

**“project EU en gemeenschappelijke voorzieningen,  
onderdeel van het programma INSPIRE in Nederland”**

- **2014/2015 - SOSPIlot - RIVM**

- <http://sensors.geonovum.nl>

- **2015-2016**

- 1. Smart Emission Nijmegen**

- <http://data.smartemission.nl>

- 2. AirSenseEUR**

- 3. OGC SensorThings API (SensorUp, Steve Liang)**

- 4. FIWARE**

- 5. LoRa - TheThingsNetwork**

# Smart Emission

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Geonovum - Springplank  
Amersfoort Nov 28, 2016



## Smart Emission

### Inclusive Citizen Sensing

- Citizen-sensor-networks for fine-grained measurements, with new low-cost sensing devices
- Transparency and democracy of pollution monitoring, 'making the externalities (e.g. noise, air pollution) visible'
- Cost-effective environmental monitoring, Open Data.

### The smart residents well-informed residents create solutions themselves



# Case: Environmental health in Nijmegen



Nijmegen is located on the River Waal in the eastern part of the Netherlands, near the German border.

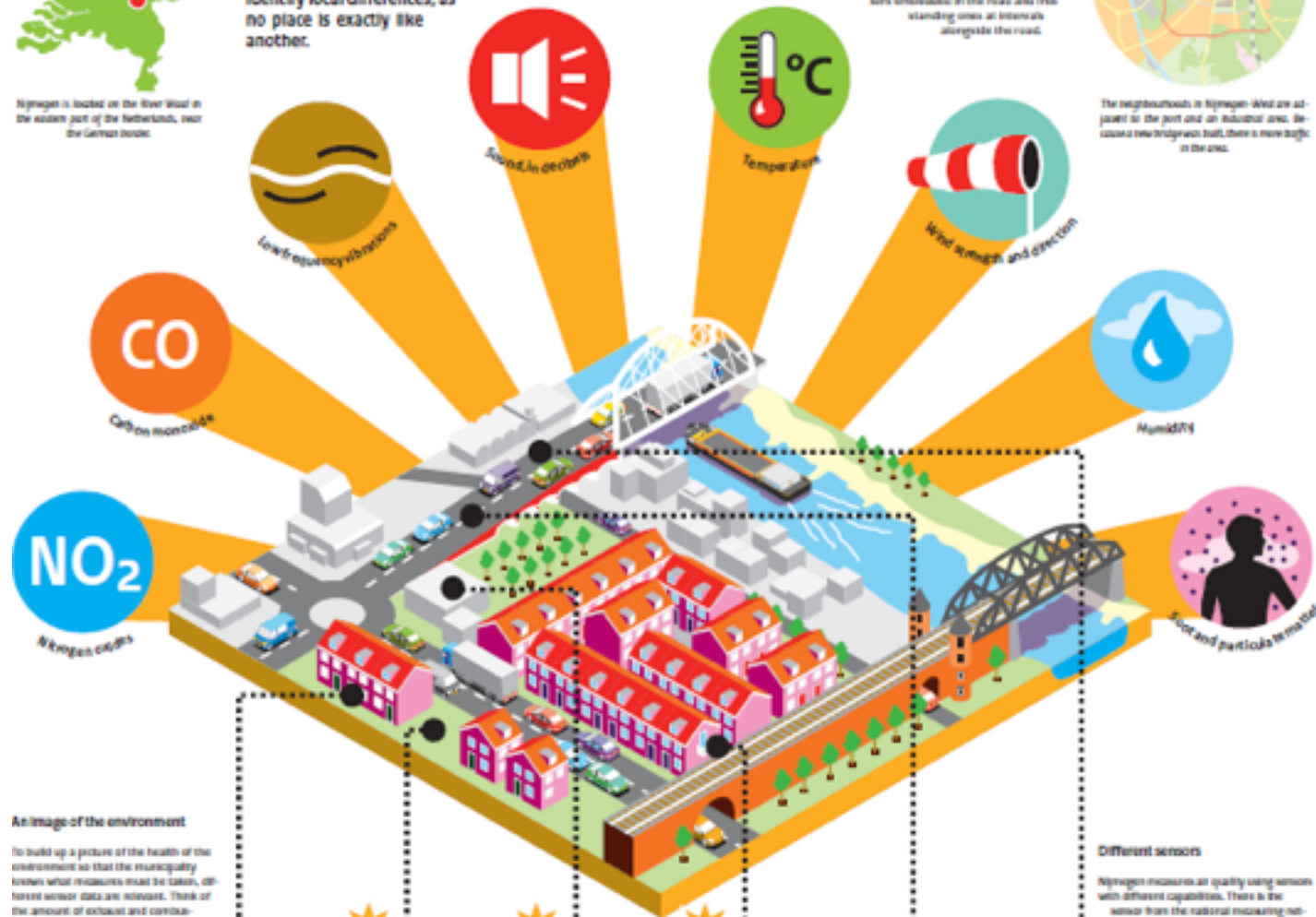
The environment is very important for people's health. That's why standards are set for the concentrations of pollutants. Sensors measure whether we keep within these standards using national monitoring networks. In addition, several municipalities and regions have their own sensors to identify local differences, as no place is exactly like another.

Nijmegen also monitors local environmental quality. With the advent of a new bridge and the construction of a ring road, the traffic situation in the western part of Nijmegen has changed. Developments in the port and the industrial area by the River Waal have been made, and residents in the nearby neighbourhood are worried about the health of their environment. The municipality is taking their concerns seriously and has placed sensors in the neighbourhood to measure the air quality and noise level.

Nijmegen also wants to collect reports about bad odours. To monitor traffic flows, the municipality uses sensors embedded in the road and free-standing ones at intervals alongside the road.



The neighbourhoods in Nijmegen-West are adjacent to the port and an industrial area. Because a new bridge was built, there is more traffic in the area.



## An image of the environment

To build up a picture of the health of the environment so that the municipality knows what measures must be taken, different sensor data are relevant. Think of the amount of exhaust and combustion gases (NO<sub>x</sub> and CO<sub>2</sub>), soot and particulate matter, but also the temperature, the force and direction of the wind and humidity. Sensors also measure noise, such as the number of decibels and low-frequency vibrations. To measure traffic flows, there are Bluetooth sensors and traffic loops.



## Different sensors

Nijmegen measures air quality using sensors with different capabilities. There is the sensor from the national monitoring network coordinated by the National Institute for Public Health and the Environment, there are seven specific particulate matter sensor units and, as part of a research project, the Radboud university has distributed a 'swarm' of thirty simple sensors among residents. One of the questions posed by this research is

# Issues and questions to deal with

## 1. Deployment of a local air quality network using low-cost sensors

- What is the quality of low-cost sensors in general?
- Which type of low cost sensors to deploy?
- ***How to calibrate the low-cost sensors?***
- How many and at what locations (spatial pattern) to deploy the sensors?
- ***What data platform for data collection and distribution?***
- ***Which standards for data acquisition and distribution?***
- ***Which (interpolation) models for further processing air quality data?***
- ***How to visualize the results?***

## 2. Involvement of citizens in the deployment and maintenance of the sensor network

- Which method to use for citizen engagement?
- Do we need to train citizens to deploy and maintain the sensor?

## 3. Involvement of citizens in the analysis of the results of local air quality monitoring

- How to engage citizens?
- How to preprocess and visualize the data for citizens?
- How to interact with citizens?
- How and when to meetup with citizens?
- What applications will the citizens need?

## Which type of low cost sensors to deploy?

### Quality and price

National Air Quality  
stations



Aireas  
"Airbox"



Smart Emission  
"Jose"



"Smart Citizen Kit"



Number of sensors applied in a city



## Jose Multi-Purpose Sensor Station - Intemo

Geolocation



Temperature



Humidity



Sound pressure



Air pressure



Rainfall



Tilting (x-y-z)



# Open Data!

Radboud Universiteit



Data open available for citizens, researchers, students, government, companies, ...

Data available for download in tabular and (OGC) geospatial formats:

***WMS-Time***

***WFS***

***SOS***

***STA***





# Data Infrastructure The Big Picture



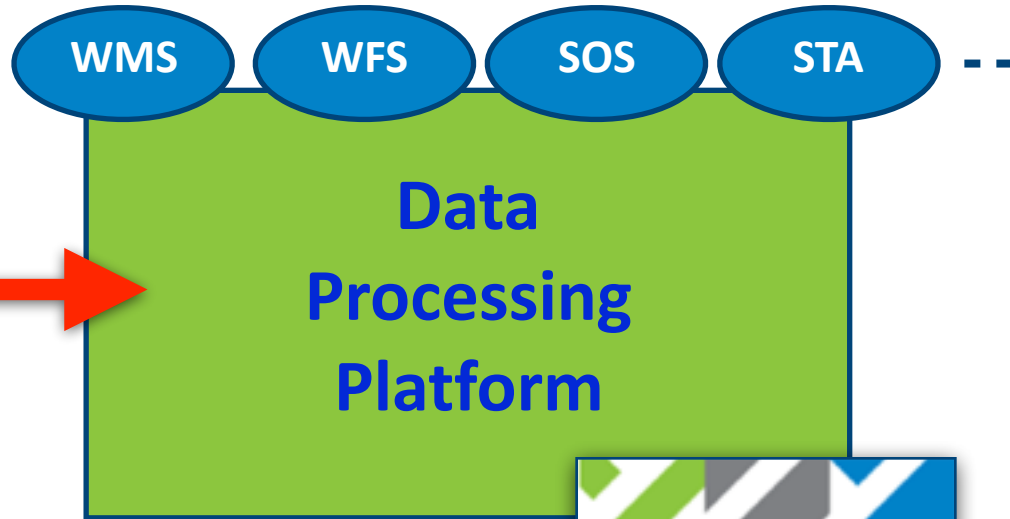
Client Apps

Logos: Q, luchtradar, GEONOVUM, IMAGEM



Data Collection Platform

CityGIS PUBLIC SAFETY logo

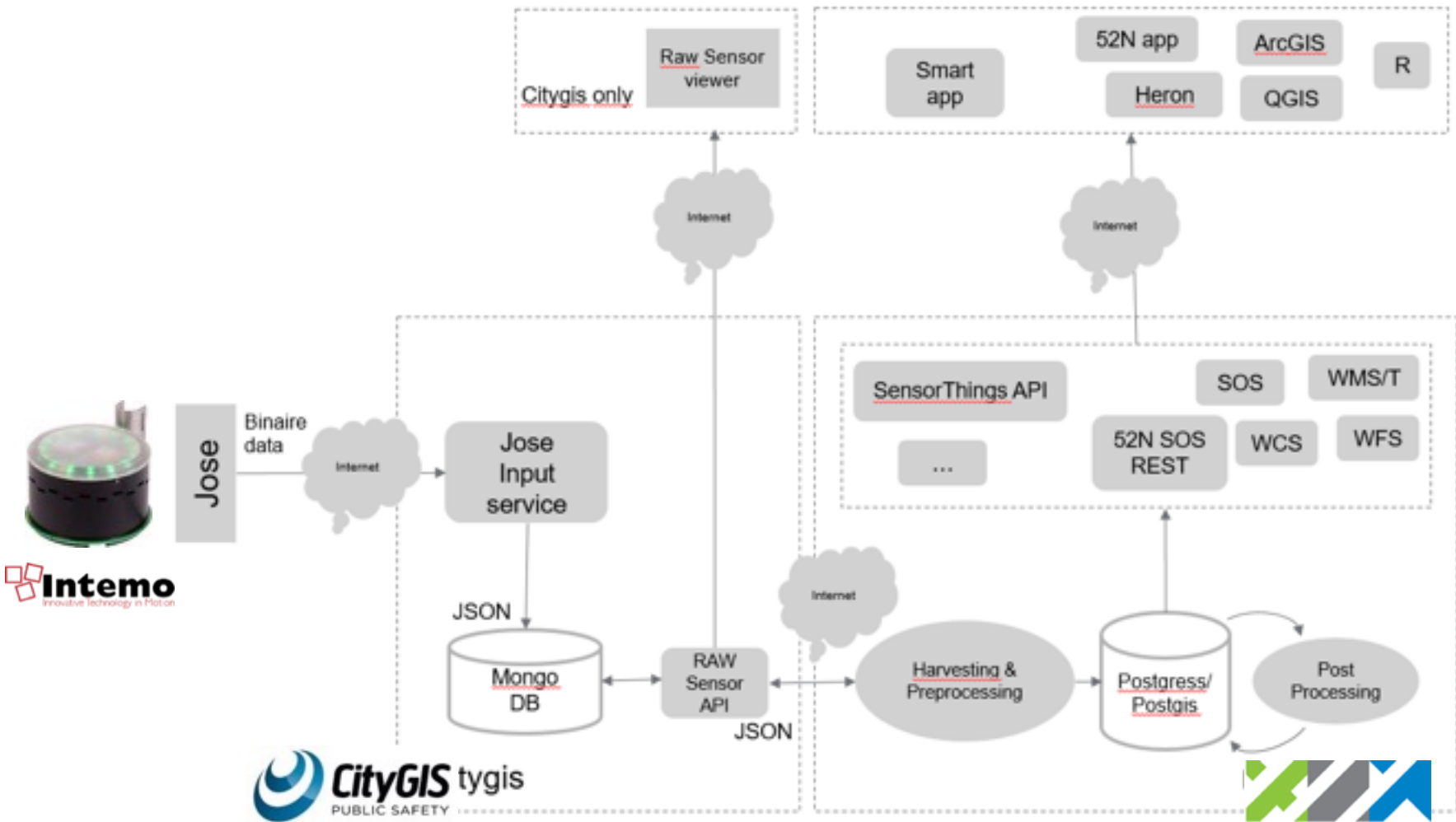


Data Processing Platform

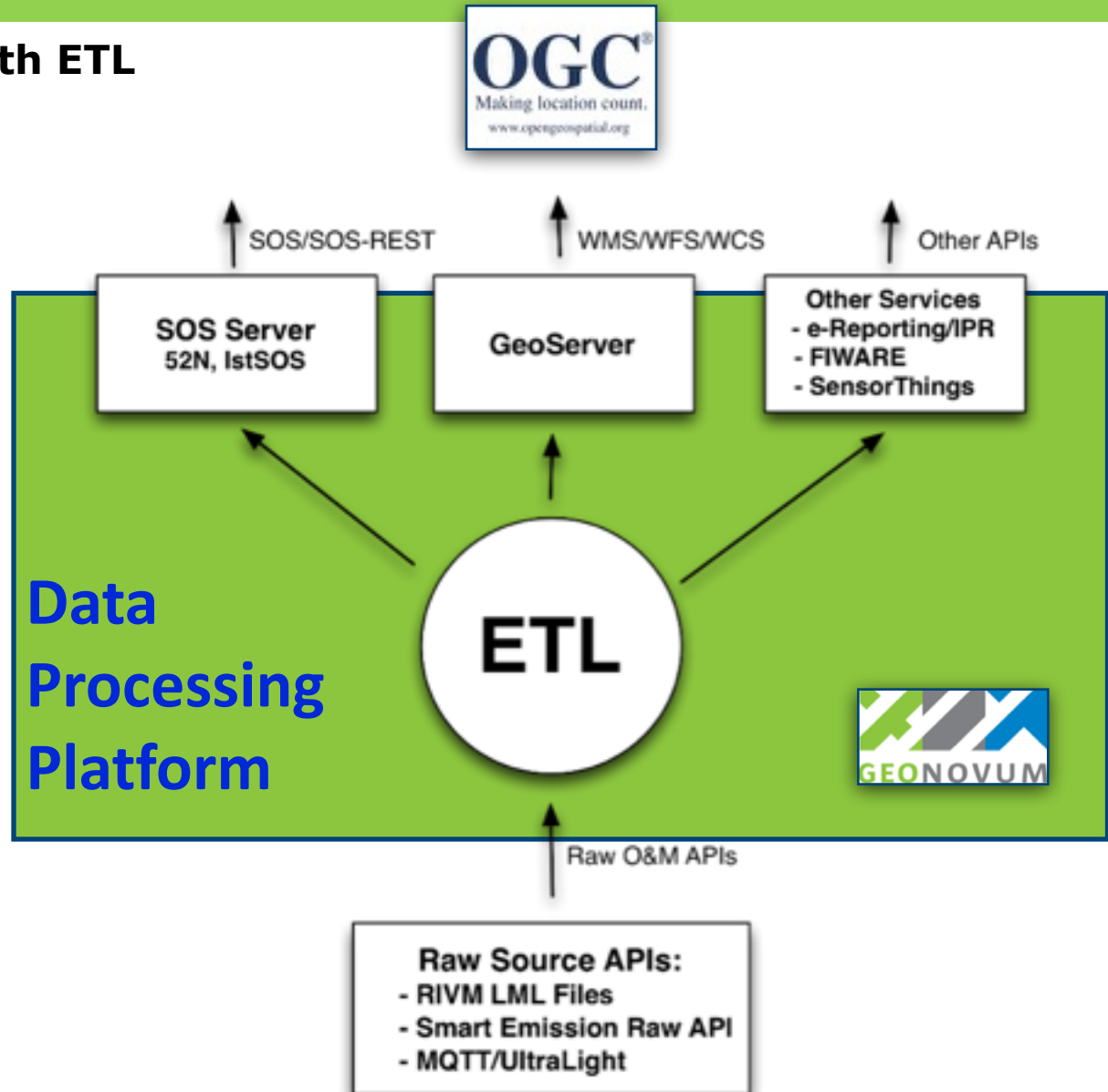
WMS, WFS, SOS, STA

GEONOVUM logo

# Data architecture: geospatial data infrastructure

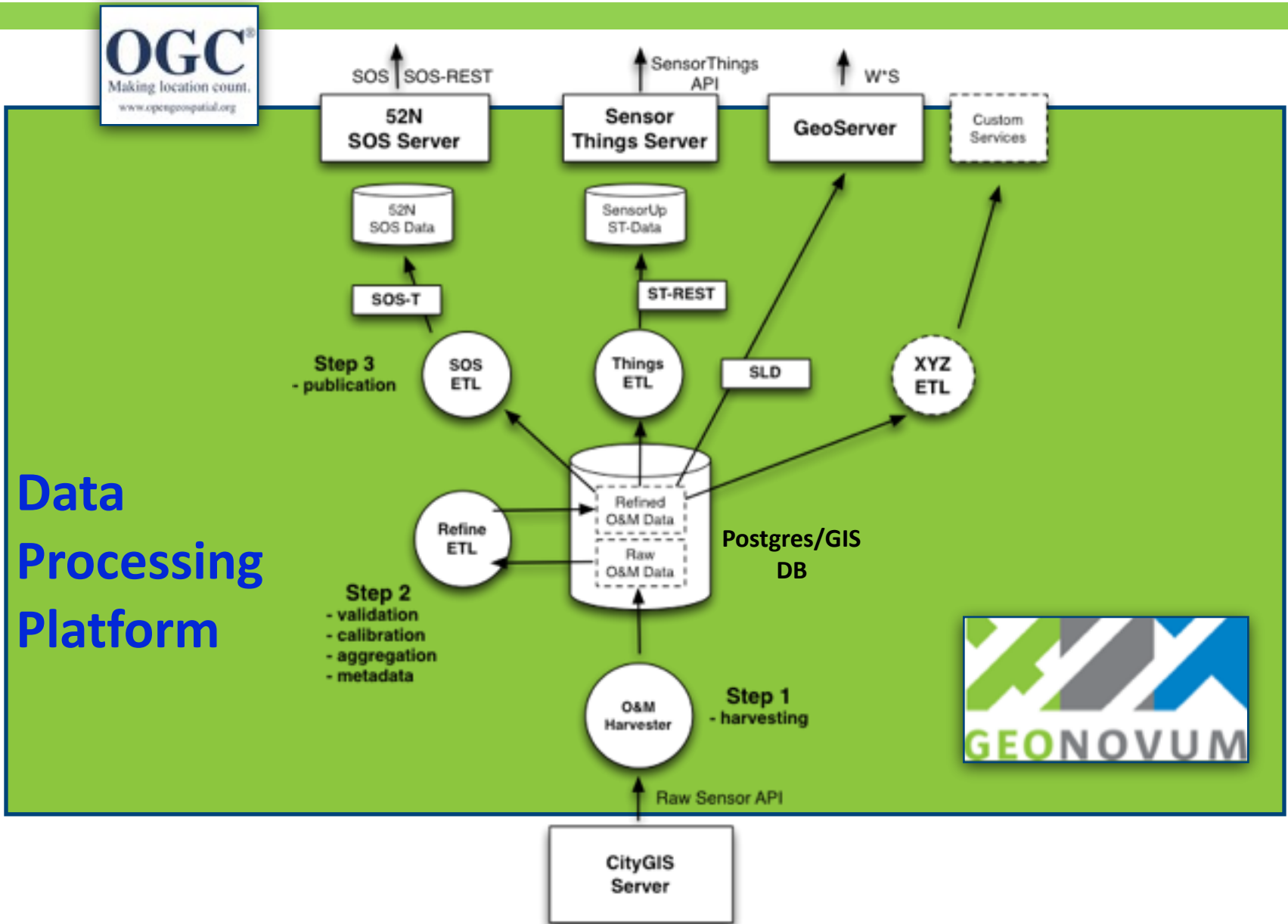


## Data Architecture with ETL



ETL =  
Extract Transform Load

# Data Architecture with 3-Step ETL



## How to calibrate the low-cost sensor for air quality?

Calibration at two national air quality locations by and in the City of Nijmegen and in laboratory setting at the National Institute of Environment and Health (RIVM)

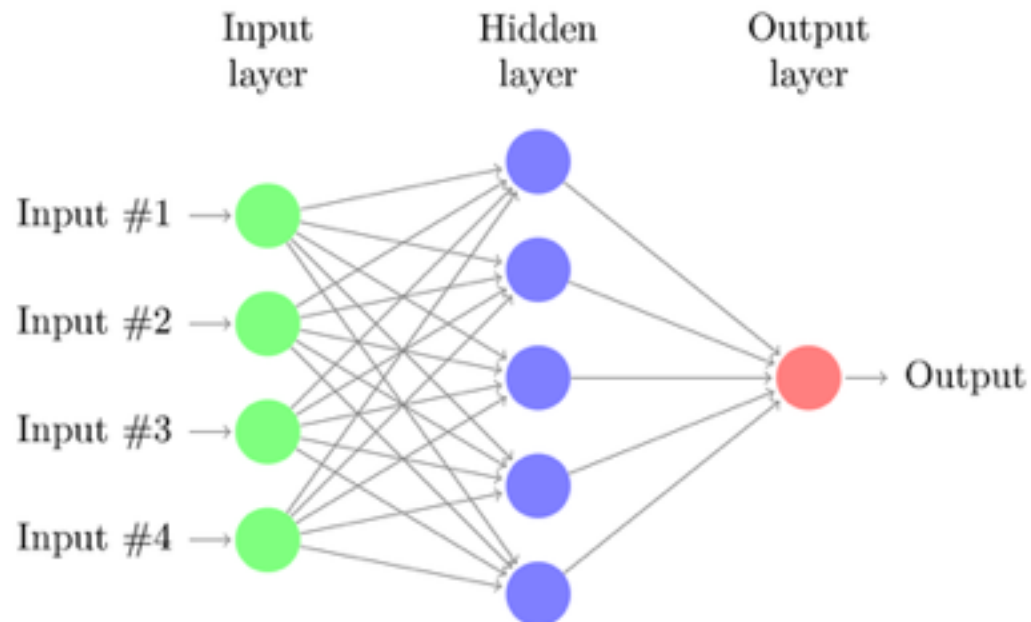


Rijksinstituut voor Volksgezondheid  
en Milieu  
Ministerie van Volksgezondheid,  
Welzijn en Sport



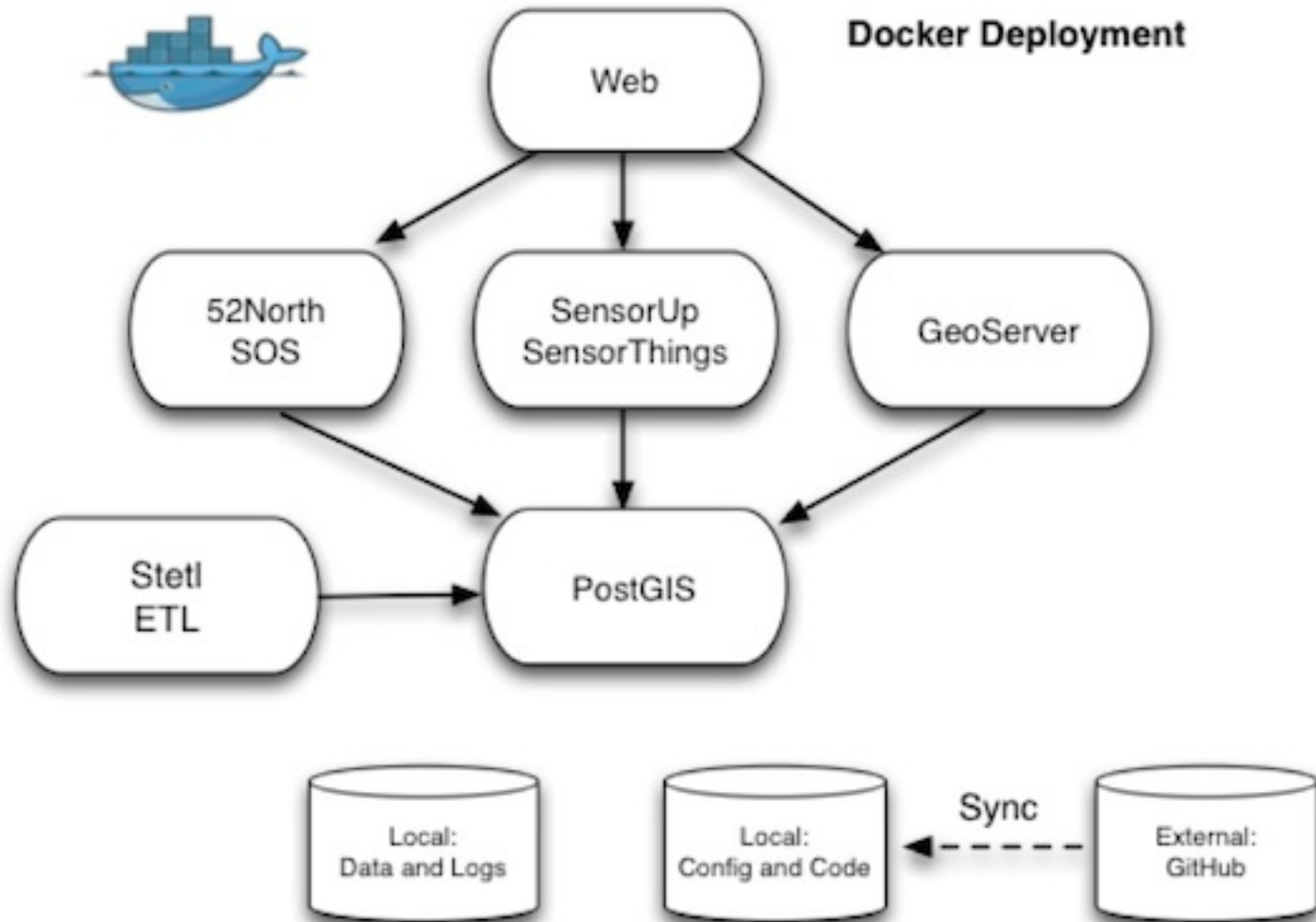
## ETL Implementation Details

- Python
- Stetl “Streaming ETL” - base ETL framework: <http://stetl.org>
- Docker deployment
- Crontab scheduling
- Open Source: <https://github.com/Geonovum/smartemission/tree/master/etl>
- Artificial Neural Networks (ANN) for Gas Calibration (by Pieter Marsman)
  - R (preprocessing)
  - sklearn <http://scikit-learn.org>

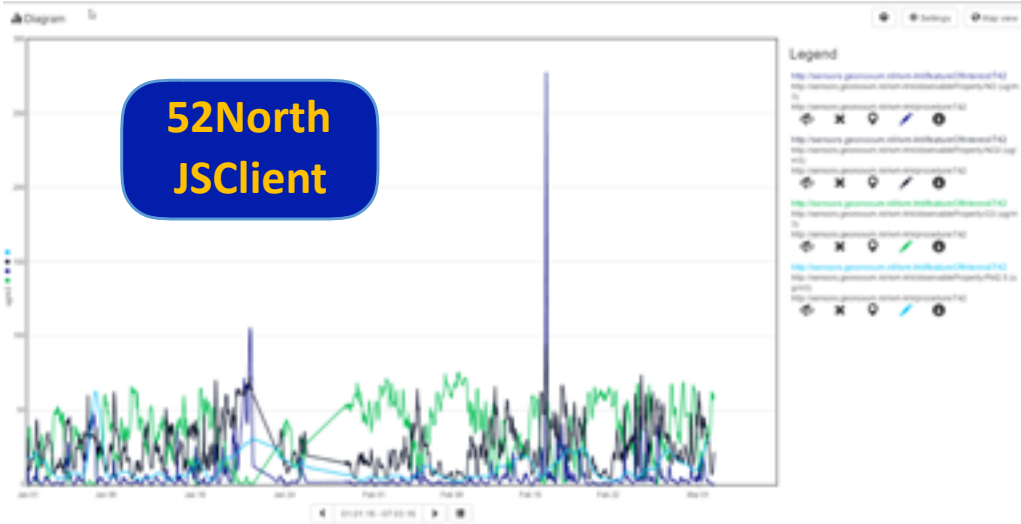
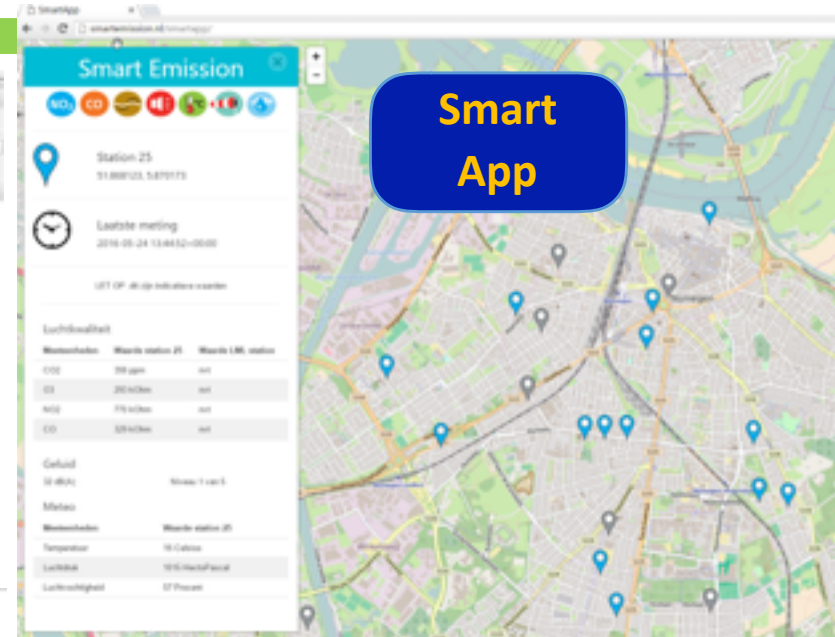
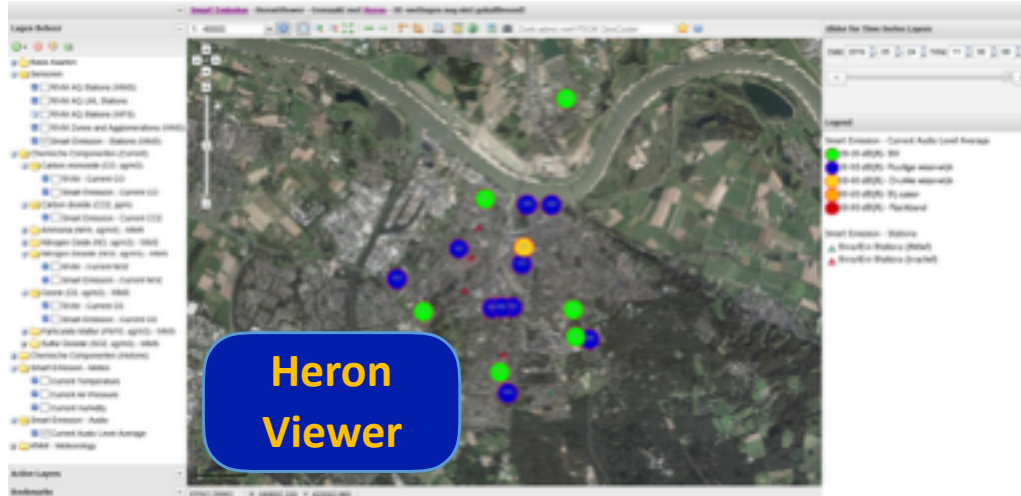




# Deployment with Docker



# Clients for data exploration and processing



<http://data.smartemission.nl> (data platform)

# JRC AirSenseEUR

## JRC TECHNICAL REPORT



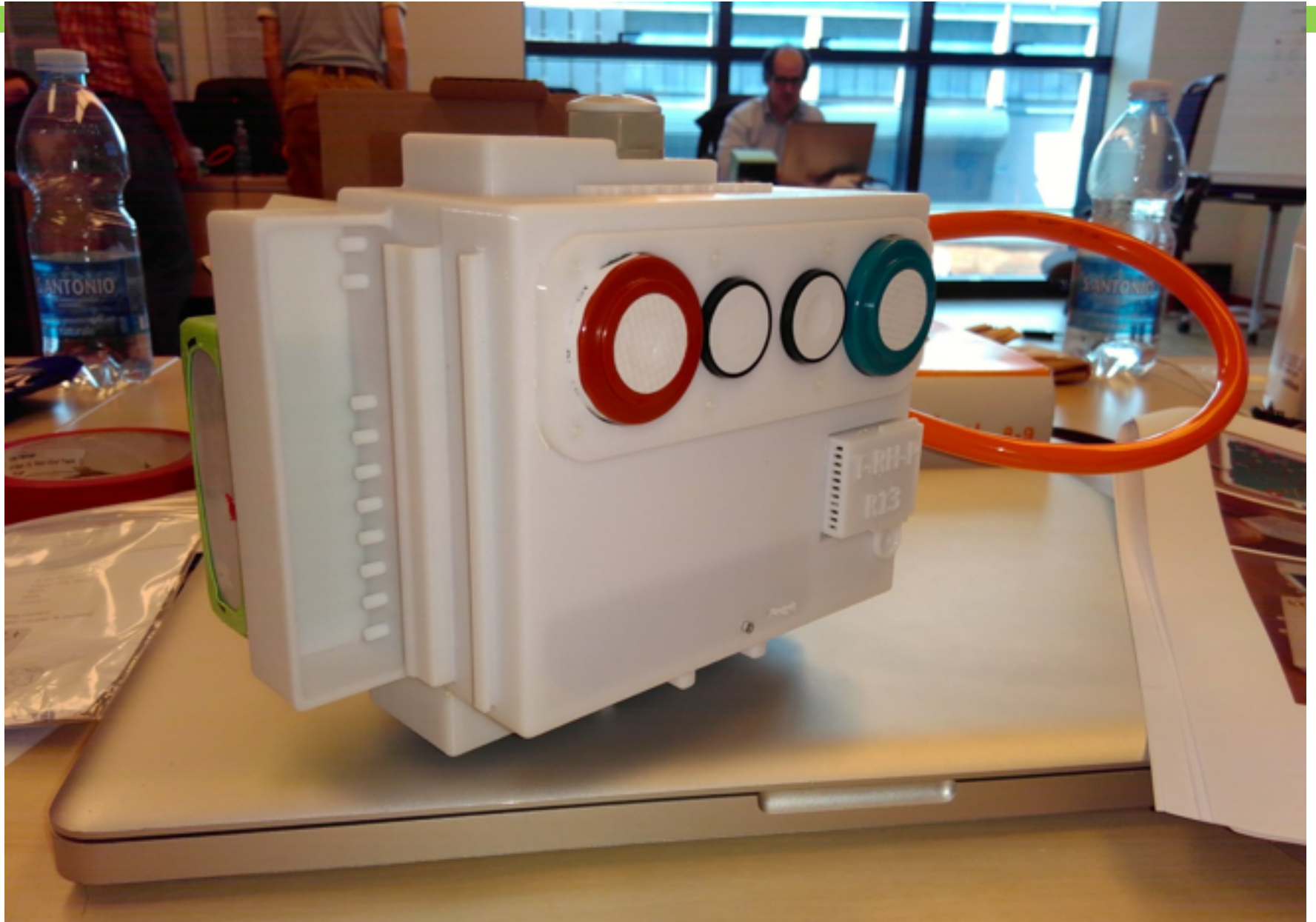
AirSensEUR: an open data/software  
hardware multi-sensor platform for air  
quality monitoring. Part A: sensor shield

Interlude:  
AirSensEUR  
Workshop  
JRC Ispra  
23-25 mei 2016

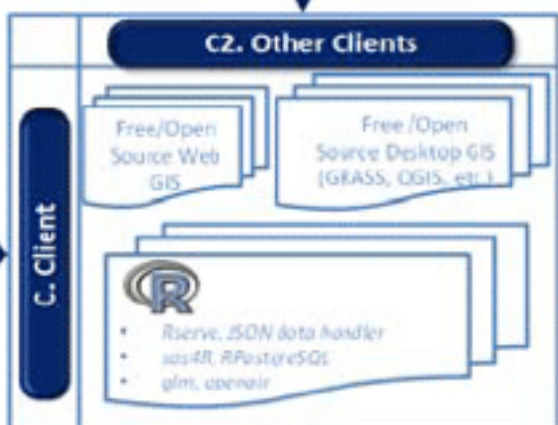
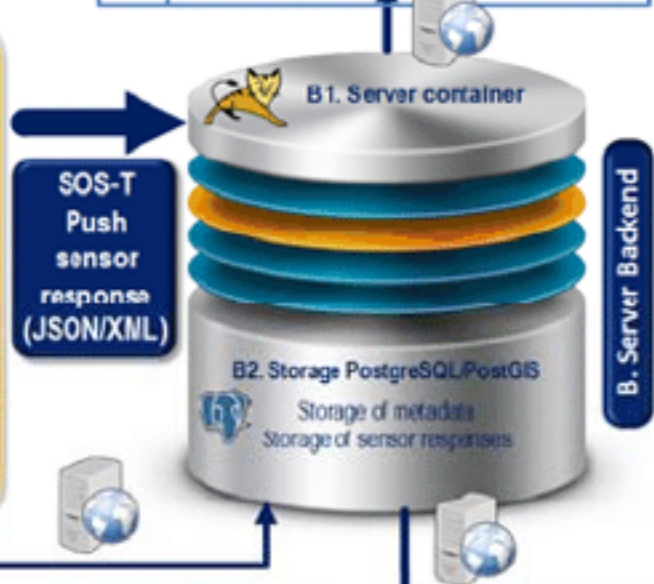
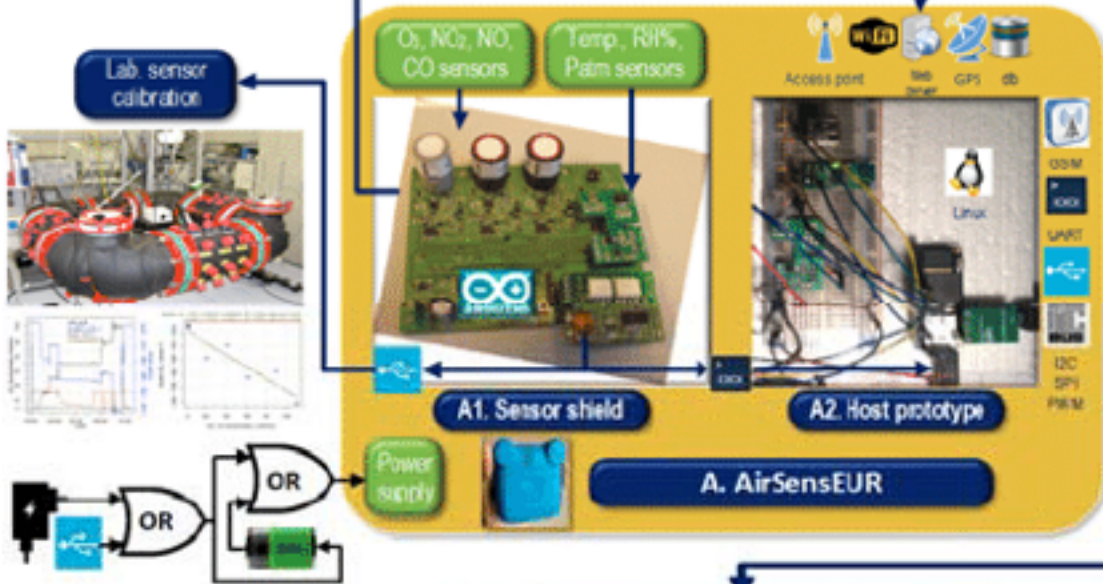
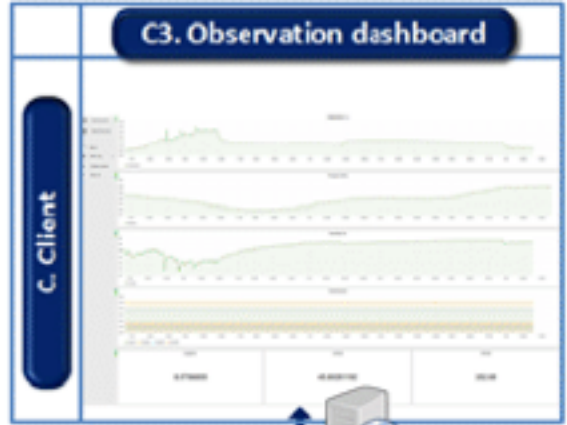
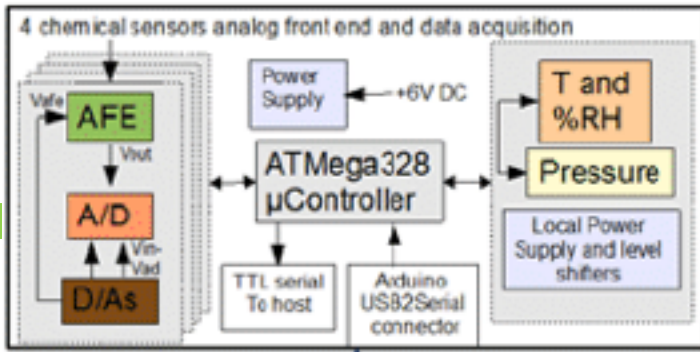
Michel Gerboles, Laurent Spinelle and Marco  
Signorini

2015

Report EUR 27469 EN











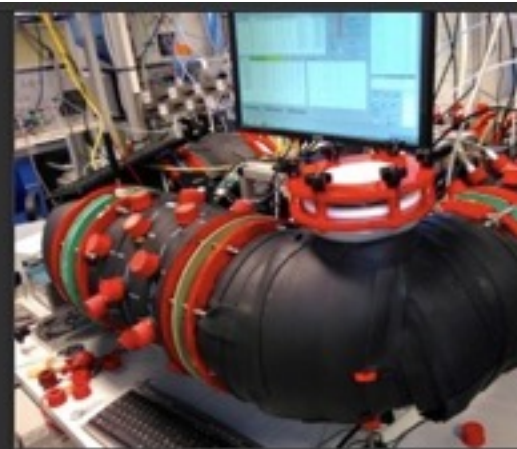
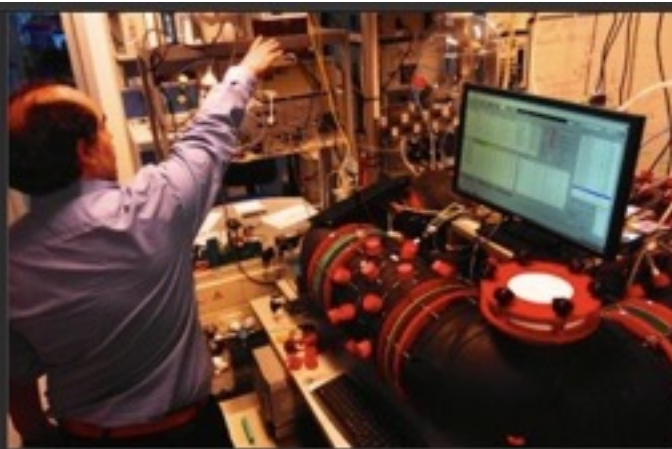
ChemSensorBoardImpl.cpp — Disk Browser 1 (Chem

```
emSensorBoard -  
AD5694R.cpp  
AD5694R.h  
ADC16S626.cpp  
ADC16S626.h  
ChemSensorBoard.ino  
ChemSensorBoardImpl...  
ChemSensorSampler.cpp  
ChemSensorSampler.h  
CommProtocol.cpp  
CommProtocol.h
```

```
46 SensorsArray* sensorBoard;  
47 CommProtocol* commProtocol;  
48 unsigned char hbTimer;  
49  
50 void timerInterrupt() {  
51  
52     if (sensorBoard) {  
53         sensorBoard->timeTick();  
54     }  
55     if (commProtocol) {  
56         commProtocol->timeTick();  
57     }
```







# OGC SensorThings API

# OGC SensorThings API Showcase Modern Standard

(REST) API-based: HTTP Verbs

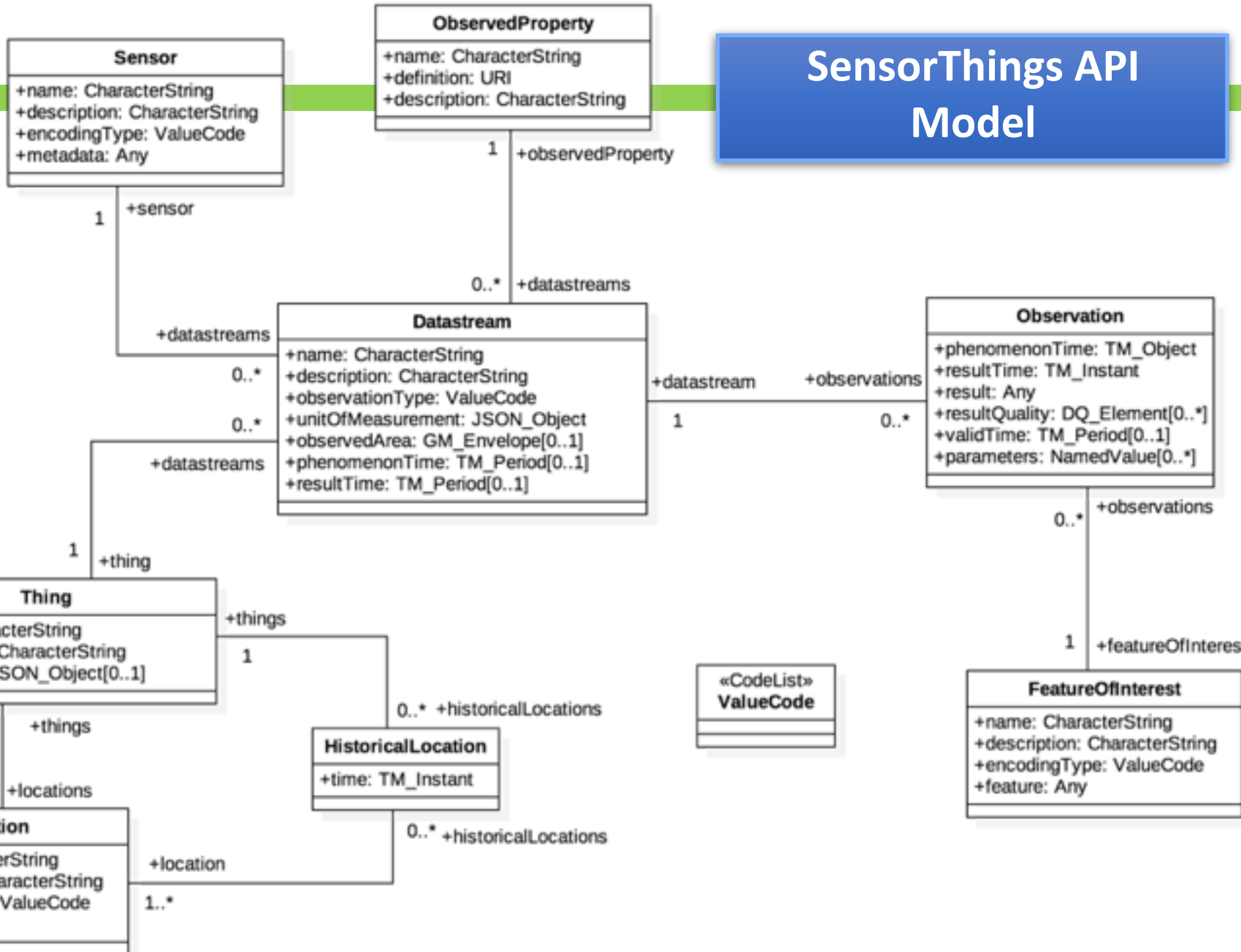
Data Model First Class Citizen

JSON Encoding

Public Versioning (GitHub)

API Implementation Examples

# SensorThings API Model



## Final Remarks

- The interest in low-cost sensor networks in cities is increasing. In the Netherlands several cities are more or less exploring local (air quality) monitoring with low-cost sensor networks.
- There are still several issues to be solved and research questions to be answered. There is need for multidisciplinary experts in these environmental sensing initiatives with strong citizen engagement.
- The geospatial data approach is an obvious start of a citizen-sensor-network for environmental monitoring for sustainable cities.



# Bevindingen

- Probeer online community te faciliteren
- Onderschat calibratie niet
- Ontsluit met meerdere standaarden: WMS-Time, WFS en SOS, STA (WCS)
- Faciliteer bulk download in meerdere formaten: GML, JSON, CSV, Excel etc
- Bulk download prima via WFS
- SOS verbleekt bij STA
- Docker maakt deployment eenvoudig

# Openstaand

- Hoe verder met Geonovum Data Platform?
- FIWARE
- Hoe verder met AirSenseEUR?
- LoRa (levering eind dec 2016): hoe in te zetten?
- WCS - Coverage - inzet RIO-model RIVM

Thank you for your attention!

More information:

Smart Emission

<http://smartemission.ruhosting.nl/> (website)

<http://data.smartemission.nl> (data platform)

<https://github.com/Geonovum/smartemission> (source code)

<http://smartplatform.readthedocs.io> (documentation)

Making Sense for Society

<http://www.geonovum.nl/onderwerpen/sensor-geo-informatie/algemeen-living-lab-internet-everything>

We would like to acknowledge for their valuable input:

All partners of the Smart Emission Consortium

## Contact



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*platform making sense for society*

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## With Smart Emission towards sustainable cities



Air Quality



Noise disturbance



Light pollution



Climate adaptation



Heat stress