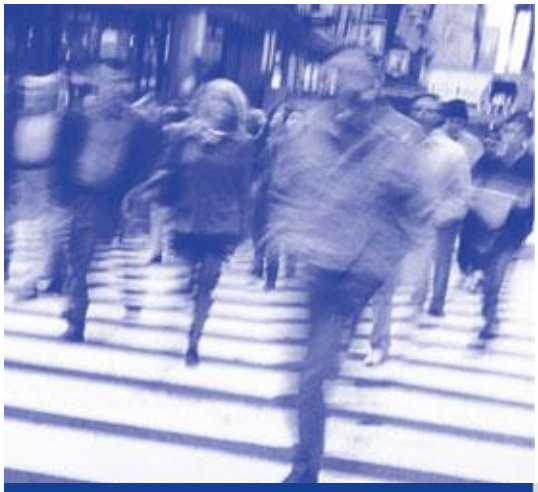

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MALAGA

DI6.07.05 Guidelines and parameters for the implementation of dynamic air quality monitoring system at city level

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Abstract

During the period of four years from 2012 to 2016, Malaga City Council installed a set of mobile stations on top of public transport buses in order to assess the air quality evolution in a larger part of the city. This pilot project was carried out within the framework of the project CIVITAS 2MOVE, Measure 6.07 Dynamic air quality measurement through mobile stations installed on top of public transport buses.

This document gives an overview of Malaga's experience in order to provide specific guidelines and parameters to other City Councils or organisations considering embarking on a similar project.

Project Partners

Organization	Country	Abbreviation
Malaga City Council	Spain	Malaga
EMT – Malaga Municipal Transport Company	Spain	EMT

Document History

Date	Person	Action	Status	Diss. Level
11/16	Jon Switters / Carlos Sánchez Pacheco	First Draft	Draft	Confidential
12/16	Daniel Fernández (EDP Ingeniería)	Revision	Draft	Confidential
12/16	Department of Mobility, Malaga City Council	Revision	Draft	Confidential
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Status: Draft, Final, Approved, and Submitted.

Dissemination Level: PC = Project Coordinator, SC=Site Coordinator, TC=Technical Coordinator, EM=Evaluation Manager.

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1 Executive Summary

The main objective of this document is to provide other local administrations with the key guidelines and parameters to effectively implement a dynamic air quality monitoring system at city level, learning from the experience of Malaga City Council during the CIVITAS 2MOVE2 project.

During the period of four years from 2012 to 2016, Malaga City Council installed a set of mobile stations on top of public transport buses in order to assess the air quality evolution in a larger part of the city. This pilot project was carried out within the framework of the project CIVITAS 2MOVE, Measure 6.07 Dynamic air quality measurement through mobile stations installed on top of public transport buses.

This measure permitted Malaga City Council to measure the air quality levels in a dynamic way using five mobile stations and one fixed station, complementing the information provided by the existing four fixed stations which belong to the Regional Government. It consisted in designing, implementing and testing a new model of mobile pollutant monitoring stations, in order to provide heat maps of air contamination levels in the City of Malaga. Each mobile station has three sensors that measure the following pollutants: CO, O3 and NO2, according to the current regulations at European and national level on this matter.

This document gives an overview of Malaga's experience in order to provide specific guidelines and parameters to other City Councils or organisations considering embarking on a similar project.

2 The Pilot Project

In relation to the overall CIVITAS objective of providing cleaner and better transport in cities, which includes reducing pollution and congestion caused by motorised traffic, this measure is directly related to the control of pollutant emissions. It is a fundamental aspect to be referenced in decision making concerning traffic management and control and in order to reduce emissions.

Before the 2MOVE2 project, there were just four fixed stations for monitoring the air quality levels in the City of Malaga, which are managed by the Andalusian Regional Government. These stations are located far from the city centre and do not relate air quality evolution with the implementation of sustainable mobility measures in the city, not even with regards to other indicators such as the traffic situation.

This measure aimed at assessing the air quality evolution in a larger part of the city. To achieve this, five mobile stations were installed on top of public transport buses representing the broadest itineraries in Malaga, in addition to one fixed station located in a different part of the city. This permitted Malaga City Council to measure the air quality levels in a dynamic way, complementing the information provided by the existing fixed stations.

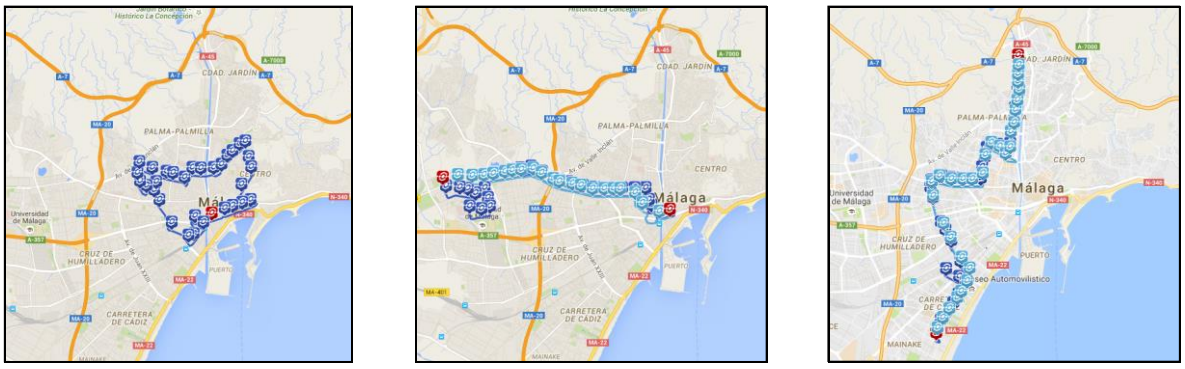

Figure 1: Itineraries of bus lines Circular 1 (C1, left), 8 (middle) and 15 (right), where the mobile stations were installed

The pollutants measured by the mobile sensors are CO, O3 and NO2, adhering to the current regulations at European and national level on this matter. Although there are other pollutants that have a significant impact on air quality, some of them are difficult to measure through mobile stations (for example, particulate matter -PM-).

In addition to these indicators, other parameters can be measured by the mobile sensors: temperature, relative humidity and atmospheric pressure.

Once the pollutants had been selected, the work focused on the study of technological requirements (mechanics and communications) and the design of the hardware (casing that holds the station, the electronics, power supply) and software.

The general functioning of the measure is shown in Figure 2. The most important equipment in this measure, along with the monitoring station, was the environmental data sink point. This is the receiver located on the public transport company facilities and it is responsible for temporarily storing data from embedded stations. It pre-processes the information and sends it to the main database of the central server.

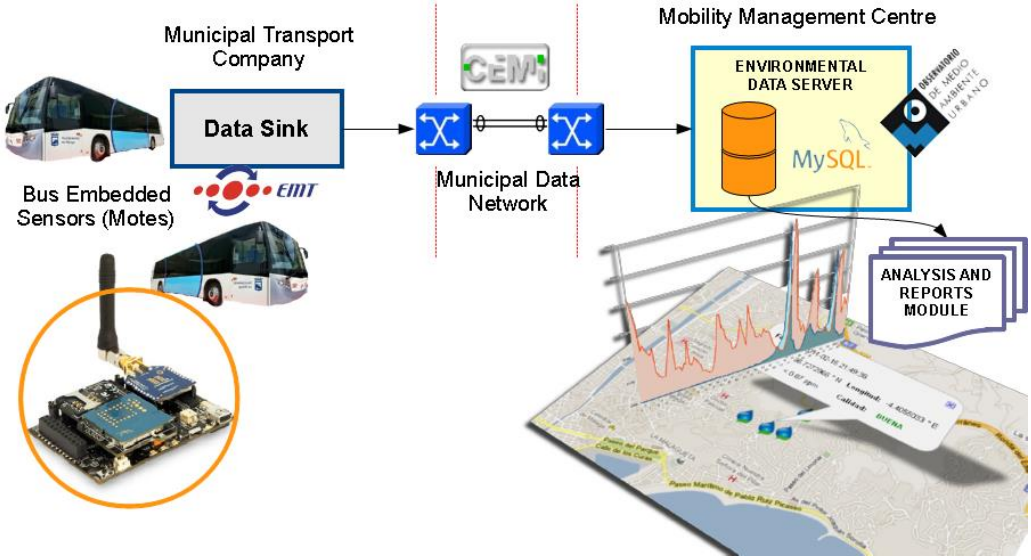

Figure 2: Functioning diagram of the measure

The innovative aspects of the measure are:

New conceptual approach – This measure has taken an approach that had not been looked at before. Procedures for air quality measurement in cities normally foresee just the use of fixed monitoring stations. Before the project, the effectiveness of mobile stations had been verified at an academic research level, but not in a field test. This has been the first time – at least in the Spanish context - that mobile stations have been used to complement the information provided by fixed ones. Nevertheless, it is still necessary to use both types because some of the air quality indicators – such as the solid particles – cannot be measured by mobile sensors.

Use of new technology/ITS – The mobile stations are an improvement on the existing technology. The system has been based on five mobile stations installed on public transport buses presenting the broadest itineraries in Malaga, which allows measuring air quality levels by city area in a dynamic way and estimating sustainable mobility measures' impact on air quality improvement. Furthermore, one unit has been installed at one of the existing fixed stations in order to compare the measurements obtained by both systems and to monitor the performance of the mobile stations installed on buses.

3 Project Results

The evaluation of this measure was based on technical tests as well as on quantitative measurements of pollutants levels and on qualitative evaluation of air quality, according to the Air Quality Reports from the Regional Environmental Department and the measurements obtained by the mobile stations. The main results include:

Strategic and operational level

- The system developed in this project provides air quality information aggregated at geographic and temporal level. It allows Malaga city to identify those areas with worst air quality levels, and the period of time when this happens. This information allows the City Council to take long-term traffic management decisions.

Air quality level

- Although there were certain deviations in the quantitative measurements between the mobile and the fixed stations, the CO and NO2 sensors used in this project were accurate enough to differentiate the air quality qualitative sub-ranges. On the contrary, the O3 sensor lost its accuracy faster than expected. Therefore it is necessary to analyse the convenience of changing the model or upgrading the one used in this project.
- Sensors used are reliable enough, being quite stable throughout the time (same levels measured after one year of permanent use in real conditions).

Statistical level

- Current number of mobile stations, even after the extension, doesn't allow the acquisition of a sufficient number of samples to obtain adequate reliability as intended for the system, for several reasons:
  - More stations are needed to cover city districts not being currently covered. It is estimated that at least 15 to 20 stations are required to cover most parts of Malaga city.
  - More stations are needed to increase measurement confidence levels (at least 75% of the time should be covered).
  - More stations are needed to cover night hours.
  - It would be advisable to use fixed stations in pedestrian areas (such as the city centre).

Technological level

- The Sensor's casing is robust enough to support operational conditions (outdoors, washing, etc). No issue has been detected after more than one year of continuous operation.
- The Data concentrator is also quite reliable and robust to be used outdoors.
- Central platform and web interface provide sufficient information for the purpose of the project. No issues have been detected with it.

4 Problems Encountered

The mere nature of a pilot project suggests that a series of problems will arise and be dealt with over the course of time. Below, is a list of the main problems experienced by Malaga City Council and the solutions that were implemented to address them. These problems have been classified according to the phase of the project in which they were encountered:

Implementation phase

- Technological Design and Implementation
  - Design of the casing. Casing should be able to protect the electronic devices at the same time as being water and dust proof.
  - Design of the power supply for the sensors. Sensors are installed outdoors, and power consumption was too high because sensors took air quality measurements at 2 minute intervals.
  - Installation of sensor on top of buses. Selection of the best place in order to avoid vibrations, contact with external elements (such as tree branches), etc.
  - Installation of sensors on top of buses. Selection of an appropriate sensor casing attachment on the roof of the buses, so they can withstand normal operational conditions (vibrations, shocks, vehicle washing…).
  - Change of the model of sensors in the middle of the project. The set of sensors selected at first was rejected after preliminary tests, so it had to be substituted with another type. After being submitted to different tests in laboratory, this second model proved to be more reliable than the initial one and, consequently, was chosen for the installation on buses.
  - Change of the calibration methodology. The set of sensors selected at first was so bad that it was decided to calibrate them in a laboratory. However, as stated above, this set of sensors was finally discarded. The second model used is sold pre-calibrated by the manufacturer.

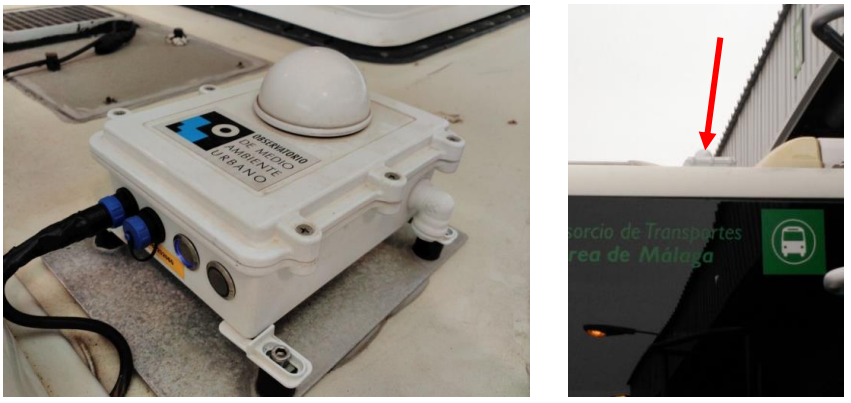

Figure 3: Example of a mobile station installed on a public bus

Operational phase

- Organisational – Coordination with public transport company. Use of public transport buses implies that the project is dependent on their specific procedures and needs, in aspects which include:
  - Although fixed bus lines are selected, buses can be assigned to different lines depending on company needs.
  - Access to sensors in buses is neither easy nor fast, as buses are currently on duty, and hence, it is not possible to stop them.
  - Buses are periodically stopped for maintenance, meaning that throughout that period (it can be up to several days), not valid measurements are obtained from associated sensors. Same applied to buses stopped due to mechanical problems.
- Technological
  - Electronic problems throughout the project lifetime. Several electronic issues occurred, affecting both data sensors (GPS broken, mother board broken) as well as problems with the data controller (wireless module broken). During the repair period, no measurements were taken.
  - The reliability of Ozone sensors. Ozone sensors lost their reliability much faster than expected (on the other hand, NO2 and CO keep in high-quality levels). The solution was to change sensors for new ones, or to look for different models with a longer lifetime.
  - Wireless communications issues. Wireless communications sometimes fail due to the high distance between the sensors and the data concentrator at the bus station. This could be solved by using more data concentrators.
- Financial
  - The use of mobile sensors has proved to be an effective solution also from an economic perspective. The investment and operating costs of a mobile station are significantly lower than those of a fixed station: around 3,620 € and 362 €/year (mobile) respectively and 100,000 € and 10,000 €/year (fixed).

Figure 4: Sensor

Figure 5: Measurement capsule (CO, NO2 & O3 sensors)

5 Recommendations for Future Projects

Following the pilot project that was carried out in Malaga, the following points have been highlighted to be taken into account for the future implementation of air quality monitoring systems at city level:

Strategic and Operational level

- The communication between the mobile sensors and the central control platform should use mobile communications to increase the “real-time” nature of the system. If this is not possible, an alternative, more data concentrators could be placed in several points in the city, so that the information provided by the sensors can be downloaded more frequently. This would help the city to take real-time traffic decisions.

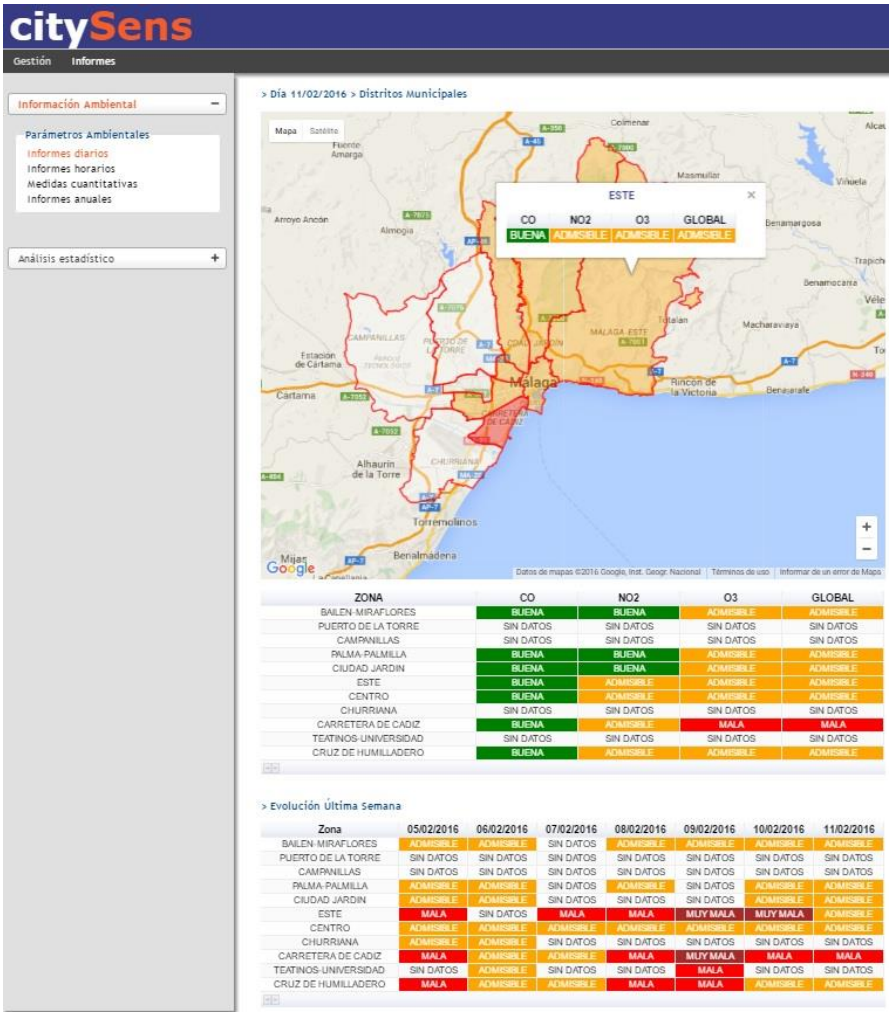

Figure 6: Web Platform - Air Quality – Daily Report – District aggregation

- In order to be effective and reach the confidence levels required by the current regulations, at least 75% of the time period should be covered by measurements. To reach this target, the following recommendations can be taken:
  - Inclusion of more sensors in the system, so that it is possible to reach sufficient confidence levels in all city areas. By doing this, the system would be considered as being “statistically valid” by other city departments, permitting a wide range of uses e.g. creation of the most healthy cycle/walking routes in the city.
  - Install sensors on other public services vehicles different from buses, so that it is possible to maximise the time the sensors are taking measurements. For example: taxis, garbage collectors, etc.

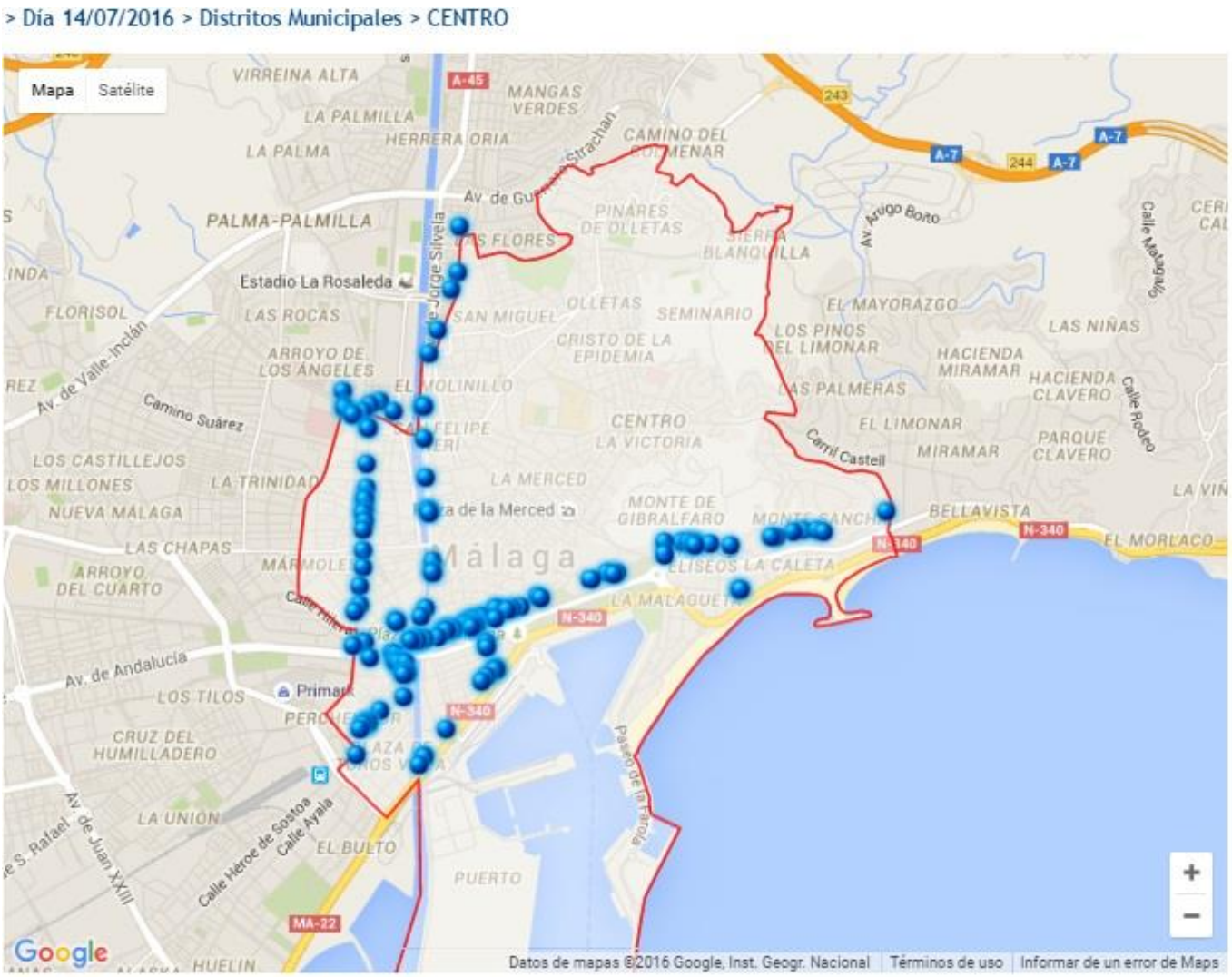

Figure 7: Area covered in the centre of Malaga by current system (with 5 mobile stations)

- Although the project was carried out to provide global information of air quality levels in Malaga city, its performance and utility could be improved by using it in other specific scenarios, such as:
  - Road “exit operations” and “return operations” on holidays periods.
  - Particular city access and routes implying too much vehicles traffic.
  - Rush hours in city centre.
  - Influence of big commercial vehicles (as e.g. trucks) on some particular hours
- Creation of new web interfaces oriented towards citizens, with more clear information about air quality limits.

Technological

- Inclusion of new air quality sensors, such as particulate, sulphur dioxide, etc.
- Further studies regarding ozone sensors, in order to find a family of sensors more reliable that the ones currently used.
- Use the same sensor architecture for other sensor projects, such as noise, weather, etc.

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