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2021 Edition

Microsensors Challenge 2021

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AIRLAB Microsensors Challenge 2021

Airparif and AIRLAB unveiled the winners of the AIRLAB Microsensors Challenge 2021 on 13 October 2021 during an international workshop on air quality microsensors. The results of the Challenge show an overall improvement in the performance of these measurement tools, especially in indoor air. Outdoor air is also increasingly being measured with these microsensor solutions, resulting in the first prize-giving since the launch of the Challenge in 2018.

The reasons of this Challenge

Air quality is a major health, economic and societal issue. Air pollution, both outdoor and indoor, is responsible for 7 million premature deaths per year worldwide according to the World Health Organisation. In response to this issue, the expectations of citizens and political and economic decision-makers are evolving towards a demand for increasingly precise personalised information on air quality. In recent years, tehnical improvements in pollution sensors (miniaturisation, connectivity, etc.) have led to the development of new networks equipping homes, urban furniture, vehicles and citizens.

AIRLAB Microsensors Challenge

The AIRLAB International Microsensors Challenge aims to regularly assess the progress in efficiency and reliability of these new air quality measurement technologies. These microsensors have been growing rapidly over the past five years due to technological advances and the increasing awareness of the health impacts of outdoor and indoor air quality. Draft standards for these devices are currently being formalised at European level. Airparif is also participates in the French Association for Standardisation's group of experts for the implementation of these future European standards. In parallel to these new standards, Airparif and AIRLAB give, through this competition, the possibility to manufacturers who wish to have their solutions evaluated by a jury of independent international experts on both metrological and ergonomic aspects. It is also an opportunity to enlighten potential users on the adequacy between the performance of the sensors, the uses and the advantages put forward: ease of use by everyone, simplified information and affordable cost, for most of them. With sufficient accuracy, even if none of them meet the European requirements imposed on analysers, in terms of reliability and accuracy used by approved air quality monitoring organisations.

This Challenge, now in its **third year**, showcases the individual performance of these devices and provides a global overview of them in order to encourage innovation. The «air market» is emerging and has a global scope, which encourages many economic players to invest in this theme. The development of environmental technologies, digital convergence, the rise of connected objects and France's leadership on these subjects suggest new opportunities, both for monitoring and for improvement actions or public information.

The **objectives** of the Challenge are therefore threefold:

• To analyse the performance of microsensors in order to meet the demand of partners to instrument buildings, cities and citizens;
• To inform users about the suitability of sensors for their intended use;
• To highlight the individual performances of these devices and the ways of improvement in order to encourage innovation and contribute to the development of this emerging market.

The **principle** of the Challenge is based on a collective and independent evaluation of the microsensor as a whole, an evaluation based on voluntary participation.

The 2021 edition

For this third edition of the Challenge, **59 solutions** were proposed by **35 companies**. The jury selected 54 of them. For 3 months, the Airparif metrology laboratory, in collaboration with Atmo Hauts-de-France, examined these solutions on more than 42 evaluation points.

Categories

In the context of the Challenge, the category of a sensor is defined as its intended use or application. There are eight categories in this Challenge. As in the previous edition, the categories have been organised into three main groups, based on the intended field of application: outdoor air, indoor air and citizen air. The latter concerns applications that target the air to which people are personally exposed in the course of their daily activities.

The **8 categories** of use grouped into **3 classes** as a function of the application environment

Outdoor Air (OA)	Indoor Air (IA)	Citizen Air (CA)
Monitoring (OA-M)	Monitoring (IA-M)	Exposure (CA-E)
Awareness (OA-A)	Awareness (IA-A)	Awareness (CA-A)
Vehicular (OA-V)	Piloting (IA-P)	

- OA-M : Outdoor Air – Monitoring
- OA-A : Outdoor Air – Awareness raising
- OA-V : Outdoor Air – Vehicular
- IA-M : Indoor Air – Monitoring
- IA-A : Indoor Air – Awareness raising
- IA-P : Indoor Air – Piloting and managing air inside buildings
- CA-E : Citizen Air - Exposure
- CA-A : Citizen Air - Awareness

The AIRLAB Microsensors Challenge takes a holistic approach to the evaluation of air quality sensors by combining criteria relating to:

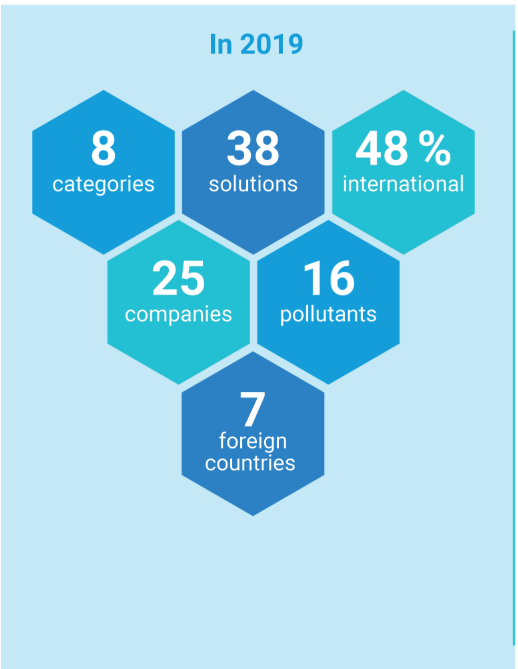
- Accuracy
- Utility
- Usability
- Portability
- Cost

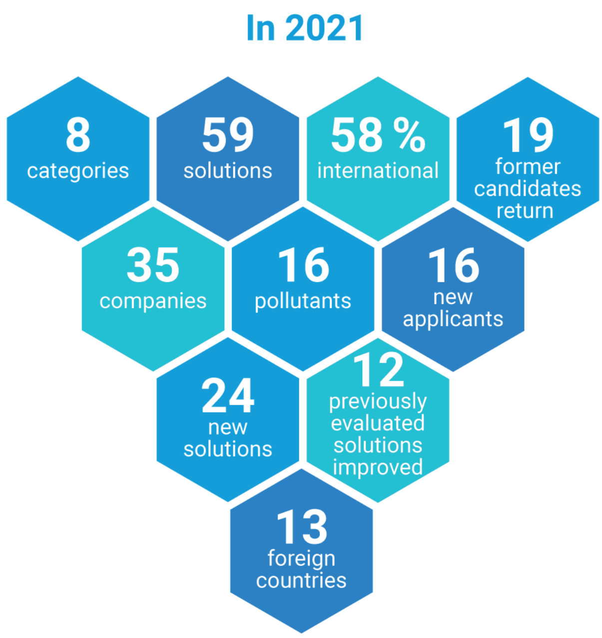
The new evaluation protocol includes a more refined analysis of the usefulness and usability of candidate solutions, with definitions for both criteria adapted to the target use.

A correctness sub-criterion has been integrated into the accuracy criterion: it differentiates between solutions that are simply correlated with reference measurements and those that are correlated and correct. Another sub-criterion of reproducibility of the proposed solutions has also been added.

The assessment sites

To cover the different categories of the Challenge, three different types of evaluation sites were used: an outdoor site; an indoor site, the Airparif metrology laboratory in Paris; and a mobile site. In the context of the Challenge, the mobile site is defined as the set of mobility vectors used for the evaluation of mobile sensors. This includes an installation on an Airparif vehicle and a number of volunteers for the testing of portable micro-sensors. For the outdoor air tests, the consortium opted for a different site from the previous editions. It is an urban background site located in Lille, with concentration levels more typical of the French average than the site then used for the 2018-2019 editions. A better performance of the outdoor air sensors was thus observed in this context, particularly with regard to particulate matter measurements.





New features and results of this edition

This new edition of the Microsensors Challenge has continued its internationalisation, with more than half of the devices tested now proposed by companies outside France. In all, 54 microsensors from 35 companies were selected by an independent and international jury. After several months of analysis, the jury unveiled 91 complete evaluations on 13 October; each sensor competed for one or more uses.

Microsensors still more efficient in indoor air, although progress is noted in outdoor air

The results of this new Challenge show a clear improvement in the quality of the microsensors participating in the competition and in their ability to share their measurement data. As in the previous Challenge, the microsensors examined stood out in particular for measuring indoor air quality. Progress is noted in outdoor air and mobility: one of the solutions proposed for the citizen air category, namely portable personal microsensors for awareness raising, received an award. For the first time, the Challenge awarded prizes to microsensors for measuring outdoor air, whose performance has improved significantly.

On the other hand, the microsensors used to carry out mobile measurements on vehicles or individuals in order to finely characterise individual exposure still do not provide sufficiently accurate measurements of air quality, due in particular to excessive sensitivity to changes in the environment, humidity and temperature, so the jury was unable to choose a winner.

For the criteria of utility and usability, the observation shows a much more mature market with regard to data interoperability; there are very few systems that do not offer REST API-type web services.

«Do It Yourself» microsensors

These do-it-yourself devices were among the new solutions tested in this 3rd edition of the Challenge. However, they did not receive a prize, mainly because of problems with the formatting and acquisition of data and variable assembly quality, making it difficult to evaluate them. The protocol and evaluation criteria also showed shortcomings for this type of solution.

All the results per sensor are freely available on the AIRLAB website (airparif.shinyapps.io/ChallengeResultsEN/) via a newly created interactive platform. It offers a navigation among the results of the Challenge, allowing searches by criteria and comparisons between the different solutions.

International Air Quality Sensors Workshop

AIRLAB Challenge Awards

2021 Laureat

- **Most accurate multi-pollutant sensor:**
  - Outdoor: **KUNAK Air Pro** (Spain)
  - Indoor: **Rubix POD** (France)
- **Citizen Air (all categories):**
  - **Magnasci uRADMonitor AIR** (Romania)
- **Outdoor Air:**
  - Monitoring: **Ethera NEMO Extérieur** (France)
  - Awareness: **Magnasci SMOGGIE** (Romania)
- **Indoor Air (all categories):**
  - **Ethera Mini XT basic+** (France)
- **Best accuracy:**
  - $PM_{2.5}$ - Outdoor: **Airlabs AirNode** (UK)
  - $PM_{2.5}$ - Indoor: **Rubix POD** (France)
  - NO_2 : **Envea Cairnet** (France)
  - O_3 : **Bettair Static Node MK2** (Spain)
  - CO_2 : **Zaack QAI** (France)
  - VOCs : **SGS AirSense Omni** (France)

The lessons learned from this third edition

Each microsensor examined measured one or more different pollutants. In general, the measurement of nitrogen dioxide (NO_2) showed a high level of performance. The measurement of fine particulate matter $PM_{2.5}$ was always more accurate than PM_{10}. The measurement of volatile organic compounds (VOCs), pollutants specific to indoor air, was disappointing overall. The measurement of carbon dioxide (CO_2), in indoor air, allowing the evaluation of room ventilation (and thus facilitating the implementation of ventilation measures and the fight against the spread of the coronavirus) has shown a high level of accuracy. The measurement of ozone (O_3) is also progressing.

In this edition, special attention was paid to the processing algorithms applied to the raw sensor measurements and their added value. This was made possible thanks to the collaboration of the candidates.

The jury also noted a clear improvement in the proposed solutions in terms of data accessibility compared to the first two editions; the data is more easily exploitable. Progress was also noted in the area of CSR, particularly with regard to manufacturing elements and data storage, with the costs of maintaining the equipment being taken into account in the evaluation.

The way forward: from sensor assessment to operational implementation

It should be noted that the World Meteorological Organisation, the World Health Organisation and the United Nations Environment Programme indicate that low-cost sensors are not a direct substitute for reference measurements, particularly for regulatory purposes, although they do represent a complementary source of information, provided that appropriate equipment is used[1]. Furthermore, the results of these evaluations allow lessons to be learned about the intrinsic qualities of each sensor but cannot be extrapolated to the performance of an operational measurement network composed of these microsensors. For the users of such a network, further studies should be carried out to assess their cost/efficiency according to the local context, both for deployment and for «full-scale» management and maintenance.

For example, in Île-de-France, Airparif and its partners are particularly committed to this work, particularly through the «Mesures et perceptions» project of the Île-de-France region. Currently underway, this project is experimenting with the use of several hundred microsensors for large-scale air quality measurement, including some in mobility. The experiments conducted by Airparif with the City of Paris and Bloomberg Philantropies have also focused on this subject in schools. In both cases, the potential contribution of a large network of microsensors to strengthening the existing air quality monitoring system was tested. These studies also show that this type of network needs to be able to rely on reference measurements both for the acceptance of microsensors before their installation, sometimes with industrialisation issues when individual microsensors are transferred to a network, and for their calibration, data quality monitoring and algorithm reinforcement.

The results demonstrated the need to have reference tools for the acceptance of the devices, their calibration, the improvement of the algorithms and the permanent validation of the data produced[2].

A new edition of the Challenge is planned for 2023. From autumn 2021, the best performing sensors of the 2021 edition will be deployed in AIRLAB projects in the fields of connected buildings and citizen participation.

[1] An update on Low-cost Sensors for the Measurement of Atmospheric Composition, World Meteorological Organization, World Health Organization, United Nations Environment Programme International Global Atmospheric Chemistry, EMEP, December 2020

[2] Experimentation for a better knowledge of air quality in Parisian schools, Airparif report, 2021 (in French)

Results by category of use

The sensor results for these categories are presented in the summary tables below.

Outdoor Air – Monitoring (OA-M)

brand	name	star-score
ENVEA	CAIRNET	★★½☆☆
Vaisala	AQT530	★★½☆☆
bettair	BETTAIR_STATIC_NODE_MK2	★★½☆☆
SouthCoast	Praxis_OPCube	★★★☆☆
AGRISCOPE	AIRSCOPE	★★★☆☆
eLichens	eLos	★★★☆☆
ADDAIR	AQMesh	★★★☆☆
TSI	BlueSky	★★★☆☆
Airlabs	AirNode_2	★★★☆☆
VOCSens	EnviCam	★★★½☆
IQAir	AirVisual_Outdoor	★★★½☆
RUBIX	WT1	★★★½☆
KUNAK	Kunak_Air_Pro	★★★½☆
nexelec	PMO	★★★½☆
ATMOTRACK	Atmo02-FPNO2	★★★½☆
Ethera	NEMo_Extérieur	★★★½☆
Decentlab	DL-PM	★★★½☆
Ecomesure	ECOMSMART	★★★½☆
Sensirion	Nubo_Air	★★★½☆
Magnasci	uRADMonitor_CITY	★★★½☆
Magnasci	SMOGGIE	★★★½☆
Sensorbee	SB3320	★★★½☆
Magnasci	uRADMonitor_model_A3	★★★★☆

Outdoor Air – Awareness raising (OA-A)

brand	name	star-score
Vaisala	AQT530	★★½☆☆
eLichens	eLos	★★★☆☆
nexelec	PMO	★★★☆☆
Airly	Airly_PM+GAS	★★★☆☆
VOCSens	EnviCam	★★★½☆
ATMOTRACK	Atmo02-FPNO2	★★★½☆
Ethera	NEMo_Extérieur	★★★½☆
Sensirion	Nubo_Air	★★★½☆
IQAir	AirVisual_Outdoor	★★★★☆
Magnasci	uRADMonitor_model_A3	★★★★☆
Magnasci	SMOGGIE	★★★★☆
NanoSense	QAA	★★★★☆

Outdoor Air – Vehicular (OA-V)

AIRLAB

brand	name	star-score
Ecomesure	ECOMTREK	★★½☆☆
ATMOTRACK	Atmo02-MP	★★★½☆
ATMOTRACK	Atmo02-RPCONH	★★★½☆

Indoor Air – Monitoring (IA-M)

AIRLAB

brand	name	star-score
Zaack	Zaack_QAI	★★★½☆
Meo	node_2.0	★★★½☆
inBiot	MICA_Wall	★★★½☆
DomNexX	nexxSense_QAI_SEN-04X	★★★½☆
RUBIX	POD_2	★★★½☆
nexelec	Carbon	★★★½☆
Kaiterra	Sensedge_Mini_SE-200	★★★½☆
ATMOTRACK	Atmo02-FPSO2	★★★½☆
3Castagni	AQSens4	★★★½☆
SGS	AirSense_Omni	★★★½☆
Ethera	Nemo_Diagnostic	★★★½☆
Decentlab	DL-PM	★★★½☆
Ecomesure	ECOMZEN	★★★½☆
Ecomesure	ECOMZEN_2	★★★½☆
Ethera	Mini_XT_basic	★★★★☆
Ethera	Mini_XT_basic+	★★★★☆
Magnasci	uRADMonitor_model_A3	★★★★☆
Magnasci	SMOGGIE-CO2	★★★★☆
NanoSense	P4000NG	★★★★☆
NanoSense	E4000NG	★★★★☆

Indoor Air – Awareness raising (IA-A)

AIRLAB

brand	name	star-score
Sensilla	Sensilla_Gen1	★★★☆☆
Zaack	Zaack_QAI	★★★½☆
ATMOTRACK	Atmo02-FPCONHSO2	★★★½☆
Ecomesure	ECOMLITE_2	★★★½☆
inBiot	MICA_Wall	★★★★☆
nexelec	Carbon	★★★★☆
nexelec	ATMO	★★★★☆
Kaiterra	Sensedge_Mini_SE-200	★★★★☆
3Castagni	AQSens4	★★★★☆
Ethera	Nemo_Diagnostic	★★★★☆
Ethera	Mini_XT_basic	★★★★☆
Ethera	Mini_XT_basic+	★★★★☆
Magnasci	uRADMonitor_model_A3	★★★★☆
Magnasci	SMOGGIE-CO2	★★★★☆
NanoSense	P4000NG	★★★★☆
NanoSense	E4000NG	★★★★☆

Indoor Air – Piloting and managing air inside buildings (IA-P)

brand	name	star-score
• ATMOTRACK	Atmo02-RPCO	★★★⯪☆
• Meo	node_2.0	★★★★☆
• inBiot	MICA_Wall	★★★★☆
• DomNexX	nexxSense_QAI_SEN-04X	★★★★☆
• nexelec	ATMO	★★★★☆
• Kaiterra	Sensedge_Mini_SE-200	★★★★☆
• Ethera	Mini_XT_basic	★★★★☆
• Ethera	Mini_XT_basic+	★★★★☆
• Ecomesure	ECOMLITE_2	★★★★☆
• Magnasci	uRADMonitor_model_A3	★★★★☆
• NanoSense	P4000NG	★★★★☆
• NanoSense	E4000NG	★★★★☆

Citizen Air - Exposure (CA-E)

brand	name	star-score
• TERA	Tera_PMSCAN	★★★⯪☆
• Magnasci	uRADMonitor_AIR	★★★★☆

Citizen Air - Awareness (CA-A)

brand	name	star-score
• TERA	Tera_PMSCAN	★★★⯪☆
• ATMOTRACK	Atmo02-Citizen	★★★⯪☆
• Magnasci	uRADMonitor_AIR	★★★★☆

Results by pollutant

Only the sensors with the best accuracy are shown below.

Outdoor Air (OA) >> PM2.5

brand	name	score
• Airlabs	AirNode_2	9.4
• Sensirion	Nubo_Air	9.3
• ATMOTRACK	Atmo02-FPNO2	9.2

Outdoor Air (OA) >> NO2

brand	name	score
• ENVEA	CAIRNET	8.3
• KUNAK	Kunak_Air_Pro	7.8
• Airly	Airly_PM+GAS	7.6

Outdoor Air (OA) >> O3

brand	name	score
• bettair	BETTAIR_STATIC_NODE_MK2	9
• KUNAK	Kunak_Air_Pro	8.9
• ADDAIR	AQMesh	8.6
• Airly	Airly_PM+GAS	8.6

Indoor Air (IA) >> PM2.5

AIRLAB

brand	name	score
• RUBIX	POD_2	8.5
• Kaiterra	Sensedge_Mini_SE-200	8.5
• ATMOTRACK	Atmo02-FPSO2	8.4
• Meo	node_2.0	8.4
• Ethera	Mini_XT_basic+	8.2
• NanoSense	P4000NG	8.2

Indoor Air (IA) >> CO2

AIRLAB

brand	name	score
• Zaack	Zaack_QAI	9.7
• Kaiterra	Sensedge_Mini_SE-200	9.6
• Ethera	Nemo_Diagnostic	9.5

Indoor Air (IA) >> VOCs

AIRLAB

brand	name	score
• SGS	AirSense_Omni	7.8
• Meo	node_2.0	7.2
• inBiot	MICA_Wall	7.2

Citizen Air (CA) >> PM2.5

AIRLAB

brand	name	score
• Magnasci	uRADMonitor_AIR	9.2
• TERA	Tera_PMSCAN	9
• ATMOTRACK	Atmo02-Citizen	8.3

This Challenge is part of AIRLAB's activities: launched by Airparif and its partners, AIRLAB brings together a community that is committed to improving air quality. Large companies, SMEs and start-ups, research institutes, local authorities, citizens: everyone brings ideas, skills, resources and means. AIRLAB contributes to protect the health of citizens, to support innovative companies and to develop employment by promoting the development and implementation of solutions to air pollution in Paris and Ile-de-France. It also encourages their promotion at national and international level. AIRLAB is supported by its founding members: Airparif; Région Île-de-France; Marie de Paris; Métropole du Grand Paris; Préfecture de la Région Île-de-France; Île-de-France Mobilités; SNCF; Véolia; Icade; EDF; Engie; and all of its partners, a list of which is available on its website www.airlab.solutions.

The AIRLAB Microsensors Challenge 2021 is organised by Airparif with the support of Atmo France, the Swiss Federal Laboratories for Materials Science and Technology, the Fédération interprofessionnelle des métiers de l'environnement atmosphérique, the Observatoire de la qualité de l'air intérieur, Lab'Aireka, Incub'Air, the Centre Scientifique et Technique du Bâtiment, the European Union's Interreg TransfAIR project and the World Meteorological Organisation.

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More information on www.airlab.solutions

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