REPORT

Prototype realization and installation

ACTION B3

Life MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA

Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Prototype realization and installation
Action/Sub-action	B3 - Prototype of monitoring system for Noise LEZ design - data analysis techniques definition
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1. Introduction and objectives

ACTION B.3: Prototype of monitoring system for Noise LEZ design - data analysis techniques definition - UNIFI

Foreseen start date: 1st October 2016 Actual start date: 1st September 2016
Foreseen end date: 30th June 2017 Actual end date: 30th June 2017
Status: Completed
Partner Responsible: UNIFI
WPLeader of Action B.3: Lapo Governi

B3.1 Smart continuous monitoring system: Prototype for Noise LEZ design - data analysis techniques definition-UNIFI

UNIFI has been working on the prototype project since September 2016 and therefore on the low-cost noise monitoring system specifications. As mentioned also during the kick-off meeting, it was necessary to anticipate this study and analysis activity even before the completion of the analysis on the state of the art in charge of the Project Coordinator (Action A1.2) in order to speed up the acquisition procedures of the components and therefore the installation of the prototype system within the times foreseen by the proposal.
At the beginning of October 2016, a survey was also carried out in correspondence of the pilot area for the future installation of the system so as to understand the possible location of the sensors and the power supply possibilities. The draft of the system specifications was transmitted by UNIFI to the Project Coordinator in the second half of October 2016 to allow an appropriate review and sharing. By mid-December 2016, the coordinator's analysis phase has been completed (Action A 1.2) and then a final sharing on the monitoring system's specifications in order to acquire the hardware and software components has been carried out by January 2017.
The procedure defines the technical specifications and an initial control procedure (lasting 2 months) to be carried out on the first control unit supplied. In the months of January/ February 2017 the sensor network project and the methodology and instrumentation to be used for the control of the units were examined in depth. Furthermore, a specific survey was carried out in Monza on 22 February for the definition of sensor positions. The stations initially proposed have been revised: for 4-5 positions a station with possible power supply has been identified in correspondence to public facilities (schools, civic centre) which will allow the possibility of a continuous monitoring; for the other positions, at the roadside on a light pole, the station was identified in reference to the possibility of natural lighting for operation with a solar panel. For some delays in the formal approval procedure and sending of the purchase order by UNIFI, the delivery of the first control unit took place in March 2017. In the same month data transfer technologies from the network to the server were evaluated and the web platform for data collection acquired by the control units has been defined.
Furthermore, the preliminary verification protocols were defined to test the first control unit and those to be periodically carried out during the ante and post-operation monitoring. The first control unit was installed on the roof of the Polo Scientifico in Sesto Fiorentino (University of Florence) where preliminary tests have been made for a period of two months. Once the checks have been successfully completed, UNIFI has authorized the company supplying the devices upon completion of the supply of the 10 control units. On 13 April a further survey was carried out with the partners MONZA and VIENROSE for the installation of the sensor network in the pilot area. On 15 and 16 May, further inspections were carried out with the partners MONZA and VIENROSE for the installation of the sensor network in the pilot area. In particular, all the surveys were carried out in

the fixed stations connected to the electricity grid and the works and procedures to be carried out by the partner MONZA for the construction of the electrical connections were defined. On May 16th, the measurement stations on the pile were analyzed in detail with the partners MONZA, VIENROSE, ISPRA and with the presence of ARPA Lombardia, which collaborates in the monitoring of air quality. On 23 May the SIM (purchased by the partner MONZA) were acquired. At the beginning of June, some technical problems were solved (example of a malfunctioning of a SIM). Furthermore, together with the VIENROSE partner, the acoustic parameters to be acquired through the control units were discussed and defined, as well as the periodic monitoring procedures of the monitoring network. Finally, the organizational procedures for the installation of fixed and mobile control units have been completed together with the partner MONZA. In particular, concerning the fixed control units, the partner MONZA has worked to set up the electrical connection line for the devices, while for the control units on the light pole, given that only one pole of those identified is owned by the municipality while the others four are owned by ENEL SOLE, the installation authorization has been requested and obtained by ENEL SOLE. The 10 control units were then installed on the days of 19-20 June 2017 with the collaboration of both the partner MONZA and the Blue Wave company which has provided the devices. From 20 June 2017 the control units are constantly monitoring. On June 27-28, one week after the installation, a first in-situ operation check was carried out at all the installed control units.

B3.2 Smart continuous monitoring system: input on noise monitoring system-ISPRA

ISPRA collaborated with UNIFI in the initial phase of the noise monitoring system design and in particular about the analysis of the state of the art on smart and low-cost acoustic monitoring systems (preliminary action A1.2).

ISPRA sent a formal letter to UNIFI in which the requirements of the system defined by UNIFI, also shared in the meeting held in MONZA on December 15, 2016, were considered congruous and consistent with what was analyzed in the literature, during the development of Action A1.2.

B3.3 Smart continuous monitoring system: input on noise data analysis and management - VIENROSE

VIENROSE has actively collaborated in the discussion and definition of the acoustic parameters to be acquired through the control units, as well as in the definition and coordination of the monitoring procedures of the monitoring network. In particular, VIENROSE participated in joint inspections for the definition of measurement stations and operational procedures for the periodic monitoring of the operation of the sensor network.

2. Description of the noise low-cost sensors' network

The pilot area selected by the project and to be monitored consists of a district of the city of Monza (Figure 1).

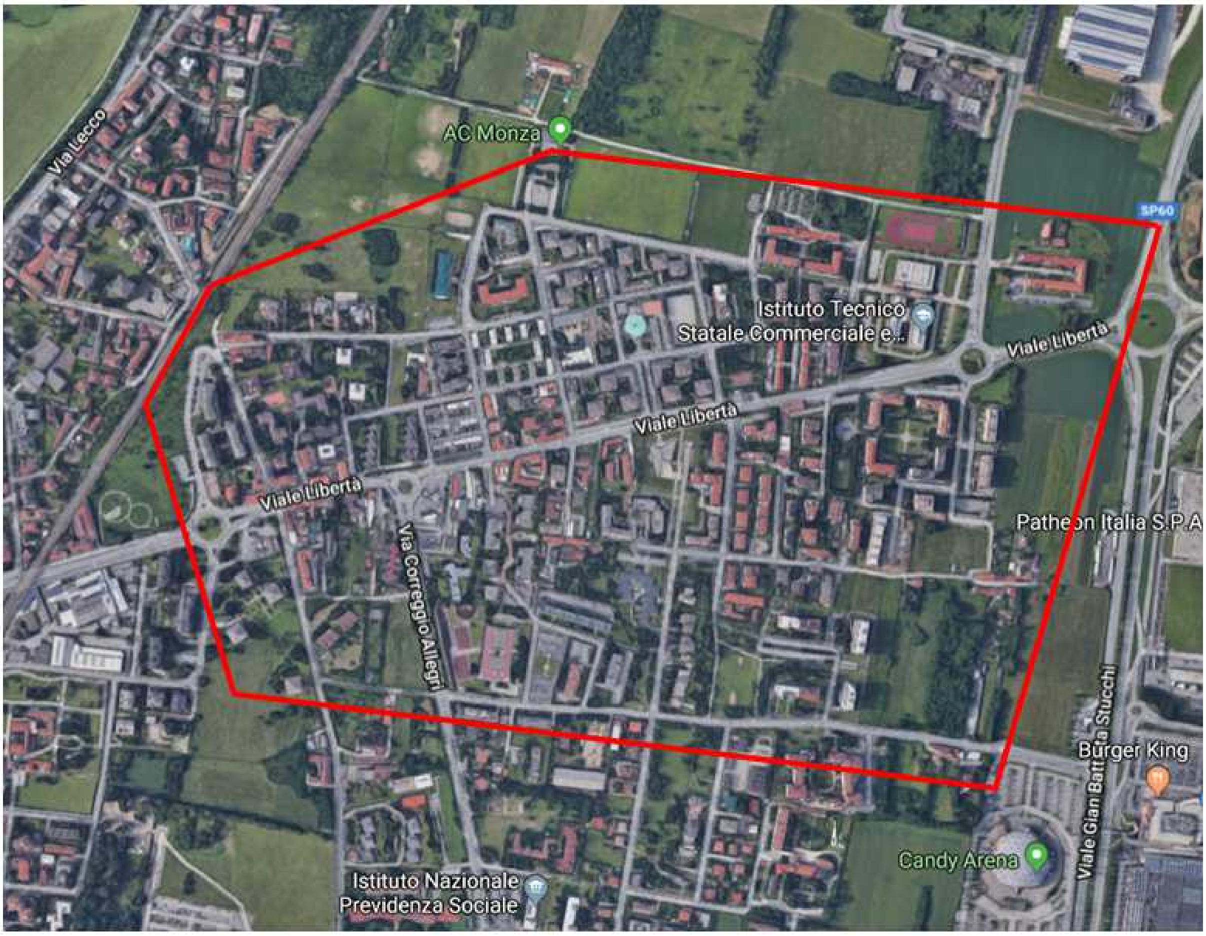


Figure 1. Perimeter of the pilot area ("Libertà" district - Monza).

A main road (Libertà street) and roads characterized by medium-low traffic are present in the selected pilot area. Significant average levels of noise pollution affect a large number of citizens so that Libertà district is identified as a hotspot in the Action Plan of the city of Monza. The noise strategic map of the city of Monza, dated 2012, highlights that in a range of 30 m from the Viale Libertà almost the 100% of the receivers are exposed to levels higher than 65 dB(A) during the day and 55 dB(A) during the night.
The Smart Noise Monitoring System (SNMS) network is meant to adequately cover the pilot area and the different types of roads. Secondarily, the possibility to have a connection to the electric energy network (avoiding the use a solar panel) is considered as an added value for the selection of measuring positions.

From a practical point of view, 10 monitoring stations have been installed in the pilot area of the Libertà district, as illustrated in Figure 2. In particular, 2 microphones have been placed along the Viale Libertà, the main street where the traffic flow mix is expected to mainly change from ante to post operam scenario. The other microphones have been uniformly distributed along other streets belonging to the pilot area.

The 10 control units were then installed on 19-20 June 2017 and from the 20th of June 2017 are continuously monitoring noise levels. It should be noted that the systems with the name "hc" have been installed on the facade of public buildings such as schools and the civic centre (an example is shown in Figure 3) while those whose name starts with the letter "T" have been installed on light poles (an example is shown in Figure 4). Specifically,

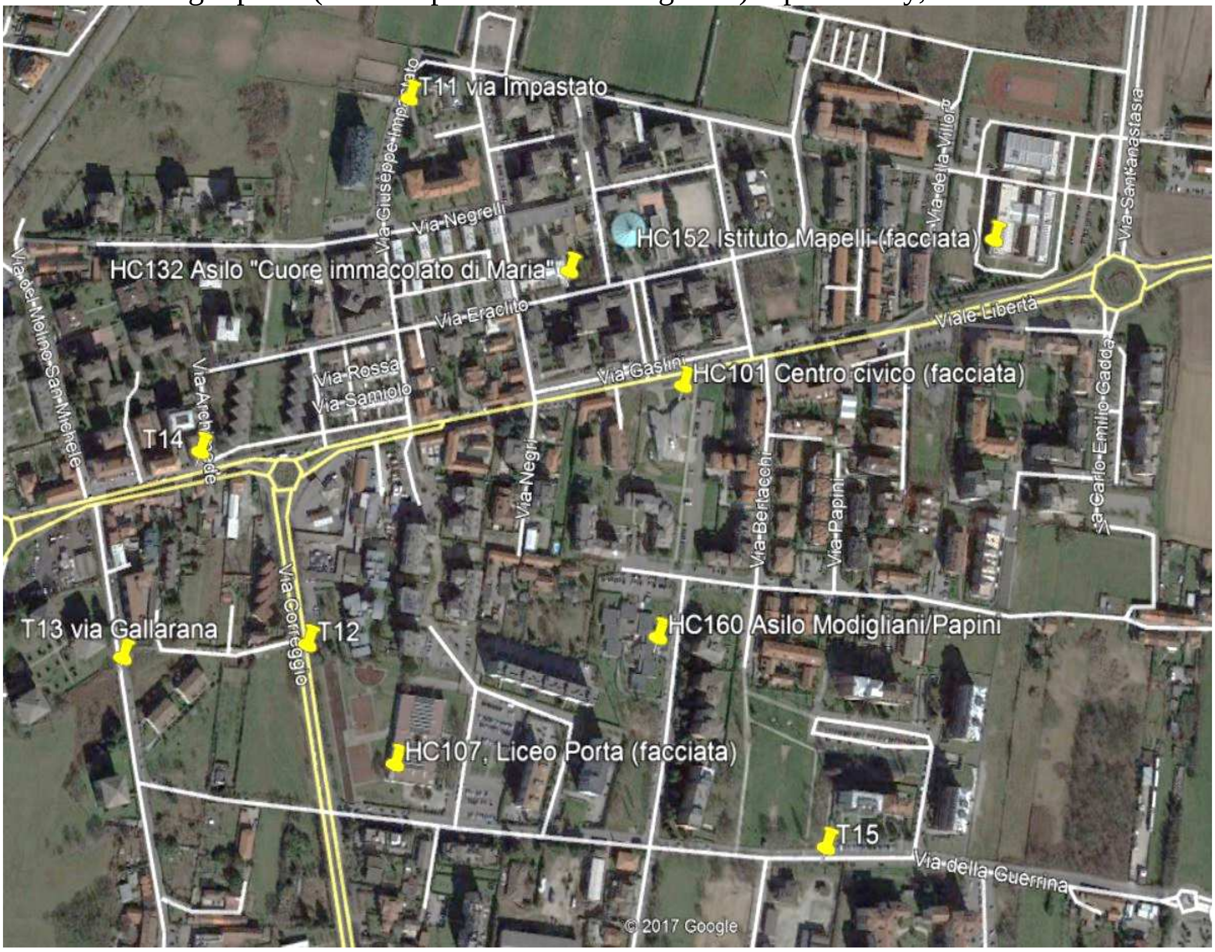


Figure 2. Site plan with the identification of noise monitoring stations.

Figure 3. Example of SNMS installed on the façade of a public building.

Figure 4. Example of SNMS installed on a light pole.

The SNMS technical specifications were defined keeping in mind the aim of a long-term monitoring of acoustic parameters. These are expected to be useful to understand the variability of acoustic climate in the pilot area with mainly reference to the overall A-weighted continuous equivalent sound pressure level.
According to the previous general requirements and to the outcome of the state-of-the-art analysis, the following main specifications of monitoring units have been defined:
- acoustic parameters: overall A-weighted continuous equivalent sound pressure level, “LAeq” and continuous equivalent sound pressure level, “Leq”, as 1/3 octave band spectrum data;
- timing for data recording: data will be acquired with a time basis of 1 second in order to permit the recognition of unusual events in the eventual analysis phase;
- timing for data transmission: data will be sent to the remote server every hour;
- data transmission network: the data will be transmitted through the 3G cellular telephonic network;
- power supply: small solar panel (30cm x 20cm) and battery for energy storage or direct connection to electricity network;
- sensors location: on streetlight or on façade, height 4 m above the ground level;
- sensor type: ¼ or ½ inch low-cost microphone with removable rain protection;
- floor noise < 35 dB(A);
- frequency response at nominal frequencies of 1/3 octave from 31.5 Hz to 8 kHz within the class I specs ± 1dB.

Starting from the specs listed above, the monitoring system architecture has been mainly based on monitoring units designed in the Life DYNAMAP project (these units comply with all the specs), tailoring the data transmission, storage and post-analysis to the needs of the LIFE MONZA project.
Referring to the hardware components, each monitoring unit is designed to achieve a high energy efficiency and low computational burden. In particular, it has an average variable electric absorption among 200 mW and 400 mW, depending on uplink transmitting power in

function of the distance to the nearest radio base station of cellular network and the kind of used transmission protocol (2G, 3G). They thus can be powered through solar panels (size 30cm x 35cm) and an integrated power battery with the possibility of being directly connected to the electricity network.

Two types of microphones have been used:

- For sensors placed on poles that use solar panel energy: In order to obtain these high performances of energy efficiency, digital MEMS microphones were used that do not require the use of an external ADC. The MEMS microphones have been adapted onto a ½ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator.
- For sensors placed on façades that use power supply connection, electret microphones have been used. For reasons related to shielding for electromagnetic compatibility they have been adapted onto a ¼ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator.

These units are also equipped with a low-power microcontroller able to perform, by mean of IIR digital filtering, the calculation of the A-weighted continuous equivalent sound pressure level, "LAeq", and, by mean of FFT, of the 1/3 octave band continuous equivalent sound pressure level, "Leq".

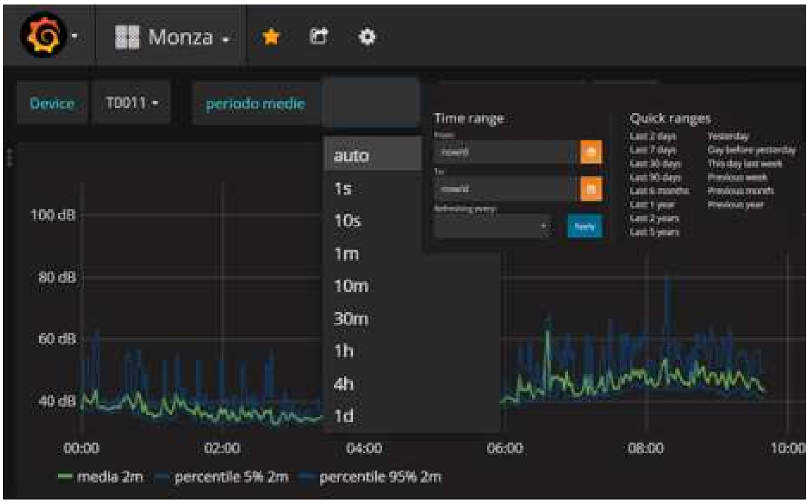
In the usage scenario foreseen for the pilot area, the units will periodically (every hour) connect to the internet and transfer the gathered acoustic data, together with statistics on battery level and quality of the transmission signal. The data will populate a dedicated database, optimized for handling large amounts of data. It has been also planned to build up a web application that allows visualization of the location of the control units on a navigable map, data representation and download.

3. Data download and post-processing procedures

Starting in March 2017, data transfer technologies from the network to the server were evaluated and the web platform for collecting data acquired by the control units was defined.

Starting in March 2017, data transfer technologies from the network to the server were evaluated and a temporary web platform for the collection of data acquired by the control units was defined.

From the platform the user can download data collected by each sensor according to the LAeq, parameter also in terms of frequency bands in 1/3 octave, and in a selectable time span.



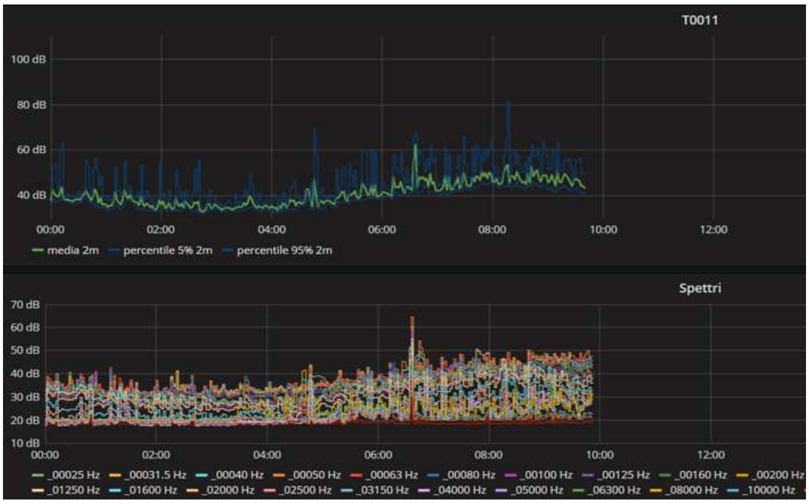


Figure 5. Web interface with possibility of selecting the time period to view and/or download.

Once data of ten sensors will be downloaded, they will be post-processed by using the Matlab software according to parameters and verification procedures defined in the following monitoring actions.