compounds and odours). During this phase, the following activities will be carried out:

- proposal of a methodological approach for an odour guideline with the purpose of defining acceptability and monitoring criteria for odour emission produced by industrial activities.

In the perspective of the improvement of life quality and citizens wellness, odour pollution is becoming a more and more relevant topic. In fact, among the variables that could influence the citizens, the sense of a healthy environment and odour emissions play an important role, as they deeply affect the human life quality and psycho-physical wellness. For this reason, in the last decade the scientific community has been developing an increasing attention for odour pollution, generally caused by industrial activities. Different types of productive plants such as tanneries, refineries, slaughterhouses, distilleries, and especially civil and industrial wastewater treatment plants, landfills and composting plants are often sources of olfactory nuisances.

In order to establish a policy and a system to defend residents from annoyance caused by odour impact, it is necessary to define a common reference for the determination of odour concentration. The dynamic olfactometry is the most suitable measure technique to provide punctual odour concentration data but it is not sufficient to evaluate completely a case of olfactory nuisance, because it does not allow to obtain information about chemical composition of the odour sample, to conduct continuous measurements and above all because it needs very high costs and times of analysis.

For this reason, an integrated approach is convenient for odor monitoring including chemical characterization, the development of sensor-system based on solid-state gas sensors (i.e., electronic noses) coupling to a predictive approach, based on dispersion models. This will be achived by the standardization of different sampling and analysis methods of Volatile Organic Compound both in indoor and outdoor environments.

The emission of VOC represents not only an important indicator for the evaluation of the air quality but even an element for the estimation of the environmental sustainability of the new materials and technologies. In order to perform this estimation, it is necessary to have an appropriate and standardized investigation tool. In fact, for determination of such compounds, there are a lot of sampling methodologies (both on and off line, active or passive sampling, GC/MS, GC/FID, HPLC, etc.) that would be necessary to compare and optimize. These include methods for chemical analyses and source identification of Particulate Matter.

Particulate matter (PM) sources and processes are deeply investigated in order to provide useful information for air quality management policies. During the project, it will be necessary to combine different information to determine the different origin of high PM events. It will be useful to join different instruments such as:

- dual channel system for automatic sampling of $PM_{10}$ and $PM_{2.5}$;
- OPC monitor, optical particle counter that allows to perform the real-time dimensional characterization of particles with optical diameter greater than 0.3 micron;

- PBL Mixing Monitor, a sequential automatic system able to estimate the low PBL layers mixing ratio by means of ß activity related to Radon decay products;
- sonic anemometer in order to determine wind speed and direction on three non-orthogonal axes.

The coupling of this system with chemical characterization (ionic components, Polycyclic Aromatic Hydrocarbons (PAHs) and carbonaceous fraction (OC, EC) and statistical methods application could give further details about the PM origin and diffusion.

WG4 Workplan Objectives will include:

- Assessment of characterisation, quality assurance, quality control, property database, standardization of AQC gas sensors;
- Assessment of testing, standard operation procedures, safety aspects for AQC gas sensors;
- Evaluation of case-studies in round-robin testing of AQC gas sensors in odour-pollution, air-pollution, indoor control, outdoor control;
- Report/Recommendations of the new sensing AQC technologies for the future strategies in the EU research programmes of air quality monitoring and environmental management;
- Report on scaling up, applications and commercialisation of AQC gas sensors.

WG4 Deliverables:

- Evaluation Summary of AQC gas sensors performance through validation for selected case studies of environmental monitoring in the air-quality plans;
- Overview of the current state-of-the-art on regulations, protocols and standards of the no-sensors based AQC: possibilities of procedures extended to the AQC sensors;
- Recommendations/Guidelines for the validation methodology/protocol of AQC gas sensors;
- Recommendations on environmental applications of low-cost AQC gas sensors.

## E. ORGANISATION

### E.1 Coordination and organisation

Chaired by the Action Chairperson, EuNetAir will be coordinated by a Management Committee (MC) according to the “Rules and Procedure for Implementing COST Actions”. MC will supervise and coordinate the implementation of the activities based on the Memorandum of Understanding (MoU) signed by participating COST countries governments.

In line with the COST mission, i.e., to strengthen Europe in scientific and technological research by international cooperation and networking between European researchers in the ERA and extra-EU top-level scientists, the EuNetAir Action will have 4 coordination aspects to achieve its objectives: Management, Networking, Dissemination and Training.

Management

Management Committee (MC): MC is responsible for the overall direction of the COST Action and will ensure its stated aims are fulfilled by fostering active interaction, capacity building, networking activities and effective information transfer between the teams. The MC will have a main structure based on a Chair, a Vice-Chair and a Secretary with the Chairs of the Working Groups (WGs) and the Members from participating COST countries. The MC will steer and oversee the activities, and ensure that the milestones are accomplished. In the MC, all COST Action countries, that sign the MoU, will be represented by up to 2 members per country. The MC will plan the implementation of the tasks, the establishment of the WGs, a series of events for each WG, and the work scheduled to be done in between the planned events. Participants will specify their own aims and contribution to the Action through the Expression of Commitment scheme recommended by the Domain Committee (DC). Inclusion of selected representatives from the target groups of the Action in the WG panels is recommended. The Chair, Vice-Chair, Working Groups Chairs and Sub-Working Group Leaders (SWGL) will be elected at the kick-off meeting. The MC and WGs will meet twice a year, usually in conjunction with each other. Moreover, the MC will communicate regularly by email and web-systems (video- or audio- or tele-conference) and will continue, at least each three months in between meetings, to check that the planned activities of the Action are timely accomplished in the schedule, to review critical points and maintain a clear focus on the objectives and milestones.

The tasks of the MC will be:

- Appointment of Action Chair, Vice-Chair(s), WG Coordinators, SWGLs, STSM Evaluation Committee, ESR Coordinator and Manager, Gender-Balance Coordinator and Manager, Dissemination Coordinator and Manager, and other Coordinators for specific tasks o groups;
- Planning of MC meetings, Scientific Meetings, Conferences, Workshops, Training Schools;
- Assessment and Reporting of the progress made by Working Groups;
- Promotion of cooperation and data exchange between WGs;
- Promotion and approval of STSMs, according to the recommendations of the Evaluation Committee chaired by a Coordinator/Manager;
- Promotion and approval of participation of ESR to training schools and education, according to the recommendations of the ad-hoc Committees, or WG Coordinators, chaired by ESR Coordinator/Manager;
- Establishment of a Secretariat for the Action conferences/workshops which should include a Local Organising Committee and a Scientific Committee;
- Promotion the set-up of joint-research, including STSMs, and the writing of common publications;
- Preparation of Annual Reports;
- Liaison with COST Office and Domain Committee;
- Establishment and updating of an Action website for internal communication, advertising the Action events, dissemination of STSM findings, WG reports, and other results;
- Organising of contacts with other appropriate COST Actions and other relevant EU programmes/projects, including recommendations for national research funding;
- Deliver the Action outputs with the most efficient use of the COST resources and budget.

MC will establish restricted groups to implement these activities and manage the Action. They are:

Steering Group (SG): A SG of the MC will be nominated. This SG will be responsible for the operative management work and comprises the Chair, the Vice-Chair(s), the Secretary, the WGs Coordinators, the ESR Coordinator, Gender-Balance Coordinator, Dissemination Coordinator and other Rapporteurs for specific reporting or issues. This SG will be responsible for decision concerning the Intellectual Property Rights (IPR) management and related background/foreground of the COST Action partnership. SG will supervise on reporting of Action progress and advancements in the WGs area. SG will be involved in daily business to ensure regular contact and exchanges between different WGs and the harmonization of their activities. The SG will set clear milestones and will validate the documents, prepared by Core Group (CG), for the MC meetings. SG will meet at six months and simultaneously with MC meetings. Exchange between SG members will be currently defined by e-mails and other web-systems to manage Action planned activities.

Core Group (CG): A CG of the MC will be nominated to assure more rapid, efficient and flexible coordination of EuNetAir. This CG comprises the Action Chairperson, Action Secretary, WGs Coordinators, ESR Manager, STSM Manager, Gender-Balance Manager, Dissemination Manager, Editorial Manager. These Managers will be emerging researchers nominated by the MC as task manager. The CG will prepare the various documents (scientific, orientation, dissemination, plans, etc.), validated by SG, for the MC meetings. CG will meet very often in special occasions and will be strongly connected by emails and other modern web-communications.

Networking

A common framework would facilitate and enhance information exchange between COST Action partners in the ERA and extra-EU zone. Thus, it would lead to closer collaboration between COST member states and non-COST countries. At the same time by preserving individuality and diversity of technologies, methods and models it will foster growth of individual researchers and national research capabilities that provide expertise to local/national authorities by addressing specific air quality/environmental concerns. Furthermore, it would provide a platform for better understanding and appreciation of environmental issues in different regions of Europe. The research institutions of the COST Action are selected on their complementary AQC expertise, essential for achievements in a multidisciplinary integrated approach.

The research is carried out in the participating countries by national funding, while COST will provide necessary coordination. Once more, organization of Action concerns only the coordination of participants coming from European research institutes, universities and industry, including outstanding S&T organizations from non-COST area. To enhance international networking and capacity building activities, other than thematic Working Groups organized in Sub Working Groups (see section E.2), various means will be implemented:

Special Interest Groups (SIGs): SIGs will be created on specific issues to timely environmental items which are more interdisciplinary and involve well-defined expertise from different WGs. Every SIG will elect a chairperson, who will refer directly to the MC Chair. While a Sub-Working Group (SWG) will be created intra-Group with the own chairperson referred to the related WG Chair, a SIG is crossed Working Groups aiming to mix different expertise from various WGs. A SIG could be nominated to follow hot issues on new S&T environmental research, Calls from FP7 and Non-FP7, Joint Programming Initiatives, European Platforms, Public Private Partnerships, etc. These SIGs will preferably meet simultaneously with MC or WGs meetings or specific meetings or different occasions to define strategies and exchange of information. Such expert meetings may be organised according to specific aims. A Rapporteur from MC will be appointed to monitor the activities and outputs.

STSM Evaluation Committee: A high priority will be given to Short Term Scientific Missions (STSM) in order to establish personal contacts between researchers and more communities in the field of AQC. It will be attributed high priority to Early-Stage Researchers (ESR) and female-applicants for gender-balance. The goal is to support the development and validation of specific sensing technologies, models and methods for AQC and to enhance the collaboration between science and industry, COST-partnership and non-COST partners for networking and capacity building. A STSM Evaluation Committee will be created ad-hoc, and nominated by MC, to assess the impact of the scientific visits and their output. Budget will be allocated to STSM for exchange of students, early-researchers and senior scientists between the participating research groups. Calls for Tenders of STSM could be regularly planned during the Action. A motivation and a simple visit-plan should be submitted to the Training & Knowledge Transfer Coordinator, who will present the current applications of highest quality to the MC. Depending on the available budget, the MC will decide which applications should be granted.

International Experts and Keynote Speakers: Participants, Key-Experts and Invited Speakers from COST countries and non-COST countries will keep the members of the COST Action up-dated on the most recent results, as well on general trends within the global AQC research community. Round-table discussions on sensing nanotechnologies and environmental topics of mutual interest will be arranged in a positive atmosphere, encouraging the exchange of knowledge, experience and innovative ideas. The COST Action is the most suitable instrument for supporting this kind of open, flexible and growing networking in frontier research and nascent engineering area including the generation of new international research projects.

Finally, the activities of networking and capacity building are:

- Organisation of the various training opportunities such as training schools, short-term scientific missions, training at selected centres, including participants in COST Action;
- Encouragement of publications of scientific and technological collaboration in special issues of scientific journals;
- Fostering links with other relevant EU programmes/projects and industry;
- Organisation of joint-workshops with other COST Actions on interdisciplinary areas.

Dissemination

Editorial Board: During the elaboration of the State-of-Art Report, Final Report and Special Reviews, an Editorial Board, nominated by MC, will coordinate the work and collect the necessary information from the WGs members. This group will also be responsible for setting up the Action fact sheet, the Action Leaflet, the Action Poster at the beginning of the Action. Additional editorial activities, e.g. a periodical Newsletter, during the Action will be managed by the Editorial Board. The members of the Editorial Board can be added sequentially according the needs and the aims of the dissemination activities. A Dissemination Manager (DM) will oversee the creation and maintenance of a website in accordance with COST Office requirements. This DM will report to MC. The interactive Action website will contain information about partner groups, research activities, conference/workshops/symposia, list of potential host groups for short visits and training, forthcoming activities, device/sample exchanges, joint-activities, mutual publications, common participations at S&T events, target groups, end-users.

It will faithfully provide the Agenda and Minutes of each MC meeting; including annual, cumulative and final reports; provide a complete list of EuNetAir MC members and a short CV of each member. Periodic Newsletter, edited by Editorial Board, will keep the network informed by circulating to scientists and end-users on major findings of the COST Action, relevant meetings, activities and most recent publications related to the COST Action issues. A large promotion of the Action website toward general public will be provided as well.

Local Organising Committee (LOC): This COST Action is concerted at European level, including non-COST area, and provides the necessary coordination for national research on AQC. The coordination of national research will be implemented by conferences, workshops, symposia, training courses, field campaigns, experiments, models development, STSMs, and dedicated website and newsletter. Cross-cutting activities will be organized in collaboration with other complementary programmes and organisations. Such meetings of COST Action will be organized in various COST countries at participating institutions by installed Local Organising Committee. This LOC will be delegated from MC to organise the Meeting and a Local Chair will report to MC on the organised event in a short summary. The LOC will be changed meeting-by-meeting depending on item and venue of workshop, outcomes of training courses.

Training

Training Schools will take place preferably in conjunction with the workshops organized by the COST Action in order to present the different aspects of the sensing technologies for AQC, methods, models, forecasting, protocols and standards for environmental monitoring and eco-sustainability. These courses will be devoted to PhD students, young scientists, early-stage researchers (ESR) and woman-scientists. The teachers will be from participating COST partnership and international keynote experts. Additionally, ESRs will be stimulated to participate at research laboratories of the COST partnership for short-term scientific visits to strengthen knowledge, exchange and training on job. A tutor in the host-institution will report to ESR Manager on visit of ESR by a simple summary. The ESR manager will collect the various ESR visit-reports to prepare yearly a detailed communication to MC. This will be very useful for high quality of the impact generated by the short-visit and scientific mission.

The main activities of Coordination of the COST Action are:

- Organization of a kick-off meeting to which all members will be invited. During this meeting the detailed workplan and the management structure will be discussed and decided.;
- MC meetings will be held twice per year where the forthcoming Action activities will be planned and those that have taken place will be reviewed;
- Thematic Workshops on AQC will be organized in various COST countries at participating Action institutions with a frequency of at least one per year.
- Action attaches upmost significance to the training of ESRs. Therefore, in addition to the STSM, there will be specific training schools on selected AQC timely topics every year;
- Action will complete its activities via the organization of an International Conference at the end of the COST Action.

Table of Action EuNetAir Milestones and Deliverables:

| YEAR | MILESTONES | DELIVERABLES |
| --- | --- | --- |
| 1 | Quarter 1: Kick-off Meeting. MC setup. Action Workplan established. MC Meeting 1.<br>Quarter 2: Action website setup. Start-up of Editorial Board for Leaflet, Brochure, Newsletter.<br>Quarter 3: MC Meeting 2. WGs Meeting 1. Scientific activities.<br>Quarter 4: Scientific strategies: State-of-art on AQC. Training School organization. Workshop organization. | Quarter 1: MC setup and Action Workplan established.<br>Quarter 2: Definition of WGs and WGs Workplans. Newsletter: Issue 1. Action Leaflet/Brochure: Release 1.<br>Quarter 3: Publication of the List of EuNetAir Action R&D infrastructures and main facilities. Scientific Activities. ESR/STSM Report and Dissemination.<br>Quarter 4: Action website fully operational with the publication of short Curricula of partners. Newsletter: Issue 2. State-of-Art on AQC tech: Release 1. Training School 1. Workshop 1. Annual Report. |
| 2 | Quarter 1: MC Meeting 3. WGs Meeting 2. Updating of Action website.<br>Quarter 2: Editorial Board for Newsletter. Dissemination activities.<br>Quarter 3: MC Meeting 4. WGs Meeting 3. Training School organization. Workshop organization.<br>Quarter 4: International Conference organization. Annual Reporting. Editorial Board for Newsletter and Leaflet. Updating of Action website. | Quarter 1: S&T activities and Liason with EU Programs. Updating of Action website.<br>Quarter 2: Dissemination. Newsletter: Issue 3.<br>Quarter 3: Training School 2. Workshop 2. S&T strategies.<br>Quarter 4: Action website updating. Newsletter: Issue 4. Action Leaflet and Brochure: Issue 2. International Conference 1. Annual Report. |

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| 3 | Quarter 1: MC Meeting 5. WGs Meeting 4. Dissemination activities.<br>Quarter 2: Editorial Board for Newsletter. Scientific strategies: State-of-art on AQC.<br>Quarter 3: MC Meeting 6. WGs Meeting 5. Training School organization. Workshop organization. Editorial Board for updating of website. Dissemination activities.<br>Quarter 4: Editorial Board for Newsletter. Scientific activities. | Quarter 1: Dissemination. S&T strategies and activities. STSM/ESR activities Report.<br>Quarter 2: Newsletter: Issue 5. State-of-Art on AQC tech: Release 2. Dissemination.<br>Quarter 3: Action website updating. Training School 3.Workshop 3. S&T strategies.<br>Quarter 4: Newsletter: Issue 6. STSM/ESR Reporting. Dissemination. Annual Report. |
| 4 | Quarter 1: MC Meeting 7. WGs Meeting 6. Scientific activities.<br>Quarter 2: Editorial Board for Newsletter. Dissemination activities. Training School organization. Workshop organization.<br>Quarter 3: WGs Meeting 7. Scientific strategies and activities.<br>Quarter 4: International Conference organization. Editorial Board for Newsletter. Editorial Board for Leaflet/Brochure. Updating of Action website. Dissemination activities. Final scientific strategies: State-of-art. MC Meeting 8. | Quarter 1: S&T strategies. Link to EU programs and Industry: Reporting.<br>Quarter 2: Action website updating. Newsletter: Issue 7. Training School 4. Workshop 4. Dissemination. STSM/ESR Report. S&T strategies.<br>Quarter 3: Dissemination. S&T activities.<br>Quarter 4: Action website updating. Action Leaflet/Brochure updating. Newsletter: Issue 8. State-of-Art on AQC tech: Release 3. International Conference 2. Annual/Final Report. Final Evaluation. |

### E.2 Working Groups

The Action is structured into four Working Groups (WGs):

- WG1: Sensor materials and nanotechnology
- WG2: Sensors, devices and systems for AQC
- WG3: Environmental measurements and air-pollution modelling
- WG4: Protocols and standardisation methods

The scientific program will be carried out in close cooperation among all WGs and strong overlap between the members of these groups is expected in all fields of interest. To maximize the impact of the COST Action all four WGs will closely collaborate. Strong interactions amongst these WGs will build-up a multidisciplinary Action that will be responsive, adaptive, flexible and open to new scientific and technological demands.

WG Chairs will be elected at the kick-off meeting. Each WG Chair will coordinate activities in the WG and 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 defined in the Action scientific program;
4. coordinate the Sub Working Group Leaders chairing the sub-groups in the proper WG;
5. promote the set-up of joint research (e.g. making use of STSMs, science/technology and scientists exchanges, web-seminars, etc.);
6. promote the writing of common publications;
7. report the WG progress to the MC and SG.

Each WG will have a Chair and a Vice-Chair person who are selected in the COST Action partnership as well-recognized experts, and report to the MC. They will coordinate the WG networking and capacity building activities and stimulate short term mission activities. They will also provide their WG contribution to the annual reports via reporting on activities within their WGs.

Each WG will house a number of ESR and women from the member states. Other WGs may be added and modifications of any existing WG (addition of other members with new competences from COST area) may take place during the Action. The scientific program of each WG is described in Section D2.

Depending on the number of participants and the specific work to be carried out, each WG will be divided into smaller specialized units. All Sub-Groups will participate to regular WG meetings for synchronization and to specific ad-hoc expert meetings. In principle, there will be 2 WG meetings per year, one of them taking preferably place immediately before the next MC meeting.

Since the large participation of COST and international partnership, the four WGs will be organized in different Sub-Working Groups (SWG) chaired by a Sub-Working Group Leader (SWGL). This SWGL will coordinate and manage the activities of the Sub-group and will be responsible for reporting to its related WG Chair.

Generally, each WG will have a Committee (WGC) lead by a Chair with a Vice-Chair including the SWGL persons.

The Sub-Working Groups (SWG) in each WG are defined as follows:

WG1: Sensor materials and nanotechnology

- Sub-Working Group 1.1 (SWG 1.1): Metal oxides nanostructures for AQC gas sensors
- Sub-Working Group 1.2 (SWG 1.2): Carbon nanomaterials for AQC gas sensors
- Sub-Working Group 1.3 (SWG 1.3): Emerging sensor materials (organic/inorganic, hybrid, nanocomposites, polymers, functional)

WG2: Sensors, devices and systems for AQC

- Sub-Working Group 2.1 (SWG 2.1): Gas nanosensors and new transducers
- Sub-Working Group 2.2 (SWG 2.2): Portable gas sensor-systems

- Sub-Working Group 2.3 (SWG 2.3): Wireless technology and AQC sensors network
- Sub-Working Group 2.4 (SWG 2.4): Intelligence algorithms and distributed computing for networked AQC gas sensors

WG3: Environmental measurements and air-pollution modelling

- Sub-Working Group 3.1 (SWG 3.1): Environmental measurements at laboratory and in field air-quality stations
- Sub-Working Group 3.2 (SWG 3.2): Air-quality modeling and chemical weather forecasting
- Sub-Working Group 3.3 (SWG 3.3): Harmonisation of environmental measurements

WG4: Protocols and standardisation methods

- Sub-Working Group 4.1 (SWG 4.1): Protocols, standards and methods for AQC by analyzers/instruments (no-sensors) technologies
- Sub-Working Group 4.2 (SWG 4.2): Protocols, standards and methods for AQC by sensors (no-analyzers) technologies
- Sub-Working Group 4.3 (SWG 4.3): Benchmarking of new products and market of commercial AQC sensors

**E.3 Liaison and interaction with other research programmes**

The interaction with other COST Actions and other European and International programs will be maintained throughout the duration of the Action. These will be achieved via:

1. Fostering links with other relevant EU programs;
2. Organisation of joint workshops and seminars with other COST Actions on interdisciplinary areas and common cross-objectives, conference special sessions, young scientist and ESR common training schools;
3. Organisation of possible annual WG meetings together with main activities (conferences/meetings) of other relevant Actions in a mutual benefit;
4. Organisation of mutual publications and benefits: producing joint-newsletters, special issues, developing databases and websites, common Action flyers.

EuNetAir partners already participate in other European programs and bilateral actions between European countries, including extra-EU cooperation in science and technology.

Within the COST community, it is intended to promote collaboration with other Actions. It is planned to cross-link EuNetAir with already established COST Actions. Collaboration with COST Action EuMetChem ES1004 “European Network for online integrated air quality and meteorology modelling” will help to gain deeper understanding of the influence of atmospheric pollution and climate change. Furthermore, COST Action EuNetAir will be able to provide additional data to fit model parameters to real life situations.

Networking with other COST Actions like COST Action FP0903 “Climate Change and Forest Mitigation and Adaptation in a Polluted Environment” will give opportunities to identify additional needs in the field of air pollution monitoring, especially the demands on the sensor systems. In return EuNetAir might provide state-of-the-art sensing technologies.

Besides these joint-activities with other Actions such as COST Action ES0804 “Advancing the integrated monitoring of trace gas exchange between biosphere and atmosphere” and further COST Action TU0902 “Integrated assessment technologies to support the sustainable development of urban areas” are planned. Aim of these potential activities will also be the exchange of data, model parameterization and test of equipment and procedures.

Exchange and cross-activities in the environmental monitoring, air-quality modelling, meteorology and forecasting are expected with other COST Action ES0602 “Towards a European Network on Chemical Weather Forecasting and Information Systems”.

In the framework of nanotechnologies and devices, a relationship is expected with COST Action MP0901 “Designing Novel Materials for Nanodevices: From Theory to Practice”.

In a first step, the Chairs of these Actions will be contacted personally in order to find out at which level a potential collaboration will be achieved. Selected members of these Actions will be invited to participate to the MC or WG meetings, and vice-versa.

Additionally, cooperation with other European funded activities is planned. The European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM) is a European partnership network of the European Environment Agency (EEA) and its member and cooperating countries with the objective of supporting European policy in the field of air pollution and climate change. It offers tools for exchanging and reporting air quality data between the partners. Participation will help to improve the data, on which European policies are based.

Outside the COST community, contacts will be established with the following ongoing FP7 European research projects like S3 (cooperation in gas sensors between EU-Russia), ORAMA (development of novel metal oxides materials for electronic applications), AIRMONTECH (air quality monitoring technologies for urban areas), OFFICAIR (on the reduction of health effects from combined exposure to indoor air pollutants in modern offices).

In the area of sensor technology interaction with the on-going GOSPEL (European Network of Excellence in Artificial Olfaction, funded by EU FP6) network is intended. GOSPEL uses micro- and nano- systems for artificial olfaction to solve localized gas sensing problems. Cooperation might accelerate the development of a cross-border air quality monitoring. Moreover, a strong interaction will be explored with FLEXSMELL, FP7-People Marie Curie Action, a network for initial training aiming at the development of printed chemical sensing systems onto flexible substrates for logistic and food security. The mutual exchange will fertilize both EU initiatives.

Several of the potential participants of this Action as listed in the list of experts are also implicated in at least one of the projects mentioned above. They will be given the task to inform this COST Action regularly about the activities within the corresponding project and vice-versa. Other key-experts will be invited as Outstanding Scientist or International Expert to relevant Action meetings. A specific Rapporteur - with well-established international network - could be nominated by the MC to establish the contacts with these external Actions/Projects, to promote the interactions with the present Action and to manage the following activities:

- External experts will be regularly invited to participate and contribute to MC or WG meetings;

- Participation of Action members to other Bodies internal meetings will be promoted;
- All potential collaborations will be promoted and supported through the establishment of a specific “Interest Group” between two or more Actions, or other international stakeholders;
- Participation to meetings, workshops and conferences of Action members to meetings of these external communities.

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

In the Action about 20% of the participants are female. Unfortunately, the technological and scientific sector object of this Action is male-dominated: this is usually reflected in the participation profile and responsibility positions. Therefore, contacting female to become participants and to nominate them as WG leader and/or MC Vice-Chair and/or WG Vice-Chairs and/or Sub-WG Chairs will be of highest priority in order to follow of 50% balance of female experts in the leadership of the Action. A gender coordinator will be preferably one of the female MC-members. Both the Action as a whole and its individual participants will be encouraged to put into reality a balanced participation of women and men and to raise awareness of the combat against gender stereotypes. In terms of gender balance, priority will be given to the active participation of women in the work program of the Action, when deciding on Working Group composition and task coordination. Support for female scientists with family will be promoted in such a way they can travel with children.

According to our preliminary survey nearly all participating teams involve many young researchers who will be further supported by the Action. In the backbone of Action 19% of the participants are ESR and several of them are potential MC members. An ESR-Coordinator, preferably one ESR from the MC, will be responsible for ESR-related activities. As first activity a “social scientific network services” based on free web software inside the Action managed by ESR components inside the different scientific teams will be created to promote the cohesion inside the specific scientific community and to point out the specific needs of the ESR components and the way to overcome them. By using this instrument an ESR group inside the Action will be created that is a very effective instrument to support new talents and actively involve ESRs into the definition process of the Action strategy, work-plans and activities.

Furthermore, due to the strong interdisciplinary aspect of the Action, as many STSMs as possible - especially devoted to younger researchers - will be organised to support in an intensive way the exchanges of knowledge between the different participants and communities and to create their own international profile. In the same manner, the organization of ad-hoc workshops and training schools will be supported to offer the most positive environment for the early stage researchers and researchers from different communities.

**F. TIMETABLE**

The total duration of the Action is four years. The specific coordination activities of this COST Action will be decided at the first MC meeting, in the first month of the Action, when preparations for the first conference, workshop and WG meetings will be made. STSM plans and event announcements will be advertised immediately following the kick-off MC meeting. The Action website will be active since the second quarter of year one, when the Brochure will be also released. The newsletter will be circulated twice a year. During the first year, the MC will plan the detailed implementation of the tasks and the establishment of WGs. The first period of six month is devoted to building the WGs in line with the topics outlined in Section D2. WGs will meet formally for the first time in the third quarter of year one, and 1-2 times a year thereafter. All four WGs will be active for the whole Action duration. The MC will ensure that the work is well focussed, that fruitful collaborations between the participants are either initiated or developed and that synergy is created between the WGs. Workshops will be held preferably twice a year, maybe except for the first year of the Action. Training courses, exchange visits and field campaigns will be possible, as appropriate, in Year 2, Year 3 and Year 4. WGs outputs (i.e., technical documents, state-of-art, plans, strategies, guidelines with criteria and protocols) and workshop/conference proceedings will be released at the end of every year. The timetable of the scientific joint-papers is unpredictable. Annual Reports for DC and COST Office will be published at the end of each year, and a detailed schedule for preparation of these reports will be decided in the kick-off meeting of the Action. Due to the nature of the COST framework of collaboration, the specific topics of the work may be shifted with time in order to adjust to specific needs identified by the Action. Below is given a tentative Timetable:

| YEARS | Y1 | Y1 | Y1 | Y1 | Y2 | Y2 | Y2 | Y2 | Y3 | Y3 | Y3 | Y3 | Y4 | Y4 | Y4 | Y4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **QUARTERS** | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| **ACTIVITY** | | | | | | | | | | | | | | | | |
| WG1 activities | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| WG2 activities | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| WG3 activities | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| WG4 activities | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Kick-off Meeting | X | | | | | | | | | | | | | | | |
| Establish Workplan | X | | | | | | | | | | | | | | | |
| Action Website Setup/Update | | X | | | X | | | X | | | X | | | X | | X |
| Action Leaflet and Brochure | | X | | | | | | X | | | | | | | | X |
| Newsletter | | X | | X | | X | | X | | X | | X | | X | | X |
| Workshop | | | | X | | | X | | | | X | | | X | | |
| Training School | | | | X | | | X | | | | X | | | X | | |
| Annual/Final Report | | | | X | | | | X | | | | X | | | | X |
| State-of-Art | | | | X | | | | | | X | | | | | | X |
| Exchange Visits: STSM | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Exchange Visits of ESR | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Field campaigns | | | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Mutual Publications | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| International Conference | | | | | | | | X | | | | | | | | X |
| WGs Meeting | | | X | | X | | X | | X | | X | | X | | X | |
| MC Meeting | X | | X | | X | | X | | X | | X | | X | | | X |

The milestones and deliverables of Action are reported in Section E1.

**G. ECONOMIC DIMENSION**

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: BE, BG, CH, DE, DK, EL, ES, FI, FR, HU, IT, LT, NL, PL, 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 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 COST Action MC will define a flexible Dissemination Strategy for the needs of the different target audiences through a wide range of highly adaptable communication channels whereas working towards Action objectives. EuNetAir will adapt the nature of the message to its target audiences. Target groups are expected to evolve with the Action development and innovative ways. Because of the direct societal impact of the addressed Air-Quality Control (AQC) topic at the EuNetAir project, the Dissemination Strategy will cover almost all sectors of the society. The expected impact will not be circumscribed to the European area, but is expected to be worldwide. Different levels of dissemination are envisaged according to the various target audiences that can benefit from the outputs of the projects, which are summarised in the following:

- Other COST Actions;
- EU research programs;
- European Commissions: DG RTD Research, DG ENV Environment;
- United Nations Environment Programme (UNEP) and World Health Organisation (WHO);
- Standardisation organisations at National and supra-National levels;
- National and regional Ministries of Environment;
- Environmental protection organisations;
- Other bodies dealing with chemical weather forecasts;
- Meteorological services;
- Manufacturers and operators of air-quality control system;
- Nanotechnology based industries (manufactories, service providers);
- Universities, research institutions, academies;
- Individual Researchers: Early stage researchers and other researchers working in the field, and graduate and PhD students;
- Media: scientific and non-scientific press, digital media, TV and radio;
- General public;
- Local and Government Authorities;
- Policy-makers and regional planners.

**H.2 What?**

The Action will prepare a dissemination and sustainable operation plan that will be updated throughout its duration to transfer results to different target audience and communities. During the Action the following dissemination activities are planned:

- Creation of a dedicated public website where generic information and materials of the Action will be published, along with reports, published and un-published articles, datasets, etc. accessible via a password protected area for all the partners involved;
- An action Leaflet and Poster will be designed at the beginning of the Action;
- One open Kick-off Workshop during the first year;
- During the first two years thematic Workshops on sensor materials and nanotechnologies, sensor-systems for AQC, environmental measurements, air-pollution modelling, protocols and pre-standardisation, with contribution from External expert, will be run in order to produce a State of Art report, to improve the multidisciplinary knowledge between key partners of each theme, enhance AQC practices, environmental sustainability and to produce workshop notes to be published on the Action's website;
- Organization of two Open Conferences (one the 2$^{nd}$ year and one the last year), under MC supervision, with exhibition of action partner capabilities (i.e. sensor-systems, modelling) to facilitate knowledge transfer and dissemination;
- Annual Meetings (preferable via web/video conferences) to identify new collaborative research actions and research projects, providing synergies between partners capabilities;
- Organisation of Summer Schools on sensor materials, technologies, processes and modelling;
- International Early-Stage Researchers exchange and scientists mobility between partners involved in Action and Non-COST partners;
- Contribution and participation to national and international conferences;
- Pursue joint publications, based on the available datasets from the different partners;
- Non-technical publications in general press for public dissemination at local, national and international level.

**H.3 How?**

The Action MC, together with WGs Chairs, Action Secretary and Action-website Manager will play a key role in the dissemination of the information by taking care that the Action website is always updated and timely contents. The MC will supervise the dissemination plan to evaluate needs of updating of the initially-planned dissemination activities and eventually push new contingency plans for dissemination. The aim of the Action dissemination plan is to transfer the knowledge and networking results towards a wide community of research and industry, scientists, engineers, managers, technicians, opinion-makers, decision-makers, stakeholders, etc.).

The production of joint publications will be strongly supported by the MC and proper credit to the COST Action will be given in the acknowledgements. Special efforts will be deployed to have contacts with as many key players and stakeholders as possible. Links will be established with EC (DG-Research, DG-Environment, etc.), relevant European networks and international bodies. Links will also be established with international societies interested in problems of nanotechnologies, materials, green-technologies, air quality, climate change, environmental sustainability. During the meetings of the MC and WGs, International Agencies involved in the related fields of this COST Action and representatives of the users will be invited for exchange of information, coordination, developing synergies and collaborations. Moreover, national/international and European S&T associations (e.g., European Materials Research Society, International Society for Olfaction and Chemical Sensing, Electrochemical Society, Institute of Electrical and Electronics Engineers, American Association for Advancement of Science, etc.) will be contacted to have some Action partners giving presentations at their yearly meetings.

The achieved results will be disseminated by using different channels:

- Online (Website, Newsletter): A website or Portal offering different levels of access (public, members). Besides information on the aims and the current activities of the Action the website should contain a forum to communicate and find partners for cooperation e.g. to establish new research projects related to the Actions topic. Also an obligatory newsletter will inform members and guests about latest meetings, national project calls.

- Own sessions on conferences like Eurosensors, International Meeting on Chemical Sensors (IMCS), Semiconductor Gas Sensors (SGS), IEEE Sensors, Transducers, International Symposium on Olfaction and Electronic Nose (ISOEN), European Materials Research Society Meetings (EMRS), Electrochemical Society Meetings (ECS), International Conference on Environmental Science and Technology (CEST), International Conference on Air-Quality, Science and Application, and similar thematic meetings. To disseminate the results of the COST Action in the different experts' communities the best way is the organization on specialized sessions on conferences. By this approach a broad basis for discussion is established. Also there is the possibility of countercheck the Actions advancements.
- Workshops: Besides offering a fast way to exchange information on latest results workshops also offer the possibility to invite International Experts from other communities or networks. This will help to coordinate concerted actions of different Actions or Networks. For this it is intended to hold these workshops together with international conferences (e.g., EUROSENSORS, EMRS, IMCS, SGS, IEEE SENSORS, TRANSDUCERS, ECS, ISOEN, CEST, etc.).
- Summer/Winter Schools and Training Schools introduce young scientists in the field of air pollution monitoring and the involved technologies. Since the schools are performed at international level there is also the establishment of international cooperation in very early stages of scientific career possible.
- Review Papers will give information to the community on the current state of technological development of the sensing technology and systems. Review papers allow to classify the results obtained in the framework of the COST Action into work done by other groups and networks.
- General Public will be addressed also by publishing articles on weekly and monthly journals and non-technical publications, including Open Days and Info Days organized also in the involved research institutions and by taking part in dissemination initiatives like "Night of Researchers", events of outreach towards High Schools, public governance, opinion-makers, stakeholders, Industrial Liaison Offices (ILOs) and policy-makers.