Project title:

Development of a real-time information and monitoring system to support the risk assessment of engineered nanomaterials (ENMs) under REACH

Project Acronym: **NanoMONITOR**

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Deliverable

DA4a. Report on the functionalities and system requirements of the NanoMONITOR integrated system

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List of acronyms

API	Application Programming Interface
ENM	Engineered nanomaterials
GUI	Graphical user interface
NMs	Nanomaterials
SMEs	Small and medium sized enterprises

Summary

The main goal of NanoMONITOR is to develop an innovative system to generate robust, accessible, comparable and interoperable data on the concentration of engineered nanomaterials in outdoor and indoor areas. The term "nanomaterial", hereinafter NMs, refers here to intentionally produced materials with at least one external dimension in the size range from approximately 1-100 nanometer

This system includes: 1) a **compact size air monitoring station** designed to provide real-time information of the concentration of nanosized (1 to 100 nm in diameter) and ultra-fine airborne particles (10 to 300 nm in diameter) in indoor workplaces and outdoor environments, and 2) a **web based data-acquisition software** aimed at supporting the acquisition, management and processing of data on the concentration of ENMs retrieved from air monitoring stations or uploaded by data providers.

The present document describes in detail the functionalities and requirements to be considered during the development of the monitoring station and the web based software platform on the basis of the opinions of the target audience of the project and the experience of the members of the consortium.

The selection of the main functionalities of the NanoMONITOR air monitoring station and associated data acquisition / management software was based on the analysis of the information requirements laid down on REACH regulation and the information retrieved from tailored designed questionnaires distributed among the target industry. This information together with the experience and expertise of the members of the consortium in measurement devices and data acquisition application has enabled a first description of the whole system specifications.

A back-end Application Server accompanied by a Web based client application was identified as a proper option to cover the functionalities of the data acquisition software. This solution allows the user to retrieve data from the monitoring stations, download historical data or display information in multiple views. On the other hand, a modular air monitoring station including a particle measurement unit, a particle collection unit and a tailored designed programmable control has been proposed to cover the functionalities identified.

A special interest on the implementation of functionalities to support the use of measured data for risk assessment purposes was clearly identified in view of the information retrieved from the questionnaires distributed.

The exact look, design and features of the proposed air monitoring station and data acquisition software will be presented under deliverables DB2a and DB3a, where a complete description of the specifications of both sub-systems will be reported.

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1. Scope and goal of the deliverable

The present deliverable provides a detailed description of the functionalities and features of the air monitoring stations and web based data acquisition software to be developed within the project in view of the information requirement laid down on REACH regulation, opinions from the target audience of the project and own experience of the members of the consortium.

The information included in this document clearly identifies the requirements defined by companies dealing with ENMs, including producer and downstream users, public authorities and regulatory bodies. This information is of prime importance for the development of the NanoMONITOR integrated monitoring system, being the first step towards the achievement of the objectives of the project.

A more detailed description of the components and structure of the stations and the data acquisition software will be provided under actions B2 and B3, where the development of both sub-systems will be accomplished. The information retrieved under deliverable A4a includes:

- List of functionalities retrieved from questionnaires
- Specifications selected according with the objectives and expected results of the project
- Proposed structure and features of the data acquisition software
- Proposed structure and features of the air monitoring stations

2. Functionalities and requirements of the NanoMONITOR integrated system bases on stakeholder´s opinions and expectations

A stated previously, the definition of the functionalities and main features of the monitoring station prototype and data acquisition software was conducted considering the needs and opinions of the target audience of the project, the information requirements laid down on REACH regulation and the experience and expertise of the members of the consortium.

A stepwise approach was designed to collect information from the target audience, including the development of a **database of contacts** including SMEs, safety advisors from public institutions and representative persons from public bodies with responsibilities in REACH implementation, as well as the development of an **on-line questionnaire** to retrieve data on the features and operational functions that shall be considered in the design and implemented in the monitoring station prototype and the data acquisition software. This questionnaire was distributed among more than 500 contacts listed by ITENE, TRC and CEAM, being also available in the project web site.

The information compiled from surveys was analysed in depth by the members of the consortium, being reinforced with the results retrieved from action A2 and A3, where detailed information on the type and quality of measured data to be considered to support a proper risk assessment under REACH was identified.

An example of the questionnaires used to gather data on the functionalities and features of the monitoring station and the data acquisition software are depicted below:

Eliciting Stakeholder requirements on the monitoring station prototype

Thank you very much for taking part in this short NanoMonitor Project survey. NanoMonitor is a Life+ EU project that aims to develop a real-time information and monitoring system to support the risk assessment of nanomaterials under REACH. This short 5 minutes survey will help us elicit stakeholders' (project partners, municipalities, industries etc.) requirements on the NanoMONITOR monitoring station prototype.

1. What type of measured data are you more interested in?

- ☐ Number concentration
- ☐ Mass concentration
- ☐ Surface area
- ☐ Average diameter / size distribution
- ☐ Chemical nature
- ☐ Other:

2. What REACH related information are you more interested in?

- ☐ Occupational Exposure: particle breathing zone
- ☐ Occupational Exposure: background concentration
- ☐ Human via environment
- ☐ Environmental Release ratios
- ☐ Predicted Environmental concentration (PEC) values
- ☐ Other:

3. Please specify the size range you are more interested in (select all that apply)

- ☐ PM0.1 / Nanometer (1 -100 nm)
- ☐ Ultrafine (PM1) / 1 – 1000 nm
- ☐ PM 2.5
- ☐ PM10
- ☐ Other:

4. What type of contextual information would you like to measure?

- ☐ Temperature
- ☐ Pressure
- ☐ Relative Humidity
- ☐ Wind speed / direction
- ☐ Other:

5. Please specify your preferred operational settings (select all that apply)

- ☐ 24 hours / 7 days
- ☐ Remote On / off
- ☐ Programmable settings
- ☐ Other:

6. Please specify the temporal resolution of data measured by the station (select all that apply)

- ☐ Daily
- ☐ Hourly
- ☐ 15 min average
- ☐ 1 min average
- ☐ Other:

7. Please specify the areas to be monitored (select all that apply)

- ☐ Industrial (indoor)
- ☐ Industrial (outdoor)
- ☐ Urban areas
- ☐ Environment (air)
- ☐ Other:

8. Would you like to control the station using a touchable screen?

☐ Yes ☐ No:

9. Would you like to have a remote access to the data measured ?

☐ Yes ☐ No:

10. Would you like to have a remote access to the data measured ?

☐ Yes ☐ No:

Please, list other suggestions you would have concerning the structure and the functionalities of the monitoring station prototype:

Eliciting Stakeholders' requirements on the Nanomonitor web platform (on line view)

Thank you very much for taking part in this short NanoMonitor Project survey. NanoMonitor is a Life+ EU project that aims to develop a real-time information and monitoring system to support the risk assessment of nanomaterials under REACH.This short 5 minutes survey will help us elicit stakeholders' (project partners, municipalities, industries etc.) requirements on the NanoMonitor web platform.

1 Would you like to see the measurement results as a graph?

- ◯ Yes
- ◯ No

2 Would you like the web platform to comprise a map showing the measuring sites?

- ◯ Yes
- ◯ No

3 If yes, would you prefer to click on the site to get information on the measurements? Or would you prefer to have a menu bar to get information for a specific site, specific pollutant or meteorological variable and specific time period ?

- ☐ Click on the site
- ☐ Menu bars
- ☐ Both

Other (Please Specify)

4 Please specify the temporal resolution of the raw data included (select all that apply)

- ☐ Daily values
- ☐ Hourly values
- ☐ 15-min averages

Other (Please Specify)

5 Which kind of statistical analysis would you prefer? (select all that apply)

- ☐ percentile 50%
- ☐ percentile 95%
- ☐ mean / min /max

Other (Please Specify)

6 Do you agree to include also the calculation of correlation coefficients for different parameters?

- ◯ Yes
- ◯ No

7 Which measurements are the most important for you to be displayed by default (when you do not make a selection)?

- ☐ Statistical means
- ☐ NM composition
- ☐ Daily /hourly Value
- ☐ PM10, PM2.5, PM1, PM0.1

Other (Please Specify)

8 Would you like to have the possibility to extract the measurements in an excel sheet?

- ◯ Yes
- ◯ No

9 Which kind of additional information would you like to have available?

- ◯ Meteorological variables
- ◯ Informative material on ENMs
- ◯ Related publications
- ◯ Display links to similar ongoing projects and measurements
- ◯ Other (Please Specify)

10 Would the general public have access to measurements and in which form (e.g. circles of a variable diameter according the corresponding value?

☐ Yes, circles ☐ Yes, colors ☐ No access

Other (Please Specify)

11 Should we include simplified informative material and assessment on the measured values?

○ Yes ○ No

12 Please list other suggestions you would have concerning the structure and the functionalities of the web platform.

Finish Survey

New information is expected in the future due to the organization of networking activities and dissemination events, where specific sessions to gather additional data on the functionalities and features of the monitoring station prototype and data acquisition software will be organized. Such information will be considered during the development stage, promoting the implementation of those functionalities offering an added value to the target audience of the project.

Tables 1 and 2 show the opinions and information received so far from targeted audience.

Table 1. Functionalities and features of the NanoMONITOR software platform

Functionalities / features	Number
Access to data on the concentration of nanomaterials in air (outdoor)	129
Access to data on the concentration of nanomaterials in soil	75
Access to data on the concentration of nanomaterials in water	105
Access to data on the operative conditions and process (contextual information in indoor areas)	98
Additional information available: meteorological variables	50
Additional information available: publications	39
Alarm system to support high pollution events	118
Auto storing function to avoid loss of data	86
Data import functionalities (.xls / .csv)	138
Data sharing functionalities (i.e. upload of information by users)	81
Information of exposure scenarios	83
Information on the predicted environmental concentration of nanomaterials (PEC) at regional level	124
Measurements to be displayed by default: particle concentration	115
Measurements to be displayed by default: PM10, PM2.5, PM1, PM0.1	79
Multi-language (English + national languages)	95
On line access to data measured by monitoring stations / sensors	79

Functionalities / features	Number
On line access to historical data on the concentration of ENMs	68
Operation in multiple browsers: Mozilla, Google chrome and Safari	80
Operation in Smartphones (APP version)	109
Password protected access	90
Professional and non-professional versions	80
Query functionalities	69
Stand-alone application (download)	41
Temporal resolution of the raw data (15 min averages)	78
Temporal resolution of the raw data (daily)	20
Temporal resolution of the raw data (hourly)	42
Variety of display functions (tables and figures)	107
Web based access	106

Table 2. Functionalities and features the NanoMONITOR monitoring station prototype

Functionalities / Features	Number
Direct measurement of particle number concentration (#/cm3)	132
Direct measurement of mass (mg/cm3)	96
Direct measurement of lung deposited surface area	84
Direct measurement of particle size distribution	61
Low weigh	32
Ability to operate 24/7	141
Touchable screen	106
Easy-to-use software interface	105
Solar powered	49
Lockable, secure enclosure	109
Data transmission functionalities (3G/4G)	138
Air filtration using sampling heads	101
High volume filtration	39
Use of impactors / cyclone to separate size fractions	129
Alarm system	29
Remote access using internet connection	119
Particle range: 1 nm – 300 nm	141
Storage systems of filtration media	48
Incorporation of temperature and humidity gauges	92
GPS location	109
Battery powered	73
Low cost: price below 15.000 €	110
360 º Omni-directional sampling inlet	95
Water trap	39

Figure 1 shows the opinions and responses retrieved so far concerning the design of the data acquisition software. We have considered all those opinions defined by more than 80 respondents, meaning that up to 50 % of the audience is interested on the implementation of the features and functionalities selected.

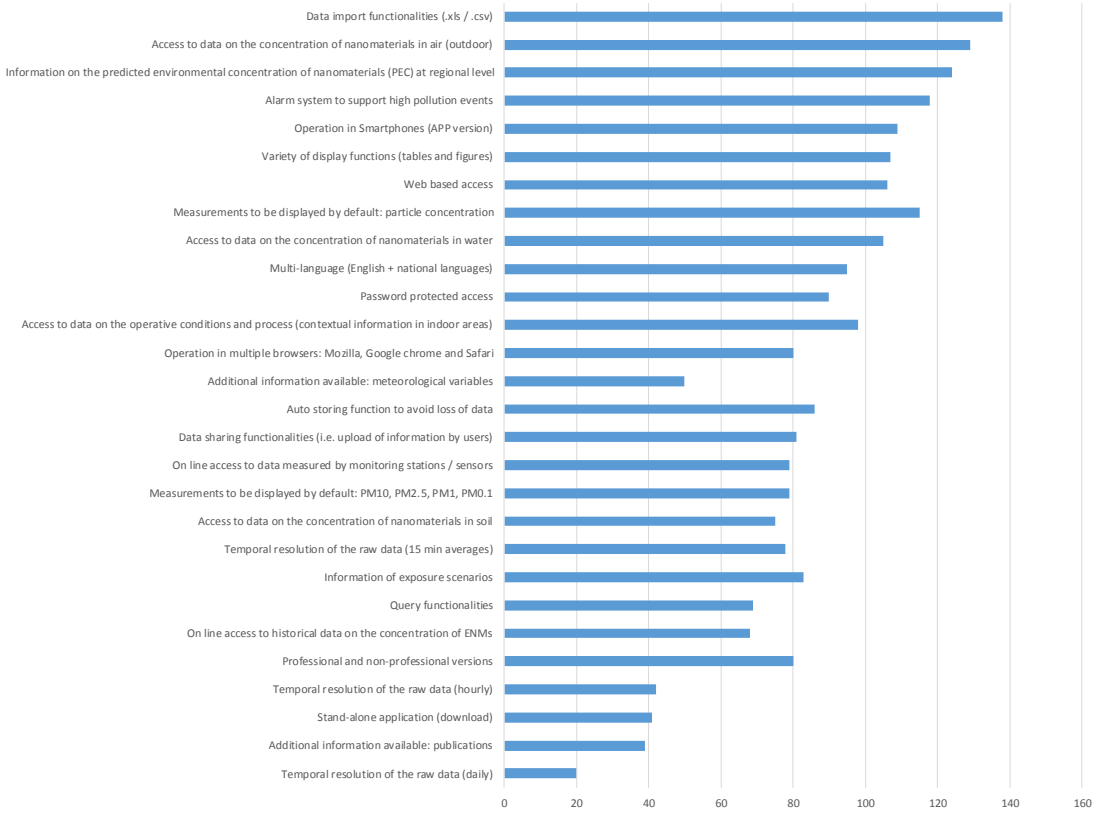


Figure 1. Number of responses concerning the features and functionalities of the data acquisition software.

Figure 2 shows the opinions and responses retrieved so far concerning the design of the monitoring station.

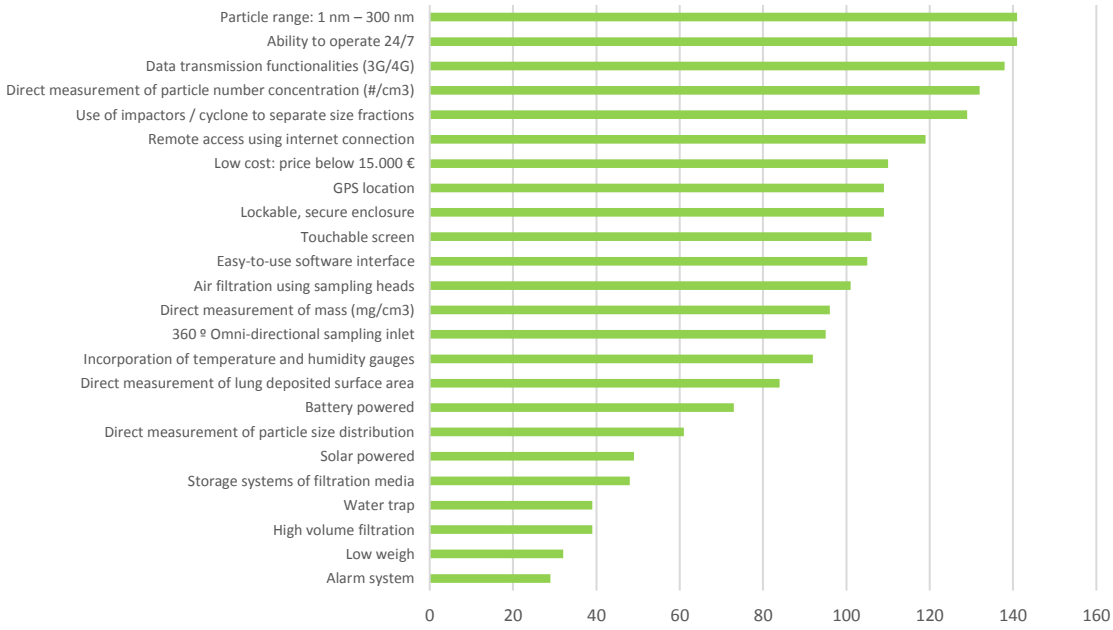


Figure 2. Number of responses concerning the features and functionalities of the NanoMONITOR monitoring station prototype

3. Specifications of the NanoMONITOR air monitoring stations

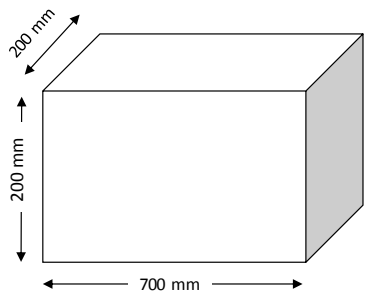
3.1. Introduction

According with the opinions retrieved, the monitoring station shall be able to provide data on the concentration of particles below 300 nm, operate 24 hours seven days and communicate data using wireless remote control systems.

Following such requirements, the members of the consortium has defined a compact size air monitoring station designed to provide real-time information of the concentration of engineered nanomaterials in outdoor and indoor areas. This prototype will be able to **detect and measure** the levels of nanosized (1 to 100 nm in diameter) and ultra-fine airborne particles (10 to 300 nm in diameter) in indoor workplaces and outdoor enviroments, providing data on the number concentration (number / cm^3), mass concentration (mg/cm^3), lung deposited surface area ($\mu m^2/cm^3$), and average particle diameter (nm).

Besides the above, the prototype will be able to **collect nanosized and ultra-fine airborne particles from an aerosol stream on a collection plate or filter**. To this end, a pump-based sampling system will be integrated in the monitoring stations. The main characteristics of the monitoring station design and functionality defined under action A4 are depicted below:

1. Mounted in a **weatherproof** box. External dimension limited to: 700 mm (L) x 500 mm (H) x 200 mm (w).
2. Remote **monitoring** of the number concentration (number / cm3), mass concentration (mg/cm3), lung deposited surface area (µm2/cm3), and average particle diameter (nm) of nanosized and ultrafine particles in indoor and outdoor areas, including workplaces, urban areas, and the environment.



3. Measurement and storage of complementary atmospheric variables of the sample: including temperature, humidity and pressure.
4. Ability to **collect nanosized and ultra-fine airborne particles from an aerosol stream** on a collection plate or filter, simultaneously or independently of the real time measurements (number, mass, surface area and average particle diameter), recording as well the sampling characteristics (i.e. L/min, sampling length, among other).
5. Modular design, including two fully integrated modules mounted in a weatherproof box:
   - Module 1. Particle measurement / monitoring unit
   - Module 2. Particle collection unit: pre-installation of a system of three air sampling channels to install size-selective inlet heads directly connected to a filter substrate or a cascade impactor.

6. Tailored designed software to control the instrument settings, collect and store data. The minimum requirements of the software include:
   - Programming: Programmable Logic Controller (PLC) or tailored designed lab view
   - Remote and local access to configure the settings of the monitoring station. Provide user configuration and scheduling of main sampling and operation conditions.
   - Remote and local access to information on the levels on nanosized and ultra-fine airborne particles measured by the station.
   - Real-time display of measurements.
   - Ability to identify relevant events during operation. Introduction of an indicator in the data sheet or the graphical representation of the data to identify a relevant event (i.e. high concentration or external situations affecting the measure).

7. Integrated cooling unit for climatize the nanosized and ultrafine particles monitoring unit.

8. External Air flow Pump (provided by the consortium), located outside the weatherproof box but controlled by the software developed to control the station.

3.2. Technical specifications

A detailed description of the technical specifications proposed are provided under this chapter:

3.2.1. External Layout of the prototype

The use of a weatherproof box is proposed by the consortium due to the need of an external isolation. Moreover, the consideration of external ventilation, IP66 protection level and portability are of special interest. Outlet plugs for external equipment and power supply shall be considered. A stated before, the station consists of two integrated modules:

- **Module 1**. Particle measurement / monitoring unit, containing the nanosized and ultrafine particles measurement system.

  Figure 3 shows a scheme of the external layout of the station and the configuration of the modular system. The space allocated to the particle measurement (Number 1 in red) is detailed.

  Module 2. Particle collection unit, containing three air sampling channels controlled by a mass flow controller (MFC).

  It shall be noted that module 2 shall consider space to allocate a set of three sampling heads connected to filter media (Filter media or cascade impactor). The cabin has to provide isolation to the interior, but allow some inlets/outlets to the exterior (exact location to be determined).

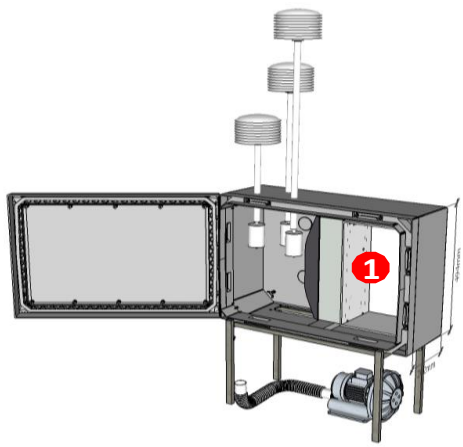


Figure 3. Scheme of the integrated system. Left: air sampling system. Right; space for the nanoparticle sensor, software and hardware control elements, and the cooling unit. External air pump included.

The consortium recommends the use of an external pump, in suction system, to provide a proper flow to the air sampling channels. This module shall be isolated and refrigerated to cool down the measurement equipment and data acquisition devices to be installed. The cooling module shall be able to maintain module 1 under the working operation temperature range of the measurement unit. Existing devices such as Delvalle Mod: HTEC050E (Peltier type) are recommended. Figure 4 shows the proposed external dimensions of the monitoring station.

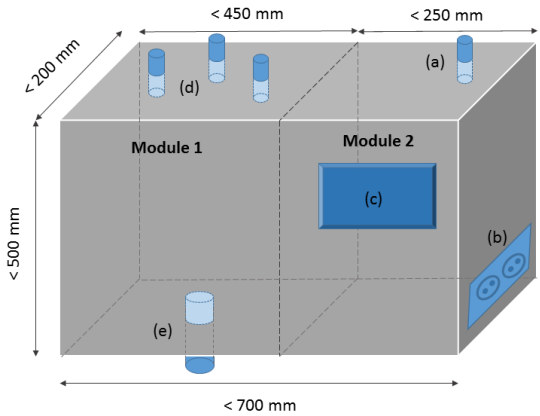


Figure 4. Scheme of the mechanized weatherproof box. a) an inlet for the ultrafine particle sensor; b) power supply system; c) a touch screen (PLC type) for connectivity with the software to run the station; d) sampling heads (inlets) for the filter system; e) air connectivity for the pump to the filter system.

3.2.2. Module 1 detailed specifications

This module comprises two differentiated parts: the sensor responsible for capturing and classification of nanoparticles and the electronics and hardware controlling the whole system functionality. In this regard, the prototype shall be provided with a measurement device for continuous sampling of nanosized (1 to 100 nm in diameter) and ultra-fine airborne particles (10 to 300 nm in diameter) in indoor workplaces and outdoor enviroments, providing data on the number concentration (number / cm3), mass concentration (mg/cm3), lung deposited surface area (µm2/cm3), and average particle diameter (nm). The system will consider:

- Impactor to avoid the entrance of particles bigger than 300 nm coupled to the vertical inlet connected to the inlet of the measuring device.
- Measurement unit (DiscMini, NanoTracer, or similar), calibrated and able to run during a 24/7 period.
- Other environmental sensors, with independent operation but recording data simultaneously as the nanoparticle sensor:
    - Temperature, humidity sampled in the inlet system.
    - Sampled ambient pressure in the atmospheric environment.

The operation of the sensor must be controlled by the hardware, allowing the user to select and schedule:

- The times of launching and switching off the sensor,
- Total duration of sampling time
- Measurement frequency

3.2.3. Specifications of the air sampling system

A scheme of the air sampling system proposed is provided in figure 5. As can be derived from the figure, the system shall include three pneumatic circuits electronically switcheables and directed to a manifold connecting the three channels to a common one where a Mass Flow Controller (MFC) will be able to select a flowrate up to 30L/min given by an external pump.

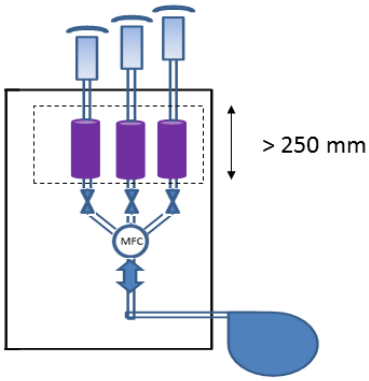


Figure 5. Schematics of Filter subsystem.

The tubing will provide conections for three independent external sampling heads, as well as internal space for internal plug of (three independent) filters/impactors within the air flow.

Overall, the system shall include:

- 3 electrovalves;
- 1 manifold;
- MFC: Mass Flow Controller;
- Tube connexions and couplings;
- Air flow Pump (provided by the consortium), located outside the cabin but allowing an inlet for connexion;
- Impactors and/or samplers, and independent and interchangeable cutting heads provided by the consortium. It shall be noted that is important to allow a given space of at least 250 mm for interchangeability and versatility of the storing system.

The operation of this part must be controlled by the hardware located in module 1, but being independent of the operation of the air sampling channel from module 2, allowing the user to select and schedule:

- the times of launching and switching off the pump,
- flowrates in each channel,
- total duration of sampling time in each channel,
- number of repetitions (cycles) among channels.

3.2.4. Hardware - Software (control unit)

A tailored designed control unit was proposed to support the acquisition of data measured by the station and guarantee a proper control of the operation settings. The components selected to develop this control unit are listed below:

- Control system: a communication port with the user (e.g. a PLC touch-screen) to manage the settings of the instrumentation and change the measuring parameters.
- An interpreter to translate and communicate the nanoparticle sensor with the input data port and vice versa, export data to the storage system

- Data management:
  - Electronic storage of the measures in a physical support (i.e. hard disc / SD card)
  - Sending the readings in JSON format to a server each 10 seconds
- Remote connection. 3G/4G signal (modem / router) to send the logged data in real time to a server for further distribution. Analogously, remote connection with the control system to input parameters and functionality from distance, as well to download stored data.
- Power leds to indicate operation or failure of the sensors and the 3G/ 4G signal.
- Outdoor adapted power supply connectors (2, one of which will provide control to the external pump).

A tentative scheme of the control hardware is shown in Figure .

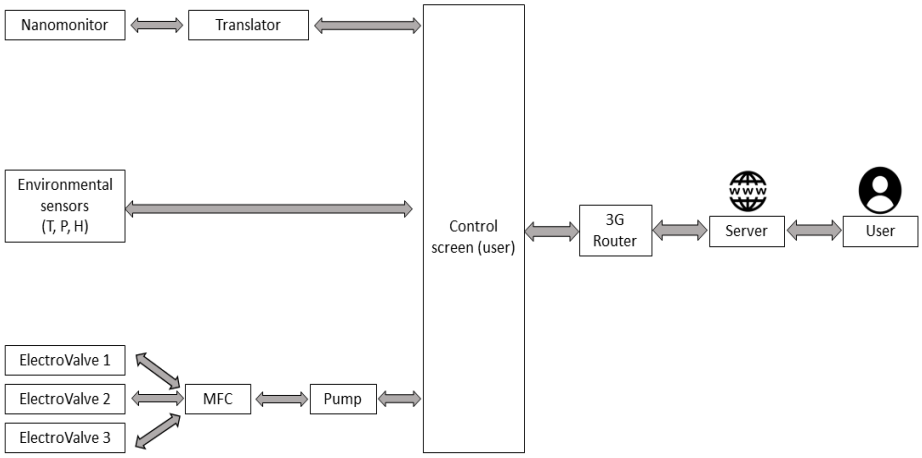


Figure 6. Schematics of the control hardware.

The input parameters that the user should be able to control and manually modify are shown below (in grey, output information provided by the software):

Table 3. Instrument settings

Sensor system			Filter system						
				Channel 1		Channel 2		Channel 3	
Operation	On/Off		**Start time**	Date	Time	Date	Time	Date	Time
Start time	Date	Time	**End time**	Date	Time	Date	Time	Date	Time
End time	Date	Time	**Flowrate**	Set Point	*Real Value*	Set Point	*Real Value*	Set Point	*Real Value*
Nr Repetitions	0 - n	*Counter*	**Nr Repetitions**	0 - n	*Counter*	0 - n	*Counter*	0 - n	*Counter*
Comment			**Comment**						
Location			**GPS coords**						

Additionally the user should be able to discretionary check and/or modify the following items of the system (that will be stored within the rest of quantities –see table-):

- time and date;
- coordinates (two parameters latitude, longitude);
- place/equip identification (literal);

Some requirements of the data logging are:

- Continuous storage in memory without erasing due to power failures,
- Circular storage (when memory is full, oldest data are overwritten),
- If the 3G communication fails, accumulated data are sent once is restored. To avoid this situation, data packages could be sent periodically to the server to ensure the completeness of the dataset.

The whole set of magnitudes to store and send are listed in table 4.

Table 4. List of magnitudes to be reported by the monitoring stations

Source	Magnitude	Units	I/O
Memory of monitor	ID station	Code nr	O
	Location	text	I
	GPS coordinates	gg:mm:ss	I/O
	Event recording	Sequential Code nr	O
	Comment	text	I
	Date	dd/mm/yyyy	O
	Time	hh:mm:ss	O
Environmental sensors	T environmental	ºC	O
	P environmental	bar	O
	Relative humidity	%	O
Nanoparticle sensor	PNC	p/cc	O
	Geometric Mean Diameter	nm	O
	PMC	mg/m^3	O
	LDSA	um^2/ccm	O
	I filter	fA	O
	I Diff	fA	O
	Corona voltage	KV	O
	Flow sensor	L/min	O
Filter sampling	Flow channel 1	L/min	O
	Cycle number channel 1	Sequential nr	O
	Flow channel 2	L/min	O
	Cycle number channel 2	Sequential nr	O
	Flow channel 3	L/min	O
	Cycle number channel 3	Sequential nr	O

4. Specifications of the data acquisition web based platform

4.1. Introduction

This chapter provides detailed information of the specifications and features of the web based platform to be developed within the project in view of the information retrieved from questionnaires and consecutive discussions and analyses conducted by the consortium members.

According to the needs and requirements of the targeted audience, the system shall comprise among others the following:

1. Internet access with password for companies and/or authorised users
2. Auto-storing function to avoid loss of data
4. Use of alerts when improving the software features
5. Data downloadable in excel sheets
6. Ensure cooperation with main browsers

The proposal text describes an infrastructure, accessible over the Web, for pluggable computational modules, making use of processed data from various environmental sensors, to be used by whoever is involved to the relevant analysis. The infrastructure as proposed is not limited and is scalable and expandable.

All development principles and approach are explained extensively in the following chapters, including a thorough description of the client side and relevant supporting back-end server that must implemented within the framework of the project.

4.2. Brief description of the technical solution proposed

The development and deployment of a **back-end Application Server** accompanied by a **Web based client** application was proposed. Authorized users will be able to access the web based tool in order to acquire the offered information.

The unique challenge of the technical solution proposed lies on how to facilitate access and computation on multiple & possibly heavy datasets. In any case the process to be used will be a classic input data processing (ETL) methodology, allowing the user to extract the data from the sources (acquired either by polling on specific intervals external sources, or by receiving regularly the relevant information) as they become available and from source systems, if required.

Each data flow may follow a different data organization and/or format following the instructions of an Application Programming Interface (API). These APIs will also dictate whether database (DB) connectivity is required, web services or even flat files. In general, the extraction phase aims to convert the data into a single format appropriate for storage into the central database of the Nanomonitor system.

Part of the extraction will involves data validation to confirm whether the data pulled from the sources has the correct/expected values in a given domain (such as a pattern/default or list of values). If the data fails, the validation rules it is rejected entirely or in part. Data structure will follow a normalized OOD (object oriented design) with a knowledge base for the definitions (ontology) of the concepts represented in the data holdings.

The data themselves will be a combination of descriptive geo-referenced META data, links to information such as imagery information, time series data, etc. The above structure and data, facilitate the execution of SQL queries which are triggered when respective reports are quested from the web portal graphical user interface (GUI).

A scheme of the proposed application server is depicted in figure 7.

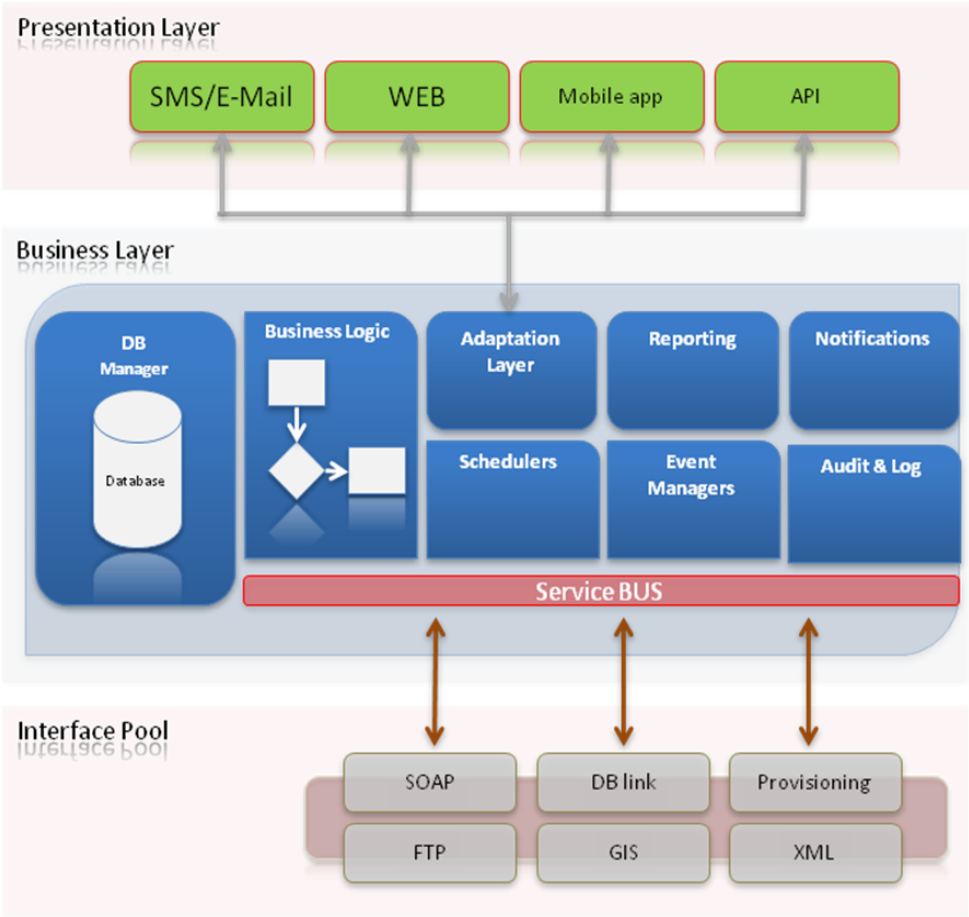


Figure 7. Application Server operation diagram

In the present project we have a collection of stations (i.e. sensors) which collect various environmental data and push them to the NanoMONITOR system for processing. During the process and storage of this information specific META data including the following info (Station Id, Kind of Station –Outdoor/indoor, Location, Area in case of indoor I.e. Production etc……..) will be considered.

A high level diagram of the solution in relation with the external entities interoperability is shown below:

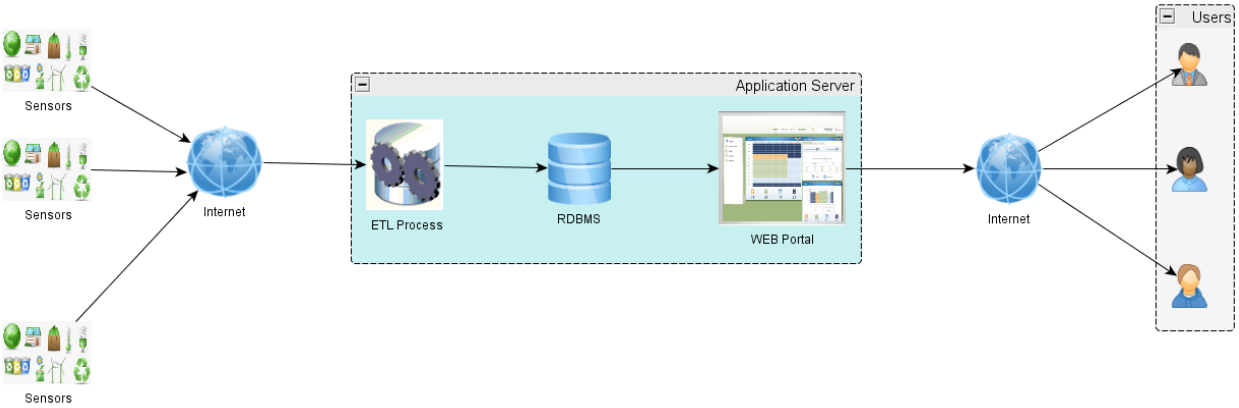


Figure 8. Scheme of the web based application proposed

4.3. Data inputs identified

Table 3 provides information on the type of data to be managed by the abovementioned input data processing (ETL) process, much of them coming from the air monitoring stations. Each station will regularly create data records containing the following fields:

Table 5. Main type of data received by the NanoMONITOR software platform

No	Field Name	Field Type	Note
1	ID station		
2	Location		
3	GPS coor (gg:mm:ss)		
4	Comment		
5	Date (dd/mm/aa)		
6	Time (hh:mm:ss)		
7	T env (ºC)		
8	P env (bar)		
9	PN (p/cc)		
10	Diam (nm)		
11	PM (mg/m3)		
12	LDSA (um2/ccm)		
13	I filter (fA9		
14	I Diff (fA		
15	Vcor (KV)		
16	Flow sensor (L/min)		
27	Flow cha 1 (L/min)		
18	Flow cha 2 (L/min)		
19	Flow cha 3 (L/min)		

The above data are of 2 types:

- Real time data
- Offline data

The above types contain identical records but they need different manipulation methods. Below we describe these methods.

a) Real time data

Every 10 secs a new record is created from each sensor. The record is available and is pushed toward the NanoMONITOR server via JSON. The transmitted data allow the server to perform the following mandatory checks prior to initiate the ETL process:

- Categorize per station ("ID station" uniqueness
- Check for duplicates (Date/Time combine)

More checks may be required and shall be decided during development phase. Operation is logged.

b) Offline data

Offline data should be loaded only when real time data are not available. Since real time data are sent every 10sec, it is expected that every day the NanoMONITOR server should receive 8640 records for each station. Therefore, in case the number of data received is smaller, it should be concluded that for the specific station ID, missing records occur.

This should produce an alarm in various forms that will be specified during the specification phase. An indicative list of these forms is:

- Logs
- email alerts
- On screen alerts

In this case, the offline data, if they exist, they should be loaded manually, via the administration GUI of the Web Portal and via a classic import functionality.

In the present phase, the acquisition of the offline data is not described, however we assume that in the end of the measuring period, all data will be collected by the stations and in the rare case we certify that some records have not been transmitted, they are going to be handled to the administrator.

Offline data format file should be CSV in plain ASCII format. Multi record per file are permitted if not preferred.

During the manual import, application should omit records that are previously loaded (during the real timer operation), based on the data that are already present (by using the check rules of the previous chapter). Operation is logged.

4.4. Features of the Web portal

The project's requirements describe an infrastructure, accessible over the Web, making available processed and/or raw data from the various data sources. The NanoMONITOR portal is the single point of access to a range of data collected from the various sources as described in other chapters. The requirements describe best practices for any such Web infrastructure. The web portal is a full graphical GUI using modern responsive HTML5 dynamic pages generation technology and it is intended to be used primarily by non IT personnel e.g. environment scientists.

The portal can be either standalone or accessed via other existing one. Therefore the user experience will be very positive including a variety of options, such as menus and interactivity. Besides, no special knowledge will be required from the end-user. Practically what is required is a standard and recent web browser as the only application required.

Beyond the classic report presentation, the NanoMONITOR Portal, will also provide basic tools for the estimation/elaboration of values such as concentrations, (from given emission estimates and meteorological/air exchange data), forecasts or historical (re-analysis FNL) data.

To facilitate data exchange and use, standard formats (including GIS formats) are supported and based on industry standard formats such as NetCDF (Network Common Data Format), HDF5 (Hierarchical Data Format) or OBJECT data in the generic OBJECT-ATTRIBUTE-VALUE triplet format supporting numerical as well as symbolic attributes.

All various stations will presented on map directly in the home page (like the site World Air pollution http://aqicn.org/map/europe/), while a main menu structure containing various selections will developed. User should able to concentrate on specific map area and select information for those stations displayed.

The Access to the web portal is determined by different level of access. Each role present specific properties and for each role different information may presented. The roles defined in the Operator are described below:

- **Administrator:** Administrator is the user who is assigned to have full access and control over the whole web portal application. This is the only role with the right to create/delete accounts or roles.
- **Public users** Public users do not need to register and they will be able to see data of outdoor stations and will have the capability to download data.
- **Companies users:** They must register to the tool after invitation or double opt-in and they will be able to view all outdoor stations and their indoor stations data.
- **Stakeholders user :** They must be registered and be able to view the outdoor station data and all the indoor data masked (they will not have the id of the indoor device).

Concerning the web portal design, although the exact look and desig of the proposed web portal will be clarified in a later stage, during specifications phase, some principles are already known:

1. The web portal will use latest and open source technologies.
2. The web portal will display collected data in a graphical form in the home page which will show also the station and their status. A main menu will be placed also having the following entries:

   - Home
   - Data Analysis
   - Exposure of risks
   - Simulation
   - Contact

3. The web portal will have tools like analytics and exposure of risk
4. The web portal must present the simulation of indoor and ambient concentration.
5. The web portal will be in English
6. For each station displayed on the map a set of data will be presented (determined by the stored information for each of it. Data will be displayed in a bar chart

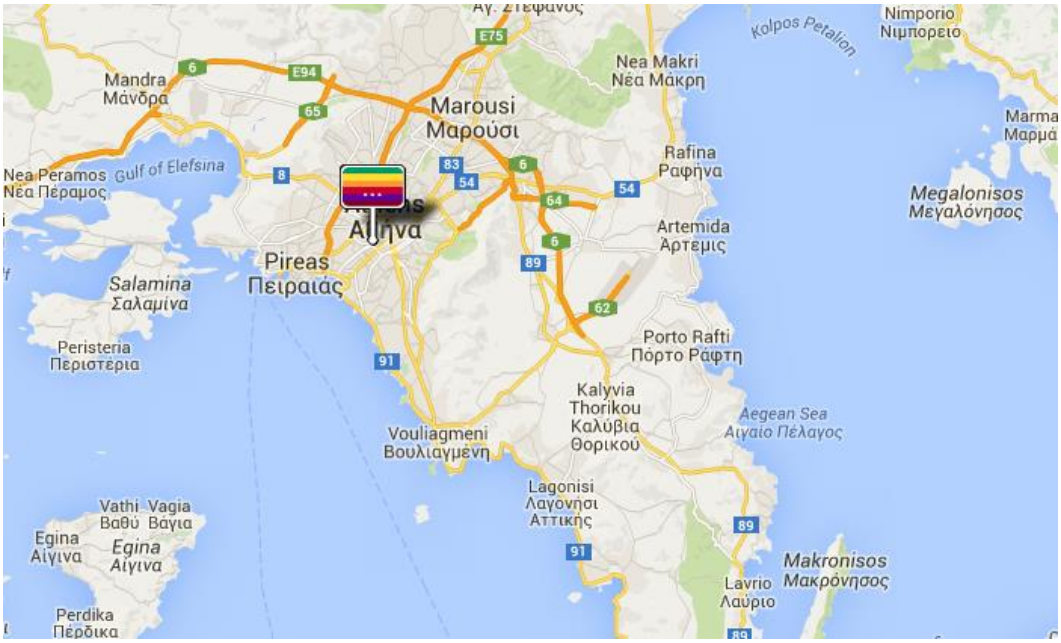


Figure 9. Indicative home screen

Figure 10. Web Portal menu indicative layout

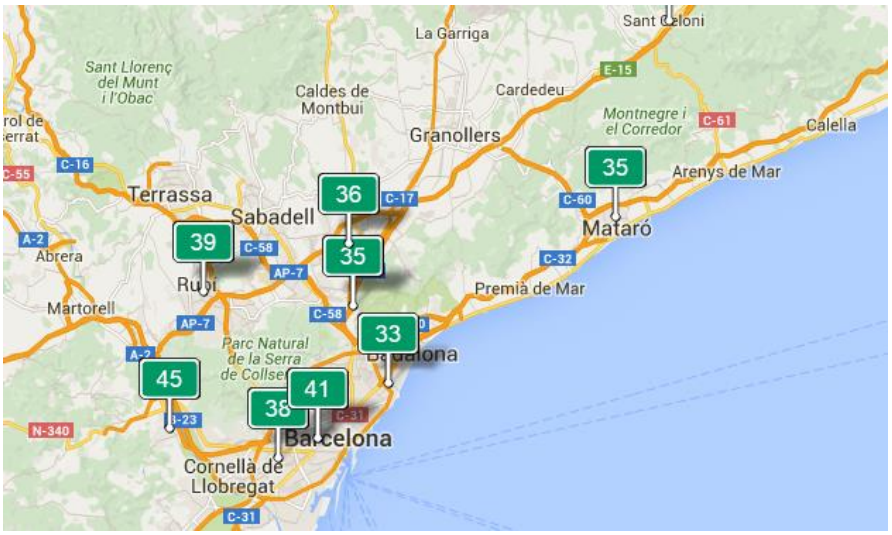


Figure 11. Stations details

The portal will use Oracle's MySQL™ RDBMS Community Edition. MySQL is the world's most popular open source database. It is available under the GPL license and is supported by a huge and active community of open source developers.

The MySQL Community Edition (free of charge) includes:

- Pluggable Storage Engine Architecture
- Multiple Storage Engines:

  i. InnoDB
  ii. MyISAM
  iii. NDB (MySQL Cluster)
  iv. Memory
  v. Merge
  vi. Archive
  vii. CSV
  viii. and more

- MySQL Replication to improve application performance and scalability
- MySQL Partitioning to improve performance and management of large database applications
- Stored Procedures to improve developer productivity
- Triggers to enforce complex business rules at the database level
- Views to ensure sensitive information is not compromised
- Performance Schema for user/application level monitoring of resource consumption
- Information Schema to provide easy access to metadata
- MySQL Connectors (ODBC, JDBC, .NET, etc) for building applications in multiple languages
- MySQL Workbench for visual modelling, SQL development and administration

4.5. Application Monitoring

The application and the various interfaces are managed and administrated via the AS Admin console. The following task can be performed either on demand or via automated schedulers:

- Interface declarations
- Interface management
- Socket Binding Groups
- Securing the Management Interfaces
- Initial/Quick/Detailed Configuration
- Declare server identities
- Outbound Connections
- Data sources management
- Load various modules
- Alarms
- Basic reports
- System user management (role based)

4.6. Operations & Performance monitoring

Each execution outcome of request (application, web client, database etc) either inside an Adapter (interface implementation) or a Service, is recorded as a logging event. Logging events can be redirected to:

- a file,
- a web-interface (as alarms),
- SNMP traps
- syslog server or
- Combination of above

The configuration is done in the application server and is hot-deployable. To suppor a proper performance, an Indicative list of raised alarms are also proposed:

System-alarms

- High CPU usage
- High Disk usage
- Low system Memory

Adapter-alarms

- Disconnections with external systems
- Communication errors
- Other interface related errors

Application-alarms

- Service unavailability
- Application unavailability
- Different Thresholds exceeded
- Other application error alarms

4.7. Analytics

The Analytics engine offers a number of ways for end users to perform interactive analysis and export reports. For the most casual user, this might involve simply changing a filter setting on a report to view a different slice of data. For a data analyst this could mean writing powerful, multi-dimensional expressions.

The two reporting primary tools are the Analysis Tool and the integrated On-The-Fly Analysis tool. The Analysis Tool is a traditional OLAP (Online Analytical Processing) tool, which uses open source solutions. OLAP tools perform analytic tasks on specialized, analysis-tuned data collections. The integrated On-The-Fly Analysis tool enables more straightforward ad-hoc query, reporting and analysis operations.

The analytics component is a powerful platform that provides via Web GUI the ability to users to login, view and create reports. Each user or group of users, according to their role can have a configurable view containing their reports in a structure that can aid in terms of usability. Users can create, delete and modify folders in order to group resources, such as OLAP views or predefined reports. Figure 11 show examples of the graphical display of the data.

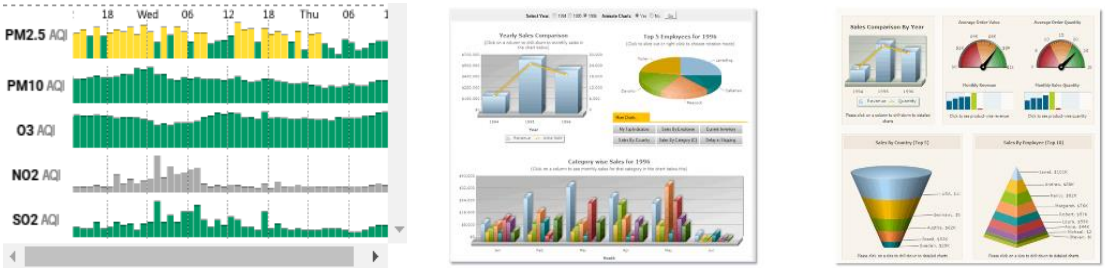


Figure 11. Station specific statistics screen

The analytics engine may deliver different levels of analytics. Each subsequent level is a superset of the previous one:

- **Level 1**: Static reporting using an embedded reporting library.
- **Level 2:** Managed reporting with simple interactivity, scheduling, security, and distribution using a reporting server.
- **Level 3:** Highly interactive reports and dashboards using a reporting server.
- **Level 4:** Self-service ad hoc driven reports and data analysis using a Analytics server
- **Level 5:** Advanced analytics against a data mart using the Nanomonitor DB server.

Some of the key functionality that this platform provides is listed below:

- ✓ Reports can be exported to various formats including PDF, WORD, EXCEL, XML, CSV and HTML formats.
- ✓ Apart from the predefined reports, users can create their own ad-hoc reports.
- ✓ A variety of graphical tools is available including Flash Charts, Maps and Widgets.
- ✓ An OLAP View tool is also available for creating and viewing custom KPIs.
- ✓ Role-based user management for defining access to specific reports and functionality.

For the needs of the specific project Analytics tool will offer customized and adapted reports. An indicative list could be:

- Data Analysis
- Exposure of Risk
- Simulation tool (e.g. future projection of concentrations)

4.8. Auditing & Security

Detailed log files are kept with a large amount of records of information regarding system events. The logs are kept in the system for a configurable time e.g. 24 months. All logs are compressed and can be sent to external storage to be kept for longer period of times.

Indicative log output for an event:

TimeStamp : AssociatedJavaClass : MessageSeverity : MessageBody

Column Name	Description
Timestamp	The TimeStamp when the written log event occurred. The Timestamp is in YYYY-MM-DD HH:mm:ss format. (i.e. 2007-01-07 10:36:55).
JavaClass	The Java Class which handled the event.
MessageSeverity	The Severity of the message. Supported messages severities are: INFO – This is an informational message. WARN – This is a warning message. This action indicates that something is not according to specifications but system operation is not adversely effected. DEBUG – This is a debug message. This logging level is used during investigations for likely causes of system outage. ERROR – Error messages. The message body indicates the fault. CRITICAL – Critical messages indicate service outage and should be handled immediately.
MessageBody	The message body indicates what the message is about. Log messages are described in detail in the User Manual.

The platform offers also enhanced security by implementing different protective mechanisms:

- Access to application parameters is allowed only via GUI which has different access levels.

- Actions are logged internally in the database and therefore any action can tracked upon request.
- Access to application data is allowed only to users having the adequate access role. Roles are configured only by users with administration privileges. On-the spot locking feasible.
- Access to system follows OS guidelines & audit functionalities.
- Unnecessary OS services can disabled preventing tasks that impose a risk
- Installation of 3rd party security tools (compatible with the OS)

The Platform complies with and supports all standard security technologies for such systems. Security mechanisms are implemented within the context of the Platform's Software modules, as well as externally. The Platform supports implementation of various security schemes in each of the following levels:

- **Network Security** – The Platform, both in terms of Software and supported Hardware components, is fully compatible with standards based network security mechanisms, including Firewalls, VLANs, Web Application Firewalls etc. Assigning separate VLAN IDs to the traffic classes regarding the Platform (e.g. administration / monitoring traffic, application traffic etc.) is a standard part of the system design for each deployment.
- **Software Module Security** – Each Software component of the Software is subject to hardening prior to system deployment. Every process not used within the context of the service is disabled. Hardening is performed for multiple components of the Platform, including OS, DB, Application Software etc.
- **User Roles** – The Platform integrates a highly flexible User Role configuration engine. Each role is assigned specific privileges, including access to specific data and services, access to application configuration interface etc. Both users and processes are uniquely defined and authenticated.
- **Action Logging** – Each action performed by any user is fully logged in the database and can be retrieved for auditing purposes. The logs are written in standard ASCII encoding and are rolling on a per configuration basis.
- **Alarm Monitoring** – Embedded Alarm Monitoring functionalities are part of the Platform's core. The Platform supports alarm notification messages via various channels e.g. SNMP for integration with external and/or centralized Alarm Monitoring Systems.

4.9. Backup and Restore

All data is stored in the MySQL™ database. Therefore, a full database backup taken daily acquires all the stored information. The number of kept backups is configurable through the Admin console.

The system can accept also centralized backup clients to be installed. The local file systems of the servers hold the OS and the application with its entire configuration. It is suggested that a backup of the above data should be taken before every upgrade of the application.

5. Conclusions

On the basis of the opinions of the industry and the expertise of the members of the consortium, a web based application connected to the air monitoring station prototype was designed. The main features and specifications of the system are summarized below:

NanoMONITOR data adquisition software

- Web based application
- Back-end Application Server
- On line access to historical data in .csv / excel files
- Access to real time data transmitted by the stations
- Access to georeferenced data on the concentration on ENMs in environmental compartments

NanoMONITOR monitoring station prototype

- Remote access to data
- Real time data on the concentration of particles below 300 nm
- Ability to operate 24 hours seven days
- Remote configuration option
- Touchable screen interface

The development of the web based application and the monitoring station will be conducted under the scope of actions B2 and B3. AXON, with high experience and expertise in software applications will conduct the development of the software package. ITENE and CEAM will conduct the design, development and assembly of the monitoring station prototype.

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