EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Brussels, 13 April 2018

COST 047/18

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "Indoor Air Pollution Network" (INDAIRPOLLNET) CA17136**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action Indoor Air Pollution Network approved by the Committee of Senior Officials through written procedure on 13 April 2018.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA17136
INDOOR AIR POLLUTION NETWORK (INDAIRPOLLNET)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. "Rules for Participation in and Implementation of COST Activities" (COST 132/14 REV2);
b. "COST Action Proposal Submission, Evaluation, Selection and Approval" (COST 133/14 REV);
c. "COST Action Management, Monitoring and Final Assessment" (COST 134/14 REV2);
d. "COST International Cooperation and Specific Organisations Participation" (COST 135/14 REV).

The main aim and objective of the Action is to The main aim and objective of this action is to advance the field of indoor air pollution science, to train a new generation of ECIs, to highlight future research areas and to bridge the gap between research and business to identify appropriate mitigation strategies that optimise indoor air quality.. This will be achieved through the specific objectives detailed in the Technical Annex.

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 60 million in 2017.

The MoU will enter into force once at least seven (7) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14 REV2.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14 REV2.

TECHNICAL ANNEX

OVERVIEW

Summary

In developed countries, we spend 80-90% of our time indoors, where we receive most of our exposure to air pollution. However, regulation for air pollution focuses mainly on outdoors and the indoor environment is much less well characterised. The concentrations of many air pollutants can be higher indoors than out, particularly following activities such as cleaning and cooking. With increasing climate change impacts, related energy efficiency measures are making buildings considerably more airtight. Such measures can increase indoor pollutant concentrations even further. Therefore, to reduce our exposure to air pollution, we must consider both the indoor and outdoor environments and the role of ventilation, in order to mitigate through appropriate building operation, use and design.

INDAIRPOLLNET (INDoor AIR POLLution NETwork) will improve our understanding of the cause of high concentrations of indoor air pollutants. It will assemble experts in laboratory and chamber experiments, modelling studies and measurements of relevance to indoor air quality (IAQ), including outdoor air chemists. Our network includes experts in chemistry, biology, standardisation, particulate matter characterisation, toxicology, exposure assessment, building materials (including those manufactured specifically to improve IAQ such as green materials), building physics and engineering (including ventilation and energy) and building design. This Action aims to significantly advance the field of indoor air pollution science, to highlight future research areas and to bridge the gap between research and business to identify appropriate mitigation strategies that optimise IAQ. The findings will be disseminated to relevant stakeholders such as architects, building engineers and instrument manufacturers.

Areas of Expertise Relevant for the Action	Keywords
● Earth and related Environmental sciences: Atmospheric chemistry and composition ● Environmental engineering: Air pollution	● Indoor Air Pollution ● Indoor Air Chemistry ● Indoor air measurements and modelling ● Indoor Air Quality

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination

- The overarching aim of this network is to define a blueprint for the optimal indoor air chemical characterisation campaign.
- To improve understanding of indoor air pollution.
- To highlight improved and/or new techniques for indoor air chemistry measurements.
- To highlight improvements for indoor air chemistry models.
- To highlight methods to improve future buildings.
- To inform developing standardisation protocols.
- To identify potentially harmful species in indoor air.
- To collate and review data to form rigorous recommendations for future indoor air pollution science.
- To transfer knowledge towards policy makers and other stakeholders with an interest in indoor air quality.

Capacity Building

- To develop a new scientific community at the interface of outdoor and indoor air chemistry.
- To maximise research collaboration in indoor air pollution in Europe.
- To facilitate future grant proposals after the Action has ended through building a network of experts.
- To provide rigorous scientific training for the next generation of European ECIs in indoor air chemistry.

- To disseminate our findings to the wider research community.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. CHALLENGE

1.1.1. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

In developed countries, we spend 80-90% of our time indoors where we receive most of our exposure to air pollution. Despite this fact, regulation for air pollution focuses on outdoors: the indoor environment is less well characterised or even recognised as a potential location for exposure to air pollution. Air pollutant concentrations are often higher indoors than outdoors, particularly following activities such as cleaning and cooking and there is evidence that many indoor air pollutants are harmful to health (Nazaroff and Goldstein, 2015). More than 2 million healthy life years are lost across the EU-26 because of indoor air pollution (Hänninen et al., 2014). Just over half of this burden is attributed to indoor exposure to outdoor pollutants, the rest to combustion, moisture, and emissions from building products *etc*. (tobacco smoke exposure excluded). Another concern is that energy efficiency measures are making buildings more airtight, further degrading indoor air quality (IAQ). There is a clear need to balance energy conservation goals with satisfactory IAQ. This balance can only be achieved by gaining a fundamental understanding of the indoor environment and its relationship to outdoors through ventilation. Both environments are characterised by the presence of reactive species and chemical reactivity is a key area for focus.

INDAIRPOLLNET (**IND**oor **AIR POLL**ution **NET**work) will improve our understanding of the conditions and processes that cause high concentrations of indoor air pollutants. It will assemble experts in laboratory and chamber experiments, modelling studies and measurements of relevance to IAQ, including outdoor air chemists. Our network includes experts in chemistry, biology, standardisation, household energy, particulate matter characterisation, toxicology, exposure assessment, air cleaning, building materials (including those manufactured specifically to improve IAQ such as bio-based composites and green materials), building physics and engineering (including ventilation and energy) and building design. The network will facilitate knowledge exchange between indoor and outdoor air chemists (*e.g.* for measurement techniques, field campaign organisation and analysis of results) where relevant, but with consideration of related and relevant disciplines (*e.g.* building physics, design and operation) to design indoor field studies that are relevant for a wide range of buildings. **This Action aims to significantly advance the field of indoor air pollution science, to train a new generation of Early Career Investigators (ECIs), to highlight future research areas and to bridge the gap between research and business to identify appropriate mitigation strategies that optimise IAQ**. The findings will be disseminated directly to relevant stakeholders such as architects, building engineers, building managers, property developers, urban planners and instrument manufacturers.

1.1.2. RELEVANCE AND TIMELINESS

Increasing climate change awareness is driving rigorous energy efficiency measures with buildings becoming more airtight. IAQ is strongly dependent on the ventilation efficiency: adverse health effects can be associated with decreased ventilation rates (Sundell et al., 2011). Consequently, when buildings are modified to decrease energy use such as introducing variable ventilation rates during

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occupancy/non-occupancy periods, it is critical that IAQ is not inadvertently made worse for the occupants. Ventilation also transports outdoor air pollutants indoors and natural and mechanical ventilation systems use different proportions of indoor and outdoor air. There are clearly vast differences in building types and uses, geographical locations and locales (*e.g.* urban or rural settings), ventilation systems and indoor and outdoor sources. Chemical processes indoors must be well understood, in order to extrapolate results to a wider range of buildings and locations than in the relatively few in which measurements have been made (Nazaroff and Goldstein, 2015).

Our network is timely from both a scientific and technological perspective. A wide range of state-of-the-art instruments have been recently developed to characterise air pollution outdoors, which have the potential to aid understanding of indoor atmospheres. For instance, expertise now exists to measure radical concentrations (such as the hydroxyl radical, OH), to speciate thousands of volatile organic compounds (VOCs), as well as to begin to determine the composition of complex mixtures such as particulate matter (chemical and biological). Sensor development is also at an exciting stage. Many sensors are being developed and marketed commercially, although few currently have sufficient accuracy and selectivity to be used as research tools (Lewis and Edwards, 2016). Identifying how to make sensors more reliable whilst maintaining ease of use and relatively low cost is a key goal, particularly to help smart buildings and cities to develop in the future.

Models for indoor chemistry predict that many complex species are important indoors (Sarwar et al., 2002; Carslaw et al., 2012; Mendez et al., 2015), but there are few measurements existing to test model predictions. Bringing together outdoor and indoor air chemists, including measurement experts and modellers, is crucial to advance understanding of indoor air pollution. Further, the involvement of experts in building materials, physics (*e.g.* air flow), operation and use, will ensure that the Action focuses on conditions that are relevant for where people live, work and study.

Recent research in indoor air chemistry has provided some tantalising results that require further study. Ozone-terpene chemistry is critical in this respect: many products (*e.g.* fragrances, cleaners, paints) contain terpenes (Nazaroff and Goldstein, 2015) that react with ozone (O_3) to produce reactive species such as OH (note that a parallel exists outdoors in areas dominated by vegetative emissions). Concentrations of OH of ~2 x 10^6 molecule cm^{-3} have been measured indoors in the presence of nitrous acid (HONO), comparable to outdoor concentrations (Gomez Alvarez et al., 2013), likely due to surface chemistry involving HONO (or other species). Concentrations of ~2 x 10^7 molecule cm^{-3} were measured indoors during the use of an air cleaning device, which mixed ozone and limonene in an internal chamber before venting OH radicals into the room (Carslaw et al., 2017). The presence of OH indoors facilitates oxidation of VOCs into potentially more harmful species, such as oxygenated VOCs (oVOCs) and secondary organic aerosol (SOA). However, confirmation of these findings is needed along with more detailed model analyses to understand their implications.

1.2. OBJECTIVES

1.2.1. RESEARCH COORDINATION OBJECTIVES

The overarching aim of this network is **to define a blueprint for the optimal indoor air chemical characterisation campaign**, which is relevant for the buildings we use and for the way that we use them. The Action will achieve the following research coordination objectives:

Improved understanding of indoor air pollution: the Action will elucidate source apportionment of indoor pollutants, both in the gas- (*e.g.* oVOCs, radicals) and particulate-phases (*e.g.* size distribution, concentration, composition). The relative importance of indoor versus outdoor sources, natural versus manmade sources and primary emission versus secondary chemistry for indoor air composition will be considered, as well as the impact of human behaviour on IAQ. Whilst fragmented information exists on all of these factors, exchange of expertise across this network will facilitate a more holistic understanding of the key sources of indoor air pollution.

Improved and/or new techniques for indoor air chemistry measurements: the current state-of-the-art for indoor and outdoor measurements will be reviewed, with the former improved and the latter adapted/optimised/developed for indoors. New measurement techniques will be highlighted where relevant and comparisons between instruments facilitated. The area of sensor technology is particularly pertinent in this respect.

Improved indoor air chemistry models: indoor air chemistry models contain many uncertainties owing to relatively few measurements indoors (compared to outdoors). These uncertainties will be identified to permit understanding of the level of accuracy required in future measurements and to design new experiments accordingly.

Improved buildings for the future: this Action's findings will help with future building design, as well as the manufacture and use of materials within, providing information/services to occupants and building managers. By applying our results to future buildings, the Action can promote those that ensure both comfort and good health. The use of 'green'/low carbon materials will be considered, as well as smart air quality management via sensors and air cleaning technologies.

Improved standardisation protocols: the results will inform a developing ISO programme for an Indoor Air Quality Management System (ISO/TC146/SC6) and translate scientific knowledge to practical information for professional building designers, operators and facility managers.

Identification of potentially harmful species in indoor air: through the identification of key species (in terms of concentration) and with knowledge of their likely health effects, the Action will be in a strong position to identify species that are worth further investigation by air pollution health experts.

Data collation, review and formation of rigorous recommendations for future indoor air pollution science: this Action will bring together experts in complementary fields to define relevant indoor air chemistry measurements for the future. Guidelines for the construction, building/furnishing materials and consumer products sectors will also be produced.

Knowledge transfer towards policy makers and other stakeholders with an interest in indoor air quality: findings will be disseminated through workshops (where key stakeholders will be invited), international conferences (including special sessions/workshops) and publications. They will be relevant to a range of stakeholders including policy makers, managers of and workers in public buildings, researchers in health effects of air pollutants, building engineers and the indoor and outdoor air pollution research community.

1.2.2. CAPACITY-BUILDING OBJECTIVES

This interdisciplinary network includes indoor and outdoor air chemists, laboratory and chamber experimentalists, measurement specialists, modellers, exposure scientists, building scientists, engineers and architects and will enable us to achieve the following capacity-building objectives:

Development of a new scientific community at the interface of outdoor and indoor air chemistry: the network will build the critical mass required to consolidate knowledge and advance progress, so strengthening this research area in Europe. In particular, the expertise of outdoor air chemists, which has been gathered from a more mature field of research than indoors, will permit capacity-building that would not otherwise be possible. Clearly, not all of the measurements/approaches used outdoors are relevant for indoors, but some methodology and instrument techniques can accelerate characterisation of the indoor environment. Combining in situ measurements and modelling expertise with laboratory measurements facilitates a more holistic approach than would be possible in the absence of this network. Finally, the involvement of relevant 'end-users' such as architects, those working with standardisation and instrument and building engineers, will ensure our results are applicable to real and relevant buildings.

Maximise research collaboration in Europe: network members are involved in a number of funded/ongoing projects, including planned field studies with direct relevance to the network. The Action will maximise knowledge sharing between projects (*e.g.* through short term scientific missions (STSMs) offering significant added-value. It will also enable a forum for discussion between researchers and relevant end-users and between academia, industry and other sectors, to integrate current knowledge both from within the network and further afield and to direct future research in this area in Europe.

Submission of future proposals: this Action and the 'blueprint' generated will put the network in a very strong position to apply for funding to carry out the campaign identified in this Action proposal (*e.g.* Maria Sklodowska-Curie Innovative Training Network, H2020) once the Action ends. Future grant submissions will be strengthened through better knowledge of indoor air chemistry processes and a relevant and informed pool of experts.

Scientific training: this Action will provide rigorous training for the next generation of European ECIs in indoor air chemistry. At each annual workshop, specific activities will be provided for this group through training schools and fora (*e.g.* seminars and workshops given by more established members of the network) to form a truly interdisciplinary, but cohesive community of young researchers within Europe.

Dissemination: a web site will be used to post regular updates to the public, as well as enable a blog for network members. Results will be prepared for high impact journals and conferences. Special sessions/workshops will be run at international conferences. Outcomes will be communicated through the professional networks of individual members, including representatives from government, business and end-users (*e.g.* property owners and managers).The results will also be relevant for a proposed Indoor Air Quality Management System (through ISO/TC146/SC6).

1.3. PROGRESS BEYOND THE STATE-OF-THE-ART AND INNOVATION POTENTIAL

1.3.1. DESCRIPTION OF THE STATE-OF-THE-ART

Measurements of air pollutants have been made indoors and outdoors for many years, typically dominated by regulated pollutants such as O_3, nitrogen oxides and particulate matter (PM). As technology has improved, along with our appreciation of the complexity of chemical processing in the atmosphere, measurements have become more complex and wide-ranging. For instance, PM concentration and size are routinely determined and techniques to understand PM composition are reaching maturity (Rossignol et al., 2013). Also, secondary oxygenated and nitrated VOCs can be quantified with advanced outdoor instrumentation using high resolution and field portable gas/liquid chromatography techniques, which can also be coupled with mass spectrometric detectors for laboratory analyses (Rossignol et al., 2013; Fischer et al., 2014).

Analytical techniques to determine atmospheric radical concentrations have evolved considerably over the last 30-40 years, typically involving spectroscopic or chemical conversion techniques. Such observations are challenging as radical species have low concentrations, typically part per trillion (ppt, one part in 10^{12}) or below and have lifetimes of the order of seconds. OH, NO_3 (nitrate), HO_2 (hydroperoxy) and RO_2 (sum of organic peroxy) radicals can be determined quantitatively, as well as the combined reactivity of all trace gases towards OH. Radicals (OH in particular) play an important role in controlling the chemistry of air pollution. Measurements of radical species outdoors, along with those of other key pollutants, have allowed us to understand how atmospheric pollutants are emitted, transformed and lost. Whilst more complex measurements are now commonly used outdoors, they are used infrequently indoors and certainly not to the extent where conclusions can be drawn about the relative importance of different sources of indoor pollution, so enabling the identification of appropriate mitigation measures.

One important area of development in outdoor measurements that may be relevant for deployment indoors is sensor technology. Sensors offer many advantages, such as lower space, noise, price and power requirements. However, these advantages are often coupled with lower sensitivity, reduced chemical specificity and a smaller range of measured pollutants (Lewis and Edwards, 2016). The indoor environment potentially offers a more optimal environment for sensors being less variable in temperature, something that causes interferences with current technologies. Potential designs for indoor chemical sensors indoors will be explored by this network, as well as options for deploying them with more established instruments for cross-validation.

Finally, models for indoor air chemistry exist with varying degrees of complexity (e.g. Sarwar et al., 2002; Carslaw et al., 2012; Mendez et al., 2015). They typically account for air exchange with outdoors through ventilation, indoor deposition (large surface areas indoors), photolysis by attenuated sunlight through windows and from indoor lighting and indoor chemistry. Surface chemistry on furnishings, building materials and human bodies is increasingly recognised as important (Nazaroff and Goldstein, 2015), but there is insufficient information to represent these processes accurately in models. The role of water/humidity on IAQ is another area that remains largely unknown. Models used in other fields, such as indoor energy consumption models or stochastic models in general, will help us to best represent human behaviour, given the latter has a direct impact on IAQ (*e.g.* window opening, indoor lighting).

1.3.2. PROGRESS BEYOND THE STATE-OF-THE-ART

There are significant constraints for indoor measurements (*e.g.* space, the presence of occupants precluding noise and exhaust), so instruments must be well adapted to this environment. This Action will identify innovative methods using outdoor measurement techniques where relevant, as well as further developing techniques used indoors. Issues such as miniaturisation, power requirements and sampling volumes will be considered. For instance, the instruments used to measure OH outdoors are shipping container size, but can be miniaturised for aircraft (Stone et al., 2012), hence use indoors.

The Action will be in a strong position to exploit sensor technology for use indoors through its network of experts. Pollutants that are most affected by the increasingly common varying ventilation schedules in energy efficient buildings will be identified. Smart and simple digital solutions to couple pollutant sensors to the ventilation system will be explored where appropriate, *e.g.* using a cloud server or as part of the Internet of Things. Although high CO_2 concentrations activate ventilation systems in some buildings, pollutants that are more health relevant will be the focus here. In addition, sensors that can measure indoors and outdoors with the same technology, or that co-investigate microbial and chemical pollution, might permit smart control of building ventilation.

Models for indoor air chemistry are currently limited by the available measurements for validation. Measurements of non-routine species such as radicals, oVOCs (e.g. complex carbonyls and organic nitrates) and detailed aerosol composition are either sparse or non-existent. Such measurements are challenging, but need to be extended to indoors. Through a formal identification of key model uncertainties (*e.g.* in deposition, photolysis and surface emission and production rates), INDAIRPOLLNET will permit the prioritisation of future experimental needs to allow indoor air chemistry models of the future to be significantly improved.

There are several challenges that exist alongside the chemistry, which are not unique to this field. Experimental research typically generates large amounts of data, often for integration into models. Consideration must be given to how and where the data should be collected and at what spatial and temporal resolution (e.g. linked to the expected human response). These factors are considered in the activities described in Section 3 to ensure that the project aim is fully addressed.

1.3.3. INNOVATION IN TACKLING THE CHALLENGE

In terms of innovation, this Action will provide:

- a better understanding of IAQ and identification of future research priorities
- new/improved measurement technologies for indoor air pollutant measurements with direct links to business and market implementation
- recommendations for (types of) materials/products to use indoors
- improved indoor air chemistry models

Indoor and outdoor air chemists rarely work together despite obvious synergies in the two research fields (*e.g.* aerosol formation, surface chemistry, O_3-terpene reactions). Through using the relevant expertise of the outdoor community, understanding of indoor air chemistry will progress more quickly and repetition of past research will be avoided.

Building operation and IAQ are generally treated as two independent research fields. Building operation has been driven by energy efficiency measures in recent years and buildings have become more airtight, often at the expense of IAQ. This network will provide opportunities to identify ways to design and use buildings using a holistic approach that considers energy efficiency, whilst maintaining the IAQ for the health and comfort of the occupants.

The broad range of network partners will ensure that these innovations are relevant for numerous end-users in business, governments and society. The bridge between the research and the relevant businesses and markets is missing at the moment, but is necessary to ensure that the research leads to products/materials that can be easily implemented in practice.

1.4. ADDED VALUE OF NETWORKING

1.4.1. IN RELATION TO THE CHALLENGE

The Challenge described in Section 1.1 is best addressed through networking to bring together those with expertise in a number of relevant disciplines, as well as across sectors. The network includes indoor and outdoor chemists (gas- and particle-phases), biologists and physicists, experimentalists (field and laboratory) and modellers, instrument manufacturers and standards experts. The network also includes building engineers, material designers and architects, who will advise on the impact of building design, use and operation on indoor air chemistry, but also inform how building characteristics should be documented and measured to inform building design. The involvement of indoor air toxicologists and exposure assessment experts permits consideration of the health effects of pollutants over relevant timescales for exposure. Such a network of expertise will provide the holistic approach required for future building design, as well as put us in a strong position to react to new developments as they happen and disseminate key results widely.

Given the years of expertise that have been invested in developing outdoor air chemistry measurements, there is significant added-value from indoor and outdoor chemists working together, as well as from coordinating existing research activities. Many measurements needed to better understand IAQ are made routinely outdoors and it is sensible to exploit relevant expertise. Similarly, aspects of surface and O_3-terpene chemistry are relevant to atmospheric chemists.

The network will afford opportunities for ECIs to develop through annual training/fora, as well as to engage in STSMs. These activities will help career development, providing useful skills early on in their careers. This Action will develop inter-sectorial STSMs, particularly between academia and industrial partners, to facilitate understanding of operational practices within different sectors.

1.4.2. IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

Indoor air pollution is a relatively new research area and large networks to coordinate study in this field do not exist. This Action will bring together a core of experts that will contribute to a significant advancement of this field that would simply not be possible at the national level. The results will be globally relevant given the Action will consider how different outdoor conditions (e.g. high/low pollution), building designs and operation affect indoor air chemistry. For instance, different climate zones around Europe will affect building systems significantly. As well as differences in local temperatures and humidity levels both indoors and outdoors, some buildings will rely on heating, others on cooling, and there will be differences in ventilation regimes (*e.g.* natural versus mechanical). These differences will impact the resulting air pollutant concentrations.

Internationally, there are large conferences such as *Healthy Buildings* (most recently in Poland in 2017) and *Indoor Air* (next in Philadelphia in 2018). Focused workshops have also been held as somewhat ad-hoc funding has become available. Whilst these permit opportunities to discuss research, the absence of an established community means that momentum is lost once scientists return home.

Several recent/current European research projects investigated aspects of IAQ: EPHECT (http/www.ephect.eu), EUNetAir (http://www.eunetair.it/), OFFICAIR (http://www.officair-project.eu/), SINPHONIE (http://www.sinphonie.eu/), OSIRYS (http://www.osirysproject.eu/) and ECOSEE (http://www.eco-see.eu/), focusing on consumer product emissions, sensor development for air quality, IAQ in European offices, IAQ in schools and innovative eco-building materials respectively. This Action will build on the important findings from these projects with INDAIRPOLLNET to provide a holistic approach to understanding chemical processing in indoor environments. This Action will facilitate the necessary time, funding and momentum to consolidate and significantly advance the science.

2. IMPACT

2.1. EXPECTED IMPACT

2.1.1. SHORT-TERM AND LONG-TERM SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS

Our network comprises a significant fraction of relevant stake-holders to maximise impact, with 19% of our network from business enterprise, including 8 SMEs and a larger company. It will provide clear benefits for society and aid policy-makers that consider health impacts of air pollutants and building design. The expected short-term impacts are:

- A blueprint for future indoor air chemical characterisation of relevance to building users
- Identification of a strategy to experimentally investigate the efficacy of potential mitigation measures
- Annual reports that identify a roadmap for improved IAQ in a particular area (see Section 2.2.2) and with an identified set of innovation partners for each
- Increased awareness of:
    - The links between IAQ, energy efficiency, ventilation, building materials & health effects
    - The links between indoor activities (particularly those leading to high concentrations of indoor air pollutants such as cooking, cleaning and air freshener use) and IAQ
    - The importance of building design, materials, operation and use for IAQ

The expected long/medium-term impacts are:

- The creation of a new interdisciplinary network and research base for indoor air pollution in Europe (and with links further afield)
- Improved/new air pollutant measurement technology
- Improved building design, such as recommendations for optimising energy efficiency whilst maintaining the health of building occupants
- A new range of indoor products (e.g. cleaning fluids, building materials) that potentially exclude particularly reactive chemicals from their formulations
- More healthy indoor environments
- A new generation of world-class researchers in indoor air pollution.

2.2. MEASURES TO MAXIMISE IMPACT

2.2.1. PLAN FOR INVOLVING THE MOST RELEVANT STAKEHOLDERS

The results from the network activities will be beneficial to a range of stakeholders including: the building regulations sector; those who manufacture goods for use indoors (*e.g.* building materials, furnishings, cleaning products and air-fresheners); those who use analytical techniques for determination of air pollutants; those who provide sensors and connected objects for both occupants and building managers; those interested in health effects of air pollutants; researchers in indoor and outdoor air pollution and property owners and managers. Large multi-nationals who set great value in creating a happy workforce will also be interested, given comfort in buildings is an important aspect of a good working environment. Stakeholders that are not involved in the network (*e.g.* policy-makers in public health, climate-change, building and product regulations, HVAC (Heating, Ventilation, Air-Conditioning) manufacturers and software developers, consumer product manufacturers) will be invited to our workshops and encouraged to engage with us.

Many stakeholders are already part of the network, which will aid development, use and dissemination of the results through their contacts. Their involvement will be particularly helpful to identify innovation partners to link to the results in each annual report, in order to design approaches to optimally improve IAQ. For instance, members of our network are involved in retrofitting houses to reduce energy use. This Action also has instrument developers who will be in a strong position to manufacture new instruments for indoor air research. The network members will identify and approach relevant new stakeholders and facilitate their involvement in the network.

ECIs and PhD students in IAQ research will be invited to attend a custom event each year (before or after the annual workshop). A training school will be held in years 1 and 3. Potential topics include: an introduction to IAQ; instrumentation and models for IAQ; standards for IAQ; auditing IAQ. Forum meetings in years 2 and 4 will be based around the workshop theme (see Section 3). ECIs will present their work and chair sessions, whilst more experienced members of the network will run workshops/make presentations. The ECIs will help to organise the forum activities and will train and develop at the forefront of IAQ research to become future leaders in the field.

For the public, a web page will be designed to allow users to explore IAQ in a typical house. The user will pick an indoor activity (such as cleaning or cooking) and the concentrations of air pollutants attained through this activity will be estimated depending on ventilation conditions and room size (informed by the Action activities and linked to regulatory standards and guidelines). The user would also receive age-specific information sheets. This activity would help users to understand how IAQ could be improved through relatively simple measures.

2.2.2. DISSEMINATION AND/OR EXPLOITATION PLAN

The project results will be disseminated amongst academics through at the very least, an editorial/commentary piece and a journal article submitted at the end of the project (see Section 3): several other publications will likely arise from network activities such as case studies initiated through partner involvement in complementary projects. Findings will be reported at conferences and meetings, with special sessions at international conferences such as Indoor Air and/or Healthy Buildings. Findings will also be disseminated through the ISIAQ (International Society for Indoor Air Quality and Climate) newsletter, to reach an international audience. A dedicated web site will contain a members-only area for preliminary discussion of results, workgroup activities and organisation, as well as an outward facing area.

An annual report will summarise key activities each year and provide roadmaps for innovation partners to act on our findings (*e.g.* input for start-ups who focus on innovative technical solutions). The Action will use existing networks of contacts including national government departments for building, planning, chemical regulation and health, industrial partners, property managers and owners to identify relevant innovation partners based on our roadmaps and also to further disseminate results. For instance, we have representation in the International Energy Agency’s Air Infiltration and Ventilation Centre (http://www.aivc.org/) that recently produced a report on Residential Ventilation and Health. To inform and inspire the next generation of scientists, an article will be produced for Chemistry Review, a magazine aimed at post-16 chemists and sold in 42 countries. An article in this magazine linked to the web site, would provide a fantastic resource for teachers and students and give this Action wider coverage.

The most obvious potential for exploitation from the network once it is completed will come from the future submission of a proposal (*e.g.* through H2020) to carry out the indoor air chemistry analysis program designed through the Action. To achieve this ambition, ways for the network to continue to cooperate after the project ends will be identified. During the project, a key means to exploit the Action’s results will be through the production of long-term datasets of relevant parameters at meaningful (so health-relevant) timescales (*e.g.* indoor pollutant concentrations along with relevant building and occupancy information) that could be shared with the indoor air modelling, energy efficient buildings and toxicological communities. The most efficient way of allowing them to exploit these results will be to invite them to relevant meetings as results are disseminated. Given the nature of the collaboration, there should be opportunities to exploit new measurement techniques such as improved sensor technology. The findings of the Network should be used for policy implementation. Although air quality standards are established within the legal framework of many countries to protect public health, there are no equivalent legally binding indoor air quality standards. Finally, the results will help to formulate a new ISO Indoor Air Quality Management Plan.

2.3. POTENTIAL FOR INNOVATION VERSUS RISK LEVEL

2.3.1. POTENTIAL FOR SCIENTIFIC, TECHNOLOGICAL AND/OR SOCIOECONOMIC INNOVATION BREAKTHROUGHS

Scientific innovation breakthroughs vs risk
The innovation in approaching our research objectives is to form a unique community made from members working in a number of interdisciplinary fields. Although the focus is on chemical characterisation of indoor air, for full understanding it is necessary to consider building physics, design, operation and use, human activities within and products used. The Action assembles experts that will allow a holistic consideration of the indoor air chemistry, for relevant buildings where people live, learn and work and to define methods to obtain/maintain good IAQ. The multidisciplinary network of people involved will minimise the risk of not being able to achieve the major scientific objective, namely, to design a blueprint for an ideal indoor air chemical characterisation campaign.

Technological innovation breakthroughs vs risk
It is likely that new techniques and/or technologies can be recommended for measurements indoors as a result of this proposal. Outdoor field instruments (*e.g.* OH and PAN measurements) have already been used indoors (Gomez Alvarez et al., 2013; Fischer et al., 2014) and our assembled network represents decades of experience in the fields of indoor and/or outdoor chemistry, as well as building engineering and instrument (including sensor) development. Some of the instruments have already been successfully used outdoors and some of the operating conditions indoors (less variable temperature for instance) might simplify deployment, hence minimising risks associated with their deployment indoors. There is a technological risk associated with the development of the sensors: there will be challenges involved (*e.g.* miniaturisation, power, sensitivity, long-term drift) that may mean some will be unsuitable for some of the targeted chemicals. However, by having a number of different sensor companies and academic experts involved in this area, the Action can focus our efforts on the most promising methods to maximise success, *e.g.* through regular automated calibration or methods to correct for signal drift. Further, the European standardization activities (CEN/TC 264/WG 41 and CEN/TC 264/WG 42) that minimize the technological risk associated with sensor development can be used as a reference, with the aim of attracting more industry interest. Care will be required with identifying the location of the campaign(s) to make sure it(they) is(are) representative, but with the experience of the network and the wide representation of different countries, outdoor pollution levels and building design, the Action has the breadth of experience and competencies required to define the best environment(s).

Socioeconomic innovation breakthroughs vs risk
Healthy buildings are central for well-being and health. Given the recent focus on energy efficiency in response to climate change, we need to fully understand the associated impacts on indoor air chemistry, to avoid committing future generations to unacceptable IAQ. There is significant manufacturing and commercial activity in consumer and building products across Europe, as well as further afield. Understanding the impacts of using these products indoors, as well as 'greener' replacements on indoor air chemistry will aid product development, whilst supporting and developing competitiveness in major European industry sectors. The major risk in this area is that there is insufficient collaboration between academic and industrial scientists to ensure the research is translated into best practice with e.g. new product formulation. A high proportion of business enterprise partners in the network (19%) in 9 different companies should minimise this risk. Identifying innovation partners at each stage and actively engaging with relevant stakeholders at annual meetings and conferences, will also help to make sure our findings have practical applications.

3. IMPLEMENTATION

3.1. DESCRIPTION OF THE WORK PLAN

3.1.1. DESCRIPTION OF WORKING GROUPS

Activities will be divided into 6 Working Groups (WGs) and culminate in a final workshop to define the optimal indoor air chemical characterisation campaign. The first stage will summarise existing model and experimental results indoors (WG1) and outdoors (WG2) to establish what is known and what remains unknown. WGs1-2 feed into WG3 which covers 'What' to measure indoors, whilst WGs1-3 will feed into WG4, which addresses 'How' to measure indoors. WGs1-4 will inform WG5 which addresses 'Where' to make indoor measurements. WG6 will provide the blueprint for the optimal indoor air measurement campaign, with the results presented in the final workshop.

The Action contains an ambitious programme, but our network members have highly complementary skills, and are in a unique and strong position to complete the tasks. The WGs are inter-connected, but each will focus on a specific research objective and involve sub-group meetings of relevant network members. The whole network will meet at an annual workshop to summarise progress, address the overall Action aim and to facilitate community building and network consolidation. Annual reports will constitute additional deliverables to those listed below and provide roadmaps for innovation partners who will be identified at the annual workshops.

WG1: What do existing measurement and model results reveal about indoor air chemistry?
Measurements of indoor air pollutants to date have focused on schools and offices, with fewer in homes, hospitals and leisure settings and consist mostly of regulated outdoor pollutants (*e.g.* PM, O_3 and nitrogen oxides): further measurements of these species are unlikely to yield major new insights. More recently, outdoor techniques have been used to measure more exotic species indoors such as OH radicals, a range of VOCs and aerosol composition (Gomez Alvarez et al., 2013; Rossignol et al., 2013; Tang et al., 2016; Stönner et al., 2017). Such measurements have provided insight, but now is a good time to review where future efforts should focus. Indoor air chemistry models also exist (*e.g.* Carslaw et al., 2012; Mendez et al., 2015), though validation of their results has been limited owing to the absence of the relevant measurements. Indoor models have highlighted the importance of OH (and other) radicals indoors, even in the absence of high concentration activities, with predicted concentrations at the low end of those observed outdoors. Future studies must be designed to reduce model uncertainties, so major sources, transformations and losses of pollutants indoors can be better understood and appropriate mitigation strategies developed.

Key objective: To identify species to measure indoors based on existing indoor results.

In order to achieve this objective, the following **tasks** will be carried out through reviews of existing literature and current projects, with results presented at workshop 2 in month 12:

1. Identify key indoor gas- and particle-phase species based on existing measurements and model results. This will include measurements in buildings, but also relevant measurements from chamber or laboratory studies (e.g. kinetic experiments, toxicological assessments).
2. Provide source apportionment of indoor pollutants, both in the gas- and particulate-phases (*e.g.* indoor vs outdoor; human vs natural, primary vs secondary).
3. Identify parameters that cause major uncertainties in indoor air models.
4. Provide a list of recommendations for WGs3-6.

Milestones and Deliverables:
Month 1: Start-up workshop (Workshop 1) for all participants of the network
Month 6: Progress meeting
Month 12: Workshop 2; Recommendations for WG3 on species to be measured indoors (D1)
Month 12: ECI Training School 1 (D2)
Month 18: Editorial submitted summarising findings and recommendations (D3)

WG2: What can the indoor and outdoor air chemistry communities learn from each other?
Outdoor air pollution research is relatively more advanced than indoor air research, with measurements made over a longer period of time and better established and validated models. Aerosol process models, such as kinetic models, thermodynamic models, and SOA partitioning models developed by the outdoor community may be useful and even directly applicable to indoor problems. There are many parallels between indoor and outdoor chemistry and an important part of this Action will be to use existing expertise from outdoor air chemistry for use indoors where relevant. Further, indoor air research (*e.g.* O_3-terpene reaction chemistry, aerosol formation, deposition onto surfaces) that could benefit outdoor air chemistry understanding will be identified. This WG will facilitate community building between the indoor and outdoor air chemistry experts.

Key Objective: To use existing outdoor air quality expertise and develop it for use indoors.

In order to achieve this objective, the following **tasks** will be carried out through reviews of existing studies, with the results presented at the second workshop in month 12:

1. A review of outdoor measurement and modelling results to date to understand:
    a. What have been the key challenges for outdoor air chemistry field campaigns? This will include challenges with the chemistry, the instrumentation and models, as well as climatic variation (*e.g.* temperature, humidity).

   b. How have these been overcome?
   c. What is the best way to understand the sources, transformations and sinks of air pollutants and how can this knowledge be applied to mitigation?
2. Identification of relevant areas of indoor research for outdoor community

Milestones and Deliverables:
Month 1: Start-up workshop (Workshop 1) for all participants of the network
Month 6: Progress meeting
Month 12: Workshop 2; Recommendations for WGs3-4 based on outdoor research (D4)
Month 12: Summary of indoor air chemistry research for outdoor air chemistry community (D5)

WG3: Which should be the key species we aim to measure indoors in the future and why?
Year 2 of the network activities will focus on WG3. Future indoor air measurements should be driven by the need to understand more about particular species/groups of species (*e.g.* tracers for human activities or metabolism), rather than measuring species because the instruments exist already. Without being too prescriptive, a list of ~10-20 species (or groups of species) critical for future understanding will be identified, along with the temporal and spatial resolution required to improve the models. The Action will identify related measurements that might be complementary to the chemical pollutants, such as provision of samples for toxicological testing (to link to potential health effects) or microbiota in indoor dust (to link to indoor biological processes). It will also consider how the increased use of green materials may affect IAQ and pollutant composition. This WG will consolidate the community building aspects of year 1 and also facilitate new interactions.

Key Objective: To identify key species to measure indoors and the rationale for doing so.

In order to achieve this objective, the following **tasks** will be carried out through meetings in year 2, with results presented at the third workshop in month 24:
1. Identify the species to measure in a future indoor air chemistry measurement campaign, based on the information from WGs1-2 and further discussion, *e.g.* on health impacts.
2. Develop a clear rationale for the selected species (*e.g.* tracers of specific oxidation chemistry, highly abundant and/or of health concern) and rank in order of importance.
3. Provide recommendations for WGs4-6.

Milestones and Deliverables:
Month 12: Start-up meeting at Workshop 2
Month 18: Progress meeting.
Month 24: Workshop 3; Recommendations for WGs4-6 (D6).
Month 24: ECI Forum 1: workshop '*Future indoor air measurements*' (D7)

WG4: How should we measure the key species identified in WG3?
Year 3 activities will focus on WG4, to identify how to best determine concentrations of species identified in WG3. The Action will identify potential indoor measurement techniques, such as sensor technology and potential miniaturisation of outdoor instruments. Sensor development for pollutant measurements is likely to be a key focus for this WG, particularly the means to link sensor measurements to building operation and consequently mitigation. Opportunities for coordinating future measurement activities will be explored, such as using existing outdoor instrumentation to make indoor air measurements (*e.g.* in a home laboratory; in an adjacent building during an outdoor campaign; during parallel, related projects with partner involvement; in an experimental test house). Again, there are good opportunities to further enhance the community building during this WG.

Key Objective: To identify the best techniques to measure the species identified in WG3.

In order to achieve this objective, the following **tasks** will be carried out through meetings in year 3. The results will be presented at the fourth workshop in month 36:
1. Identify whether experimental techniques exist at present to measure the species identified in WG3 and split them into three classes:
   a. Those that can be measured already or with relatively minor modifications
   b. Those that need significant modifications (*e.g.* miniaturisation) or improvements (*e.g.* the sensitivity of existing sensors) to existing instrumentation
   c. Those for which no technique exists at present either indoors or outdoors

2. For 1a, explore whether any complementary activities may be possible within the network over the remaining lifetime of the project.
3. For 1b, identify what modifications are required.
4. For 1c, make recommendations for future developments, *e.g.* complementary instruments and techniques for use indoors and outdoors.
5. Provide recommendations for WG6.

Milestones and Deliverables:
Month 24: Start-up meeting at third workshop
Month 30: Progress meeting
Month 36: Recommendations for WG6 on how/if key species can be measured indoors (D8).
Month 36: ECI Training School 2 (D9)

WG5: In what type of buildings should we aim to run a field campaign?
This WG will be driven by WGs1-4, constrained by the instrumentation required to make the measurements. An understanding of how practical it is to measure relevant building parameters (*e.g.* ventilation rate, human occupancy) is needed and how this affects the variability and uncertainty in the resulting chemistry indoors. It is crucial to sample environments that are representative for many people to provide meaningful results, in term of configuration (*e.g*. ventilation system, occupancy, architecture, materials used, geographical location, locale (*e.g.* urban vs rural)) and building use. The Action will consider how differences in these factors as well as in cultural norms, lead to differences in IAQ across Europe (and further afield) to guide our recommended building types. Recognising that there are fewer links between indoor air chemists and building experts than between indoor and outdoor chemists, this WG will be started at the end of year 1 to give the new linkages time to form over the course of years 2 and 3.

Key Objective: To identify the best buildings in which to measure indoors.

In order to achieve this objective, the following **tasks** will be carried out through meetings in years 2-3, with results presented at the fourth workshop in month 36:
1. Briefly review past studies in order to assess:
    a. Best type of building to use and why, considering its use (*e.g.* school, residence), design (*e.g.* naturally or mechanically ventilated) and geographical location.
    b. What are the advantages/disadvantages to using public or residential buildings?
2. Using the information from 1. along with WGs1 and 3-4, identify and rank building types.
3. Provide a list of which building parameters are required (*e.g.* ventilation rates, surface characterisation) and how to measure them, in order to interpret the chemistry.
4. Provide a list of logistical requirements (power, space, *etc*.) to assess building suitability.

Milestones and Deliverables:
Month 12: Start-up meeting at Workshop 2
Month 24: Progress meeting at Workshop 3
Month 36: Recommendations for WG6 defining where we should measure indoors (D10)
Month 36: List of building parameters to be quantified (D11)
Month 36: List of logistical requirements for measurements indoors (D12)

WG6: Blueprint for an Indoor Air Chemical Characterisation campaign
The full network will combine findings from all WGs in year 4 to define the optimal indoor air campaign. This will provide a blueprint for what should be measured, and how and where to measure it, whilst ensuring that results are appropriate for model validation. As well as determining the composition of IAQ for typical buildings, a strategy to investigate the efficacy of mitigation measures will be identified, such as changes to building materials, indoor activities and the use of innovative products and technologies (*e.g.* sensing and smart IT-based management). Should the opportunity arise to carry out a campaign before the end of the Action from funding elsewhere, the Action members will be in a strong position to do so given the assembled expertise and workpackages.

Key Objective: To define a blueprint for an Indoor Air Chemical Characterisation Campaign

In order to achieve this objective, the following **tasks** will be achieved through a final workshop to be held in month 42, with recommendations collated for submission for publication(s) by month 48.

1. Review the information from WGs1-5.
2. Make recommendations for optimal design of an indoor air chemical characterisation campaign taking into account what, how and where measurements should be made.
3. Identify a strategy to investigate the efficacy of potential mitigation measures.
4. To identify means to fund the campaign and to continue to cooperate after the Action ends.

Milestones and Deliverables:
Month 36: Start-up meeting at Workshop 4
Month 42: Final workshop (number 5)
Month 42: Blueprint for indoor air chemistry measurement campaign (D13)
Month 42: ECI Forum 2: workshop '*Future indoor air chemistry*' (D14)
Month 48: Publication(s) submitted (*e.g.* to Indoor Air) defining optimal Indoor Air Chemistry Measurement Campaign (D15); strategy for determining efficacy of mitigation measures (D16)

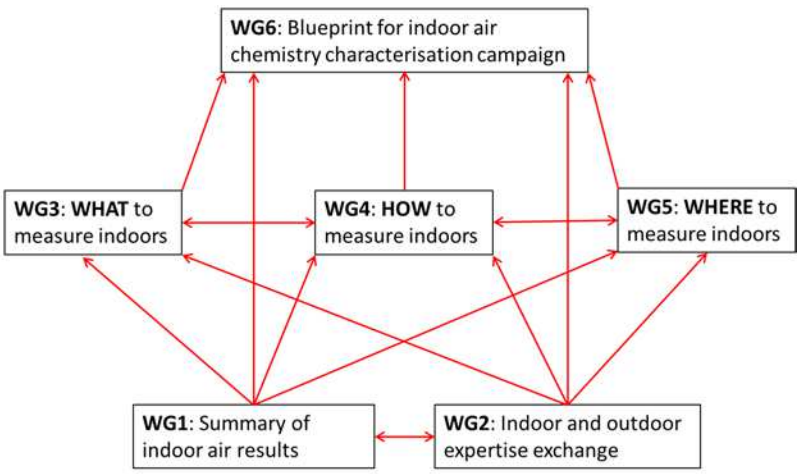
3.1.2. GANTT DIAGRAM

For each WG, tasks will be assigned at the start-up meeting. Where possible, opportunities for additional informal meetings (*e.g.* sub group meetings) at conferences will be taken. There will also be communication via on-line tools/email between formal meetings. Meetings will be alternated between network member states around Europe depending on the composition of particular WGs. The GANTT diagram shows the various activities over the 48 months of the Action lifetime.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
WG1	S					P						R						J																														
WG2	S					P						R																																				
WG3												S						P						R																								
WG4																								S						P						R												
WG5												S												P												R												
WG6																																				S						R						J
Annual report												x												x												x												x
Workshop All	x											x												x												x						x						
ECI forum/training												x												x												x						x						
MC meeting	x					skype						x						skype						x						skype						x						x						

S=start-up meeting; P=progress meeting; R = recommendations/deliverables; J =journal article

3.1.3. PERT CHART



WGs1-2 will produce a summary of current knowledge. Building on these two WPs, WP3-5 will define what species should be measured indoors, how best to measure them and in which types of buildings. Finally, WP6 will set the blueprint for the indoor air chemistry characterization experiment that is required to advance the science significantly in this field of research.

3.1.4. RISK AND CONTINGENCY PLANS

The main risk is that members of the network may feel unable to find time to contribute to the Action activities, or that the partner's funded activities cease making participation more difficult. In order to minimise this risk, the Action has many experts that could address the objectives in each WG, so activities are not reliant on the contributions of only 1-2 people. Tasks for each person/group to complete will be clearly defined, as well as realistic deadlines set for doing so. Meetings will also be organised to facilitate optimal efficiency in terms of discussion (with exchanges between meetings such as defining questions beforehand or drafting discussion papers), but also considering travel times for network members. Participation via the internet (*e.g.* Skype) will also ensure maximum input. WG leaders will be assigned to motivate WG members, monitor progress closely and help group members to complete tasks on time. Finally, many of our network members have worked together on large collaborative projects before and such experience enhances cooperation and minimises risk. However, if deliverables and milestones are unlikely to be completed on time, tasks will be reassigned to others accordingly within the consortium (or the Action will seek relevant new members).

There is also some flexibility in the WG structure. After year 1, each WG is reliant on the outputs from several WGs. If one of the WGs is slightly late delivering a Milestone because some new and interesting research has arisen for consideration, input from other WGs can be considered without losing the opportunity to include new information or causing delays in achieving the overall deliverables. This provides additional resilience, but also flexibility. The Management Committee (MC) will closely monitor the progress of the WGs to prevent slippage where possible. Significant interaction is expected between the WGs and will also be encouraged. The Action will also be in a strong position to react to new legislation if it arises and to make our outputs relevant for such legislation, given the involvement of several network members in relevant ISO projects.

3.2. MANAGEMENT STRUCTURES AND PROCEDURES

Management of the Action will be carried out as per the regulations and procedures described in the COST Rules and with the aim of ensuring the Action objectives are achieved. As for all COST Actions, a MC formed by up to 2 national experts of the signatory countries, will be in charge of implementing, supervising and coordinating the activities of the Action, as well as promoting capacity building, managing the budget and disseminating the results. A Chair and Deputy Chair of the Action will be elected at the first MC meeting and a Grant Holder will be selected. The MC will oversee the composition of various WGs, ensuring that the objectives can be achieved, accounting for the possible non-participation of some members at certain key times as detailed in the contingency plans. The deliverables and tasks are spread evenly over the 4-years and between different areas of expertise to avoid overloading network members. Each member will be involved in several WGs, so their expected tasks within each will be clearly defined. The MC will ensure that funds are distributed accordingly in order to achieve the objectives, milestones and deliverables of the Action in a timely and efficient manner. It will also oversee the dissemination of results and the planning of network activities (*e.g.* workshops, STSMs, ECI training and Fora).

Each WG leader will ensure that activities run smoothly. This person will be someone who is able to commit the necessary time, but diversity will also be considered to ensure there is input from ECIs, COST Inclusiveness Target Countries as well as a good gender balance. He/she will be responsible for reporting on progress at meetings and helping prepare annual reports as well as identifying any targets that are unlikely to be met, so the MC can put contingency plans into action (e.g. identify other/new network members to complete tasks). WG leaders will need to communicate effectively with each other for smooth operation of the network. There will be a flow of knowledge exchange between WGs over the Action lifetime and it is expected that the WG leaders will be in regular contact. They will also be expected to keep the network informed of relevant developments within their WG topic over the full 4 years of the network, not just when they are 'active'. An ECI leader will be identified (ECIL) and help plan ECI specific activities. Finally, a Webpage Manager (WM) will ensure that the Action has an online/social media profile, as well as providing a forum for the network members to collaborate e.g. through a blog. The Chair, Deputy Chair, WGLs, ECIL and WM will coordinate the preliminary activities to be approved by the MC. MC meetings will be held at each of the main workshops, with additional meetings held on-line as necessary.

3.3. NETWORK AS A WHOLE

The network includes indoor and outdoor air chemists (both gas- and particle-phase), engineers, modellers and experimentalists, exposure scientists, toxicologists, materials and standardisation experts, architects and measurement scientists. Although there are pockets of work going on around Europe and the recent European projects highlighted earlier have brought sub-groups together, our network is novel in assembling the expertise necessary for a more holistic approach to understand indoor air chemistry and would simply not be possible on a national level.

Our network comprises members from higher education institutes, business enterprise (including SMEs), governmental/inter-governmental organisations, NGOs and standards organisations. It contains experienced scientists who have led large multi-million euro projects (funded by the EU and others), as well as recent PhD graduates. The network statistics will be monitored as more researchers join the network in order to evaluate the Action's success in achieving gender balance, a range of early and later career researchers and a good geographical spread. Efforts will be made to include a large number of ECIs, with PhD and post-doctoral researchers associated with some of the network members expected to join the network.

There are two IPC members. Prof. Glenn Morrison from the University of North Carolina has been instrumental in driving indoor surface interaction science over recent years as well as being an advocate of combining indoor and outdoor chemistry expertise. Dr. Manabu Shiraiwa from the University of California, Irvine provides expertise in heterogeneous and multiphase chemistry focusing on atmospheric processes through both modelling and kinetic studies. They are involved with a $50M programme on Chemistry of Indoor Environments that focuses on indoor air chemistry and is funded by the Sloan foundation. Their involvement will help to provide a bridge between European and US research.