

# Crowdsourcing of Noise Map Pollution using Smartphones

Journées des Laboratoires SIG de Suisse  
romande

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- Noise societal and environmental issues

**Context** : Green Paper on Future Noise Policy (1996) published by the Commission of the European Communities reports that between 17 and 22% (close on 80 million people) of the Union's population are exposed to continuous daytime outdoor noise levels caused by transport above what are generally considered to be acceptable - more than 65 dB(A), which is the level at which people become seriously annoyed during the daytime.

**Cause** : road transport noise stands for the dominant noise source and accounts for 90% of the population exposed to noise levels higher to 65 dB(A).

**Consequences** : Noise can cause annoyance and fatigue, interfere with communication and sleep, reduce efficiency and damage hearing.

Anthropogenic activities - especially motorized transportation modes - result in pervasive noise that implies a lessening of both the richness and abundance of the animal species, an alteration of the communication which can threaten the reproduction and predation.

- At french level

The law n° 92-1444 from **31 december 1992** regarding fight against noise codifies at once the prevention, the reduction and the limitation of both noise emission and propagation susceptible to harming resident health.

The decree from **30 June 1999** relating to the acoustic characteristics of residential buildings regulates the acoustic insulation for all new buildings.

The decree no. 2006-1099 from **31 august 2006** relating to the fight against neighborhood noise sets acoustic criteria at once for sports, cultural and professional activities.

Regarding land transports, any new project or development plan concerning road or rail infrastructure must take into account noise according to the article L571-9 of the Environment Code (**2010**).

- At european level

The Environmental Noise Directive (END) 2002/49/CE relating to the assessment and management of environmental noise aims at defining a common approach planned to avoid, prevent or reduce the harmful effects, including annoyance, due to the exposure to environmental noise.

Four main axis:

- monitoring environmental noise;
- informing and consulting the population;
- addressing local noise issues;
- developing a long-term european strategy.

....



... in the context of noise monitoring - the drawing up of strategic noise maps for **cities of more than 100 000 inhabitants**.

In both **urban** and **suburban areas**, methods to contend with noise pollution consist in various actions (*e.g.* road resurfacing, acoustic screens insertion, speed limits reduction, traffic deviation, new public transportation policies setting up, etc.).

The action plans can be evaluated upstream its implementation through **noise propagation simulations**.

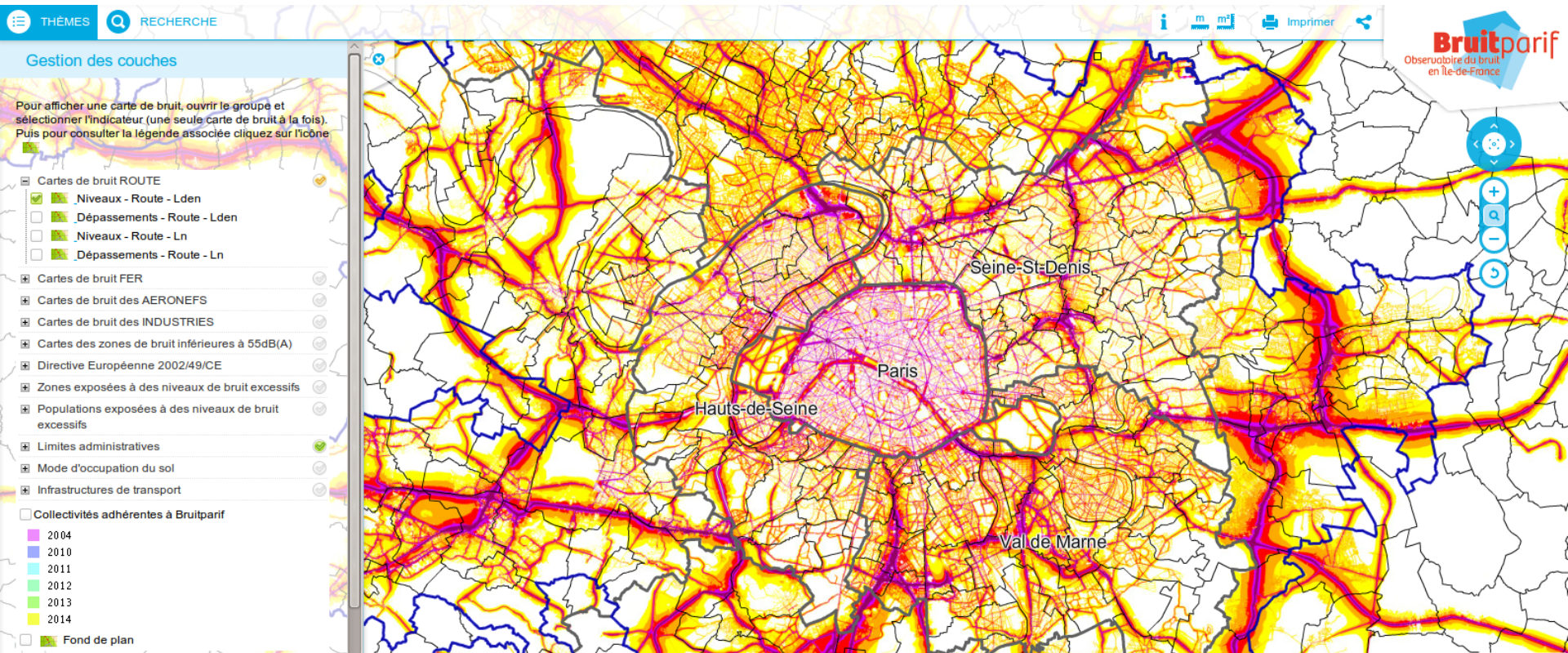
- European Noise Directive 2002/49/CE recommends to use the French engineering model NMPB 2008 if considering road traffic noise.

The method, edited by the Roads and Motorways Engineering Department (Sétra1), comprises two methodological guides:

- (1) deals with the calculation of sound emissions from road traffic;
- (2) the second one describes the computation of noise propagation.

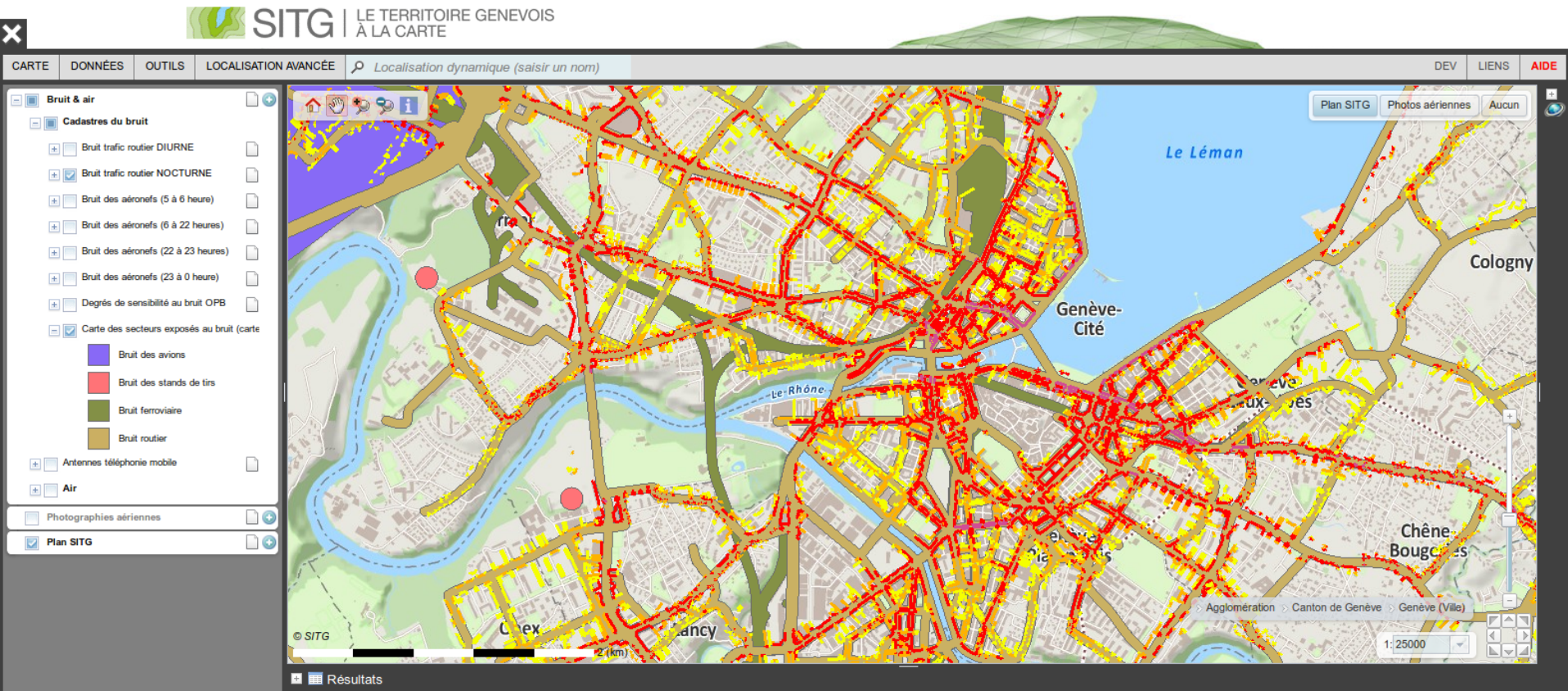
# Simulation-based noise maps

European Network for Redistributing Geospatial Information to user Communities - Open Data



<http://carto.bruitparif.fr>, June 2015





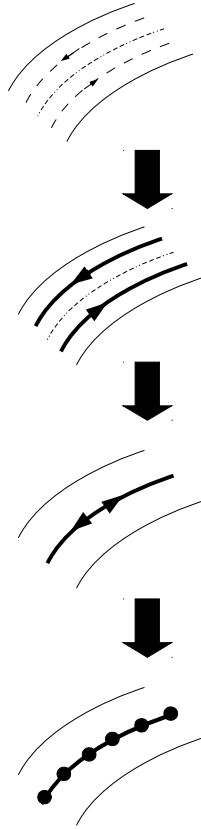
<http://ge.ch/sitg/>, June 2015

- Strategic Noise mapping in the EU [2002/49/EC]
  - ◆ Any city over 100 000 inhabitants
  - ◆ Data intensive
  - ◆ Computationally intensive
  
- EU action plans and urban mobility plans
  - ◆ Complex process
  - ◆ Time consuming
  
- Comparing variants:
  - ◆ **Need for a simplified approach**

- ANR project Eval-PDU (“sustainable cities”)
  - ♦ Environmental impact assessment of urban mobility plans
  - ♦ Air, noise, socio-economic effects...
  - ♦ Test of several scenarios of urban mobility plans (Nantes, France)
- Noise mapping:
  - ♦ Propose a “2D simple approach” of the French standard method NMPB 08, with low computation time (a day)
  - ♦ Include the method in a GIS software: OrbisGIS

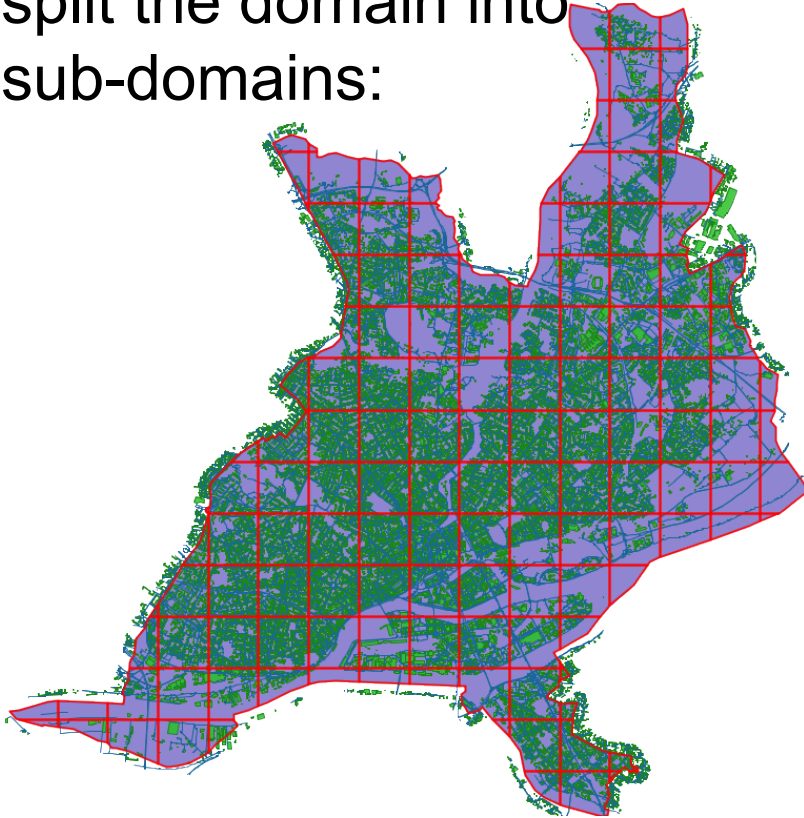
## Noise emission from traffic data :

- ♦ Average vehicle speed
  - ♦ Light vehicle/hour
  - ♦ Heavy vehicle/hour
  - ♦ Tram vehicle/hour
  - ♦ Speed limitation
  - ♦ Road category ex: “Highway 2x2”
  - ♦ Reference spectrum for each vehicle category
- Computation of the frequency distribution of the sound pressure level in 1/3 octave bands from 100 to 5000 Hz





- Parallel computing, split the domain into sub-domains:



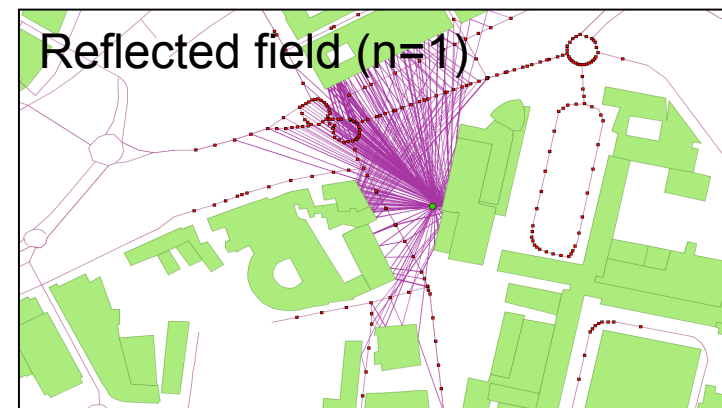
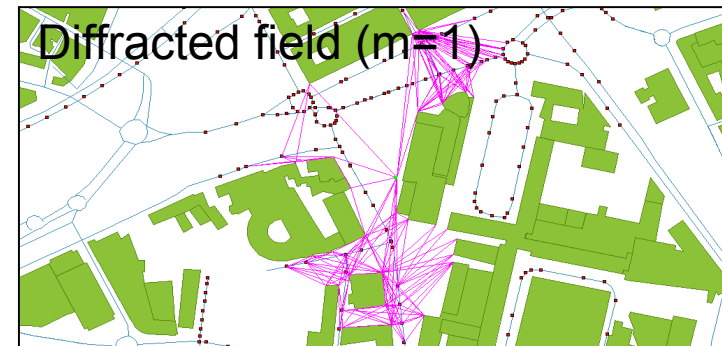
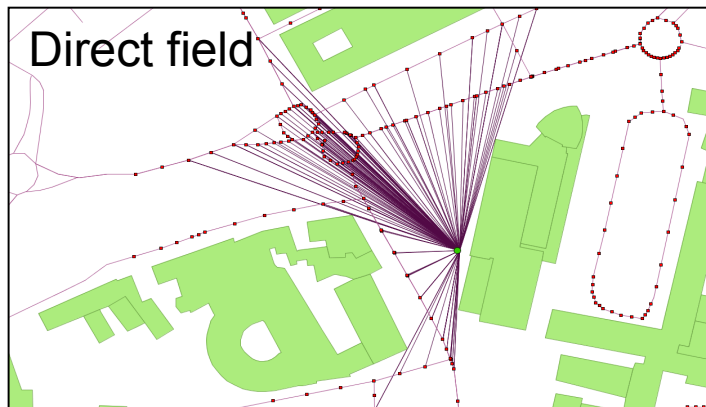
- For noise mapping, quality constrained Delaunay triangulation of a sub-domain:



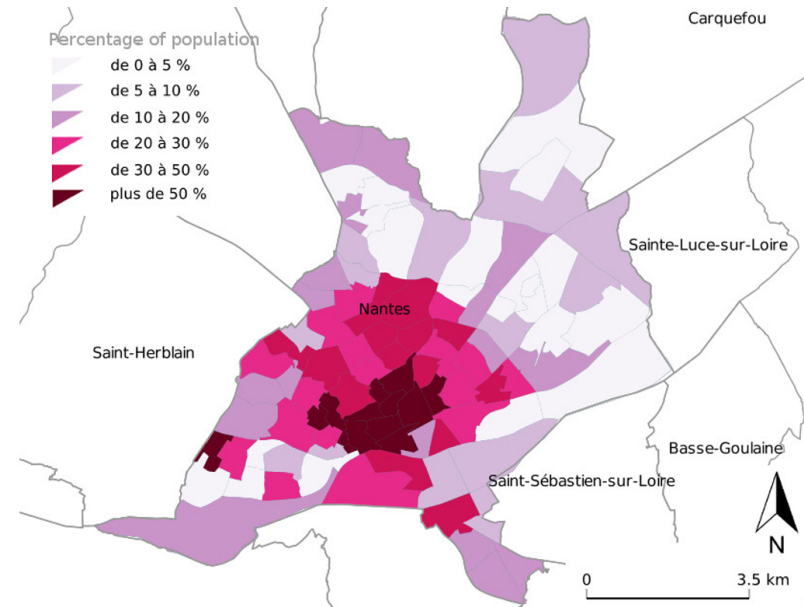
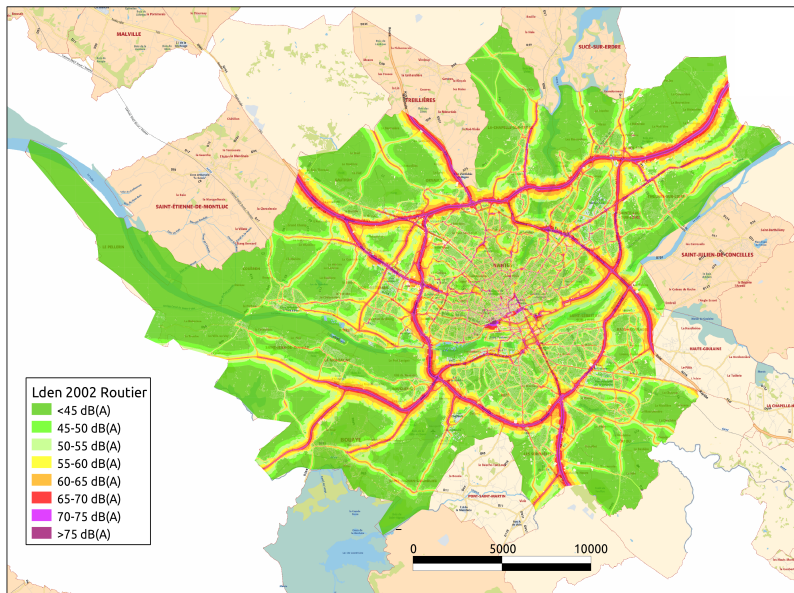


For a given receiver: research of all propagation paths: direct, reflected

- ♦ (order  $n$ ), diffracted (order  $m$ )
- ♦ Calculation of sound level
- ♦ for each path



LDEN	2008 base year		Scenario 1		Scenario 2		Scenario 3	
	Number	%	Number	%	Number	%	Number	%
< 50 dB	67 180	23.9	69 628	24.8	66 929	23.8	68 996	24.6
50-55 dB	29 071	10.3	28 764	10.2	27 986	10	27 458	9.8
55-60 dB	33 347	11.9	34 636	12.3	33 070	11.8	33 329	11.9
60-65 dB	54 093	19.3	57 052	20.3	51 512	18.3	54 405	19.4
65-70 dB	53 505	19	50 807	18.1	55 640	19.8	53 280	19
65-75 dB	36 243	12.9	33 254	11.8	38 092	13.5	36 017	12.9
>75 dB	7 478	2.6	6 776	2.4	7 688	2.7	7 431	2.6



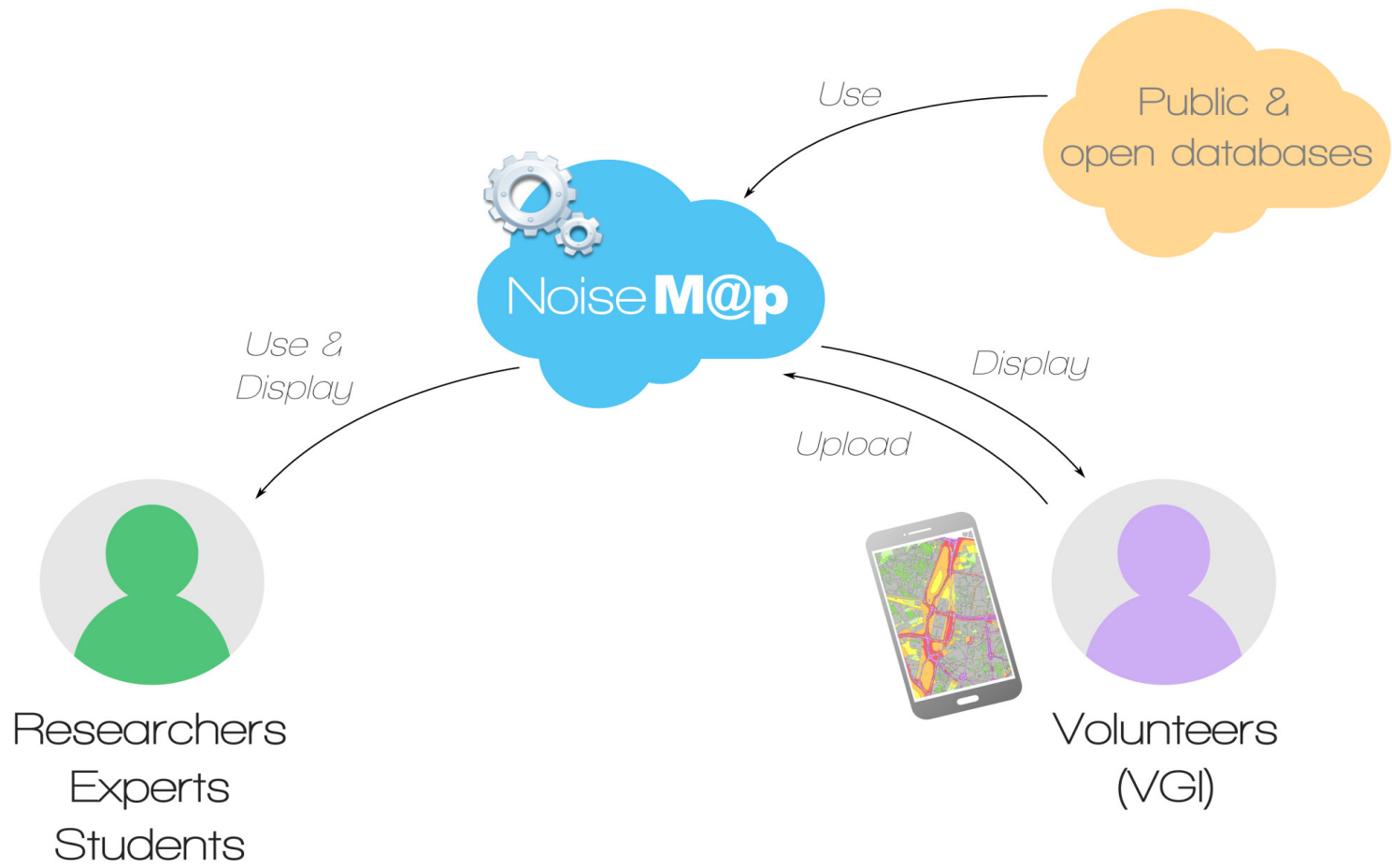
<http://noisemap.orbisgis.org/>, June 2015

- NoiseM@p :
  - reduce manipulation time and computation time.
  - new alternative to classical tools in order to produce noise maps using only Open Source software.
  
- But...
  - modelling of the main urban noise source, namely the road traffic, requires many information (e.g. traffic flow, light/heavy vehicles proportion and respective speeds, etc.).
  - input data which is most of the time not available over the whole surface of the land cover.
  - simulations do not include all noise sources and the numerical methods employed can not account for time sound levels fluctuations (i.e. sound events).
  - Noise simulation maps are statics and always out of date (outdated traffic volume).

make it difficult to analyze the noise impact at different spatio-temporal granularities.

# NoiseM@p platform

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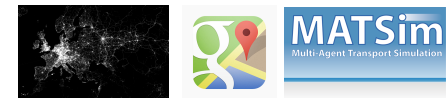
## Geographical data:

- OpenStreetMap (OSM): <http://www.openstreetmap.org/>
- Data Gouv: <https://www.data.gouv.fr/>



## Road traffic data:

- Trafficways: <http://www.trafficways.org/>
- Google Maps: <https://www.google.fr/maps/>
- MATSim: <http://www.matsim.org/>



## Rail traffic data:

- OSM TchouTchou: <http://www.raildar.fr/>



## Flights:

- Flightradar24: <http://www.flightradar24.com/>



## Ships:

- MarineTraffic: <https://www.marinetraffic.com/>



## ▪ **Multiple sensors:**

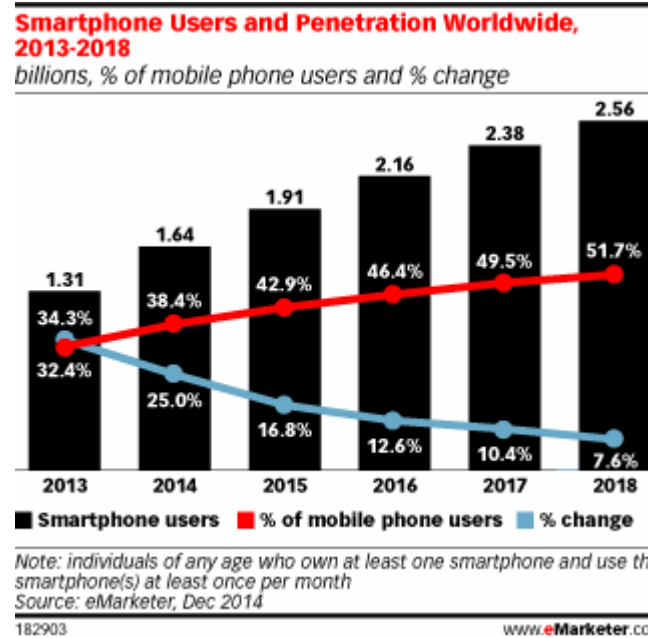
- ♦ position sensors:
  - a GPS which detects the location of the smartphone using either the GPS, a trilateration or a triangulation of cell towers, or else the wifi networks;
  - a magnetometer that measures the strength of earth's magnetic field;
  - a gravity field sensor which estimates the acceleration effect of Earth's gravity;
  - a proximity sensor, comprising both an infrared LED and infrared light detector;
- ♦ motion sensors:
  - a 3-axis accelerometer that measures the acceleration according to the three cartesian axis;
  - a gyroscope which detects the orientation or the changes in the orientation of the device;
- ♦ environmental sensors:
  - a camera sensor;
  - a temperature sensor which estimates the ambient air temperature;
  - a photometer that determines the light intensity of the environment;
  - a barometer which measures the atmospheric pressure;
  - an air humidity sensor;
  - a microphone.



# The smartphone sensing opportunity

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87% of the world's population owned a mobile phone subscription

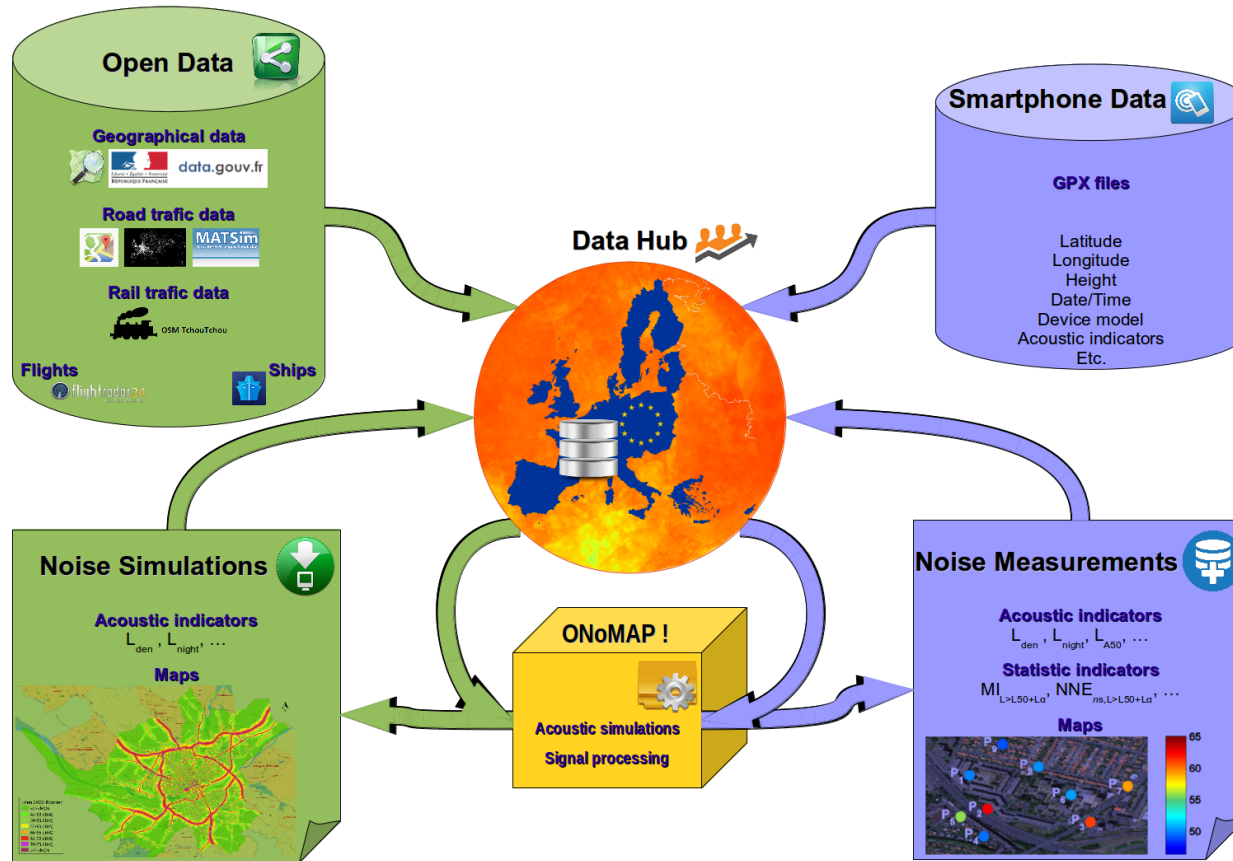


<http://www.emarketer.com>, June 2015



# The idea

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# The project 2014 - 2017

European Network for Redistributing Geospatial Information to user  
Communities - Open Data

- The project objectives are to:
  - ♦ Develop VHS at different territorial scales (regions, member states, Europe), providing unique and mutually consistent points of access to heterogeneous data sources for both end-users (via geoportals) and machines (service interfaces, APIs).
  - ♦ Demonstrate the validity of the concept, design, implementation and deployment of VHS through the development of a set of **innovative applications in different domains**. The proposed applications will address the needs of businesses, citizens and public institutions, making use of both public and private (open) geospatial data.

- Innovative application: **participative noise map**
  - ♦ Consistent with the european Environmental Noise directive 2002/49/EC, whose goal is “*define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to the exposure to environmental noise*”
  - ♦ “Classical” approaches for producing noise maps:
    - **Modelling** of noise emission and propagation (NMPB, CNOSSOS): see the NoiseM@p project at [noisemap.orbisgis.org](http://noisemap.orbisgis.org) (Ifsttar, CNRS)
    - **Measuring** real noise in urban areas: need a large amount of “qualified” data.

- Innovative application: **participative noise map**
- Using smartphones (*i.e.* citizens) for a massive acquisition of noise data in urban environment
  - ♦ [see also NoiseTube, WideNoise, NoiseSpy, NoizCrowd, NoiseWatch, NoiseBattle, NoiseQuest]
  - ♦ Build a “qualified” noise database
  - ♦ Produce “real” noise maps on the basis of the database
  - ♦ Open the database to the community

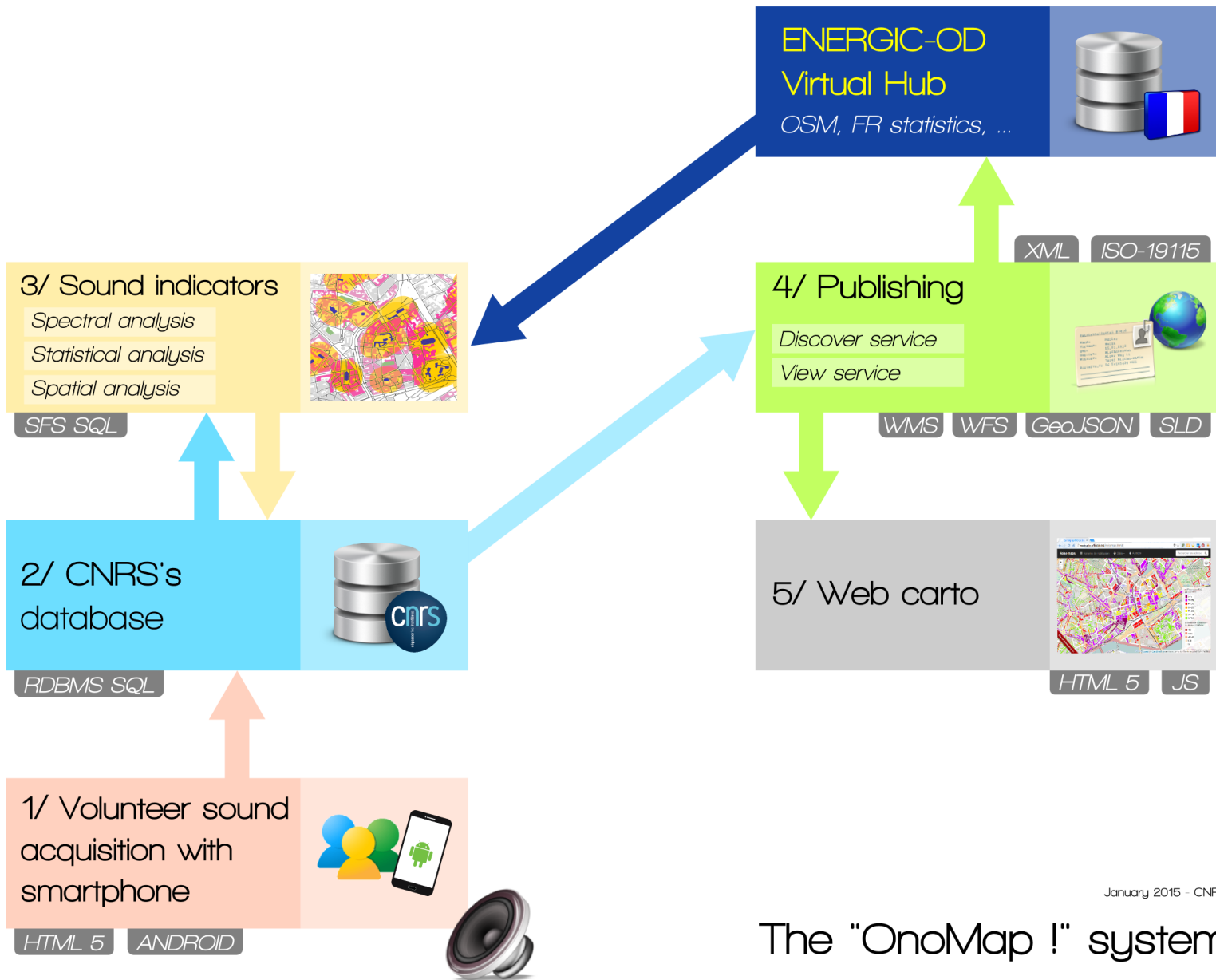
- A “global infrastructure” made by specialists in Geomatics and in Acoustics
- Development of specific treatments to qualify the noise database
- Use the noise database to build noise maps and noise indicators (mixed data from participative measurements, laboratory measurements and simulations)



# Platform

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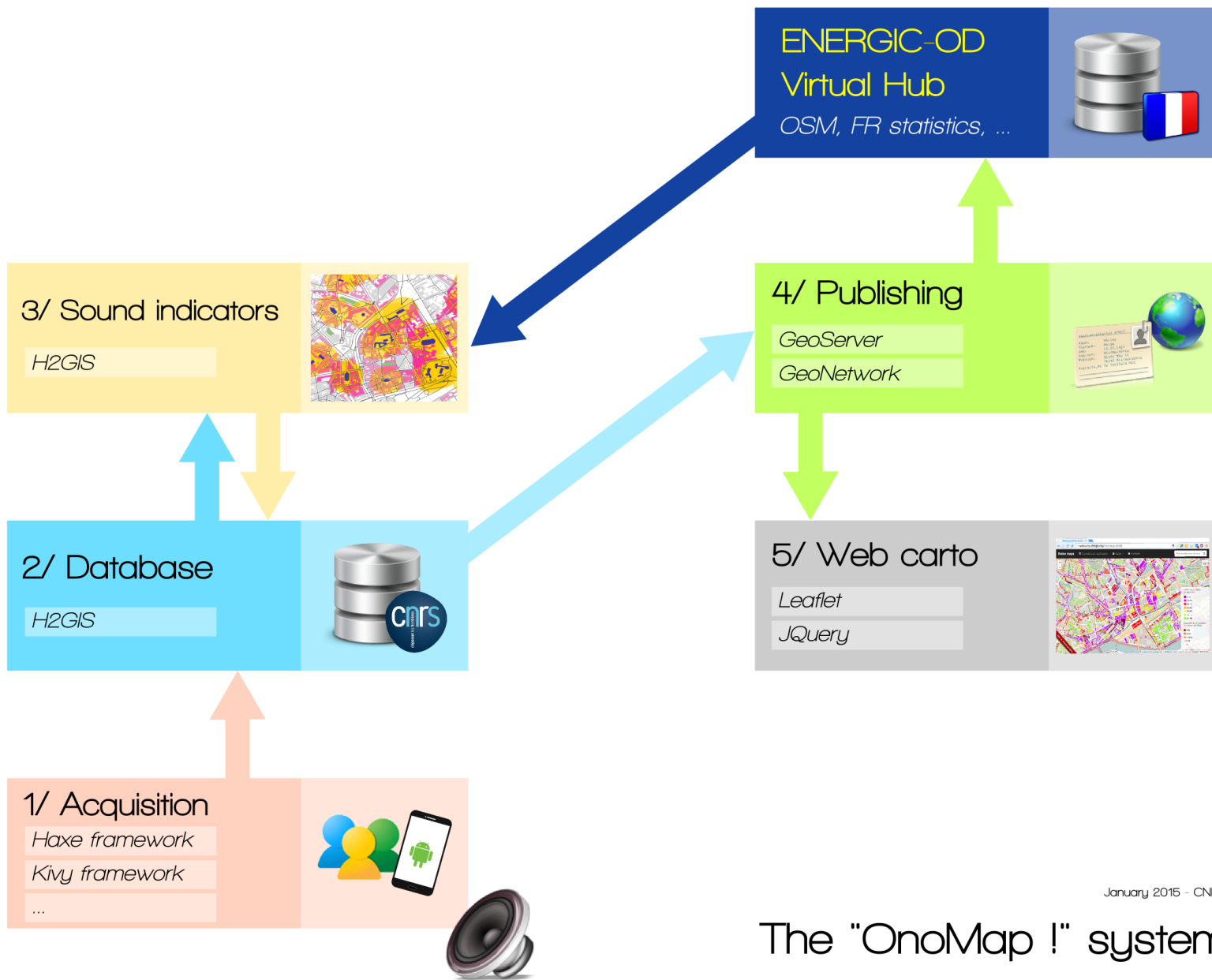
- Geographical coverage: Available for the European countries but the system will be tested on a city in France not yet identified.
- Technological choices: open source, standardized, OGC.



January 2015 - CNRS

# The "OnoMap !" system





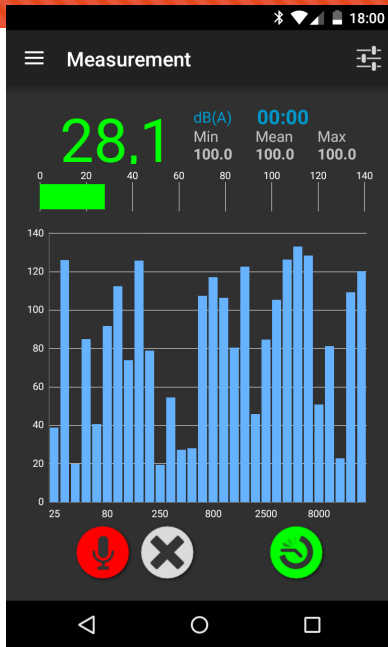
# The "OnoMap !" system



- Acquisition (quality of the sound measurement, accuracy of the GPS position, user practices).
- Data storage (time dimension, spatial relations).
- Data processing (availability, scale, statistical representativeness...).
- Visual display (map, dataviz...).
- VI participatory (professional, noise map party, serious gaming).

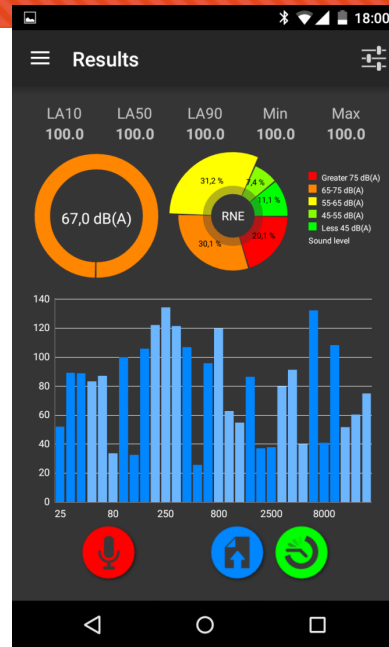
# Development progress NoiseCapture Android App

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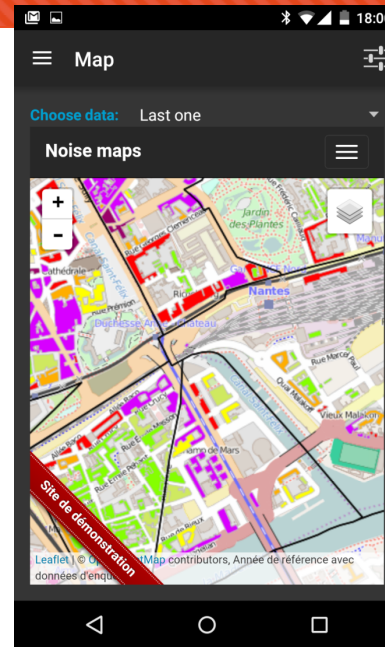
## MEASUREMENT

- Instantaneous data dB(A)
- Global sound level
- Third octave band spectrum
- Min, Max and Mean values



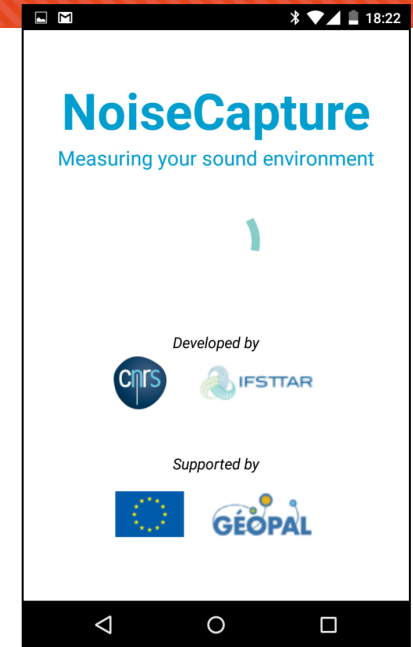
## RESULTS

- Equivalent SPL dB(A) (1s)
- Sound Exposure Level (SEL)
- Repartition of Noise Exposition (RNE)
- Noise spectrum
- Noise indicators:  $L_{A10}$ ,  $L_{A50}$ ,  $L_{A90}$ ,  $L_{Amin}$  and  $L_{Amax}$



## MAP

- Noise maps: geo-referenced SEL along the path (every 1s)
- Show:
  - last measurement
  - user's measurements
  - all users' measurements
- Internet access of the data with many information



## ADDITIONAL CONTENTS

- About: project information
- Help: how to use the application
- History : manage data in the webphone
- Settings: manage user parameters



Made by research



Designed for GIS



Free to use