

# Smart metering/sensing: Low-cost Environmental Monitoring Station (Madeira / ARDITI)

MADEIRA


INFORMATION AND  
COMMUNICATION  
TECHNOLOGIES AS  
AN INTEGRATED  
TOOL




## IN BRIEF

CIVITAS-DESTINATIONS ARDITI's Environmental Monitoring Station is a relatively low-cost equipment which allows measurement and monitoring of levels of CO<sub>2</sub>, CO, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub>, NO, PM2.5/PM10, Noise, Temperature, Humidity and Atmospheric pressure, which can be stored on a database and presented in real-time on a webpage.

### For who is this article intended?

 If compared to existing commercial solutions this solution offers a low-cost alternative to **Cities, Municipalities and Regions** for air quality / noise recording and monitoring.

 This document provides an overview of the station prototype, including Equipment, Sensors and Connectors; Housing prototype; Connection Scheme; Software Overview; Interface to access / view station data and some Additional Requirements.

### Overview: [topic of CIVITAS-DESTINATIONS project being addressed](#)

Under CIVITAS-DESTINATIONS project measure MAD2.2 (Madeira - Smart metering/sensing and user generated content to improve planning and mobility services) aims at using smart metering / sensing data (and crowdsourcing data / user generated content) to improve the planning, monitoring and control of mobility services. Gathered data can be related to urban accessibility, traffic and environmental indicators and users' satisfaction. It makes use of smart, low cost solutions, based on wireless networks and crowd-source data. The Environmental Monitoring Station presented in this article is one of the results of ARDITI work in measure MAD2.2 of CIVITAS-DESTINATIONS project.

### Overview: [further description details of this solution](#)

ARDITI's Environmental Monitoring Station measures levels of CO<sub>2</sub>, CO, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub>, NO, PM2.5/PM10, Noise, Temperature, Humidity and Atmospheric pressure, which can be presented in real-time on a webpage and stored on a database for monitoring and historic recording. Sensor control, reading and communication software is installed / configured in a local smart router / computer which runs the necessary software to control the sensors, measure indicators and communicate with the server database. If compared to existing commercial solutions this solution offers a low-cost alternative to cities for air quality / noise monitoring. It can easily be adapted / customized for different

scenarios. 3D model files for the casing have been created in open DXF (Drawing Interchange Format).

Not considering human resources costs, 3.000€ was the estimated cost to buy / purchase and assemble components, produce the custom case and assemble current prototype of the station (concrete installations may incur additional costs). Based on a “transfer ruling protocol” to be agreed and signed by both parties, ARDITI can help / support successful applicants to replicate the stations by supplying the necessary information, including the list of components/sensors, 3D model files for the protection casing in DXF format and the software that needs to be installed in the smart routers. On a first stage the web application for viewing data (a database is also required) may be located on ARDITI’s webserver / database.

### Equipment, Sensors and Connectors

Following the initial design of the station, next step was selecting the list of sensors, based on their quality, cost, availability and openness (to external HW and SW connection); Then developing software (mainly in Python) and connecting sensors to the central unit (a smart router / dedicated computer, which in the current version is the GL-AR300M Mini Smart Router, from GL-iNet manufacturer. Figure 1 lists the Technical specifications of sensors used.

Reading / Indicator	Sensor used	Output/ Interface
Particles (PM2.5, PM10)	Nova PM sensor SDS011	USB
Ozone (O <sub>3</sub> )	Sensoric O3 3E 1	4-20 mA
Carbon Dioxide (CO <sub>2</sub> )	Yocto-CO2	USB
Sulphur Dioxide (SO <sub>2</sub> )	SO2 SL 4-20mA Transmitter	4-20 mA
Nitrogen Dioxide (NO <sub>2</sub> )	NO2 2E sensor with 4-20mA transmitter, 0-20ppm	4-20 mA
CO	CO ECO-Sure (2e) 4-20mA Transmitter	4-20 mA
Nitrogen Oxide (NO)	4-NO-2000	0-5 V
Temperature, humidity, air pressure	Yocto-Meteo	USB
Noise	Digital microphone with integrated sound card	USB

Figure 1 - Technical specifications of sensors used (ARDITI, 2019)

### Housing prototype

With the interconnected sensors encased in a box to accommodate all the components and sensors, the boxes are not water proof, due to the need of the exposure of the sensors to the outside air, thus needing protection shields as shown in Figure 2. The protection is attached to the box and attached to a supporting mount. Three housing prototypes have been created and tested. One of such prototypes is presented in Figure 3 and was used as the base to estimate the right dimensions and compartments of the final version of the box / housing, presented in Figure 4. Using our DXF model files, construction of the housing was made in “carbon steel” by a subcontracted provider.

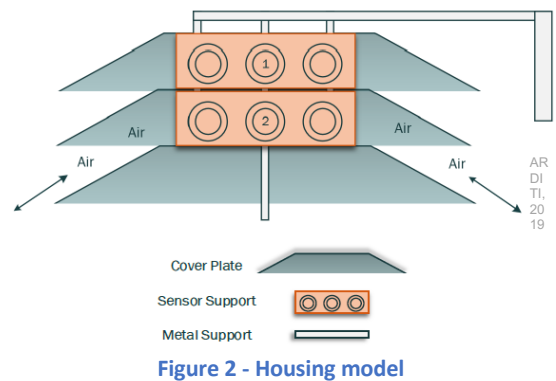


Figure 2 - Housing model



Figure 3 - An early prototype



Figure 4 - Sensors and housing in final prototype

## Connection scheme

The modular platform has been designed so as to integrate different sensors in order to satisfy the requirements of each city. This gives the possibility for each location to have specific characteristics, where the number of sensors integrated in the device can be selected/decided by each city. As presented in Figure 5 some sensors provide a direct reading via USB while other require either a voltage or a current intermediate reader. A USB hub provides all the USB ports needed by the system, including connection to a 3G Modem in case wi-fi Internet is not available to the router (e.g. in remote zones). The only special case to note is the NO sensor, which requires a voltage reader and power supply of 5V. To achieve this, a DC/DC converter connected to the 23V output of the voltage reader was used. Then an amplifier (OpAmp) are used to maintain the output signal readable. Figure 6 presents actual / current connectors inside the housing / box.

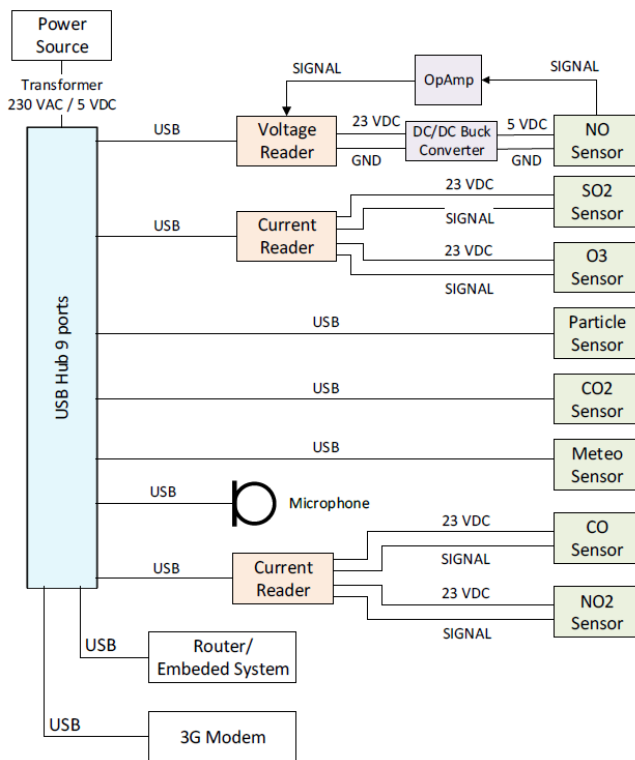


Figure 5 - Connection scheme (ARDITI,2019)

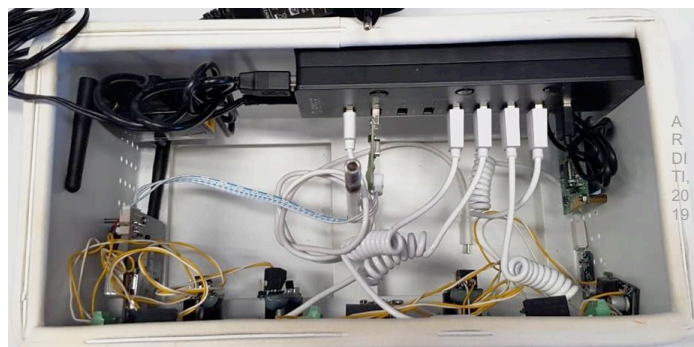


Figure 6 - Sensors, smart router and connectors

## Software Overview

The access to the embed system is done remotely, to transfer files and run system commands. The software to read the sensors (*sensor poller*) is in the embedded system and is responsible for capturing the data points and send them to a central server by means of a network connection. The system is composed by a capturing component, an upload manager and a data sender. The capturing component interacts with the different modules that acquire the data and forwards it to the upload manager. The upload manager checks the server connectivity and either sends the current and saved data, or stores it locally when no connection is found. The upload manager passes the data to the data sender, which authenticates the requests and actually sends them to the central server. The VPN connection can be used to remotely control the system and perform maintenance, or software upgrades. Figure 7 illustrates the software architecture implemented.

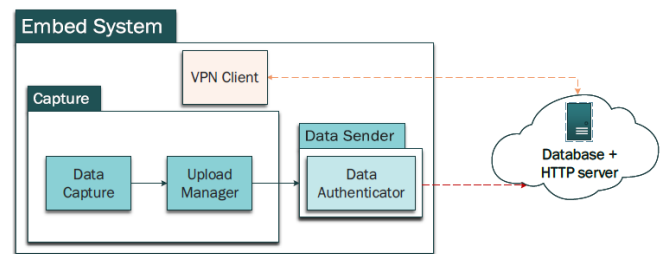


Figure 7 - Software architecture (ARDITI,2019)

## Interface to access / view station data

The data, if stored locally, can be retrieved via SFTP. Our tests show that, reading all the sensors and running the software every minute, resulting in 1440 entries per day, produces a backup file of 484 KB per day. Since the router has approximately 65 MB free after all packages installed, it is not advised to store locally more than 130 days (4 months) of data. Since the data is also sent to a central server, the API that receives it, can also provide routes to visualize it, as is the case of the one implemented by ARDITI in Madeira, where the data can be accessed via a web platform, as shown in a sample chart of Figure 8.

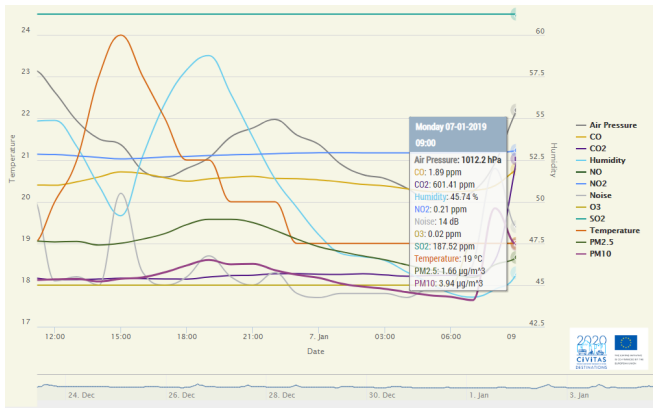


Figure 8 - Access / View station data (ARDITI,2019)

### Some additional requirements

The prototype should be installed in locations that:

- Have one standard AC electrical connection;
- Not reachable by passer-by;
- Locate the device in proximity locations for the indicators to collect the data (e.g. Not too far from the street / road);
- Placed in a vertical position to maintain it water proof as much as possible;
- It is optional to have 1 Ethernet connection (for when there is no Wi-Fi or 3G connection)

Figure 9 presents the actual outdoor installation of the station working / being tested for calibration.



Figure 9 - Outdoor installation

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