
# THE LIFE DYNAMAP PROJECT: AUTOMATING THE PROCESS FOR PILOT AREA LOCATION

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In this paper the method applied to identify the sites to be used as pilot areas to demonstrate the feasibility of real time noise mapping within the LIFE DYNAMAP project is described. The project includes the selection of two pilot areas to test the different requirements associated to major roads and agglomerations. In particular, the first pilot area will be located in the city of Milan and will cover a significant portion of the town, including different type of roads and acoustical scenarios. The second pilot area will be located along a major road, i.e. the ring road surrounding the city of Rome. In this case, about one quarter of the ring road, for a total length of 25 km, will be equipped with the Dynamap monitoring sensors. The identification of the pilot areas has been accomplished using a special tool, implemented in a GIS environment, to address the information to be retrieved and support the selection process. The tool takes into account environmental and infrastructural factors, such as noise levels, population density, number of dwellings and people exposed to noise, the presence of additional noise sources, as well as other infrastructural and environmental information, like the availability of further devices (traffic counting sensors, meteorological and air quality stations), communication networks and electric power connections. As final output, the tool has provided two ranking lists, one for the agglomeration of Milan and the other one for the city of Rome, reporting the prioritized sites where the DYNAMAP monitoring system devices will be installed.

## 1. Introduction

The LIFE DYNAMAP project is a complex five years long project aimed at demonstrating the feasibility of preparing and updating real time noise maps using low cost sensors and a general purpose GIS platform. Scope of the project is the European Directive 2002/49/EC (END) relating to the assessment and management of environmental noise. In particular, the project refers to the need for noise maps to be updated every five years, as stated in the END. Nevertheless, the updating of noise maps using a standard approach is time consuming and costly and has a significant impact on the financial statements of the authorities responsible for providing noise maps, such as road administrations and local or central authorities.

To facilitate the updating of noise maps and reduce their economic impact, noise mapping can be automated by developing an integrated system for data acquisition and processing, able to detect and report in real time the acoustic impact of noise sources. The system will be composed of low-cost sensors measuring the sound pressure levels emitted by the noise sources and of a software tool based on a GIS platform able to perform  real-time noise maps.

While this approach seems quite promising in areas where noise sources are well identified, such as those close to main roads, in complex scenarios, such as in agglomerations, further consideration is needed to make the idea feasible.

The project will be accomplished through four main steps:

- Development of low-cost sensors and tools for managing, processing and reporting real-time noise maps on a GIS platform;
- Design and implementation of the DYNAMAP systems in two pilot areas located in the cities of Milan and Rome.
- Systems monitoring for at least one year to check criticalities and analyse problems and faults that might occur over the test period. The test results will then be used to suggest system upgrades and extend implementation to other environmental parameters;
- Provision of a guideline for the design and implementation of real-time noise mapping.

## 2. Road network analysis and pilot areas location

The implementation of the DYNAMAP system requires the identification of suitable sites to be used as pilot areas for project demonstration activities. Two pilot areas are foreseen to test the different requirements associated to major roads and agglomerations.

The first pilot area is located in the city of Milan and will cover a significant portion of the town, including different type of roads and acoustical scenarios. Roads will be classified and assigned to a suitable number of clusters, on the basis of traffic characteristics. Twenty four roads representative of these clusters will be continuously monitored to provide noise levels for the update of noise maps. Traffic data collected by on site available vehicles counting devices will be integrated in the dynamic noise mapping system to improve and refine noise maps with real traffic information.

The second pilot area is located along a major road, i.e. the ring road (Motorway A90) surrounding the city of Rome. Sensors devices will be installed in hot spots where traffic counting is unavailable to feed the dynamic mapping system with real time information on noise levels. About 25 devices will be used to provide information on noise levels generated by the motorway and dynamically update noise maps. About one quarter of the ring road, for a total length of 25 km, will be equipped with the new sensors.

## 3. Milan: Pilot Area 1 selection

The selection of the pilot area related to the city of Milan was accomplished using a procedure specifically developed for the project. The procedure was applied to nine territorial areas corresponding to the districts of Milan Municipality (Fig. 1), providing as final output a ranking list showing the scores assigned to such areas as a function of a weighted number of attributes associated to them. The procedure was based on data (georeferenced or not) retrieved from public administrations that were considered useful to the project. All these information were collected into a Geographic Information System (GIS), so as to support and automate the selection process.

### 3.1 Description of the tool

The procedure to select the pilot area consists of a ranking system based on scores to be assigned to the districts of Milan Municipality. The scores depends on a series of descriptive attributes related to territory and mobility features, noise monitoring systems and air quality/weather stations availability, the criticality of the area in terms of noise levels, the presence of other noise sources, and the access to communication channels (Wi-Fi access points). In Table 1 the variables contributing to the calculation of the score are described. The score was automatically assigned using georeferenced data, on the basis of the following criterion:

- a score ranging from 1 (lowest score) to 9 (highest score) is generally assigned to districts for each variable category as a function of their position on the ranking list, achieved by combining the figures related to the variables included in the category. Depending on the variable category, districts are sorted ascending or descending (Table 1 for sorting criteria);
- a fixed score of 3 points is assigned for each air quality/weather station present in the area; likewise a 6 points score is assigned for each noise monitoring station(see Table 1).

The scores assigned to variables are then weighted using the coefficients depicted in Table 1. The total score of each zone is finally obtained by adding the resulting values. In the end, the ranking list is achieved sorting (descending) the scores associated to the district zones.

**Table 1.** Variables list, score assignment criteria and weights.

| Variable category | Variable | Score assignment criterion | Weight ($c$) |
|---|---|---|---|
| Territory | Area [km$^2$] | Sort descending | 0,25 |
| | Number of citizens [n] | | 0,50 |
| | Linear road length [km] | | 0,25 |
| Road traffic | Urban traffic plan (PGTU) class distribution [n] | Sort descending | 1,00 |
| | Average daily traffic (ADT) [n] | | 0,50 |
| Acoustic data | Population exposed to $L_{den}$ > 70 dB(A) [n] | Sort descending | 1,00 |
| | Pop. exp. to noise levels > limit for nightime [n] | | 1,00 |
| | Number of measures (> 24h) [n] | | 1,00 |
| Noise monitoring | Noise monitoring terminal(NMT) [n] | 6 pts/terminal | 1,00 |
| Non acoustic data monitoring | Road traffic monitoring stations [n] | Sort descending | 1,00 |
| | Air quality/weather stations [n] | 3 pts/station | 1,00 |
| Other sources | Railway length [km] | Sort ascending | 0,50 |
| | Tramway lenght [km] | | 0,50 |
| Data transmission | OpenWifi access points [n] | Sort descending | 1,00 |

## 3.2 Data collection and processing

Most of the territorial and mobility data were retrieved from the GIS of Milan Municipality, while information on noise levels were provided by the University of Milan-Bicocca. Both data were georeferenced and available in shapefile format, conversely, some information, like the distribution of open wifi access points were not georeferenced and a manual process was necessary to georeference them, so as to proceed with the calculation automatically. Figure 1 shows graphically the layers used to classify the nine districts. Table 2 contains a brief description of the data related to each layer.

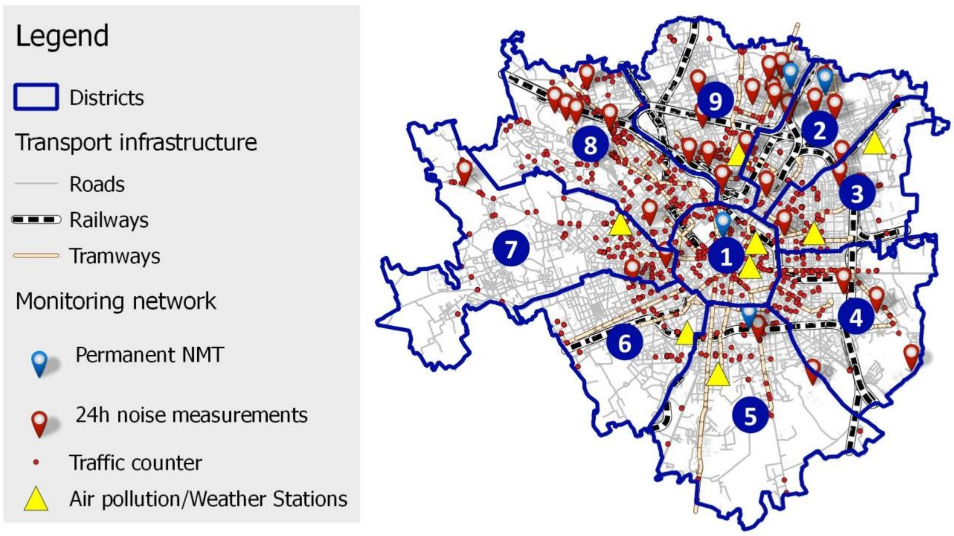



**Figure 1.** Layers used to characterize the nine districts.

**Table 2.** Description of retrieved data.

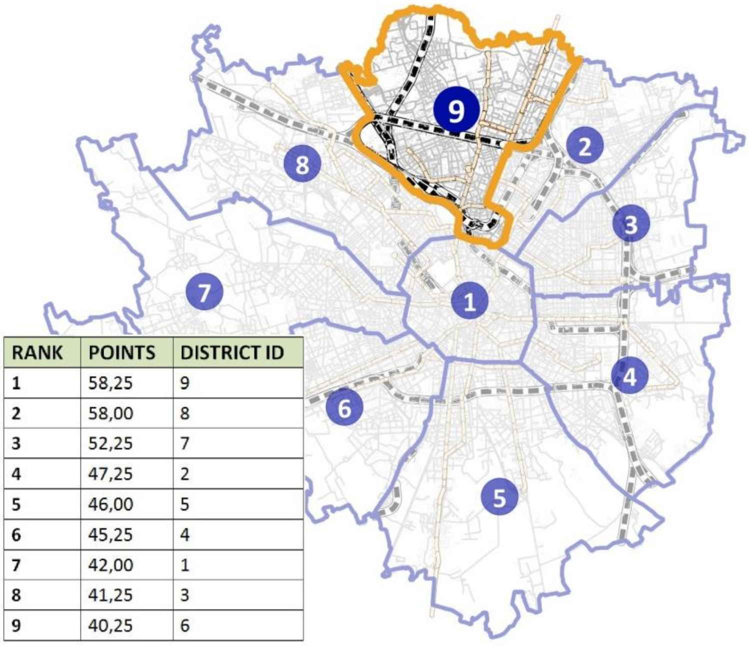
| Layer | Description |
|---|---|
| Road network | Road graph (shapefile). It contains arc distance, mean daily traffic, PGTU class. Road traffic flow data come from AMAT simulation model |
| Railways | Railway graph used to calculate the length of the network |
| Tramways | Tramway graph used to calculate the length of the network |
| Residential Buildings | Polygonal shapefile containing data about population, noise level exposure and limit values. Data come from the strategic noise map of Milan. |
| Noise Monitoring Stations | Point shapefile containing information on measure type (?) and instrument typology (fixed or temporary noise stations). Data provided by the University of Milan-Bicocca. |
| Traffic Monitoring Stations | Point shapefile including data on road traffic retrieved from counting devices. |
| OpenWifi_Access_Points | Text file regarding open wifi access point. |

### 3.3 Ranking list and description of selected area

In Fig. 2 the ranking list achieved applying the methodology previously described is shown. The table highlights that districts 8 and 9 have reached the highest scores. This was mainly due to the critical situation in terms of noise pollution estimated in these two districts. The choice of district 9 was also influenced by the availability of a consistent archive of 24 hours noise measurements and the presence of at least one permanent noise monitoring terminal. These features are of great importance as a thorough knowledge of the acoustic phenomenon in the area under examination is a key element for a successful development of the project.

Figure 2 shows that Milan district number nine has reached the highest score and as a consequence it was selected as urban pilot area for the Dynamap project. District nine is located in the north part of Milan and it has a population of about 180.000 citizens. From an acoustic point of view, it was classified as a critical area. The strategic noise map prepared for the second round of END shows that 40.000 citizens are exposed to Lden values higher than 70dB(A). The population of district nine is mostly annoyed by road traffic noise. As a matter of fact this area is characterized by major roads used by commuter traffic from the densely populated northern suburbs of the city.

Furthermore, the selected pilot area includes two sensitive sites to be protected from noise as the greatest hospital in Milan (Niguarda) and the university district of Milano-Bicocca.



| RANK | POINTS | DISTRICT ID |
|---|---|---|
| 1 | 58,25 | 9 |
| 2 | 58,00 | 8 |
| 3 | 52,25 | 7 |
| 4 | 47,25 | 2 |
| 5 | 46,00 | 5 |
| 6 | 45,25 | 4 |
| 7 | 42,00 | 1 |
| 8 | 41,25 | 3 |
| 9 | 40,25 | 6 |

**Figure 2.** Pilot area selected as urban test site for the Dynamap project and ranking list.

## 4. Rome: Pilot Area 2 selection

The pilot area of Rome is located along the ring road (A90 Motorway) surrounding the city. The ring road is a six lanes motorway, 68 km long, skirting many suburban areas where noise levels were found to be critically impacting on the residents. Critical areas are characterized by different scenarios where single or multiple noise sources are present, such as railways, crossing and parallel roads. As a consequence, the overall noise level depends on the number and contribution of the sources existing in the area. As the Environmental Noise Directive states that only the primary source should be mapped, the contribution of the other sources must be eliminated or at least dramatically reduced. To that end, suitable sites should be identified to place the sensors, so as to contain the influence of the other sources as much as possible. However, in order to check the feasibility of deleting the contribution of other noise sources, including temporary spurious events, with the ANED algorithm (Action B3), more complex scenarios have been foreseen to be part of the selected test sites. For this reason, it seemed reasonable to provide four different type of test sites, representative of the main suburban scenarios:

A. single road (A90 Motorway);
B. additional crossing or parallel roads;
C. railway lines running parallel or crossing A90 motorway;
D. a complex scenario including multiple connections.

Pilot area 2 will be composed of many test sites, distributed along the motorway A90. The final number of sites will be defined on the basis of the amount of sensors necessary to calibrate and update the maps. A maximum of 25 sensors was foreseen to be installed.

To select the sites where the DYNAMAP sensors will be placed, a GIS tool was accomplished to collect and process information related to the 67 critical areas identified by ANAS Action Plan in the first and second round of the END.

### 4.1 Description of the tool

A specific tool was developed for the pilot area of Rome taking into account the information available from ANAS data base and the Action Plan accomplished for the first and second cycle of END. The tool provides for the creation of four ranking lists of critical areas, retrieved from those identified in the Action Plan, corresponding to the suburban scenarios A to D. The ranking lists were based on a priority index associated to the critical areas, that takes into account the following information:

- noise levels;
- population density;
- number of buildings (dwellings) and amount of people exposed to noise.

For the selection process of the test sites, other information were necessary, such as the presence of additional noise sources, as well as other infrastructural and environmental information, like the availability of further devices, communication networks and electric power connections. The tool was implemented in a GIS environment, through an algorithm based on the following five steps:

Step 1: preparation of the pilot area;
Step 2: filtering of critical areas missing connection to the power grid and communication channels;
Step 3: selection of critical areas with traffic counting devices;
Step 4: identification of critical areas with additional noise sources;
Step 5: sites classification.

In Table 3 the description of the layers used as input in the GIS tool is shown.

**Table 3.** Description of layers.

| Layer | Description |
|---|---|
| Road Network | Road graph. It contains the arcs belonging to the A90 motorway |
| Other Roads (ASA) | Road graph. It contains the arcs related to roads belonging to ANAS running parallel or crossing the A90 motorway within a buffer 250 m wide each side of the motorway axis. |
| Railways (FS) | Graph of the railways running parallel or crossing the A90 motorway within a buffer 250 m wide each side of the motorway axis, identified and included in the Action Plan. |
| Critical Areas (CA) | It contains the areas where noise limits values are exceeded, retrieved from ANAS Action Plan. |
| Variable Message Panels (PMV) | Point layer reporting information on the location of Variable Message Panels. |
| Traffic Counting Devices (TC) | Point layer related to the position were traffic monitoring devices are installed. |
| Switchboard (PMV_quadri) | Point layer reporting information on the position of the switchboards along the motorway. |

### 4.2 Data collection and processing

For the selection of the sites related to the second Pilot Area, sixty-seven critical areas, located along the motorway A90 were taken into account. The critical areas were identified on the basis of the results achieved from ANAS noise mapping and action planning activities, accomplished in 2013 for the first and second cycle of END, in compliance with National and European legislation.

Data related to such critical areas were used to feed the GIS tool and provide as output a ranking lists of sites suitable to the installation of the DYNAMAP system.

For each critical area the following information were available from the Action Plan:

- receivers type;
- receivers distance from the road;
- geometrical features of receivers buildings (area, volume, numbers of floors, exposed falcade, etc.);
- noise levels at receivers and related national limits;
- noise exceeding levels;
- road name, type, geometrical features and location;
- road pavement type (standard or low noise surface);
- traffic volume, composition and speed;
- priority index;
- existing noise mitigation measures;
- noise mitigation measures to be implemented in the forthcoming years.

The proper installation of the devices on the test sites requires, however, further information, such as those related to the availability of power grid connections and communication networks, traffic counting systems and other noise sources that could influence the overall noise level.

The complete input layers were then used to feed the DYNAMAP tool, whose output resulted in four lists complying with the requirements related to the main suburban scenarios.

### 4.3 Ranking list and description of selected area

The tool provided as output four ranking lists, of critical areas, sorted by their priority index, as follows:

A. **Single road:** this list consists of areas with the mere presence of the primary source (A90 Motorway). The first twelve areas, in order of decreasing priority, were selected as suitable to host the DYNAMAP sensors;
B. **additional crossing or parallel roads:** this list includes areas with other crossing or parallel roads belonging to ANAS. Only one critical area complying with such requirements was found;
C. **railway lines running parallel or crossing the A90 motorway:** to this category belong those sites where railways are running parallel or crossing the A90 motorway. Two sites were found to be compliant with the specifications;
D. **a complex scenario including multiple connections:** this lists refers to suburban scenarios where many connections to other roads are present, including the contemporary presence of additional noise sources, such as railways. Two critical areas were identified for this list.

## 5. Conclusions

In this paper the methods used and the results achieved are described. Two pilot areas were foreseen in the project. The first pilot area, representative of an urban scenario, is located in the agglomeration of Milan, while the second one, representative of the main suburban scenarios, is placed along the A90 motorway that surrounds the city of Rome. For the selection of the pilot areas a GIS tool was developed in order to standardize the selection process and ease data collection.

As for the first pilot area, the tool required also the definition of an index to be assigned to the nine districts in which the city was split, taking into account a series of parameters, that were judged to be of interest for the identification of the test site. The selection process provided a ranking list from which district nine emerged as the most suitable area to host the DYNAMAP system.

A different approach was required for the pilot area located in Rome, where many test sites placed along the A90 motorway are foreseen. Also in this case, the identification of the test sites was based on the availability of weather and air quality monitoring stations, traffic counting devices, electric grid and communication connections, but most of all on the presence of hot spots where noise limits values are exceeded. The tool developed in this case, provided four ranking lists representative of the main acoustic scenarios:

A. single road (A90 Motorway);
B. additional crossing or parallel roads;
C. railway lines running parallel or crossing A90 motorway;
D. a complex scenario including multiple connections.

A total of seventeen sites complying with these specifications were found.

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