DYNAMAP
DYNAMIC ACOUSTIC MAPPING

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laSalle

Characterization of a WASN-based Urban Acoustic Dataset for the Dynamic Mapping of Road Traffic Noise

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Outline

1. **Introduction**
2. Motivation
3. WASN-based urban dataset
4. Discussion and conclusions

1. Introduction

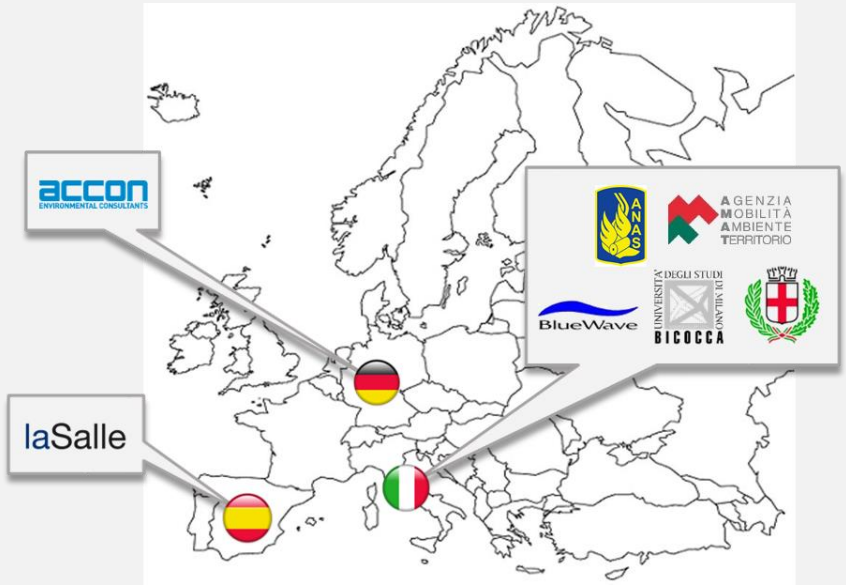
LIFE+ DYNAMAP (*Dynamic Acoustic Mapping*)**:**
The project aims at developing a **dynamic noise mapping** system able to detect and represent in **real time** the acoustic impact due to road infrastructures, following the European Noise Directive 2002/49/EC.

Project budget:
2.2 M€

Duration:
01/07/2014 -
30/06/2019

www.life-dynamap.eu/

Consortium



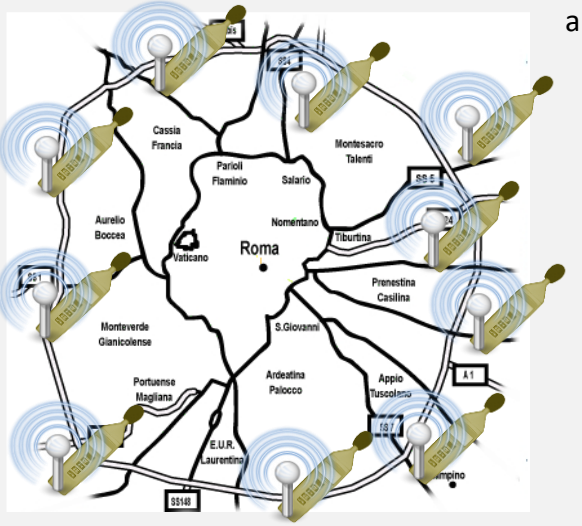
1. Introduction

Project goals

- G1. Automate **Road Traffic Noise** (RTN) mapping process using the information retrieved from a low-cost monitoring network
- G2. Develop low-cost sensors and communication devices to collect the information needed to update noise maps in real time
- G3. Implement and test the system in **two pilot areas** with different characteristics: an urban agglomeration (District 9 of Milan) and a major road (A90 motorway in Rome).

1. Introduction

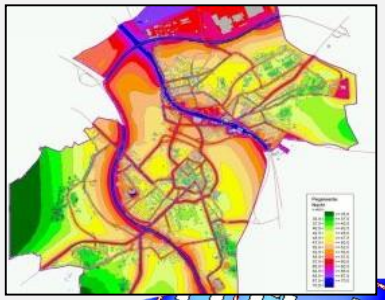
System description

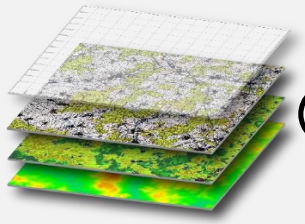


Data collecting on a server.
Data sent from the sensor are archived on a server

Data analysis for calculation of L_{Aeq} values of specific sources:
1 - Identification and removal of spurious events
→ **Anomalous Noise Event Detector (ANED)**
2 - Calculation of sound level on a defined time basis

Wireless noise sensors development



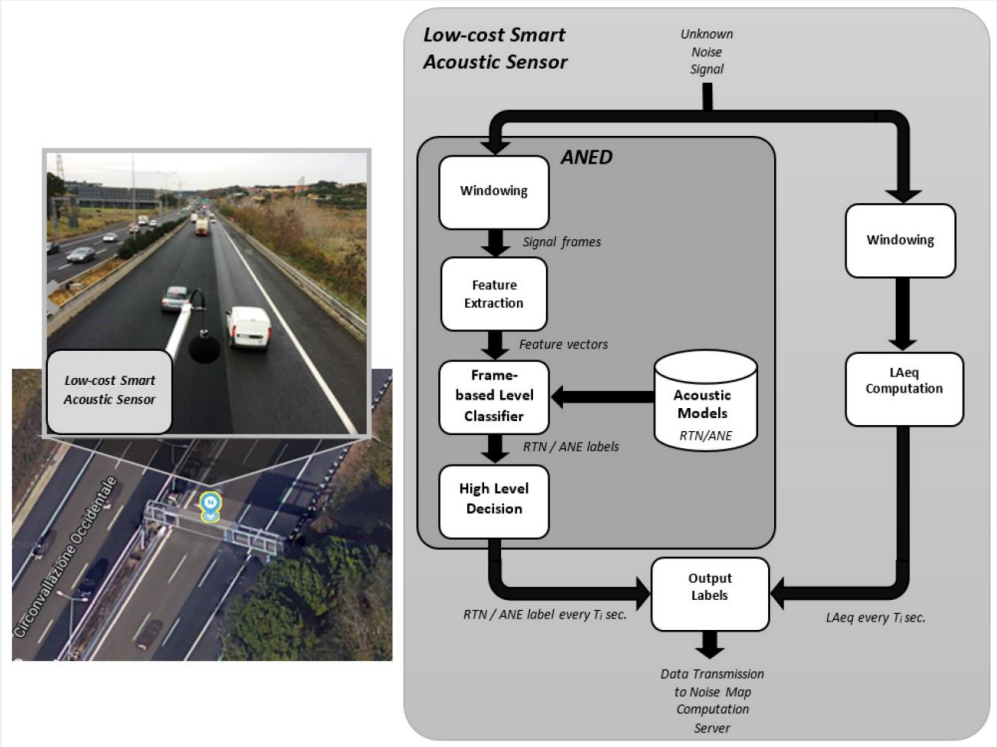


Pre-calculated spatial noise map of Source 1 + Sound level of source 1

Pre-calculated spatial noise map of Source n + Sound level of source n

1. Introduction

- **Anomalous Noise Event Detector** (ANED): An algorithm designed to identify anomalous noise events (ANE) that could distort the noise levels measured by the acoustic sensors of the Wireless Acoustic Sensor Network (WASN).



Block diagram of the ANED algorithm implemented as a two-class classifier (RTN vs. ANE), and the low-cost acoustic sensor that includes the computation of the A-weighted equivalent noise level (L_{Aeq}). On the left, an example of the sensor installed in Rome.

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2. Motivation

- The ANED algorithm has been trained and improved several times with representative acoustic data containing both RTN and **Anomalous Noise Events** (ANEs) – defined as those events unrelated to regular traffic noise (e.g., sirens, horns, speech, doors, etc.).
- The **recent deployment of the WASNs** in the pilot areas has provided the possibility to collect acoustic data through the **24 low-cost acoustic sensors** installed in their final locations within the urban acoustic environment.

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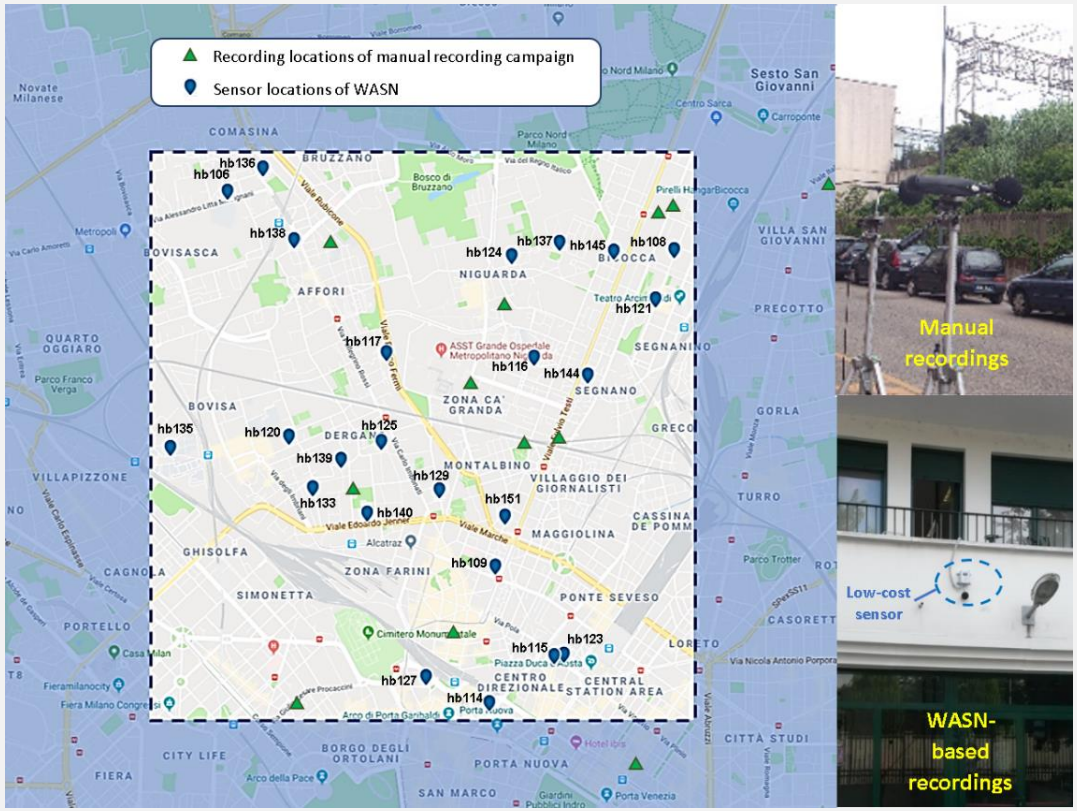
2. WASN-based urban dataset

- Recording locations within District 9 of Milan city



Map of the recording locations during the preliminary manual recording campaign (in green triangles), and the location of the DYNAMAP's 24 low-cost acoustic sensors of the WASN deployed in Milan (blue markers). Examples of each recording positions are shown on the right.

3. WASN-based urban dataset

- **Two recording days**: one weekday (Tuesday, November 28, 2017) and one weekend day (Saturday, December 2, 2017).
- **Methodology**: recording of the first 20 min per hour as audio clips sampled at 48 kHz.
- The acoustic data was obtained from all the **24 sensors** of the network. However, 4 out of them presented some operational problems.
- A total of 463 WAV files were obtained from the recording campaign, which encompasses **154 h and 20 min** of audio.

3. WASN-based urban dataset

- Expert-based labelling process of the audio data into three categories: RTN, ANE and CMPLX*.
- Identification of 26 subcategories of ANEs:

Label	Description	Label	Description
airp	Noise of airplanes and helicopters	*musi*	Music in car or in the street
alrm	Sound of an alarm or a vehicle beep moving backwards	*peop*	Sounds of people chatting, laughing, coughing, sneezing, etc.
bell	Churches bells	*rain*	Sound of heavy rain
bike	Passing of bikes, and sound of bikes chains	*rubb*	Rubbish service, sound of engine taking the container, emptying it and dropping it down
bird	Birdsong	*sire*	Sirens (ambulances, police, etc.)
blin	Sound of an opening or closing of a blind	*sqck*	Squick sound of a door
brak	Noise of brake or car's timming belt	*step*	Sounds of steps
busd	Opening bus door (or tramway), depressurized air	*thun*	Thunderstorm
dog	Barking of dogs	*tram*	Stop, start and pass by sounds of tramways
door	Door or knock noise (house, car or object), kid's ball noise	*tran*	Sound of trains
glas	Sound of glas crashing	*trll*	Sound of wheels of suitcases (trolley)
horn	Horns of vehicles (cars, motorbikes, trucks, etc.)	*wind*	Noise of wind (movement of the leaves of trees,...)
inte	Interfering signal from an industry or human machine	*wrks*	Works in the street (e.g. saws, hammer drills, etc.)

*Complex audio passages containing a high diversity of sound sources were labelled as complex sound mixtures

3. WASN-based urban dataset

- Occurrence of ANEs
  - **Most frequent**: those of short nature usually attributed to urban environments: people (22.2%), birdsongs (14.7%), door-like sounds (14.7%), human steps (13.7%) and vehicle brake sounds (12.7%).
  - **Moderate presence**: works (4.1%), horns (3.7%), sounds of bikes (3.7%), dogs barking (2.5%), bells (1.2%) and depressurized air (1.1%).
  - The remaining subcategories where **rarely** observed.
- Duration of ANEs
  - Events with the **largest duration:** interfering signals (mean length of 20.9 s), followed by sirens and airplanes (median lengths between 8 and 21 s). Sounds of trains, tramways, rain and rubbish services show median length values between 5 and 8 s.
  - The remaining events showed a **rather short duration** (between 1 s and 3 s, or even shorter).

3. WASN-based urban dataset

- Signal-to-Noise Ratio of ANEs w.r.t. background noise[1]
  - ANEs presenting **positive SNRs**
    - 4dB < Median_SNR < 7dB*: blind,* and *dog*
    - 2dB < Median_SNR < 4dB*: glas, tran, tram, bell, horn, door,* and *rub*
  - ANEs with **very low SNRs**
    - Median_SNR < 0: *inte, rain* and *wind*
  - The rest of ANEs presented a quite balanced positive and negative SNR values.

- ANEs with **high** potential **significant impact on RTN's L_{Aeq}**:
  - ANEs having both long duration and positive SNRs:
    - Tramways, door sounds, street works and people-related sounds

[1]SNRs were computed following the approach described in Orga et al. (2017).

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4. Discussion and conclusions

- ~154h of urban acoustic data obtained from the WASN in real operation from District 9 of Milan, categorized as
  - **RTN**: 129 h 12 min and 35 s (83.7%)
  - **ANE**: 13 h 16 min and 1 s (8.6%), and subdivided into 26 subcategories
  - **CMPLX**: 11 h 51 min and 25 s (7.7%).
- Comparison to the previous manual-based recording campaign
  - Different **recording positions** (street vs. façades) and **equipment**.
  - More **extensive data** collection: manual recordings only collected up to 20 min at certain time periods (mostly during the day) at 12 locations at the street before installing the sensors at the façades.
  - 11 **new ANE subcategories** have been identified
  - Confirms the **biased nature** of the problem, and the need of **extensive recordings** to characterize the urban environment properly.

4. Discussion and conclusions

- **Future work**
  - Adapting the ANED algorithm to run in real operation conditions by training it with the built WASN-based acoustic dataset.
  - Conducting a deeper analysis of the database contents, paying special attention to the complex passages and their potential impact on the algorithm's execution.

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