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09 SenForFire NEWSLETTER

SENFORFIRE. **LOW-COST WIRELESS SENSOR NETWORK FOR FOREST FIRE PREVENTION AND EARLY DETECTION (S1/1.1/E0040*)***

Part of the **SenForFire** team during the experimental burns on 16 and 17 March in the Santibáñez el Alto common pasture (Cáceres).

In this issue:

Advances in sensor technology and field validation

The first quarter of 2026 has been particularly busy for **SenForFire**, with significant progress made in management, technological development, experimentation and dissemination. In terms of coordination, highlights include the second annual progress meeting with the Joint Secretariat and the submission of new project expenditure statements, consolidating the administrative and financial monitoring of **SenForFire**. At the same time, new institutional collaborations and pilot initiatives aimed at environmental monitoring and infrastructure protection have been launched.

On the technical front, progress has been made in the development, optimisation and integration of microsensors, as well as in the design and manufacture of new prototypes for early fire detection. Controlled burns in Cáceres have enabled these technologies to be validated under real-world conditions. Furthermore, the sensor network deployed has remained operational and progress has been made in data analysis. Progress has also been made in the development of advanced AI models that utilise multiple open data sources to predict fire risk with high spatial and temporal resolution. Furthermore, the implementation of these capabilities on the cloud platform developed by **SenForFire** has begun.

Communication and dissemination activities have been equally significant, with a presence in the media, at scientific events and through training initiatives.

Interreg Sudoe
Co-funded by the European Union
SenForFire

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Social media management. Updating promotional campaigns on *LinkedIn*, *Facebook* and X, providing updates on the project's progress and supporting, amongst other things, awareness-raising initiatives such as *World Forest Day* and *Earth Hour*.

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Development of the workshop's visual identity. Creation of the visual identity for the international workshop in Toulouse, helping to ensure a consistent and recognisable image for the event:
https://senforfire.sciencesconf.org/

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Online coverage and press releases regarding the SenForFire project. The project's website has announced **SenForFire**'s participation in the programme **Conexión Extremadura**, during which the project's progress was showcased through the deployment of a sensor network and a live demonstration of the detection of a simulated fire, highlighting the effectiveness of the technologies developed.

It has also been announced that an international workshop on smart sensors for forest fire prevention, organised by **SenForFire**, will be held in Toulouse; this will promote the exchange of knowledge and collaboration among experts at European level. It was also reported that **SenForFire** members attended the FIREPOCTEP webinar "Weather hazard alerts and fire behaviour indicators", strengthening cooperation between projects under the Interreg Poctep and Interreg Sudoe programmes in the field of fire risk prevention and management.

Finally, a press release was issued to inform the public about experimental burning carried out on a pasture in Cáceres to validate early forest fire detection technologies, an initiative which has also received coverage in various media outlets. It can be viewed here:
https://interreg-sudoe.eu/proyecto-interreg/senforfire/

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CTG CROSS-CUTTING TASK GROUP: PROJECT MANAGEMENT AND COMMUNICATION COMMUNICATION

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Promotion of the project at industry events. The beneficiary, INIA-CSIC, has promoted the project by taking part in various events. On 12 February, it gave a presentation entitled “Agro-environmental management and forest fires” at the 2nd International Forum on the Rural Economy, organised by FIDER in Seville. Furthermore, on 16 February, it presented the paper “What prevention is possible in the era of ‘mega-fires’?” at the conference “Living with forest fires”, organised by the Ateneo de Madrid.

CTG CROSS-CUTTING TASK GROUP: PROJECT MANAGEMENT AND COMMUNICATION MANAGEMENT

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Annual progress meeting with the Joint Secretariat. On 16 February, the progress meeting for the second year of the project (2025), as required by the Joint Secretariat (JS), was held online.

The meeting was attended by representatives of the lead beneficiary (ITEFI-CSIC), the beneficiaries responsible for specific task groups (INIA-CSIC, CNRS-CIRIMAT and UEx), the cross-cutting task group (ITEFI-CSIC) and the communication task group (UEx), as well as other beneficiaries (IMB-CSIC, University of Évora, University of Coimbra and Arantec), with a total of twelve team members. Representing the SC were the project monitoring officer, Alexandra Lopes, and the director, Isabelle Roger.

During the meeting, which lasted approximately two hours, the progress of the project in its second year (2025), its current status and the outlook for the third year (2026) were reviewed. These issues had previously been addressed in writing via the questionnaire provided by the SC and sent out in advance.

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Submission of the project’s third expenditure declaration. On 12 March, the project’s third expenditure declaration was submitted via eSudoe. Furthermore, the **Interreg Sudoe programme** has reimbursed 75% of the costs to the beneficiaries whose claims were included in the project’s first expenditure declaration, previously submitted via eSudoe on 18 December 2025.

WG1 SPECIFICATIONS OF THE VALIDATION SCENARIOS AND TECHNICAL CHARACTERISTICS OF THE WSN

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A 1.1

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Partnership agreements and new pilot initiatives. During the first quarter of 2026, online meetings were held with municipal authorities in Legarda (Navarra) and Ripollet (Barcelona), which led to an agreement to launch environmental monitoring activities using sensors (meteorological, edaphic and atmospheric), aimed at the prevention and early detection of fires in specific scenarios linked to high-risk human activities identified by local officials.

Furthermore, meetings were held with technical staff from INECO, a public company attached to the Ministry of Transport and Sustainable Mobility, with the aim of improving surveillance and early warning systems to protect railway infrastructure and users from forest fires. As a result, a collaboration framework has been established between **SenForFire** and **INECO**.

Subsequently, a controlled vegetation burn will be carried out in which, alongside the ground-based atmospheric sensors deployed by **SenForFire**, INECO will use a drone equipped with an optical camera and particle sensors.

WG2 DEVELOP AND MANUFACTURE COMPONENTS AND SYSTEMS AND VERIFY THE PERFORMANCE OF WSN

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A 2.1

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Evaluation of gas microsensors. Research teams from the CNRS (CIRIMAT and LAAS) and the CSIC (IMB) are continuing to analyse the results obtained from the latest tests carried out on the CSIC's (INIA) test benches.

Optimisation of sensitive materials (TiO_2). The CNRS (CIRIMAT and LAAS) has carried out a new round of optimisation in the deposition of TiO_2-based sensitive layers, with the aim of reducing the operating temperature of the devices.

Integration into modules. The gas microsensors developed by CSIC-IMB that have shown the best performance in the laboratory have been sent to Ray-Ingeniería for integration into electrical modules and subsequent validation under real-world conditions.

Development of packaging solutions. The CSIC (IMB) team is making progress in the encapsulation of various devices: for infrared sensors, by integrating filters into the encapsulation itself; and for air flow sensors, by applying a photocurable resin to the bonding to ensure resistance to high flow rates during field tests.

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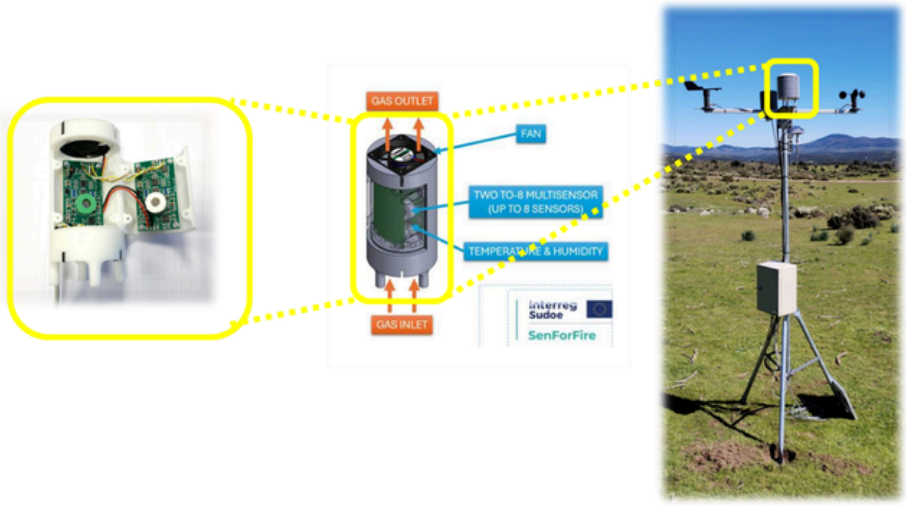
Organisation of an international meeting and conference. Researchers from the CNRS (LAAS) are working on preparations for the next follow-up meeting of the **SenForFire** project, as well as the international conference "Smart Sensors and Microsystems for Environment Monitoring and Fire Prevention".

Installation and field validation. In Santibáñez del Alto, the electronic modules produced by Ray-Ingeniería, which incorporate developments from the CSIC (IMB), have been installed as part of experimental testing. During the fires, the devices responded as expected, and a detailed analysis of the data is currently being carried out in relation to variables such as wind, humidity and temperature.

Photograph and diagram of the electrical modules produced by Ray-ingeniería for the integration of gas microsensors.

Installation of the module in Santibáñez el Alto.



Bimonthly meeting for Activity A2.1. The bimonthly meeting for the activity took place, during which progress on the manufacture of gas, air-flow and infrared microsensors was discussed.

A fortnightly online progress meeting on A2.1 activities, during which the performance of the gas microsensors in the tests at CSIC (INIA) was evaluated and the launch of the website for the upcoming international workshop on 'Smart Sensors and Microsystems for Environment Monitoring and Fire Prevention' was announced.

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A 2.2

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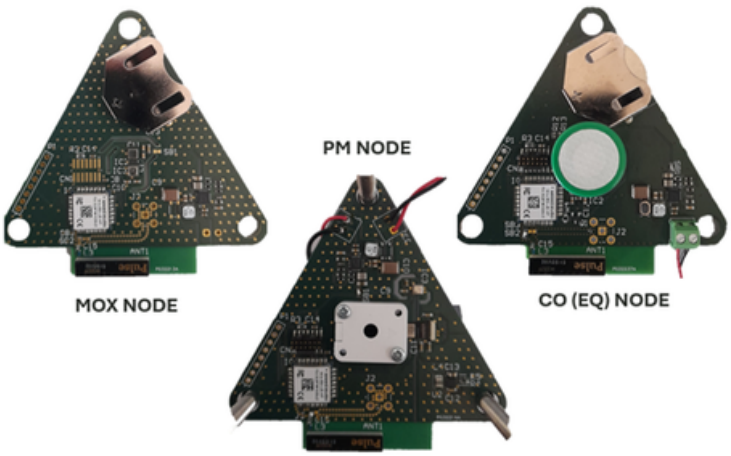
Development of early-warning fire detection prototypes. The prototypes developed as part of the **SenForFire** project consist of compact, low-power electronic modules designed to detect early signs of forest fires using complementary sensor technologies. Three types of devices have been built, targeting different combustion indicators: gas sensors to detect changes in air composition (such as volatile organic compounds), electrochemical sensors for measuring carbon monoxide, and optical sensors for identifying smoke-associated airborne particles.

All the prototypes share a common architecture based on custom-designed circuit boards, energy-efficient components and autonomous solar-powered systems, enabling their deployment in remote forest environments. They also incorporate long-range wireless communications (LoRaWAN), facilitating real-time data transmission without the need for complex infrastructure.



This combination of modular design, low power consumption and multi-sensor capability makes these devices a flexible and scalable solution for continuous environmental monitoring and early fire detection. Over the coming months, production will begin on several dozen prototypes, which will be deployed in the field for validation under real-world conditions and to pave the way for their future large-scale implementation.

A 2.5

Media coverage of the project. As part of **SenForFire**'s outreach activities, a live interview and demonstration took place on the programme **Conexión Extremadura on Canal Extremadura**. During the broadcast, the research team presented the system they had developed and explained how it works in layman's terms, highlighting its ability to detect early signs of fire by analysing gases and particles in the air.

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A practical demonstration of how the sensors work was also carried out under real-world conditions, showing how data is recorded and transmitted in real time. This initiative helped to bring the technology closer to the public, raising the profile of the project and highlighting the potential of the research carried out in Extremadura for the prevention of forest fires. The full speech can be viewed via the following link: https://canalextremadura.es

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Presentation at an educational conference in Lisbon. On 20 March, we took part in a presentation and panel discussion at the 7th Teachers' Conference "Learning Outside the Classroom", held at the Pavilhão do Conhecimento Ciência Viva (Lisbon), where the project was presented under the title "Sensors and AI for monitoring and protecting the environment".

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Preparation and submission of scientific papers. On 31 March 2026, three papers were prepared and submitted to the 10th International Conference on Forest Fire Research (ICFFR) (https://events.adai.pt/en/10th-icffr), focusing on various developments within the project. One of the papers addresses the **current status of data collection and model** building within the **SenForFire** project. Another paper focuses on the **development of the geospatial component of SenForFire**, within the framework of its monitoring and analysis systems. The third paper presents the **platform developed in collaboration with the University of Évora**, aimed at the integration and exploitation of the project's data.

R 2.1

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Completion of the SenForFire MOOC design. During the period covered by this report, the University of Extremadura and the other participants in the MOOC have finalised the design of the project's definitive MOOC programme, entitled "Technological innovation for forest fire prevention: Smart wireless sensor networks".

WG2 DEVELOP AND MANUFACTURE COMPONENTS AND SYSTEMS AND VERIFY THE PERFORMANCE OF WSN

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The course aims to raise awareness among the general public of the challenges associated with forest fires and the innovative technologies used for their prevention, detection and management. The MOOC combines content on fire behaviour with an accessible introduction to wireless sensor networks (WSN), Internet of Things (IoT) technologies, data analysis and applications developed within the framework of the project.

Structured around five thematic modules plus a welcome module, the course covers everything from the fundamentals of forest fire risk to the use of sensor technologies, wireless communication systems, data-driven tools and advanced monitoring solutions. It includes short videos, supplementary materials and assessment quizzes, as well as a final comprehensive exam.

With a practical, interdisciplinary and informative approach, the MOOC aims to raise awareness of forest fires, promote technological literacy and disseminate the results of the **SenForFire** project to a wide audience. Its main objectives include the acquisition of general knowledge about forest fires, an introduction to wireless sensor networks as a technological tool, and the dissemination of the project's results.

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Erasmus Mundus application. In February 2026, an application was submitted for the Erasmus Mundus Joint Master's programme, proposing a "Master's in Intelligent Data Analysis of Environmental Sensor Networks".

WT3 VALIDATING WSN FOR THE PREVENTION AND EARLY DETECTION OF FOREST FIRES

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A 3.2

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Monitoring and maintenance of the sensor network. During the first quarter of 2026, monitoring and maintenance were carried out on the network of meteorological, edaphic and atmospheric (gases and VOCs) sensors deployed in the summer of 2025 in the pilot areas of Fundão, Madrid, Cáceres and Andorra. The network has generally functioned satisfactorily, with isolated incidents arising from adverse weather conditions (such as heavy rain and snow) and acts of vandalism, caused by both humans and animals.

In nodes equipped with low-cost soil sensors, power supply failures associated with premature battery depletion, waterproofing issues in the housings (ITEFI-CSIC) and firmware deficiencies (RAY-IE) were detected, all of which have now been rectified. Meanwhile, the mid-range and high-end commercial nodes (Arantec) have experienced only isolated interruptions in communication and data transmission, with no significant impact on the system.

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Furthermore, INIA-CSIC has continued to monitor the moisture content of forest fuel at sensor locations installed in Guadarrama, as part of its collaboration with the Forest Fire Unit of the Madrid Regional Fire Service, as well as in the province of Cáceres, with the support of the Cáceres Forest Fire Planning and Analysis Team (EPAIF).

A 3.3

Sensor validation campaign in Santibáñez el Alto. On 16 and 17 March, a range of activities were carried out in the pilot area of Santibáñez el Alto, aimed at validating low-cost environmental sensors for the prevention and early detection of forest fires. To this end, a network of meteorological, edaphic and atmospheric sensors was deployed, together with a LoRaWAN communication gateway.

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The installed infrastructure enables real-time monitoring of critical fire hazard variables, such as temperature, air humidity, wind and precipitation, as well as soil temperature, water content and water potential. In addition, a network of approximately thirty atmospheric sensors distributed across the pilot area recorded levels of gases (CO, CO_2, CH_4, NO_2 and O_3), volatile organic compounds (VOCs) and particulate matter (PM) in the air during a controlled burn carried out on 17 March.

The burning involved the sequential combustion of nine piles of 'white broom' (Cytisus multiflorus) over a period of approximately three hours. Low-cost, ultra-low-power nodes developed by the University of Extremadura (UEx) were used, as well as nodes from Ray Ingeniería Electrónica equipped with high-sensitivity microsensors developed by the IMB-CSIC. All systems were integrated into a LoRaWAN-based IoT architecture, ensuring continuous and reliable data transmission to the monitoring platform.

The results enabled an assessment of the temporal response of the different technologies to variations in smoke dispersion and environmental conditions, with rapid responses observed in electrochemical sensors, adequate detection of aerosol dynamics in optical sensors, and more gradual variations in MOX sensors, confirming the system's validity in a real-world environment. INIA-CSIC carried out the preliminary characterisation of fuels (load and moisture content) and monitored the burning process using visual indicators and temperature measurements taken with thermocouples installed in the fuel piles.

A network of low-cost environmental sensors (weather, soil and air quality) connected via LoRaWAN for real-time monitoring.

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The process of carrying out an experimental burn of Cytisus multiflorus, with technical and scientific monitoring to validate the sensors under real-world conditions.

A 3.4

Dissemination of the results of the pilot activities. Analysis of the data recorded by the sensor network deployed in the pilot areas has been stepped up, as has its comparison with open-source reference data. In this context, data from the soil sensors (15-minute resolution) have been aggregated and compared with hourly values for temperature and volumetric water content (VWC) at different depths, sourced from the ERA5 reanalysis database of the European Union's Copernicus programme.

Furthermore, an analysis has begun to determine the correlation between soil moisture measured by the sensors (VWC) and vegetation moisture, estimated by the forestry services (Guadarrama, Cáceres and Andorra) and by the INIA-CSIC team (Madrid) using the gravimetric method. The preliminary results were presented and discussed at an online meeting held on 27 March with forestry technicians and officers from MITECO (BRIF and EPAIF) and the Regional Government of Extremadura (INFOEX), who are collaborating on the implementation of controlled burns, sample collection and the determination of vegetation moisture content in the pilot areas of Cáceres.

Two technical papers have been prepared for oral presentation at the 10th International Congress on Forest Fire Research (ICFFR), to be held in Coimbra in the first week of November. The first article analyses measurements from ground-based sensors and their correlation with vegetation moisture, whilst the second evaluates the performance of early-warning sensors (gases, VOCs and PM) during the prescribed burn carried out in Castrohinojo (León) on 31 March 2025.