European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Modelling for Air-Pollution Monitoring

Institute for Environment and Development - IDAD

Aveiro, Portugal, 14 - 15 October 2014

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Research and Innovation Needs Completion of COST Action TD 1105

Marco Alvisi

SIG 1 Leader

ENEA / Italy

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RESEARCH AND INNOVATION NEEDS AND STRATEGIC FORESIGHT ON AQC

General goal:

To collect needs in research and innovation and in strategic foresight for each partner of the COST Action TD1105 *EuNetAir* on AQC, **in order to develop a first synthetic roadmap for future actions in the field of AQC** (research, infrastructures, legislation)

Specific goals:

- 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 **investigate the best available technology** for sensor deployment, communication, power supply and data storage, analysis and display
- to **provide to the EU community and institutions a complete overview** on the research and innovation needs in ACQ in Europe
- to **provide the challenges and strategic foresight** in AQC in Europe
- to **propose a Roadmap for the implementation of infrastructures, legislation, technologies, education** on AQC in Europe

OUTLINE

- **WG1 R@I NEEDS**: Sensor Materials and Nanotechnology
- **WG2 R@I NEEDS** : Sensors, Devices and Systems for AQC
- **WG3 R@I NEEDS** : Environmental Measurements and Air-Pollution Modelling
- **WG4 R@I NEEDS** : Protocols and Standardisation Methods
- **SIG1-SIG4 R@I NEEDS** :
  - ✓ **SIG1**: Network of Spin-offs
  - ✓ **SIG2**: Smart Sensors for Urban Air Monitoring in Cities
  - ✓ **SIG3**: Guidelines for Best Coupling Air-Pollutant & Transducer
  - ✓ **SIG4**: Expert Comments for Revision of Air Quality Directive

CONCLUSIONS AND FUTURE ACTIONS

WG1 R@D NEEDS: Sensor Materials and Nanotechnology

WG1-Leader:	• **Prof. Juan Ramon Morante, IREC, Barcelona, Spain** • **Prof. Jyrki Lappalainen, Oulu University, Finland (*Cambridge Meeting WG1 Chair*)**
WG1 Composition:	**3 Sub-WG Leaders and 25 Members**

A1:	Selectivity improvement using various material structures, functionalizations, and combinations, device structures.
B1:	To stabilize the structure and morphology of sensing materials for a higher stability of the response of sensors.
C1:	Knowledge of the physiochemical interaction phenomena and modeling of the sensor‘s gas response, including gas transformation, surface reactions, etc.
E1:	The effect of RH on the response of sensors must be studied, not only at one particular value, but also in a broad RH range.
F1:	In order to obtain a confident opinion on the performance of a material, in terms of stability and reproducibility of the sensing response, the inter-laboratory reproducibility of materials should be studied.

WG2 R@D NEEDS : Sensors Devices and Sensor-Systems for AQC

WG2-Leader:	**Prof. Andreas Schuetze, Saarland University, Germany**
WG2 Composition:	**4 Sub-WG Leaders and 40 Members**

A2:	Versatile µ-transducers for integration of various (nano) materials (**low cost, low power)**
B2:	**Selective filters** integrated in sensors or sensor modules
C2:	Be open for novel sensing methods: (dosimeter approach, ecc.)
D2:	MEMS and beyond: (low cost microstructured sensors, other sensor technologies)
E2:	**Nanoparticle detection** for dust and aerosols
F2:	**Combination of sensor principles (**Temp., r.h., barometric pressure **plus** sensor correlation)
G2:	**Dynamic operation/self referencing of sensors** to obtain more than one signal from a single sensor (better selectivity and stability, self-monitoring/self-calibration) **at the sensor module level**
H2:	**Optimized calibration (**Simple calibration for manufacturers, Ideally no re-calibration)
I2:	**User and network interface** optimization (simple and easily, qualitative display, quantitative data with uncertainty estimate for sensor networks, Feedback channel for data input from the user)
L2:	**Outdoor air quality monitoring** (better information for citizens and awareness of pollution)

WG2 R@D NEEDS : Sensors Devices and Sensor-Systems for AQC

WG2-Leader:	**Prof. Andreas Schuetze, Saarland University, Germany**
WG2 Composition:	**4 Sub-WG Leaders and 40 Members**

M2:	Indoor air quality monitoring (controlled ventilation due to monitoring of hazardous VOC, Reduced health hazards plus improved energy efficiency)
N2:	Outdoor monitoring of pollution sources (Identification of sources and minimizing of emissions)
O2:	Closed loop process control (minimizing emissions at source incl. active countermeasures)
P2:	Identification of reference applications
Q2:	Sensors on/in smartphones with open data interface
R2:	Intelligent sensor modules for NOx, O3, NH3, H2S, SO2, VOC, PM,Electronics combined with sensor elements
S2:	Intelligent sensor nodes and (heterogeneous) networks (Data pre-processing and processing (in node and/or in network: parallel and distributed computing, Energy efficient communication)
T2:	Demonstrate the potential of (micro) sensor systems in the context of environmental sensing (complementarity, added resolution - spatial and temporal, improved information to and feedback from citizens), including an assessment of performance

WG3 R@D NEEDS : Environmental Measurements and Air-Pollution Modelling

WG3-Leader:	**Prof. Ole Hertel, Aarhus University, Denmark**
WG3 Composition:	**3 Sub-WG Leaders and 35 Members**

A3:	PM monitoring strategies should be**:** ➢improved - complementary by particle counts not only mass measurements,even more PM mesaurements in more than 2 channels (PM10, PM2.5) should be investigated, EC/OC measurements in 1h ?, discretization should be considered:
B3:	•Still many unknowns in respect to health effects - e.g. what in PM is causing negative health effects - constituents, ultrafine? •Airborne allergens may also be an issue of interest Assessment of health effects of emissions from agricultural sources (fungal spore, animal material, ammonia) and from wood stoves
C3:	The model systems are very difficult to expand to other air pollutants as they are highly dependent on one of two things: 1) high quality and very detailed emissions inventories or 2) access to low cost sensors in a dense network. Here it seems as only a few components can be measured.
D3:	•Observations seem mainly fixed to stationary stations on ground. Use of portable observations (e.g. on busses) should be explored much more (includes the use drones) •Secondly there is a great need of observations that are obtained away from the surface and in the free atmosphere. •Need for best praxis regarding exposure modelling – which models for which purposes – scale, type etc.
E3:	✓Many air pollutants (chemical and biological) have strong urban components. Robust urban models (not street canyon models) are lagging behind compared with LRT models and this puts limits on our understanding on urban air quality. ✓This is also relates to robust footprint modelling methods that can work on both urban and regional scale. ✓Citizens involvement projects should also in the future be encouraged.

WG4 R@D NEEDS : Protocols and Standardisation Methods

WG4-Leader:	**Prof. Ingrid Bryntse, SenseAir SA, Delsbo, Sweden**
WG4 Composition:	**3 Sub-WG Leaders and 25 Members**

A4:	**New sensors** developed in Europe should be further developed into products / systems, available on the global market.
B4:	In order to manufacture well-performing sensors or analysers it is necessary to have *automatic calibration* for high-volumes.
C4:	If we want to compete with low-cost manufacturers outside Europe we need as *efficient calibration processes* as possible.
D4:	Calibration should also include *verification using final test stations*
E4:	Calibration Guideline
F4:	Ultrafine Particle Sensors, Low-cost
G4:	Testing Protocols **Laboratory and Field Testing at National Accredited Test Laboratories**

SIG1 R@D NEEDS : Network of Spin-offs

SIG1-Leader:	**Dr. Marco Alvisi, ENEA, Brindisi, Italy**
SIG1 Composition:	**1 SIG1 Deputy and 15 Members**

Challenges:	•Low power devices, long lifetime and maintenance free /Convince the market that new air quality network can improve the quality of life /Engage the citizens through citizens observatories /Convince the public institutions of the impact of odour nuisance /To work in harsh environments
Research goals of spin-off and companies	Greater communication distances for wireless network of sensors/New sensors for odour assessment/Air-quality case-studies, stability assessment/Calibration strategies for low cost sensing devices/Work on POP (persistent organic pollutant) detection/Biosensor based on enzyme for dioxin and POP, work on POP detection/Chemical and radiation environmental monitoring/Ozone sensors, NOx and CO and CO2 sensors for automotive application/Improve stability of available sensors, compatibility with CMOS microelectronics, soft CMOS post-processing methods for reproducible high throughput manufacturing/Toxic and explosive (hydrogen) gas leakage/VOC detection developing sensors modules and sensor systems/Indoor air quality control, leak detection/Odour monitoring system (odour telephone)/Enhancement of the sensing properties by introducing functional receptive groups/Coupling different transduction modes in the same device
Priority Innovation Requirements	•Evaluate market opportunities for encouraging EU investment in specific topic of AQC and direct SME, RD effort. •Develop legislation in different areas of air quality control and push the creation, extension and adoption of regulations (i.e. methodologies, guidelines) at EU levels •Low cost devices and easy to use for odour monitoring •Training school for new “ambassadors” that can promote air quality management •Engage the citizens of the AQC concept •Education and dissemination of AQC concept (school, institutions, sales, politicians, ONG etc.)

SIG2 R@D NEEDS : Smart Sensors for Urban Cities Air Monitoring

SIG2-Leader:	**Prof. Rod Jones, University of Cambridge, Cambridge, UK**
SIG2 Composition:	**1 SIG2 Deputy and 30 Members**

S2:	**Discussion of «*Smart*»:** ✓Self-monitoring: e.g., fault detection ✓Clever design/manufacturing: e.g., self-calibrating. *Ideally both needed*. ✓Smart use of «*stupid*» (not educated) sensors
S2:	**Sensor Systems:** sensors + analysis/correction + archiving + data mining + mapping + interpretation/dissemination ✓**Deliver answers to:** General public (low pollution routes/traffic flow), Legislature/compliance Health impacts community, Activity goes way beyond *simple* sensor development
S2:	**Modelling (physical/statistical/numerical/machine learning):** •Use of sensor network models (e.g. LUR but also physical) to mapping for emission inventories and exposure. •Use of sensor network models to define/optimise network deployments •Innovative numerical approaches (share datasets?) - improve mapping/sensor performance? •Improve network configuration/calibration/QC **Technical aspects:** Future proofing - network sustainability? Sensors/technologies (e.g. comms) Network scalability/transferability ; Maintenance of data (metadata)
S2:	**Roadmap issues**:Put A/Q on same level as weather forecast - alter societal behaviour… Integrate institutional and informal networks ….

SIG3 R@D NEEDS : Guidelines for Best Coupling Air-Pollutant and Transducer

SIG3-Leader:	• **Prof. Giorgio Sberveglieri, University of Brescia, Brescia, Italy** • **Prof. Eduard Llobet, Universitat Roviri I Virgili, Tarragona, Spain (*Cambridge Meeting SIG3 Chair*)**
SIG3 Composition:	**1 SIG3 Deputy and 15 Members**

S3	Possibility of detecting VOCs at ppb levels.
S3	Need for detecting PM with affordable sensors
S3	Sensing materials based inks for fully printed sensors
S3	Appropriate testing of sensors under realistic conditions to speed up development time.
Challenges:	Develop stable transducers by mass production methods / What is the effect of temperature and humidity on the transducers? / Develop active materials by easy scalable methods / Integrate active materials in transducers reliably and inexpensively / Finding a rationale for choosing active material and transducer according to the target pollutant(s)
S3	Coupling air pollutants to transducers generally overlooked.
S3	Detecting pollutants at required levels (e,g, ppb for toxic gases, detection of nanosized PM).
S3	Sensing materials based inks for fully printed sensors.
S3	Appropriate testing of sensors under realistic conditions to speed up development time

SIG4 R@D NEEDS : Expert Comments for the Revision of the Air Quality Directive

SIG4-Leader:	**Dr. Thomas Kuhlbusch, IUTA eV, Duisburg, Germany** **Prof. Iveta Steinberga LATVIA UNIV. *(Cambrige Meeting SIG 4 Chair)***
SIG4 Composition:	**1 SIG4 Deputy and 25 Members**

S4	Link PM health effects to specific constituents.
S4	Price of health, improved strategies for economical assessment of air pollution
S4	Investigation of PM morphology (e.g. SEM-EDX) it`s relation to fibrosis.
S4	Establishing EU guidelines for indoor air quality (references values?) - review of existing situation in Europe; establishing indoor (AQ) index
S4	Exposure index, public information
S4	Review of **AQD implementation problems** and proposals how these could be targeted by application of sensors
S4	**Recommendations** on: New Metrics (e.g., Black Carbon), Data Quality Requirements, Use for Model Improvements, Specific Research Needed
S4	**Guidelines** on *Data Quality Requirements* for sensors to be used in relation to AQD (e.g, support indicative screening or complementary modeling)

CONCLUSIONS AND FUTURE ACTIONS

Propose to the next MC of the Cost Action a “Small Group” in order to:

- Decide the outline of a first, useful, easy-to-read paper on R@I Needs in AQC in Europe
- Edit and revise with Cost Action partecipants the document
- Define and write a Roadmap for the implementation of activities, infrastructures, legislation, technologies, education as output of the ACTION COST TD1105

THANK YOU!