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

## COST Action TD1105

# SENSOR+TEST 2016 - AMA Conference

## *SPECIAL SESSION*

## *Novel Sensor Solutions for Indoor Air Quality*

**NCC, Nuremberg, Germany, 10 - 12 May 2016**

**Action Start date: 01/07/2012 - Action End date: 15/11/2016 - Year 4: 2015-16 (*Extended Action*)**

# *COST Action TD1105: Overview and Plans*


**Michele Penza**

Action Chair

**ENEA - Brindisi, Italy**


COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

# Outline


- **Background / Problem Statement:**
  - ✓ *Scientific context*
  - ✓ *Challenges addressed by the Action*
- **MoU Action's Objectives:** *Main and Secondary*
- **Action Research Directions:**
  - ✓ *Methodology and Innovation*
- **Working Groups**
- **Results versus Objectives:** *Significant Highlights*
- **Future Plans and Challenges:** *Expected Impact*
- **Concluding Remarks**

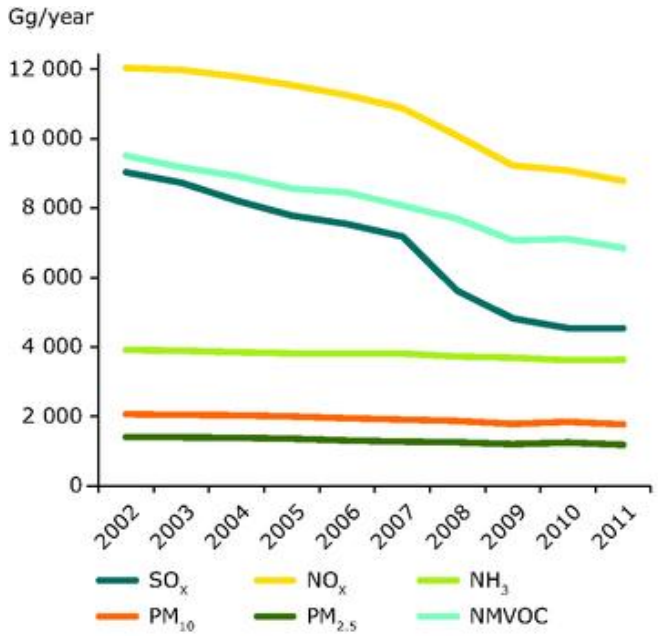
# Scientific context: Air Quality Control (2/3)

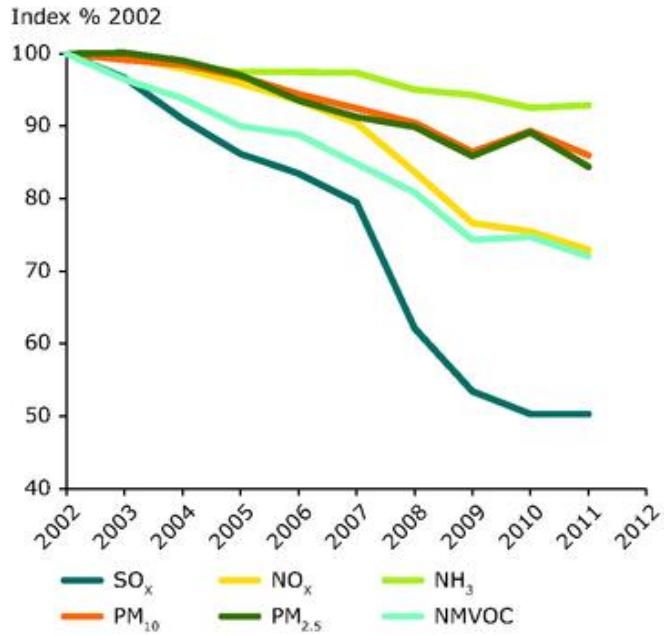

**Some Environmental Emergencies:**

**1930 - Meuse Valley (Belgium)**
**1952 - Great London Smog (UK)**
**1954 - Los Angeles (USA)**
**1984 - Bhopal (India)**
**2005 - Teheran (Iran)**
**2006 - Hong Kong**
**2008, 2015 - Shanghai, Peking, CN**
**2012 - Taranto (Italy)**
**.....**

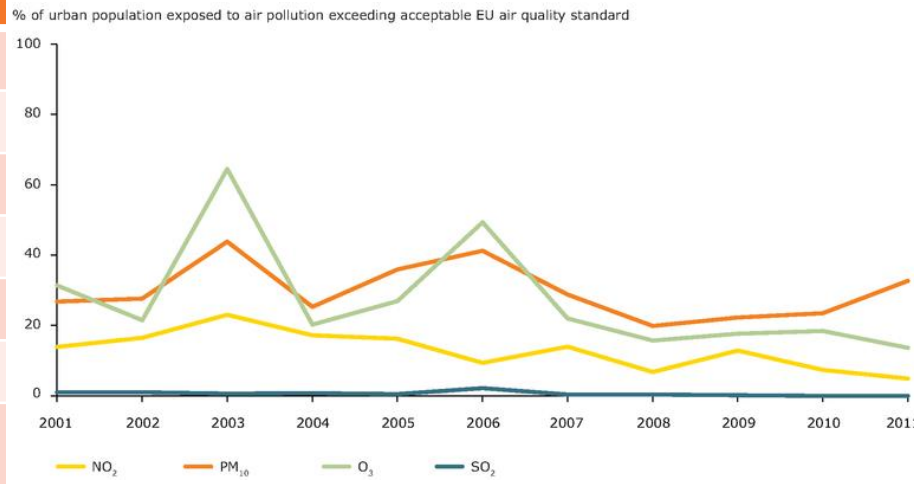
**AMBIENT AIR QUALITY**
**EU DIRECTIVE 2008/50/EC**
**and Daughters**

***European Environment Agency, EEA Report 9/2013***




| Pollutant | Limit Level |
|---|---|
| $NO_x$ | 100, 200 ppb |
| CO | 8 ppm |
| $SO_2$ | 130, 190 ppb |
| $O_3$ | 120 μg/m³ |
| $PM_{10}$ | 50 μg/m³ |
| BTEX | 6 μg/m³ |
| PAH (BaP) | 1 ng/m³ |
| $PM_{2.5}$ | 25 μg/m³ |

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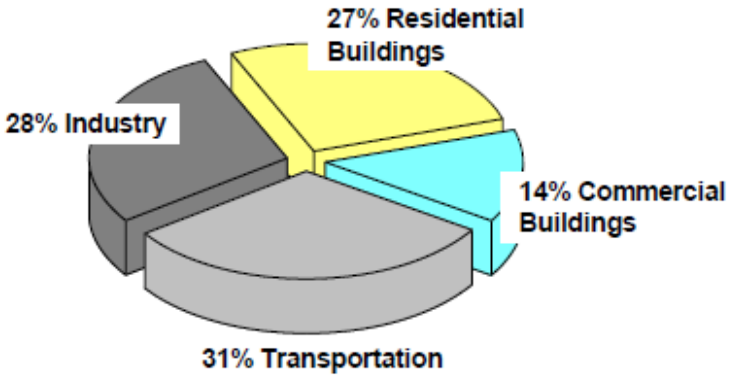
# Scientific context: Indoor/Outdoor Energy Efficiency (3/3)




*Primary energy consumption in the EU*[1]

[1] *O. Seppanen, 11th Conference on Indoor Air Quality 2008, Copenaghen, Denmark*

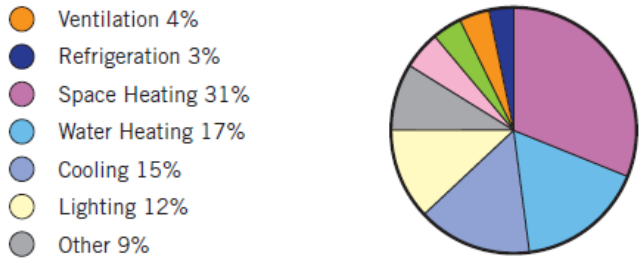
**41% Primary Energy consumed in Buildings:**

- 2/3 in Residential Buildings
- 1/3 in Commercial Buildings

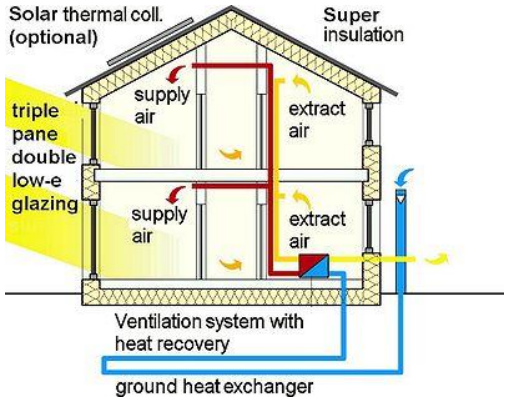
**Energy Performance of Buildings EU Directive EPBD 2010/31/EC**

**Figure 2 – Total Energy Consumption by End Use**

*Adapted from E Source, 2006*




*Source: Environmental Protection Agency's National Action Plan for Energy Efficiency Sector Collaborative on Energy Efficiency Hotel Energy Use Profile*

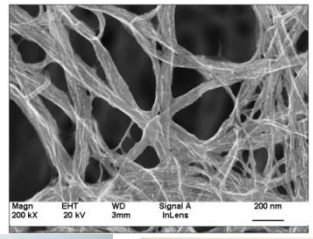



**IAQ by WORLD HEALTH ORGANIZATION**

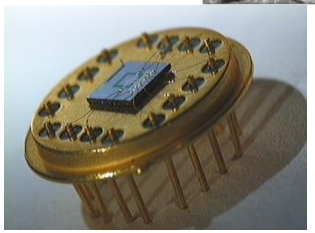
| Indoor Air | | Typical Substances | | Cure |
|---|---|---|---|---|
| Contamination Source | Emission Source | VOCs | Others | |
| • Human Being | • Breath | Acetone, Ethanol, Isoprene | | demand controlled ventilation |
| | | $CO_2$ | | |
| | | Humidity | | |
| | • Skin Respiration & Transpiration | Nonanal, Decanal, α-Pinene | | |
| | | Humidity | | |
| | • Flatus | Methane, Hydrogen | | |
| | • Cosmetics | Limonene, Eucalyptol | | |
| | • Household Supplies | Alcohols, Esters, Limonene | | |
| | • Combustion (Engines, Appliances, Tobacco Smoke) | Unburnt Hydrocarbons | | |
| | | CO | | |
| | | $CO_2$ | | |
| | | Humidity | | |
| • Building Material<br>• Furniture<br>• Office Equipment<br>• Consumer Products | • Paints, Adhesives, Solvents, Carpets | Formaldehyde, Alkanes, Alcohols, Aldehydes, Ketones, Siloxanes | | permanent 5-10% ventilation |
| | • PVC | Toluene, Xylene, Decane | | |
| | • Printers, Copiers, Computers | Benzene, Styrene, Phenole | | |

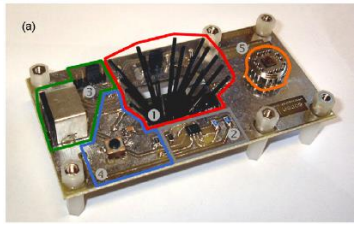
Table 1 – Typical Indoor Air Contaminants (VOCs and others)

# Challenges addressed by Action TD1105 (1/1)

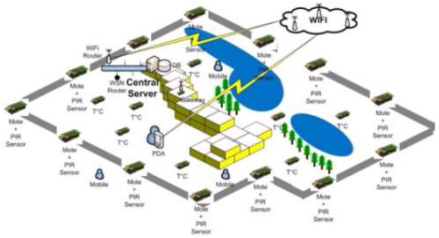


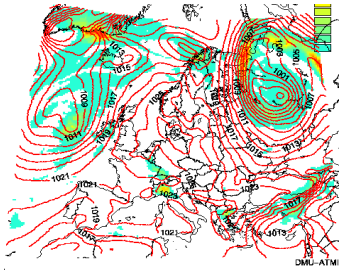
- **Nanomaterials for AQC sensors**
- **Low-cost Gas Sensors**
- **Low-power Sensor-Systems**

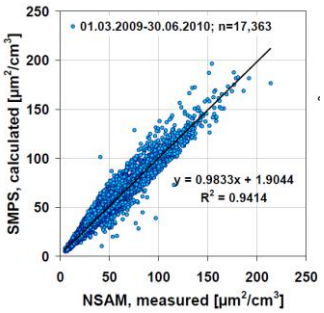




- **Wireless Technology (*Environmental Sensors Network*)**
- **Air Quality Modelling**
- **Environmental Measurements**
- **Standards and Protocols**



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

# Action's Objectives (1/1)

## MoU Main Objectives of COST Action TD1105:

- *To establish* a *Pan-European multidisciplinary R&D platform* on new sensing paradigm for Air Quality Control (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 (ESRs)* and new young scientists in the field for supporting competitiveness of European industry by qualified human potential.
- *To promote* *gender balance* and involvement of ESRs in AQC.
- *To disseminate* *R&D results on AQC* towards industry community and policy makers as well as general public and high schools.

# COST Action TD1105 *EuNetAir*: Working Groups (1/5)

**www.cost.eunetair.it**


**WG1**:
Sensor Materials
&
Nanotechnologies

**WG2**:
Sensors, Devices
& Systems for AQC

**WG4**:
Protocols &
Standardisation
Methods

**WG3**:
Env. Measurements
&
Air Pollution Modelling

INTERDISCIPLINARY
SPECIAL INTEREST GROUPS

**MANAGEMENT COMMITTEE**:

**CORE-GROUP & STEERING COMMITTEE**

- *Editorial Board*
- *Dissemination*
- *Training Schools*
- *Gender Balance*
- *Early Stage Researchers (ESR)*
- *Short-Term Scientific Mission (STSM)*
- *Intellectual Property Rights (IPR)*
- *Local Organizing Committee (LOC)*

- SIG 1: *Network of Spin-offs*
- SIG 2: *Smart Sensors for Urban Air Monitoring in Cities*
- SIG 3: *Guidelines for Best Coupling Air Pollutant-Transducer*
- SIG 4: *Expert comments for the Revision of the Air Quality EU Directive*

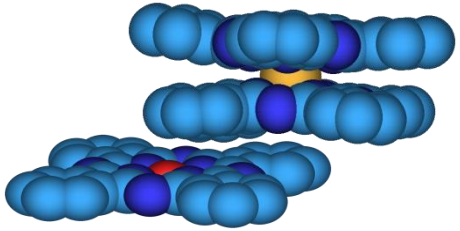
**Action (2012-2016) Size:**

**200 Experts from 120 Teams - 31 Countries**

# TD1105 *EuNetAir* WG1: Sensor Materials & Nanotechnologies (2/5)

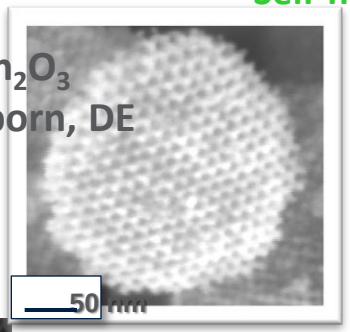
*WG1 Chair: Prof. Juan Ramon Morante, IREC, Spain*

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

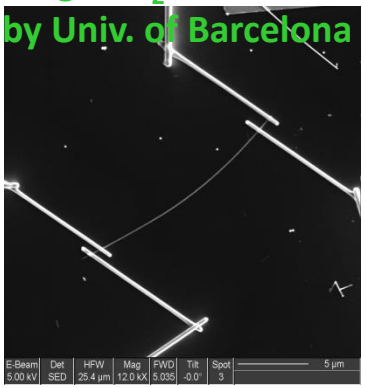


New molecular materials of polymer-macrocycles as transducers for polluting gas sensing by University of Bourgogne

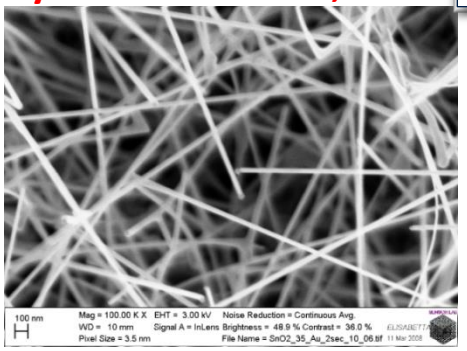
Mesoporous $In_2O_3$ by Univ. of Paderborn, DE

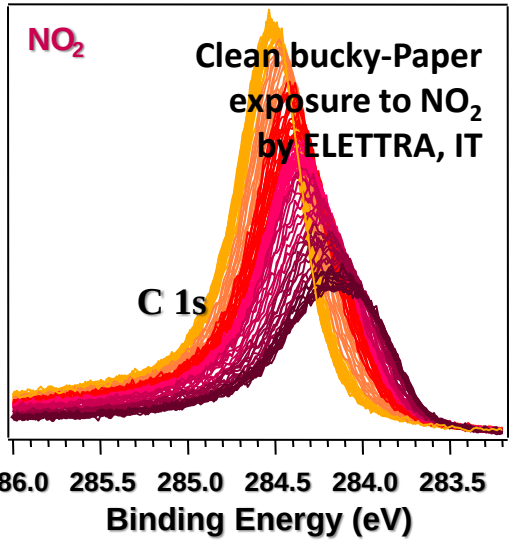



Self-heating $SnO_2$ Nanowires by Univ. of Barcelona

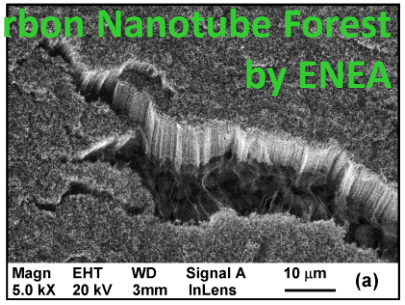


Metal oxide ($SnO_2$) Nanowires nets by Univ. of Brescia, IT

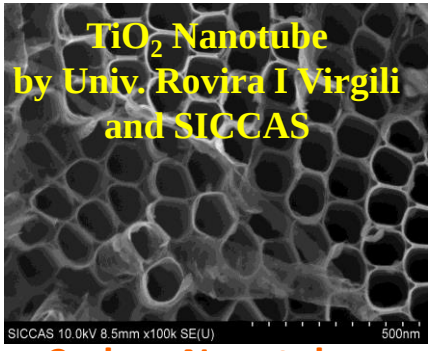




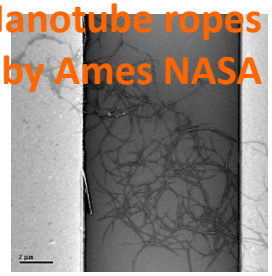

Carbon Nanotube Forest by ENEA



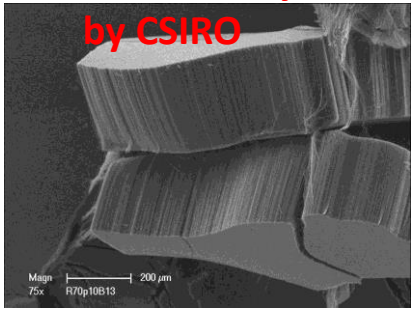

$TiO_2$ Nanotube by Univ. Rovira I Virgili and SICCAS




Carbon Nanotube ropes by Ames NASA



Carbon Nanotube yarns by CSIRO



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# TD1105 *EuNetAir* WG2: Sensors, Devices and Systems for AQC (3/5)

*WG2 Chair: Prof. Andreas Schuetze, Saarland University, Germany*

- **Sub-Working Group 2.1**:

  **Gas sensors and new transducers.**

- **Sub-Working Group 2.2**:

  **Portable gas sensor-systems.**

- **Sub-Working Group 2.3**:

  **Wireless technology and AQC sensors network.**

- **Sub-Working Group 2.4**:

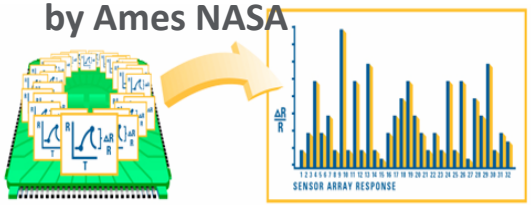
  **Intelligence algorithms and distributed computing for networked AQC gas sensors.**


Warwick University in collaboration with Cambridge University, EPFL, PennState.

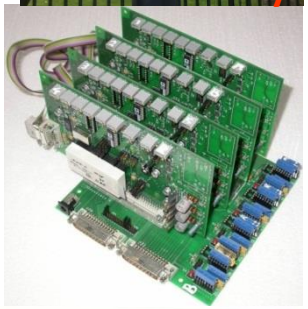
*IT PATENT ENEA*
*Carbon Nanotube Gas Sensors*

EnviroWatch mote by Newcastle University

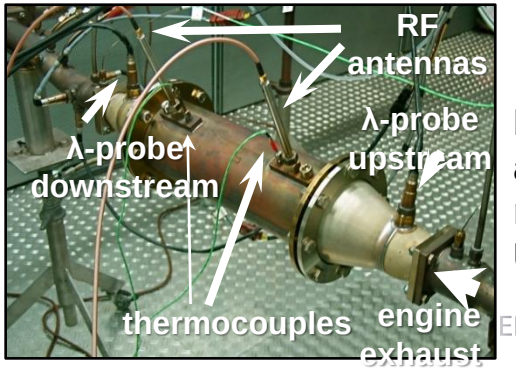
by Ames NASA




Using pattern matching algorithms, the data is converted into a unique response pattern

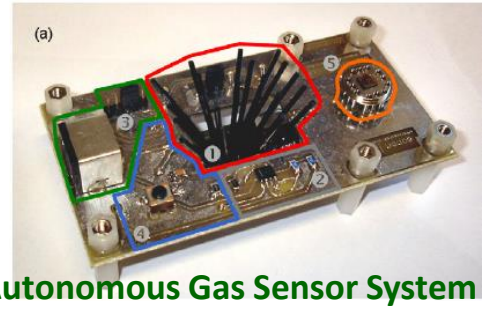


A versatile platform for the efficient development of gas detection systems based on automatic device adaptation by University of Saarland.




Direct status measurement of automotive catalysts by radio-frequency technique by University of Bayreuth, DE.

Environmental Sensor demo by IMEC, NL




Low-ppb sensitivity for $NO_2$ GaN-based sensor concept

Autonomous Gas Sensor System by IREC and Univ. of Barcelona

# TD1105 WG3: Environmental Measurements and Air-Pollution Modelling (4/5)

*WG3 Chair: Prof. Ole Hertel, Aarhus University, Denmark*

- **Sub-Working Group 3.1**:

  **Environmental measurements at laboratory and in field air-quality stations.**

- **Sub-Working Group 3.2**:

  **Air-quality modelling and chemical weather forecasting.**

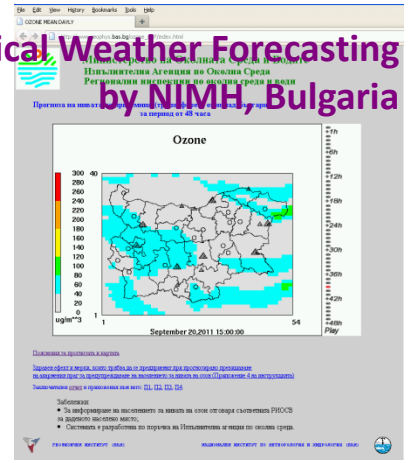
- **Sub-Working Group 3.3**:

  **Harmonisation of environmental measurements.**

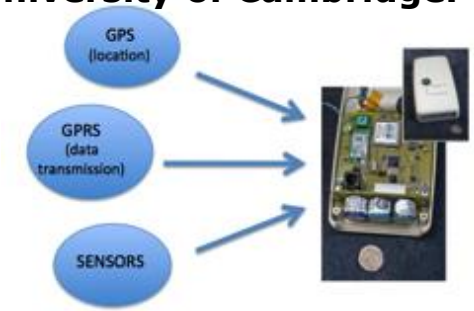
by Aristotle University, EL

AirMerge system for Chemical Weather Models

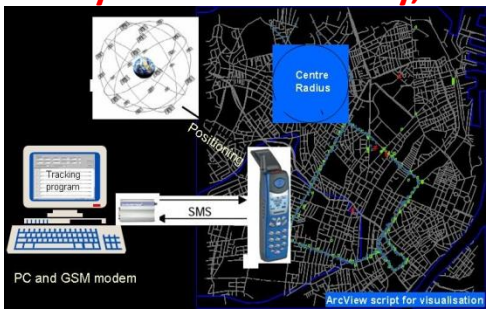
Chemical Weather Forecasting by NIMH, Bulgaria




**Mobile and static sensor network configurations by University of Cambridge.**




AQ Modeling: Tracking routes by Aarhus University, DK




Environmental measurements of PM and air pollution by CSIC, ES


AQ monitoring station by ARPA-PUGLIA, IT


AQ monitoring station by Aarhus University, DK


AQ monitoring station by Lithuanian EPA

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# TD1105 *EuNetAir* WG4: Protocols and Standardisation Methods (5/5)

*WG4 Chair: Prof. Ingrid Bryntse, SenseAir AB, Sweden*

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

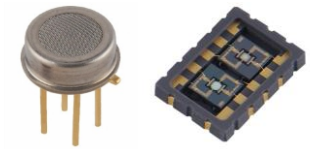
European Directive 2008/50/EC: Ambient Air Quality

EU standard EN 13725/2003: Dynamic Olfactometry

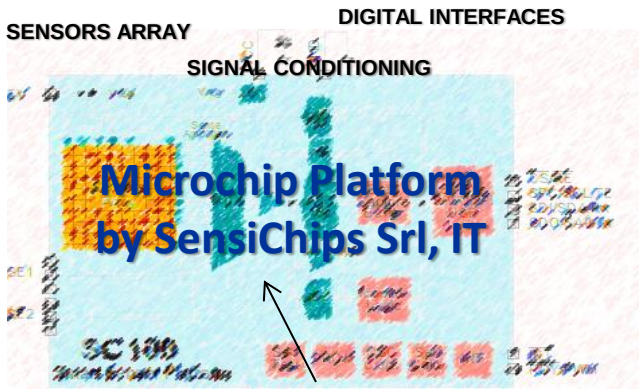
Protocols and Standardised Methods for Gas Sensors

Guidelines of Best Transducers applied to specific gases

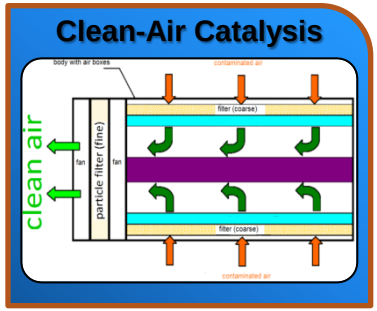
Dynamic olfactometry EN13725 by Univ. of Liege, Odometric SA, Univ. of Bari, Lenviros srl.



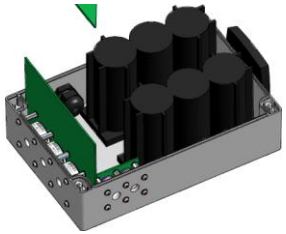
Packaged Sensors by E2V, CH




New precision multi-parametric analytical tool




Becker Gruppe, DE



Battery-Powered Sensors by Alphasense Ltd, UK

$CO_2$ IR sensor for alarm System by SenseAir AB, Sweden

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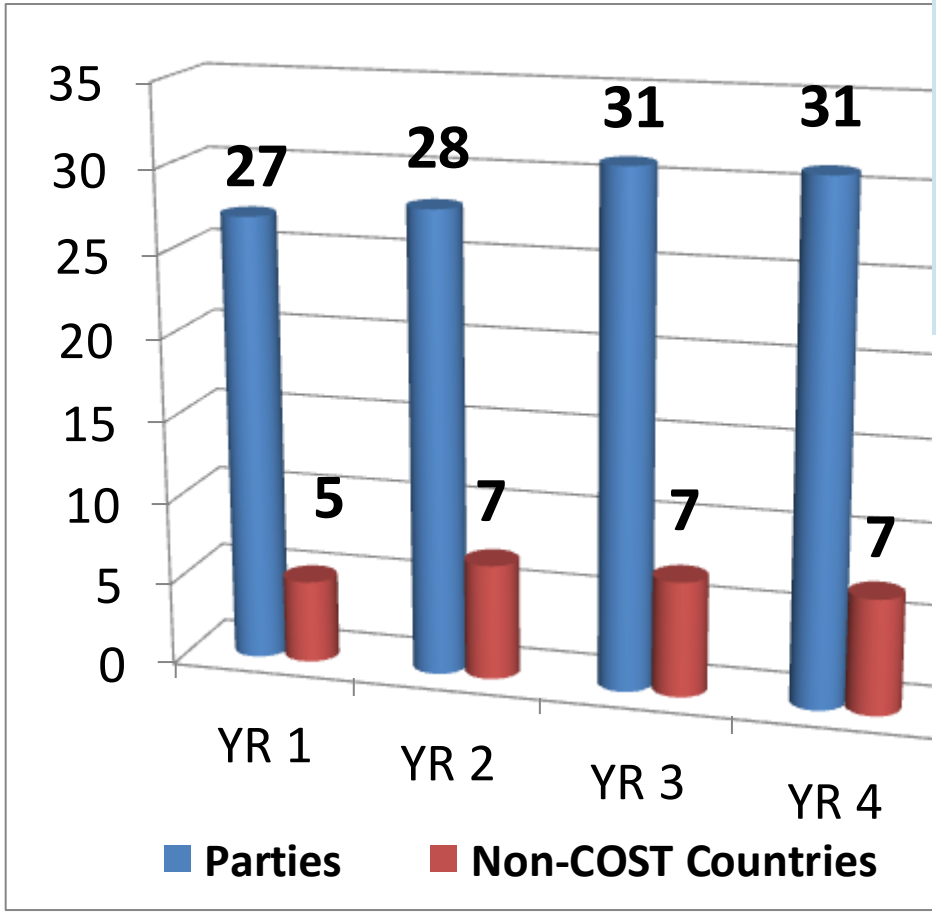
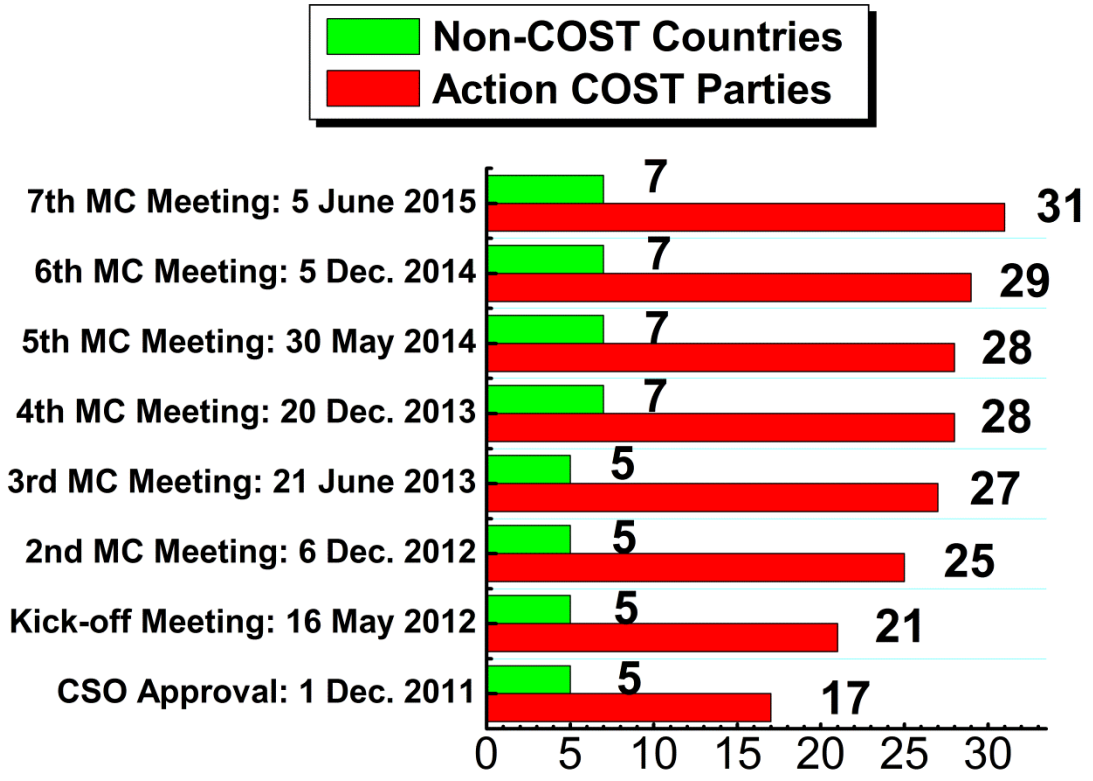
# COST Action TD1105 EuNetAir: Action Parties (31)

**Grant Holder:**
Eurice GmbH, Saarbrucken, Germany
***GH Scientific Representatives***:
Corinna Hahn, MC Member
Juliane Rossbach, MC Substitute




**Non-COST Countries: NNC + IPC**

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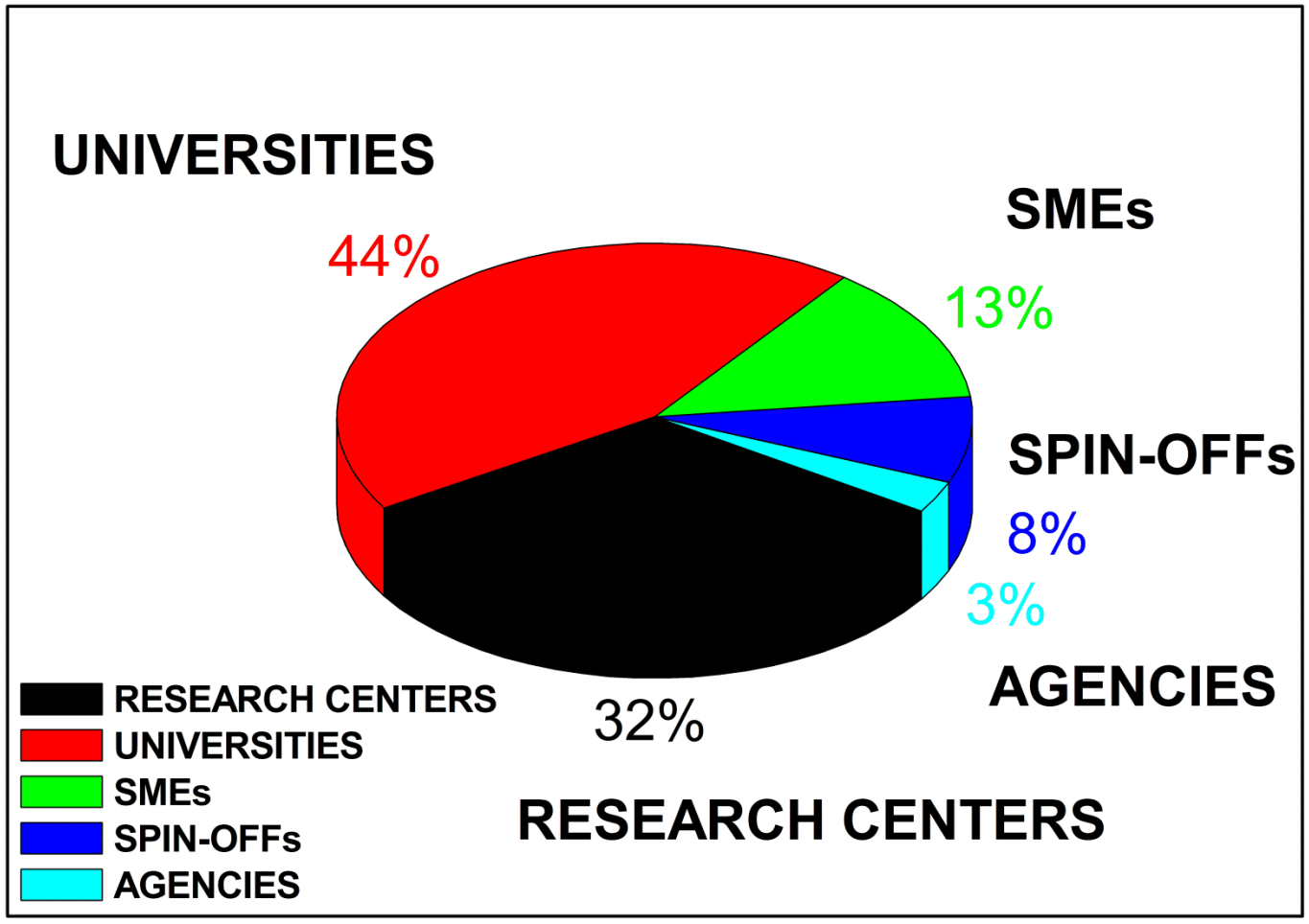
# Action Participation Statistics

## *EuNetAir* COST PARTNERSHIP May 2016




**COST Parties: 31**
**COST Organizations: 123**
**UNIVERSITIES: 55**
**RESEARCH CENTERS: 39**
**SMEs: 16**
**SPIN-OFFs: 9**
**AGENCIES: 4**

# COST Action TD1105 *EuNetAir*

**31 COST Countries (Parties) have already signed Memorandum of Understanding (MoU)**

## PARTIES: 31

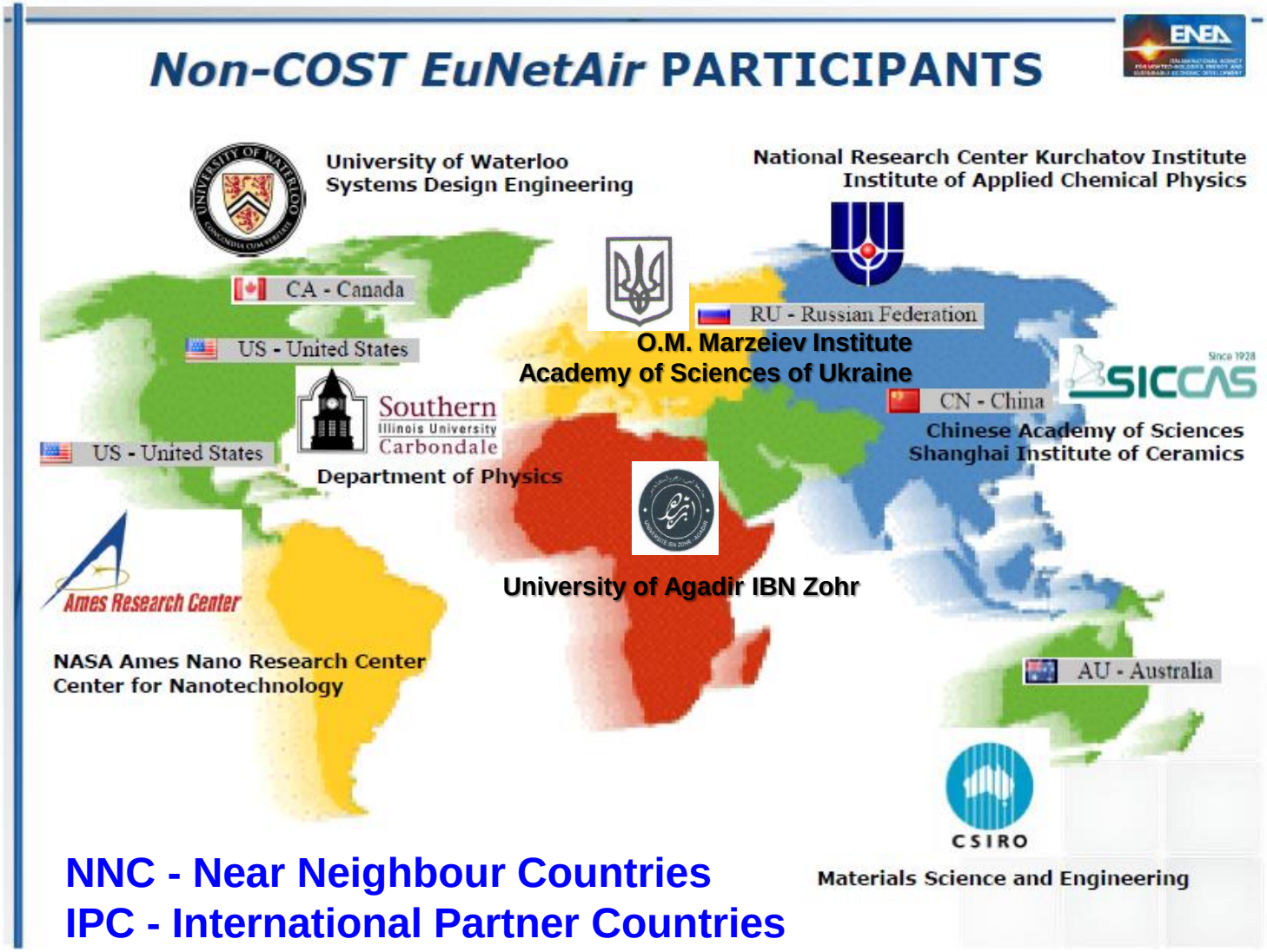
**already accepted MoU**

**Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, The Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom**

# COST Action TD1105 *EuNetAir*: 7 Non-COST Countries and 8 Non-COST Institutions

**Non-COST Countries:**
**Australia, Canada, China, Morocco, Russia, Ukraine, USA**

**Non-COST Institutions:**
CSIRO (Australia); University of Waterloo (Canada); Chinese Academy of Sciences, Shanghai Institute of Ceramics (China); University of Agadir IBN Zohr (Morocco); National Research Center Kurchatov Institute (Russia); O.M. Marzeiev Institute for Hygiene and Medical Ecology of Academy of Science of Ukraine (Ukraine); Southern Illinois University Carbondale, NASA Ames Research Center (USA).



# External Experts involved from International Organizations

| International Organization | External Expert | Action Event |
|---|---|---|
| **JRC - IES, Ispra** | *Michele Gerboles* | • Rome, 3-5 Dec. 2012<br>• Barcelona, 20 June 2013<br>• Brescia, 10 Sept. 2014<br>• Linkoping, 3-5 June 2015<br>• Vienna, 25-26 February 2016 |
| **AQUILA Network** | *Annette Borowiak* | • Duisburg, 4-6 March 2013 |
| **European Environment Agency (EEA)** | *Valentin Foltescu*<br>*Cristina Guerreiro (NILU)* | • Copenhagen, 3-4 Oct. 2013<br>• Vienna, 25-26 February 2016 |
| **US Environment Protection Agency (EPA)** | *Tim Watkins* | • Cambridge, 18-20 Dec. 2013 |
| **UNECE** | *Wenche Aas (NILU)* | • Copenhagen, 3-4 Oct. 2013 |
| **WHO Europe** | *Michal Krzyzanowski (Former Head WHO Europe Office)* | • Riga, 26-27 March 2015 |
| **MIT, USA** | *Marguerite Nyhan* | • Istanbul, 3-5 Dec. 2014 |
| **NASA Ames Research Center** | *Meyya Meyyappan*<br>*Jing Li* | • Rome, 3-5 Dec. 2012<br>• Lille, 26-30 May 2014 |
| **CSIRO, Australia** | *Philip J. Martin* | • Barcelona, 20 June 2013 |
| **QUT, Australia** | *Zorane Ristovski* | • Belgrade, 13-14 Oct. 2015 |

| Country | MC Members (58): *Male (69%) - Female (31%)* |
|---|---|
| Austria | Dr. Anton KOCK |
| Belgium | Dr Jan THEUNIS; Dr Anne-Claude ROMAIN |
| Bulgaria | Dr Dimiter SYRAKOV; Dr Ivan NEDKOV |
| Croatia | Dr. Irena CIGLENECKI-JUSIC; Prof. Vedran BILAS |
| Czech Republic | Dr. Vera KURKOVA; Dr. Zdenek ZELINGER |
| Denmark | Prof. Ole HERTEL |
| Estonia | Prof. Raivo Jaaniso |
| Finland | Prof. Kaarle HAMERI; Prof. Jyrki LAPPALAINEN |
| France | Prof. Marcel BOUVET; Prof. Jerome BRUNET |
| Germany | Prof. Andreas SCHUETZE; Dr Corinna HAHN |
| Greece | Prof. George PAPADOPOULOS; Prof. Kostas KARATZAS |
| Hungary | Ms Krisztina LABANCZ; Dr Zita FERENCZI |
| Iceland | Dr Arngrimur THORLACIUS |
| Ireland | Dr. Francesco PILLA; Prof. John WENGER |
| Israel | Dr. Liad ORTAR; Prof. Hossam HAICK |
| Italy | Dr. Michele PENZA; Prof. G. SBERVEGLIERI; Dr. G. DE GENNARO |
| Latvia | Dr. Iveta STEINBERGA; Dr. Gita SAKALE |
| Luxembourg | Dr. Arno GUTLEB |
| Macedonia Rep. | Dr. Igor ATASANOV; Dr. Ljupcho GROZDANOVSKI |
| Netherlands | Dr Sywert BRONGERSMA; Dr. Ernie WEIJERS |
| Norway | Dr Nuria CASTELL BALAGUER; Dr. Philipp SCHENEIDER |
| Poland | Dr Monika KWOKA; Prof. Janislaw GAWRONSKI |
| Portugal | Prof. Bernadete RIBEIRO; Prof. Carlos BORREGO |
| Romania | Dr Marcel IONICA; Dr Roxana Mioara PITICESCU |
| Serbia | Dr. Anka CVETKOVIC; Dr. Milena JOVASEVIC-STOJANOVIC |
| Slovenia | Dr Grisa MOCNIK; Dr Rahela ZABKAR |
| Spain | Prof. Juan Ramon MORANTE; Prof. Eduard LLOBET VALERO |
| Sweden | Prof. Anita LLOYD SPETZ; Prof. Ingrid BRYNTSE |
| Switzerland | Dr Danick BRIAND; Dr. Nicolas MOSER |
| United Kingdom | Dr John SAFFELL; Prof. Roderic JONES |
| Turkey | Prof. Zafer ZIYA OZTURK; Prof. Mehmet Fatih DANISMAN |

***Kick-off Meeting***
***Brussels***
***16 May 2012***

**MANAGEMENT COMMITTEE**

| | |
|---|---|
| MC Chair: | Michele Penza, ENEA, IT |
| MC Vice Chair: | Anita Lloyd Spetz, Linkoping University, SE |
| Grant Holder: | Eurice GmbH, Saarbrucken, DE |

| Country | MC Substitutes (33) |
|---|---|
| Austria | Dr Stefan DEFREGGER |
| Belgium | Dr Julien DELVA |
| Czech Republic | Dr. Roman NERUDA |
| Denmark | Dr. Lise Lotte SORENSEN |
| Finland | Prof. Jorma KESKINEN |
| France | Dr Jean SUISSE; Prof. Alain PAULY |
| Germany | Dr. Daniela SCHONAUER-KAMIN<br>Dr. Thomas KUHLBUSCH<br>Dr. Juliane ROSSBACH |
| Greece | Prof. George KIRIKIADIS<br>Dr. Christos KOULAMAS |
| Hungary | Prof. Zoltan HORVATH |
| Italy | Dr. Roberto SIMMARANO<br>Dr. Marco ALVISI; Dr. Saverio DE VITO |
| Macedonia Rep. | Dr. Beti ANGELEVSKA |
| Netherlands | Dr. Rene OTJES |
| Poland | Prof. Jacek SZUBER |
| Portugal | Dr. Joao Paulo TEIXEIRA<br>Dr. Ana Margarida COSTA |
| Romania | Dr. Cristina RUSTI; Dr. Marcel Adrian IONICA |
| Slovenia | Prof. Andrej DOBNIKAR |
| Spain | Prof. Albert ROMANO-RODRIGUEZ<br>Dr. Jordi LLOSA |
| Sweden | Dr Mike ANDERSSON; Dr. Marina VOINOVA |
| Switzerland | Dr Christoph HUEGLIN |
| Turkey | Prof. Necmettin KILINC |
| UK | Prof. Julian GARDNER<br>Dr Robin NORTH; Prof. Florin UDREA |

# Year 4: Scientific Planning of *EuNetAir* (1/2)

**Meetings/Workshops/Training Schools** planned **for upcoming year** (**Year 4: 1 July 2015 - 15 May 2016**): ***EXTENSION: 15 Nov. 2016***

- **WG1-WG4 Meeting** on *Air Quality Monitoring and Calibration: Horizons in Sensing Technologies, Methods and Modelling - Start of the 2nd EuNetAir Air Quality Joint-Exercise Intercomparison* organized by the VINCA Institute, Belgrade (**Serbia**), 13 - 14 Oct. 2015. *Local organizer*: Dr. Milena Jovasevic-Stojanovic, VINCA and Anka Cvetkovic, Public Health Institute of Belgrade

- The **4th International Workshop of the COST Action TD1105** on *Innovations and Challenges for Air Quality Control Sensors* at FFG (National AT COST Office), Wien (**Austria**), 25 - 26 February 2016. *Local organizer*: Dr. Anton Kock, MCL

- The **Action 4th International Training School** on *Modelling, Methods and Technologies for Air Quality Control* at Emdrup Campus in Copenhagen, by Aarhus University (**Denmark**), 19 - 22 April 2016.

*Local Organizer*: Prof. Ole Hertel, Aarhus University. Trainees: 20. Trainers: 8.

**Deadline for Trainees Application: 10 March 2016**

# Year 4: Scientific Planning of *EuNetAir* (2/2)

**MC/WG Meetings** planned **for the upcoming year**

(**Year 4: 1 July 2015 - 15 May 2016**): ***EXTENSION: 15 Nov. 2016***

• **5th SCIENTIFIC MEETING: WGs Meeting and 8th MC Meeting on New Sensing Technologies for Indoor Air Pollution Monitoring and Environmental Measurements** at Bulgarian Academy of Sciences, Sofia (**Bulgaria**), 16 - 18 Dec. 2015. *Local organizers*: Prof. Ivan Nedkov and Prof. Dimiter Syrakov, BAS

• **6th SCIENTIFIC MEETING: WGs Meeting and 9th MC Meeting on New Sensing Technologies for Outdoor Air Quality Monitoring** at Czech Academy of Sciences, Prague (**Czech Republic**), 5 - 7 October 2016. *Local Organizers*: Prof. Zdenek Zelinger, Dr. Vera Kurkova, Dr. Roman Neruda, CAS - ***FINAL MEETING***

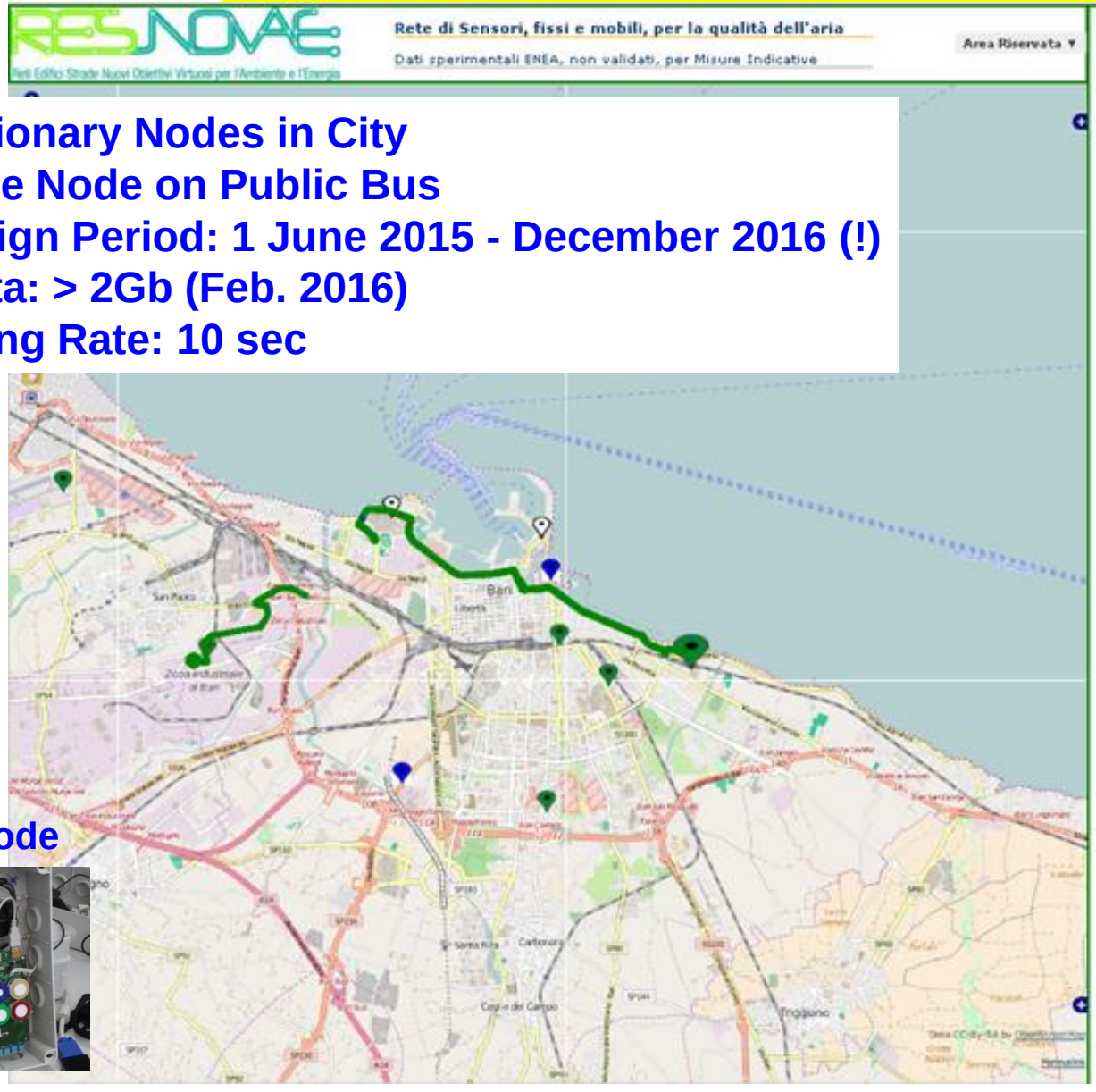
• **Special Session EuNetAir / Core-Group Meeting** to **EUROSENSORS 2015**, Freiburg (**Germany**), 6 - 10 September 2015

# IT NATIONAL PROJECT *RES-NOVAE*: OUTDOOR APPLICATIONS

## AQ ENEA Sensors Fixed Nodes Network distributed in Bari (Italy)
## Urban Control Center (UCC) collects data from City.

***Smart City Bari***

- 10 Stationary Nodes in City
- 1 Mobile Node on Public Bus
- Campaign Period: 1 June 2015 - December 2016 (!)
- Big Data: > 2Gb (Feb. 2016)
- Sampling Rate: 10 sec






**AirBOX Sensor-Node**

# IT NATIONAL PROJECT *RES-NOVAE*: OUTDOOR APPLICATIONS

## AQ ENEA Sensors Fixed Nodes Network distributed in Bari (Italy)

*Smart City Bari*











ENEA Centro Ricerche Brindisi


### ENEA Sensors Lab OpenVPN Status Monitor

nea NasusPI - Connection up, pingable. 12 clients, 603847607 bytes in, 314525951 bytes out [ 172.17.0.1 tun ]

| Username / Hostname | VPN IP Address | Remote IP Address | Port | Location | Recv | Sent | Connected Since | Last Ping | Time Online |
|---|---|---|---|---|---|---|---|---|---|
| nasuspi-5 | 172.17.0.6 | 37.19.108.20 | 52428 | | 73065 | 73872 | 23/02/2016 15:28:09 | 23/02/2016 15:28:16 | 3:01:40 |
| nasuspi-8 | 172.17.0.9 | 62.19.56.54 | 24059 | | 16932314 | 8252487 | 14/02/2016 02:06:33 | 23/02/2016 18:26:23 | 9 days, 16:23:16 |
| nasuspi-2 | 172.17.0.3 | 62.19.60.187 | 50059 | | 61118723 | 29838611 | 19/01/2016 15:31:29 | 23/02/2016 18:22:13 | 35 days, 2:58:20 |
| nasuspi-12 | 172.17.0.13 | 5.170.133.155 | 21548 | | 3986071 | 2173688 | 22/02/2016 12:31:11 | 23/02/2016 18:26:45 | 1 day, 5:58:38 |
| nasuspi-3 | 172.17.0.4 | 5.170.159.213 | 49326 | | 50720954 | 24762444 | 25/01/2016 14:59:28 | 23/02/2016 18:18:43 | 29 days, 3:30:21 |
| nasuspi-13 | 172.17.0.14 | 62.19.60.37 | 28028 | | 10410773 | 4378176 | 19/02/2016 15:22:35 | 23/02/2016 18:19:49 | 4 days, 3:07:14 |
| nasuspi-6 | 172.17.0.7 | 5.170.100.125 | 44309 | | 60155115 | 28671705 | 21/01/2016 09:35:05 | 23/02/2016 18:27:28 | 33 days, 8:54:44 |
| airbox-one | 172.17.0.20 | 192.168.172.238 | 38932 | RFC1918 | 2992201 | 3165714 | 18/02/2016 09:20:28 | 18/02/2016 09:20:28 | 5 days, 9:09:21 |
| nasuspi-1 | 172.17.0.2 | 62.19.59.82 | 13710 | | 16883240 | 8246839 | 14/02/2016 02:05:49 | 23/02/2016 18:17:56 | 9 days, 16:24:00 |
| nasuspi-9 | 172.17.0.10 | 62.19.59.173 | 34552 | | 9107149 | 4258171 | 18/02/2016 19:48:32 | 23/02/2016 18:26:32 | 4 days, 22:41:17 |
| nasuspi-4 | 172.17.0.5 | 62.19.57.93 | 34803 | | 25405866 | 12317796 | 09/02/2016 06:27:37 | 23/02/2016 18:25:51 | 14 days, 12:02:12 |
| nasuspi-10 | 172.17.0.11 | 5.170.246.120 | 20180 | | 17242918 | 8314106 | 14/02/2016 02:06:27 | 23/02/2016 18:18:10 | 9 days, 16:23:22 |

# AIR-SENSOR BOX: *Proof-of-Concept by ENEA*

## MicroSensors for Urban Air Quality Monitoring

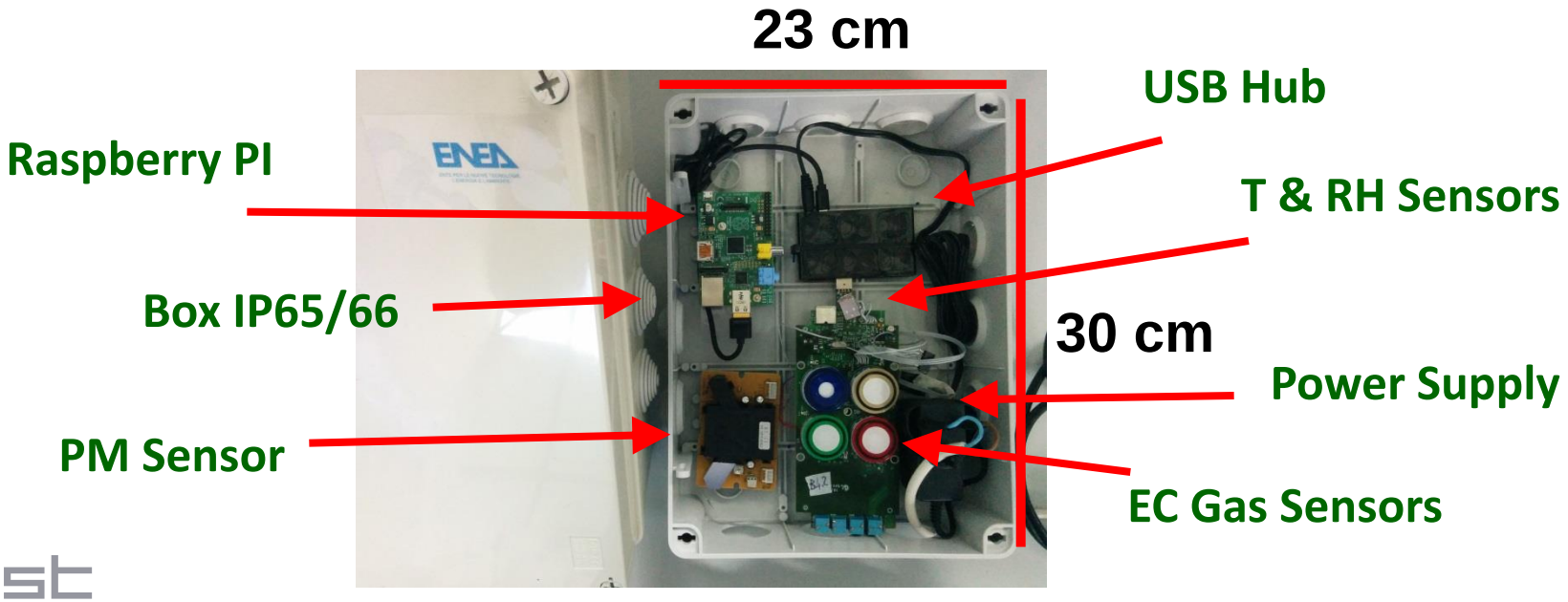
### Wireless Sensor-Node Network for Air Quality Monitoring

- ***Hardware***:

  **A. AQ Multiparametric Sensor Node:** $NO_2$, $O_3$, CO, $SO_2$, $PM_{10}$, T, RH

  **B. Electronics:** Raspberry PI, Modem GSM, SIM Card, Wi-Fi

  **C. Database:** saving data in real-time on a server (***IBM Italia collaboration***)




ENEA
AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

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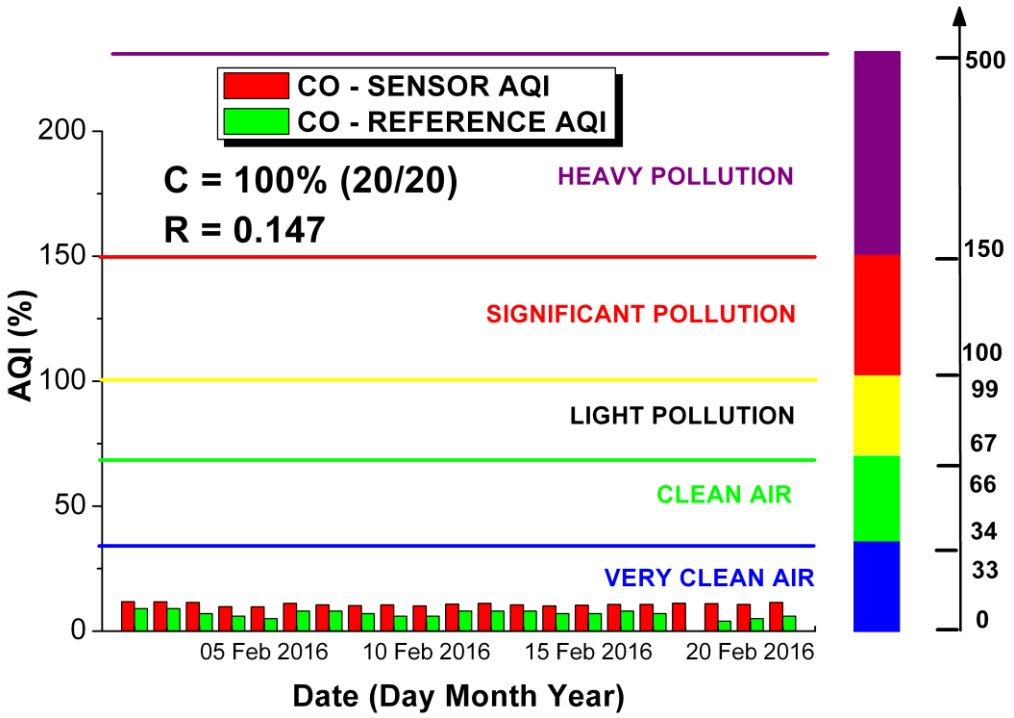
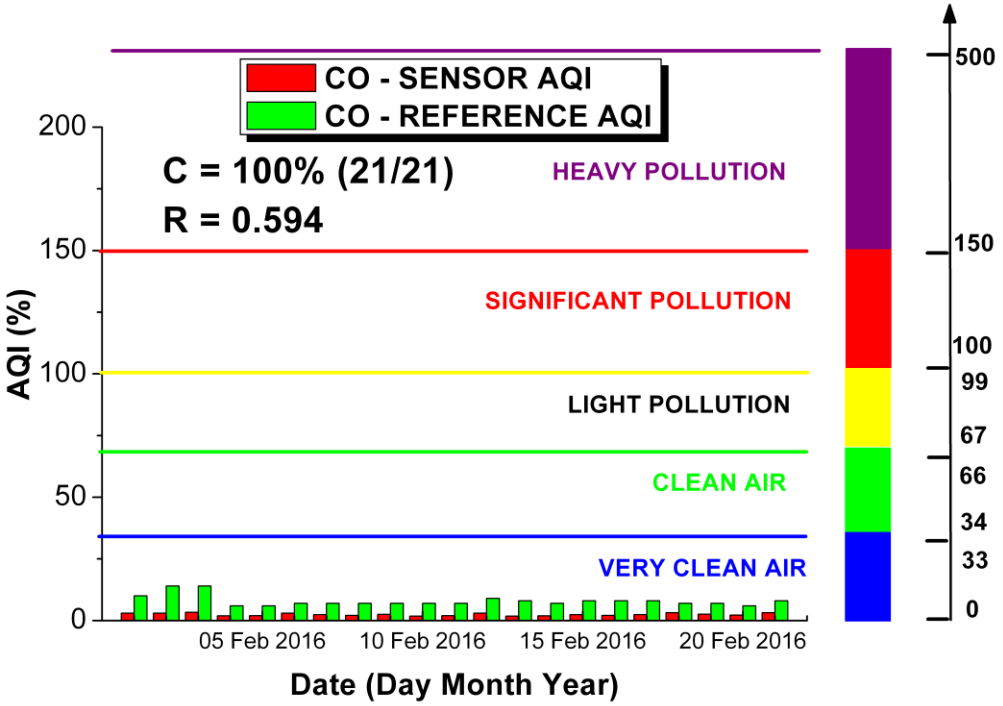
# CITY SENSORS NETWORK: *AQI from Nodes*

**CO**
**Node 2: ENEA**
**AQI Sensor *vs*. AQI Reference**
**1 - 21 February 2016**




**CO**
**Node 6: Bari AIRPORT**
**AQI Sensor *vs*. AQI Reference**
**1 - 21 February 2016**

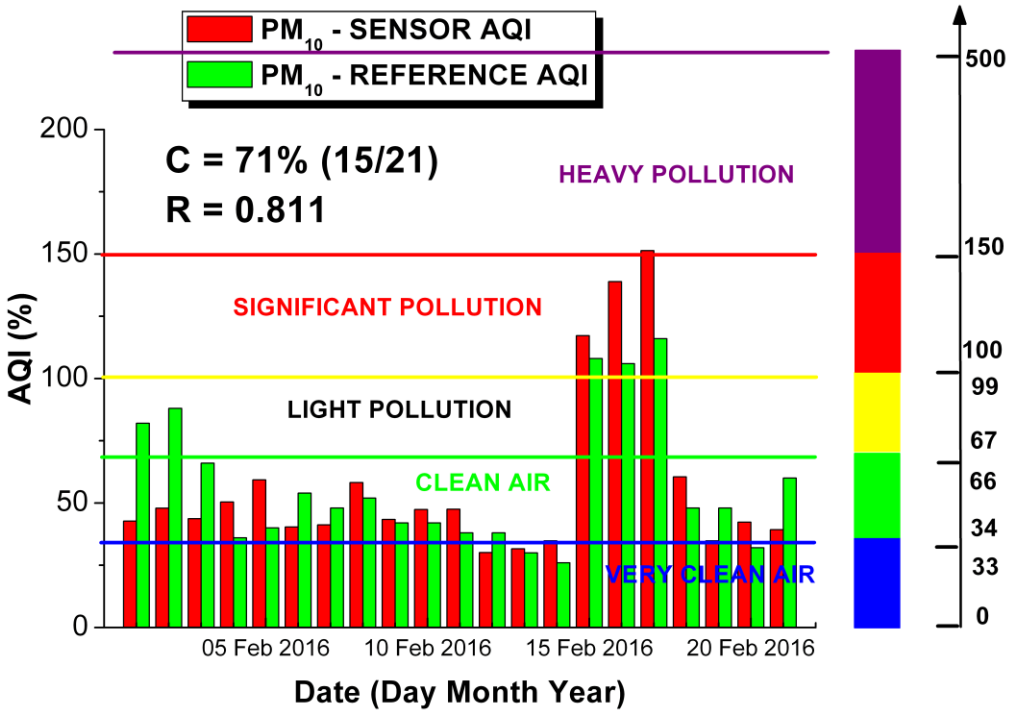



***Courtesy by ENEA***

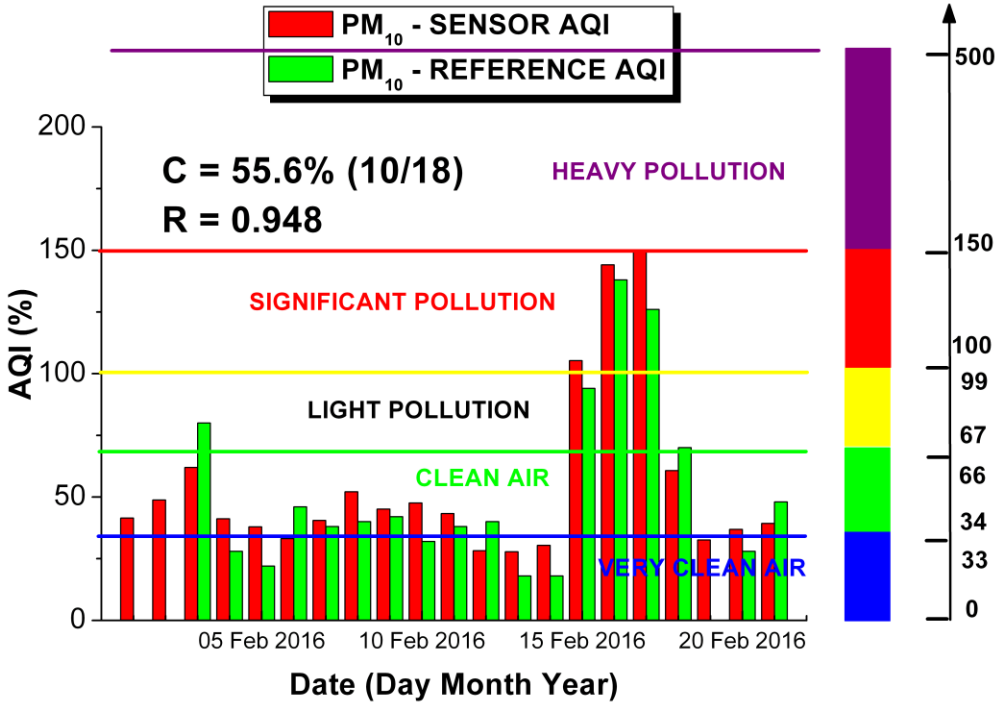
*R = Correlation Coefficient*
*C = Classification Index*

# CITY SENSORS NETWORK: *AQI from Nodes*

**$PM_{10}$**
**Node 2: ENEA**
**AQI Sensor *vs.* AQI Reference**
**1 - 21 February 2016**




**$PM_{10}$**
**Node 6: Bari AIRPORT**
**AQI Sensor *vs.* AQI Reference**
**1 - 21 February 2016**




***Courtesy by ENEA***

*R = Correlation Coefficient*
*C = Classification Index*

# Aveiro Joint-Exercise Intercomparison & WG Meeting

**13 - 27 October 2014: Starting Joint-Exercise (2 weeks duration)**

**14 - 15 October 2014: EuNetAir WG1-WG4 Meeting**

## EuNetAir Air Quality Joint-Exercise Intercomparison 2014

**Local Organizers: Prof. Carlos Borrego and Dr. Ana Margarida Costa (IDAD)**

## Air Quality Monitoring campaign at Aveiro (Portugal) city centre 2014

**Continuous measurements: CO, benzene, NOx, $SO_2$, $PM_{10}$, VOC**
**Temperature, humidity, wind velocity, wind direction, solar radiation, precipitation**

**COST partners (15 teams joined from 12 COST Countries) installed their microsensors side-by-side to compare performance with referenced equipment in the Air-Quality Mobile Laboratory**

# COST Action TD1105 *EuNetAir*: Aveiro INTERCOMPARISON

## *New Sensing Technologies and Modelling for Air-Pollution Monitoring*

# 1ST EuNetAir Air Quality Joint-Exercise Intercomparison

- **Micro-sensors typologies and monitored pollutants:**
  - Electrochemical sensors:
    - $NO$, $NO_2$, $CO$, $O_3$, $SO_2$
  - Optical sensors:
    - PM1, PM2.5, PM10
  - Metal Oxide Semiconductor based sensors (MOS):
    - $NO_2$, COV, $CO$, $O_3$, $SO_2$
  - Non dispersive infrared technology sensors (NDIR):
    - $CO_2$
  - Photoionization detection sensors (PID):
    - $COV_t$

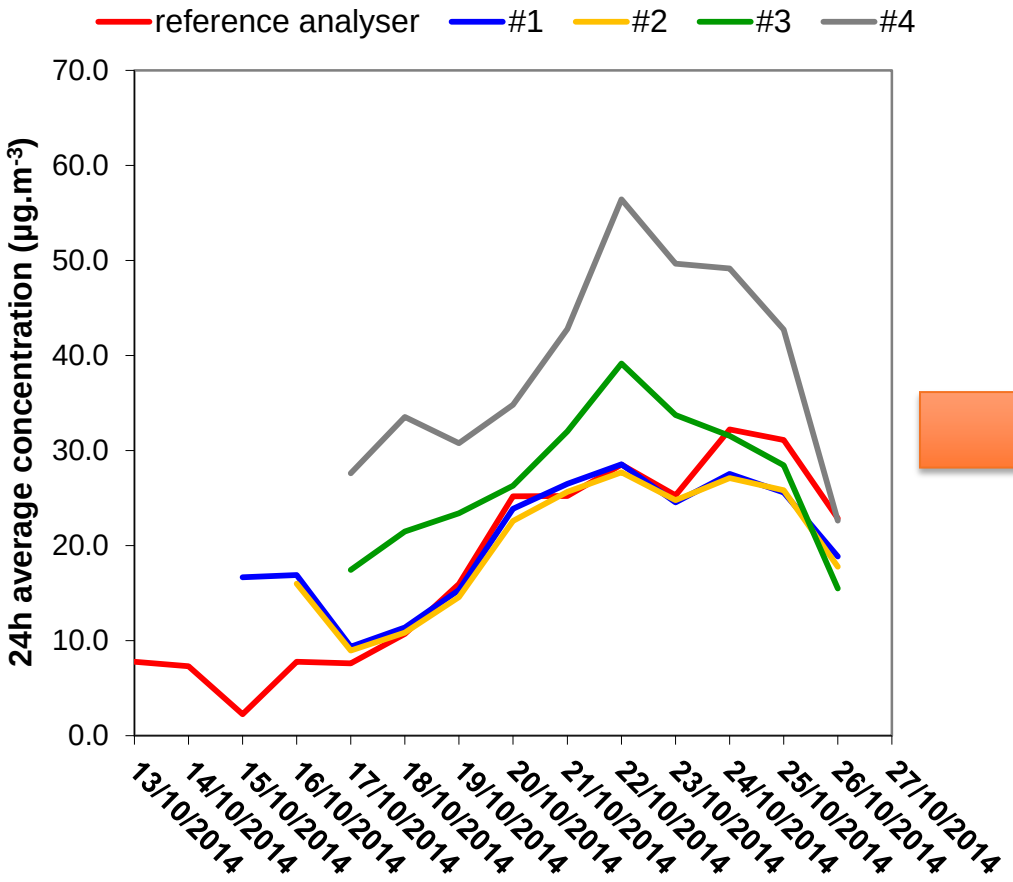


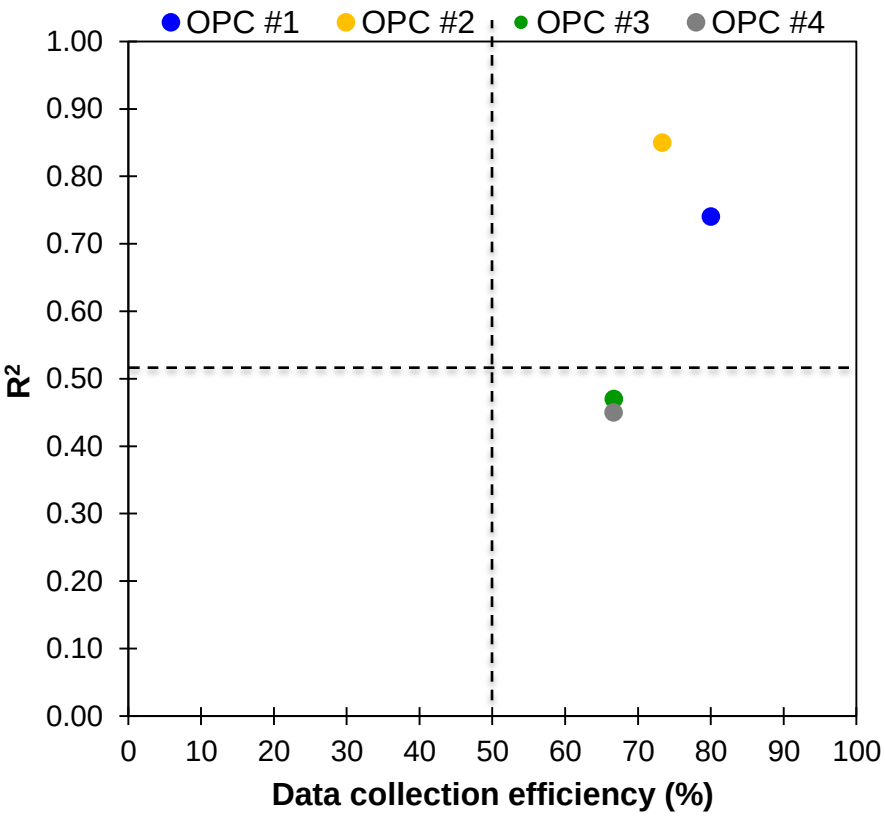

*Carlos Borrego, IDAD, Aveiro, Portugal*

# Assessment of micro-sensors vs. reference methods

*Carlos Borrego, IDAD, Aveiro, Portugal*

- **PM2.5:**



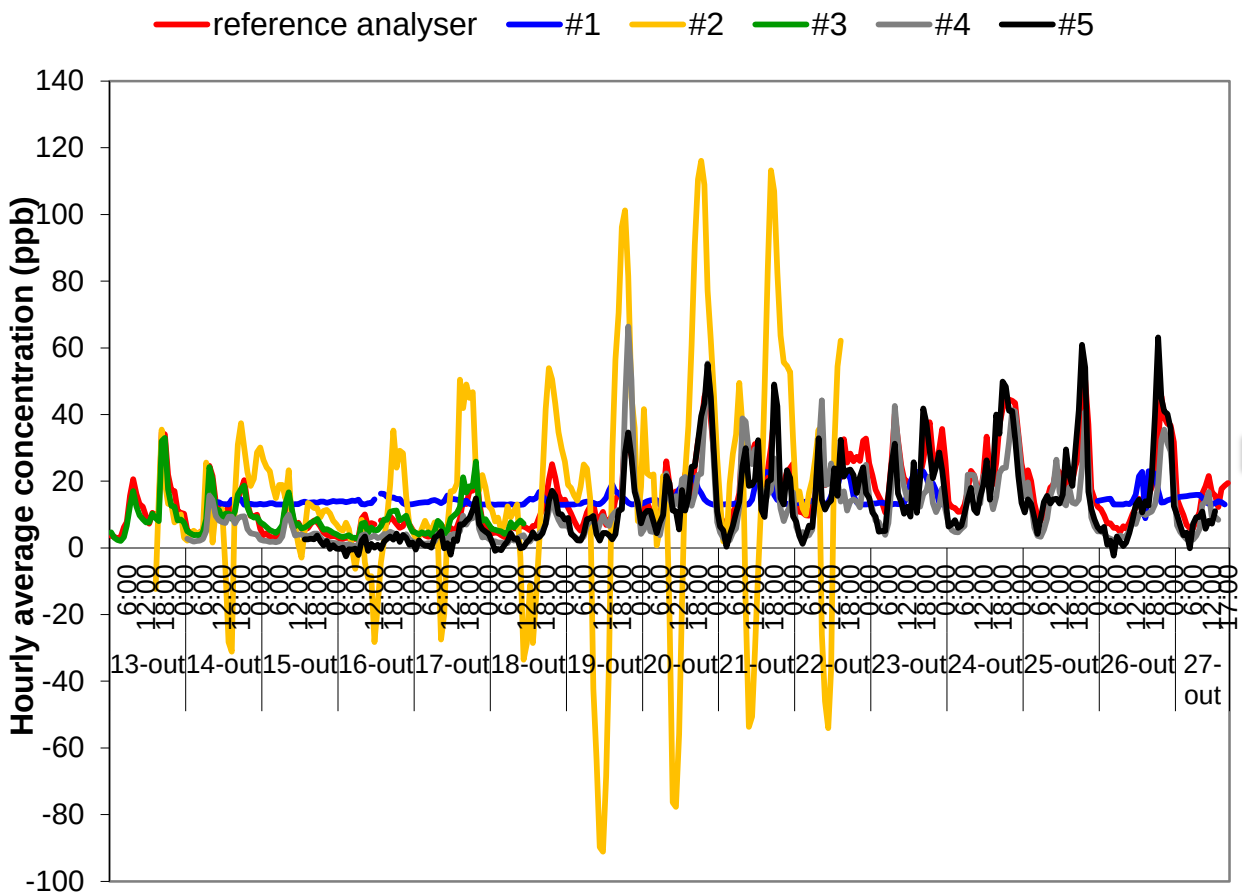



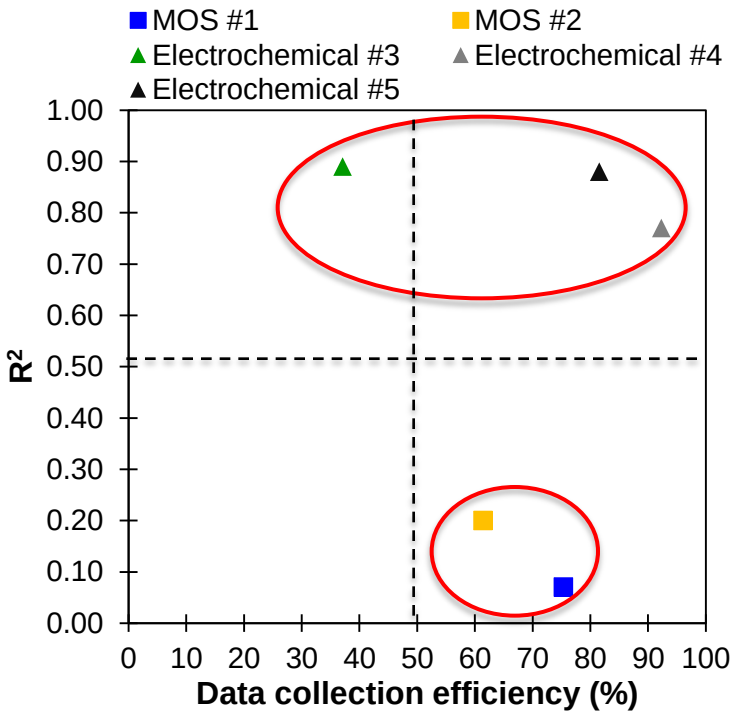

- **The optical (OPC) sensors for PM2.5 presented correlations varying between 0.45-0.85 and data collection efficiencies in the range of 67-80%.**

# Assessment of micro-sensors vs. reference methods

*Carlos Borrego, IDAD, Aveiro, Portugal*

- **$NO_2$:**




- **Electrochemical sensors showed a greater correlation with the reference method and in most cases a higher efficiency collecting data than metal oxide semiconductor (MOS) sensors.**

# Open Questions of the Air Quality Sensors

- Lower Accuracy compared to Reference Methods
- Cross-sensitivity and low Selectivity
- Low Stability and Drift to be corrected periodically
- Calibration needs periodically (e.g., at least 1 calibration/month)
- Regular Maintenance of the in-field AQ sensor nodes
- Data Quality Objective (European Directive 2008/50/EC) to be addressed for ***Indicative Measurements*** by demonstration of the equivalence to use microsensors for AQ monitoring

# Advantages and Benefits of the Air Quality Sensors

- Low-cost for deployment in Cities at high spatial-temporal resolution
- Suitability for personal exposure studies
- Suitability for emission source information
- Outdoor monitoring of gases ($NO_2$/NO, $O_3$, CO, $SO_2$, $H_2S$, tVOCs, $CO_2$, $NH_3$, etc.)
- Outdoor monitoring of particulate matter ($PM_{10}$, $PM_{2.5}$, $PM_{1.0}$, UFP)
- Indoor monitoring of gases (CO, VOCs, benzene, formaldehyde, naphthalene, toluene, etc.) and PM ($PM_{10}$, $PM_{2.5}$, $PM_{1.0}$)
- Combination of sensors with modelling for micro-scale analysis (1-2 mt resolution)

# OUTREACH ACTIVITIES from Action TD1105


**Action website:**

**www.cost.eunetair.it**

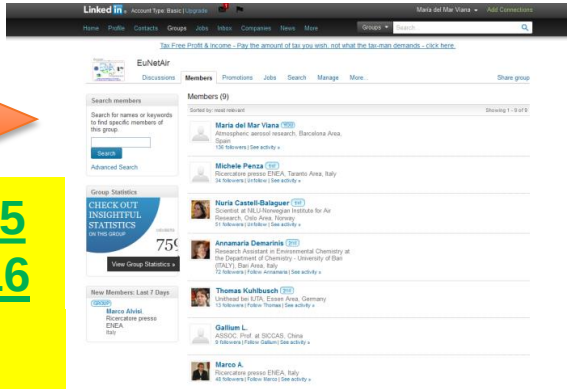
***hosted by ENEA***

**Dr. Marco Alvisi, *Webmaster Coordinator***

**Sebastiano Dipinto, Valerio Pfister, Gianfranco Zingarelli, *Webmaster Team***

**Social Scientific ESRs Network (SSEN) by LinkedIn**

**Members: >80 - Moderators: M. Viana, M. Minguillon**



**4° CALL for Short Exchange Visits launched on September 2015**

**Short Term Scientific Mission: 9 TO BE FUNDED by 15 Nov. 2016**

**Dr. Jan Theunis, STSM Coordinator EuNetAir**


**Issue 1:** published on Dec. 2012 ✓
**Issue 2:** published on June 2013 ✓
**Issue 3:** published on Dec. 2013 ✓
**Issue 4:** published on June 2014 ✓
**Issue 5:** published on Dec. 2014 ✓
**Issue 6:** published on June 2015 ✓
**Issue 7:** published on Dec. 2015 ✓

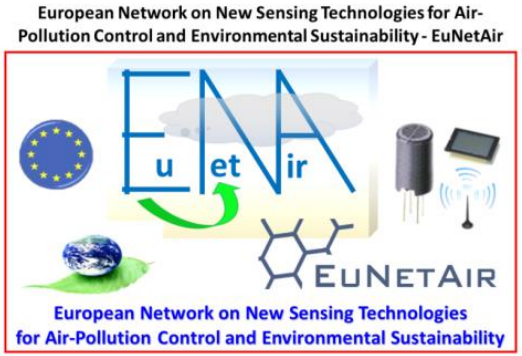
**Prof. Ralf Moos, *Editor-in-Chief***

**Dr. Daniela Schonauer-Kamin, *Editorial Board Manager***

# CONCLUSIONS

**The COST Action TD1105 *EuNetAir* is proposed to solve problems in the area of:**

- **Air Quality Control**
- **Environmental Sustainability**
- **Indoor/Outdoor Energy Efficiency**
- **Climate Change Monitoring**
- **Health Effects of Air-Pollution**



# Contact Details

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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

**CSO Approval:** 01 Dec. 2011
**Kick-off Meeting:** 16 May 2012
**Start of Grant:** 01 July 2012
**End of Grant:** 15 Nov. 2016

**www.cost.eunetair.it**

| | |
|---|---|
| **MC Chair:** | Dr. Michele Penza, ENEA, IT<br>michele.penza@enea.it |
| **MC Vice Chair:** | Prof. Anita Lloyd Spetz<br>Linkoping University, SE<br>spetz@ifm.liu.se |
| **Grant Holder:** | Dr. Corinna Hahn, Dr. Juliane Rossbach<br>Eurice GmbH, DE<br>c.hahn@eurice.eu; j.rossbach@eurice.eu |
| **Scientific Secretary:** | Dr. Annamaria Demarinis Loiotile<br>annamaria.demarinis@uniba.it |
| **Science Officer:** | Dr. Deniz Karaca<br>deniz.karaca@cost.eu |
| **Administrative Officer:** | Andrea Tortajada - Tania Gonzalez Ovin<br>andrea.tortajada@cost.eu<br>tania.gonzalezovin@cost.eu |

**http://www.cost.eu/domains_actions/essem/Actions/TD1105**

***TD1105 selected as Top-Story by COST Association***

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EUROPEAN COOPERATI

Top Story
all stories

**Taking charge of air quality control in Europe's smart, green cities**

A COST funded network of European spin-offs, SMEs, agencies, research centres and universities is working on developing cheaper and energy efficient sensors for air quality control in Europe's future smart cities.

full story

MATERIALS RESEARCH SOCIETY
*Advancing materials. Improving the quality of life.*

# Symposium PM4 at 2016 MRS Fall Meeting & Exhibit

## Boston (USA), 27 November - 2 December 2016

## *Novel Materials, Fabrication Routes and Devices for Environmental Monitoring*

- ***Symposium Organizers***: **http://www.mrs.org/fall2016**

✓ Michele Penza, ENEA, Italy

✓ Ruby Ghosh, Michigan State University, USA

✓ Albert Romano-Rodriguez, Barcelona University, Spain

✓ Meyya Meyyappan, NASA Ames Research Center, USA

- **Deadline for abstract submission**: **16 June 2016**

# ACKNOWLEDGEMENTS

## Nuremberg, Germany, 12 May 2016

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

THANK YOU VERY MUCH FOR YOUR KIND ATTENTION !

AMA
Association for Sensors + Measurement

**Special Session:**
***Novel Sensor Solutions for Indoor Air Quality***

www.eunetair.it www.cluster-essc.eu www.multisensorplatform.eu www.iaqsense.eu www.sensindoor.eu

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