SOHAR
PORT / FREEZONE

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1.0 Introduction

1.1 Project Background

SOHAR Port and Freezone is managed by Sohar Industrial Port Company (SIPC), a 50:50 joint venture between the Port of Rotterdam and the Sultanate of Oman

SOHAR Industrial Port Company (SIPC) is initiating Odor management system to provide detailed, real-time insight into the air quality in and around the port. This was an important step forward to improve living conditions, transparency, and the relationship with the stockholders and community. SOHAR Port and Freezone is a deep-sea port and free zone in the Middle East, situated in the Sultanate of Oman, 220km northwest of its capital Muscat. Located just outside the Strait of Hormuz, SOHAR Port and Freezone is an ideal location for business as it lies at the center of global trade routes, between Europe and Asia.

The Port houses three clusters: logistics, petrochemicals and metals. World-leading companies Vale, Air Liquid, Larsen & Toubro, Methanol Holding International and Jindal Power & Steel are established in SOHAR Port and Freezone. The independent terminals are operated by world-class leading companies: C. Steinweg Oman for general cargo, ADVARIO for liquid cargo, and Hutchinson Ports SOHAR for containers.

The Freezone will further accentuate the port's importance as a driver of economic growth in Oman. The development of the 4,500-hectare Freezone is planned in five phases. Due to its fit-to-suit incentives and value propositions, The Freezone is an ideal location for investors in the following clusters: semi-finished iron and steel products, plastics and rubber; ceramics; chemicals, food and perishables, white goods and furniture; and the automotive industry. As part of enhancing the environmental management at SOHAR Port and Freezone area and in coordination with EA, SOHAR Port, and Freezone initiated a project to install an integrated Odor management system for a more pro-active odor control and environmental management and to better understanding of the air quality in the surrounding areas.

1.2 Scope of Work:

This project aims to establish an Odor Detection and Management system for SOHAR port and Freezone area that will detect unexpected odors and their spread in all directions within the surrounding SOHAR Port and Freezone areas, which will help assess the status of ambient air quality in the area. The project is part of SOHAR Port and Freezone environmental enhancement program to improve the environmental management at SOHAR Port and Freezone.

Industrial Clusters

SOHAR Port and Freezone was originally planned around three key industrial clusters, namely logistics metals, and petrochemicals. The port has since added a fourth pillar with the launch of the SOHAR Food Cluster, complemented by the first dedicated agro bulk terminal in a region heavily dependent on food imports.

Logistics

The SOHAR Port South expansion is fundamental to Oman's national focus on growing the logistics and industry sectors as part of its ongoing economic diversification efforts. This expansion will aid the steady growth in aggregate cargo volumes and investments at the port by delivering additional cargo capacity and attracting more business to SOHAR.

Metals

The metals cluster at SOHAR has experienced rapid development over the years. SOHAR is equipped with deep-water jetties capable of handling the Vale max class of Very Large Ore Carriers, which are among the world's largest ships. Apart from aluminum and streel, SOHAR also hosts the largest rare earth metal plant of its kind, second only to China. The plant will manufacture antimony metal and trioxide, a precious mineral used as a flame retardant in a wide range of industries. A recent signing will also see the construction of additional ferrochrome furnaces that will increase production capacity.

Petrochemicals

SOHAR is home to Oman Oil Refineries and Petroleum Industries Company's (Orpic), whose refineries in Sohar and Muscat as well as their integrated Aromatics and Polypropylene Plants, provide fuel, petrochemicals, polymers and other petroleum products to the Sultanate and to the world. Apart from fuel products, the refinery also produces significant volumes of naphtha and propylene, which serve as feedstock for an adjoining aromatics and polypropylene plant.

Food

The Food Cluster at SOHAR includes a flourmill, a sugar refinery, a grain silo complex and an upcoming soya bean crushing facility. The cluster is able to load and unload 600 tonnes of grain per hour.

SOHAR Port South Development

SOHAR Port is undergoing the Sohar Port South Development, which will add 250 hectares to the industrial port's current capacity of 2,000 hectares by January 2019. The first phase is underway with an increase of 50 hectares in area, and additional expansions planned in subsequent phases.

Sohar FreeZone would like to acquire a network of sensing device for on line analysis of environmental emissions (gas, odors, dust and particles, noise) , for the free zone port The system provides concentration every 10 seconds, with wireless access to the data . The software can also be responsible for generating the pollutant dispersion plume using a weather station (which is optional)

The network of equipment will be installed at the environmental emissions generation points to initially monitor the concentration at source and generate the dispersion plume. Later, they should be installed at fence line or neighbor sites where gas, odor perception, and dust need to be monitored, Today, it is

recommended to complete the network at the source and at the fence line to protect the co-workers and the citizens to acquire 14 odors / Gas odor measurement equipment and 1 Mobile for the on line measurement of odor intensity.

1.3 Methodology

1.3.1 A Network of properly located Environmental Analyzers

To provide a robust and detailed environmental monitoring, the below deployment plan and implementation of 14 Ambient WT1 Lite to capture the pollutant emitted by the Sohar Port & Freezone was based on

- The size of the area,
- The various potential sources of emissions, (nature and intensity)
- The position of the impact point (neighbors, communities …)
- The other possible sources of emissions than the end customer
- and on the local climate and prevailing wind directions presented in the next figure

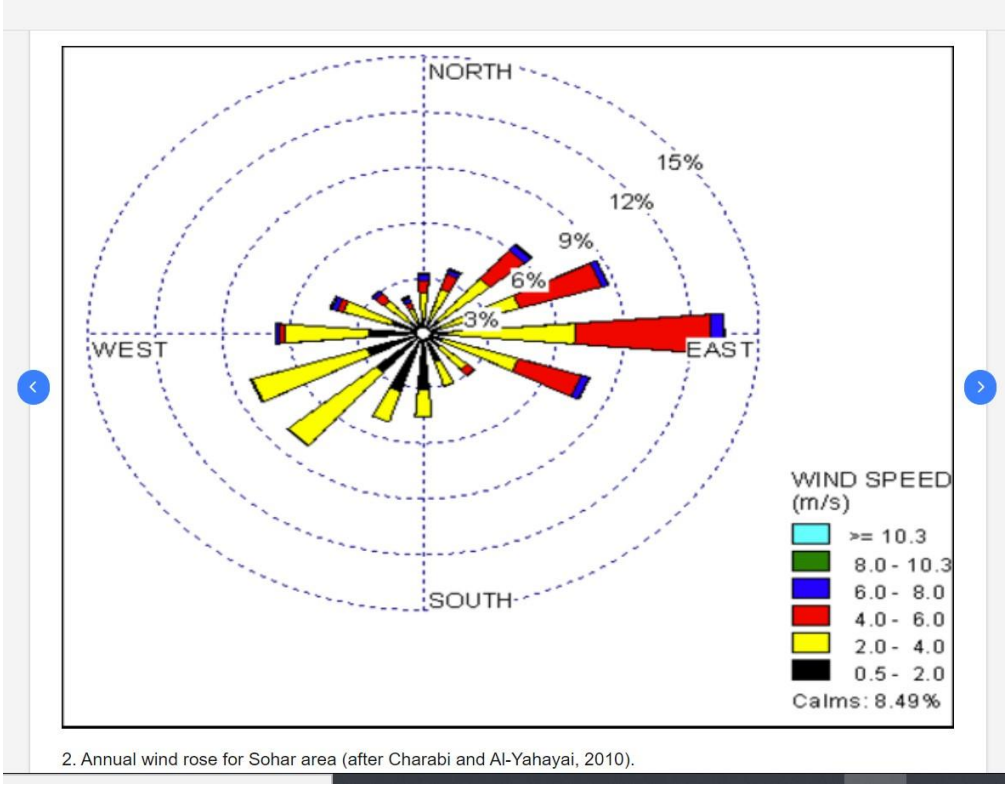


Figure 1 Wind rose at Sohar

The potential locations of the WT1 Lite according to this analysis are presented in Figures 2 to 6.

Figure 2 Bird view of the site with the Sohar Free zone in the southern part

Figure 3 Bird view of the site with the Sohar Free zone

Figure 4 Bird view of the site with the Sohar Free zone North

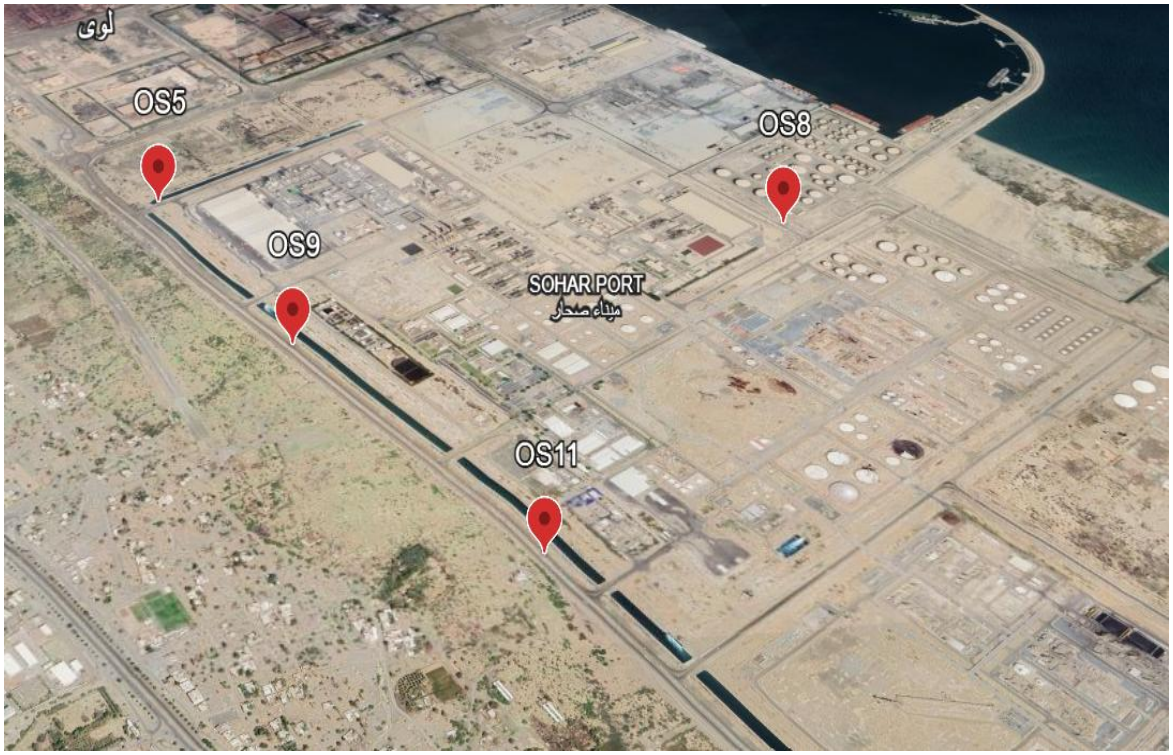


Figure 4 Bird view of the site with the Sohar Free zone North , middle and South

Figure 5 Bird view of the site with the Sohar Free zone in the southern part

We did localize the 14 units WT1 with the following parameters

- Source monitoring to be as close as possible to the various sources
- To be downwind of the dominant wind direction
- To be between the sources and the possible impact points
- To protect SOHAR Port & Free Zone from possible third parties' sources emissions

1.4.2 Equipment Description &Configuration

Figure 6 WT1 Dimension

Our solution will consist of a network of dedicated Ellona WT1 Lite (WATCH TOWER 1) Environmental Analyzers to monitor the specific representative spots.

- 24/7 real time readings of gas concentrations (up to 7 different gases) and volatile organic compounds (VOCs)
- Odor measurement and identification (possible correlation with Dynamic Olfactometry - EN13 725)
- Quantification and identification of particles
- Real-time alerts (configurable thresholds) with notifications (text message, email, etc.)
- Automated process activation (sampling, misting systems, ventilation, etc.)
- Integrated input from the community thanks to the devices unique QR codes

The main characteristics of WT1 Lite Analyzer that it can be equipped & customized with below features and sensors:

- 4 metal oxide (MOX) gas sensors for odors
- 6 electrochemical gas sensors: H2S, NH3, NO2… (from a 15+ gas list)

- 1 double-membrane PID sensor: BTX and alkanes
- Double-band optical sensor (2 optical sensors if PID not used): CO2, CH4, N2O
- 1 PM optical sensor: PM1-2.5-10 (from a list of 2 sensors: one specialized in size and concentration and one specialized in type fingerprinting)
- Temperature, humidity and atmospheric pressure sensors
- Soil and liquid sensors on demand (4-20mA)
- Software in SaaS mode
- IP 54 housing
- 12V DC input, PoE or a 12-V solar panel battery
- 110-240V AC – 12V DC Power adapter
- LTE-M/GPRS (2), Wi-Fi, Ethernet communication
- Built-in GNSS (GPS, Galileo, Beidou, Glonass)
- Data logger with up to 2 years of data storage in case of communication failure
- Over the air configuration upgrade
- Operating temperature range: -30°C / + 60°C (-86° F/+140 ° F)
- Weight: 3 kg. (6.61 lbs.)

For SIPC project, we setup the following WT1 Lite Analyzer's configuration (for each unit):

Basic configuration:

- 4 MOS sensors (odors),
- 1 temperature sensor,
- 1 atmospheric pressure sensor,
- 1 relative humidity sensor,
- GPS (initial location of the device).

Example of Deployment: Urban infrastructures on lamppost with power supply

Operating Conditions:

Operating conditions of WT1	
Temperature	De -30°C à +60°C
Atmospheric pressure	De 500 à 1500 mb
Humidity	De 0 à 100% without condensation
Chemical Products	
H_2S	Concentration below 500 ppm with 50% of humidity
SO_2 & acid gas	Concentration below 500 ppm with 50% of humidity
Ammonia	Concentration below 2000 ppm with 50% of humidity

Accessories:

To reinforce the resistance of the measuring devices to environmental conditions (UV lights, humidity, potential infiltration, corrosion…), the equipment will be placed in openwork metal protective housings (shelter) to avoid any direct impact. WT1s protected in this way must be installed in ambient air, outdoors, on lamppost structures.

- Anemometer

Perfectly designed for logging average wind speed and direction, this wind sensor comes equipped with an integrated datalogger. Self-powered by a battery and photovoltaic cell, it is offered in a complete package including cable, mounting bracket, and clamp.

If the option “dispersion plume” is selected, this proposal includes a weather station for the measurement of meteorological parameters (accurate wind speeds, wind directions and solar radiation measurements). The weather station proposed for data collection is a stand-alone device.

Figure 7 weather station and parameter

The speed measurement covers a range from 0 to 241 km/h with high accuracy (3km/h). The wind direction covers the complete compass rose with at least 16 points (22.5°) up to 1° resolution. The system can operate from -15°C to 60°C.

In order to assess the impacts of the plumes generated by the site emissions, the dispersion model needs to take into account in situ meteorological data to produce realistic maps of the impacts in the vicinity of the site.

All the meteorological data collected are usable through the same Ellonasoft web interface, at a frequency of one measurement point every 15 minutes. The set of integrated sensors (ISS) collects outdoor weather data and transmits it to a console with a datalogger. The ISS version is wireless, powered by solar energy.

The ISS version contains a temperature sensor, a rain collector, a humidity sensor humidity sensor, an anemometer and a pyranometer. The temperature and humidity sensors are installed within a passive radiation shield to minimize the impact of solar radiation on them.

The anemometer measures wind speed and direction and can be installed on the ISS or independently. ISS or independently. The Sensor Interface Module (SIM) contains the "brain" of the ISS and a radio

transmitter. The SIM is placed in front of the radiation shield in the SIM housing. The SIM collects external weather data from the ISS sensors and transmits it to the data transmission module in the cloud.

The data measured by the weather station can be consulted on a computer, a tablet by connecting via an Internet browser on the Ellonasoft platform. We consider that, according to the size of the site, only one meteorological station is sufficient to be representative of the facility - and its surrounding - weather conditions. It is therefore important to implement the station under optimal conditions, i.e. not impacted by nearby obstacles (buildings, trees, etc.).

1.4.3 Data transmission

Data is transmitted from each device to Ellonasoft platform in real time via a 3G/4G module integrated into the WT1. The 3G/4G coverage of the deployment site will be verified at the start of sensor deployment.

Note that:

- Data measurement frequency is 1 frame every 10 seconds for all parameters,
- Our solution offers Ethernet operation. This communication mode is chosen when 3G/4G coverage is insufficient on site,
- In the event of occasional loss of telecom connectivity, the device will continue to store data, thanks to an internal data logger that can store up to 2 years of data. On reconnection, the device will send the raw data stored locally back to the server, without any loss of data. In the event of a device losing its connection for a set period, an alert can be set up on the Ellona Cloud platform to warn the operating teams.

Measured data is collected and stored on a secure, future-proof cloud server. They can be consulted in real time via our platform and/or exported for use in another application or internal server (via an API).

EllonaSoft platform is a remote cloud platform, enabling users to manage their devices, monitor the various data collected by their sensors, configure thresholds and alarm models to receive customized notifications to control their environment and trigger various remediation actions.

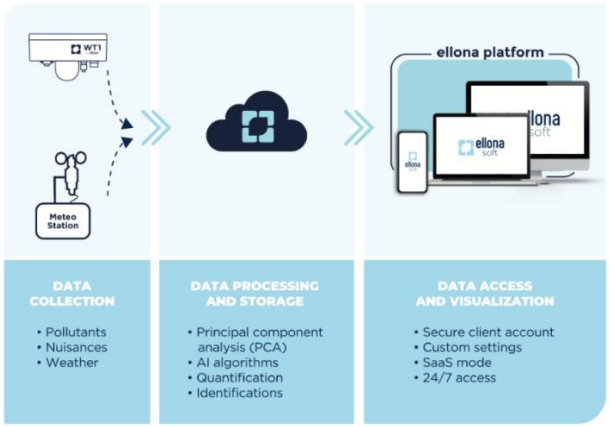


Figure 8 EllonaSoft

Key features include:

- Overview of monitored sites as map, list or detailed plan;
- Hierarchical organization of sites and devices;
- Configuration of models and alert levels for each sensor;
- View current and past alerts for the entire site and for each device;
- Visualization of collected data for each device with instantaneous or historical view;
- Implementation of algorithms for real-time event detection and identification;
- Creation of "virtual" sensors combining all the quantities available on the platform;
- Data extraction in the form of CSV files;
- Add/remove users and define their site access rights;
- Send alert notifications by SMS and/or e-mail;
- Provision of all collected data and alarms via a secure API.

1.4.4 Visualization and data processing

What we consider behind the term data is described as follow:

- Parameters (raw data) reported by the analyzers
- Alert notifications and configured alarms
- Algorithms, statistical mathematical models and results generated by the application of models/algorithms on the raw data.

The data will be:

- Stored on a secure and perennial cloud server
- Available for consultation in real time; and
- Exportable directly from the platform (in CSV format) or from a WEB application (API Rest protocol)

The access to the Ellona platform is secured by login and password, and its HTTPS format guarantees against intrusions and malversations.

This API interface is secured by an encrypted token that links the data flow to the user declared in the platform.

Below few examples of user interface:

- Map of equipment location :

Figure 9 Map of Equipment Location

- Site presentation

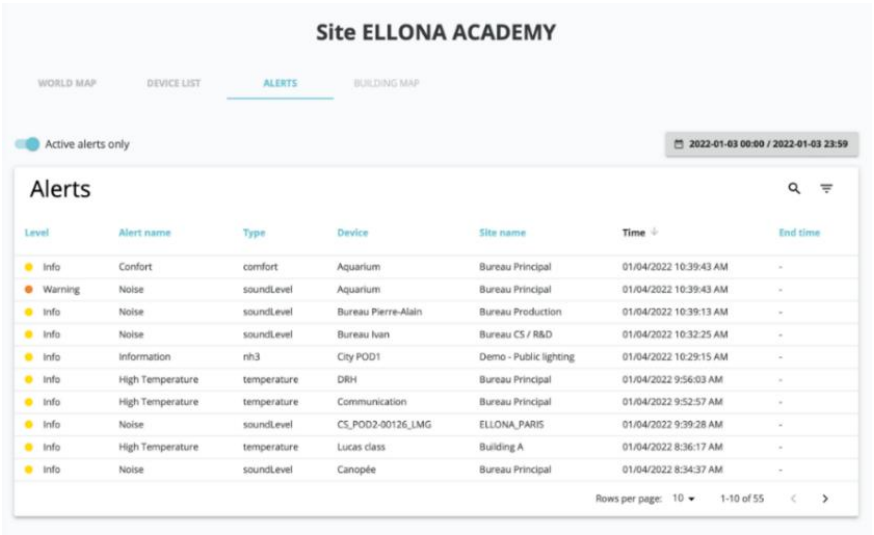


Figure 10 Ellona presentation

- Time series of pollutants and odors concentrations:

Figure 11 Time series of pollutants and odors concentrations

- Creation of Alarms :

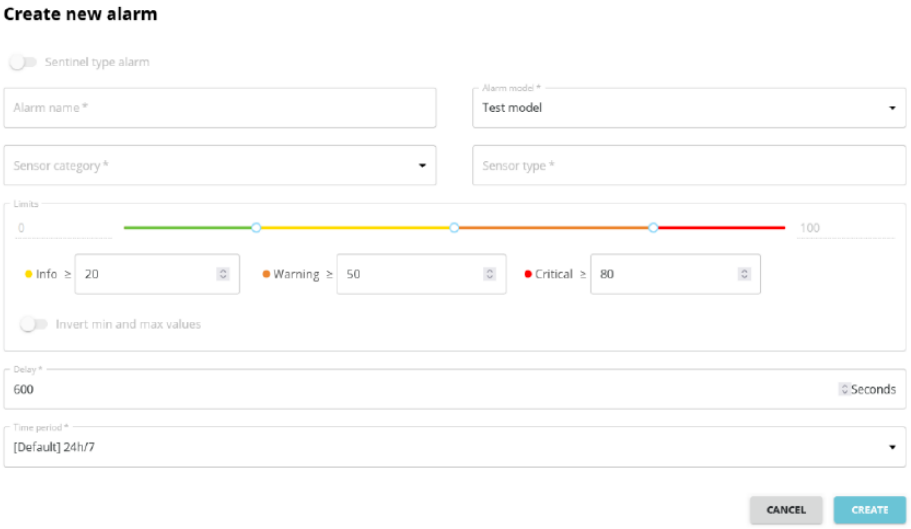


Figure 12 Creation of alarms

1.4.5 Determination of odors, Dust, Gas Emissions and nuisance sources

The WT1 Litte can provide not only gas measurement but also odor, dust and noise identification if needed. An odor is not a mono gas even if some gas is odorant like H_2S or NH_3. An odor is a mixture of various odorant volatile molecules that can count up to several hundreds of molecules. For example, a coffee odors is a mixture that can include up to 700 molecules. In case of odor measurement in the environment, the major chemical families that are involved are sulfurous, aldehydes, ketones, amines … in mixture.

Odor measurement involved two major approaches:

- Odor intensity: this aspect is designed to measure the strength of the smell
- Odor identification: this aspect aims to define the specific characteristics or identity of the odor

The WT1 is going to use the various sensors available mostly the MOS sensors, but not only, in combination, in order to measure odor intensity or the odors quality.

Odor Intensity:

Two distinctive methods could be used for odor intensity measurement:

A- **Certified approach :** This is a rigorous, standardized chronological method, using dynamic olfactometry coupled with our WT1 analyzers. This method guarantees accurate and reliable results, but is more expensive.

B- **Alternative approach (uncertified) :** This is an alternative implementation strategy, simpler and less restrictive (no need to collect samples on site) and inexpensive (as no olfactometric campaign is required)

Odor Intensity		① **Certified approach (OU)**	② **Alternative approach (IOU)**
Equipment	WT1	❖	❖
	Nalophan / Tedlar Bag	❖	
Methodology	Sampling	❖	
	Bag sniffing *with panel (dynamical olfactometry)* *by WT1(s)*	 ❖ ❖	
	logbook and/or QR code		❖
	WT1 : continuous data acquisition	❖	❖
	Data processing on Ellonasoft	❖	❖

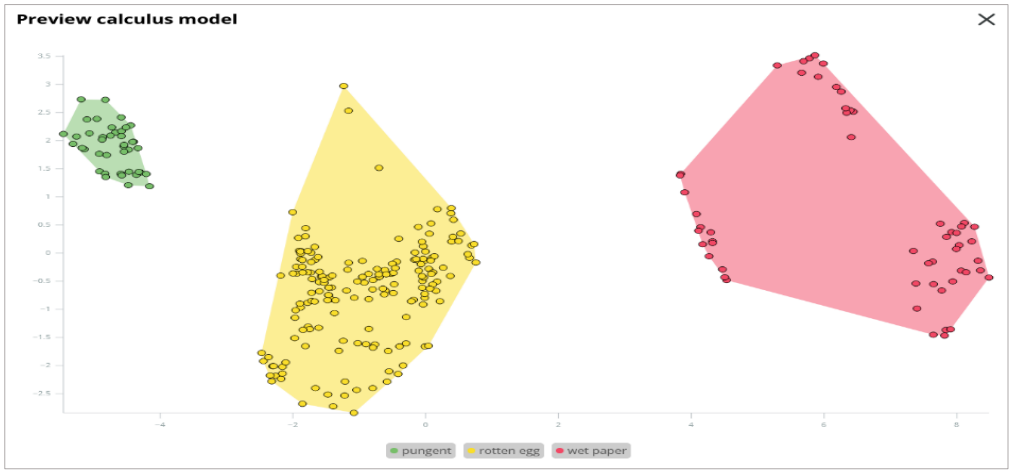
❖ Required

Facultative

Odor dust and noise Identification:

This training could be carried out by Ellona staff.

Il will enable olfactory signatures to be identified and associated with different sources of origin.



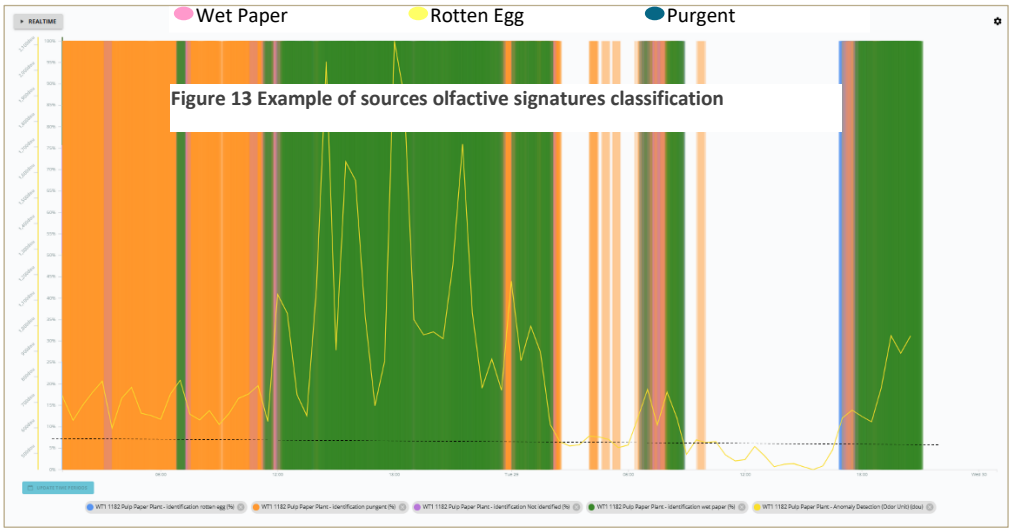


Figure 13 Example of sources olfactive signatures classification

Figure 14 Example of odor intensity threshold exceeded and source identified in real time

NOTE:

If, following this technical proposal, discussions with CGR converge towards a more standardized approach, Ellona will propose an estimate based on approach A for odor intensity (certified approach) and therefore approach 1 for source identification.

1.4.6 Dispersion Model (Optional)

To assess the impacts of the site's emissions, Ellona offers a dispersion modeling tool, which generates odor and gas plumes in the environment every 1 hour. Based on the AERMOD Gaussian plume model recommended by the US EPA, the dispersion software is a powerful 3D numerical simulation tool for the dispersion of odors and/or polluting gases. The numerical system integrates local weather, topography and emissions from odor and gas sources measured by the WT1 hardware solution to dynamically model the plume. The modeling results are then used to characterize the contribution of the site to the neighborhood within a radius of approximately 10 km.

The dispersion model Implemented Ellonasoft, allows the direction of the polluting emissions and their intensity. The advantages of this monitoring of the site's activities are the following:

- Dynamic visualization and continuous dispersion of the odor and/or pollutant plume
- Retrospective visualization of past episodes for analysis and comparison with reports in the neighborhood
- A quick evaluation of the efficiency of the measures and actions implemented to reduce the pollution levels at the source

The plume Figure 15 is represented in the form of a map with color-coded isocenters that allow an immediate assessment of the impact of the emissions on the site's neighborhood. Each color corresponds to a range of adjustable concentrations (color and thresholds) for each pollutant of interest. This visual allows users to follow online the state of dispersion of pollution on site and to evaluate the areas most impacted by source activities according to meteorological conditions.

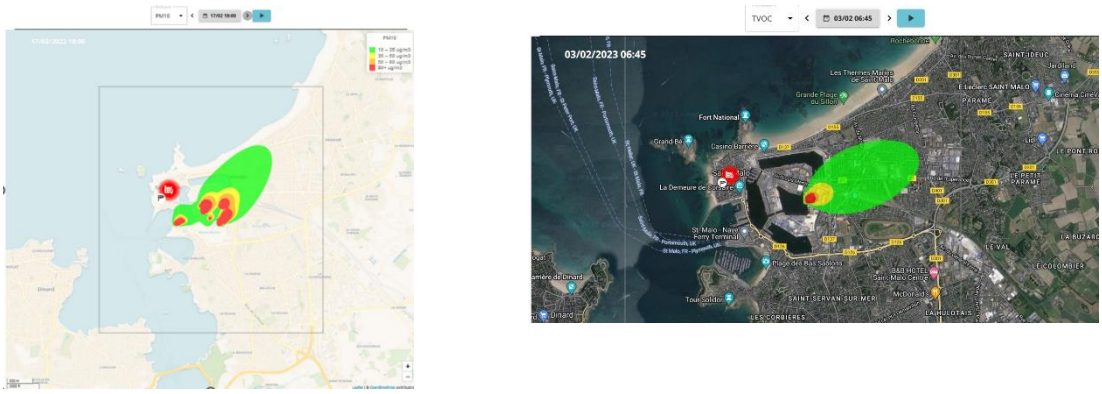


Figure 15: Example of a plume dispersion model for PM10 (map view) and odors (satellite view)

Finally, explicit calculations at specific receptors in the environment are performed (e.g. location of the most sensitive ERP such as schools, hospitals, residents).

The pollutant dispersion model is configured during the installation of the WT1 devices and the meteorological station. To make this digital tool operational, an inventory and characterization of the existing sources (up to 20) is carried out to highlight the contributions of each of them on the pollutants measured by the monitoring devices.

The emission sources can be of different natures:

- Static sources: industrial chimney, fuel tanks or other
- Surface sources: storage area …

The calculation of pollutant emissions, in real time, is based on the concentrations measured by the WT1 Lite deployed on site. Each device is associated with the closest sources, according to the main activities around each site but also to the meteorological conditions.

2.0 Appendix

Appendix 1:
Our Proposed Solution in brief

We offer a connected analyzer for the continuous, real-time monitoring and identification of physical and chemical nuisances (gases, odors, particles, noise, etc.) that can affect health and well-being in outdoor environments.

These connected systems combine networks of miniaturized sensors with innovative data processing techniques, enabling:

- Automatic triggering of depollution or sampling systems,
- complete mapping of cities, industrial sites, etc.

The data is transmitted in real time to our SaaS application, enabling users to manage their devices, configure alarm thresholds and models, and receive customized notifications to monitor their environment and trigger various corrective actions.

As part of the ELLONA system, QR codes play a key role in facilitating the real-time collection of information from workers, users or neighbors. All that's required is to scan a QR code using a smartphone, which gives access to a personalized questionnaire. This unique feature allows both analytical and subjective data to be evaluated simultaneously, enabling more accurate correlation and more targeted corrective action

Figure 16 General overview of the outdoor Ellona solution

Description of the Equipment (WT1)

Our device is an online, real-time monitoring system for outdoor environments. It measures gases (NO_2, CO_2, VOCs, etc.), odors, particles, noise, temperature and humidity.

Depending on the configuration chosen, the system can measure several parameters simultaneously using several types of sensor:

- A board dedicated to detecting odors and changes in the environment
- 6 electrochemical sensors for gas detection: H_2S, NH_3, NO_2, etc. (to be selected from a list of over 15 gases)
- 1 optical sensor (dual-band NDIR) for measuring CO_2 or CH_4
- 1 photo-ionization sensor (PID) for VOC measurement
- 1 fine particle sensor: PM1-2.5-10

Our solution has the ability to recognize the signature of gases for which there is no specific sensor and to identify odors. It can both identify and quantify odors in accordance with the relevant standards (ASTM 679 / EN 13725).

Our instrument is equipped with a dynamic measurement system and a dual air inlet/outlet channel for separate measurement of gases and particles, providing more stable and accurate sampling. Optimization algorithms are also used to ensure measurement quality.

Our analyser has an on/off and 4-20mA relay to trigger or control third party applications such as automatic sampling systems, ventilation or misting systems, etc.

It has several communication modes to ensure a link with our platform in all situations: Wi-Fi, Ethernet or LTE-M (GPRS in case of LTE-M fallback).

For all your projects, a wide range of options is available:

- The addition of solar panels and batteries to ensure instrument autonomy
- A weather station (wind speed and direction, rainfall, etc.)
- On-site calibration equipment for maintenance of instrument performance over time
- The ability to collect subjective feedback from the people using a unique QR code that is linked to each of the devices. These comments can then be correlated with the data from the physical sensors on the device.

Quality control is systematically carried out at the factory. This ensures that the performance claims made by the sensor manufacturers are met. In addition, Ellona's R&D team is actively involved not only in the selection of high quality sensors, but also in their adaptation and optimization for use in any given environment.

In the event of a connection failure, measurement data is stored locally on the device (for up to 2 years depending on configuration) and then back in the cloud when communication is restored.

Our solution integrates an environmental intelligence platform. It enables customers with one or more devices to manage and interact with their devices and process data.

Key features include:

- Map view for easy location of analyzers by location;
- Dashboard that displays all collected data;
- Real-time alerts by site or by device when a parameter exceeds a preconfigured threshold;
- Creation of new indicators (virtual sensors) based on statistical models to characterize situations (olfactory fingerprints, anomalies, etc.).
- A dispersion model (optional) to assess the concentrations of emissions from a site at their points of impact.