

**“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. AirSensEUR

3. OGC SensorThings API (SensorUp, Steve Liang)

4. FIWARE

5. LoRa - TheThingsNetwork

Smart Emission

Just van den Broecke, Michel Grothe

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



Case: Environmental health in Nijmegen



Nijmegen is located on the River Waal in the western 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 capture reports about bad odours. To monitor traffic flows, the municipality uses sensors installed 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.



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



Sound pressure



Rainfall



Humidity



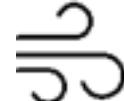
Air pressure



Tilting (x-y-z)



Light intensity, light color



Gasses (CO, CO₂, NO₂, O₃)

Open Data!

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

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

WMS-Time

WFS

SOS

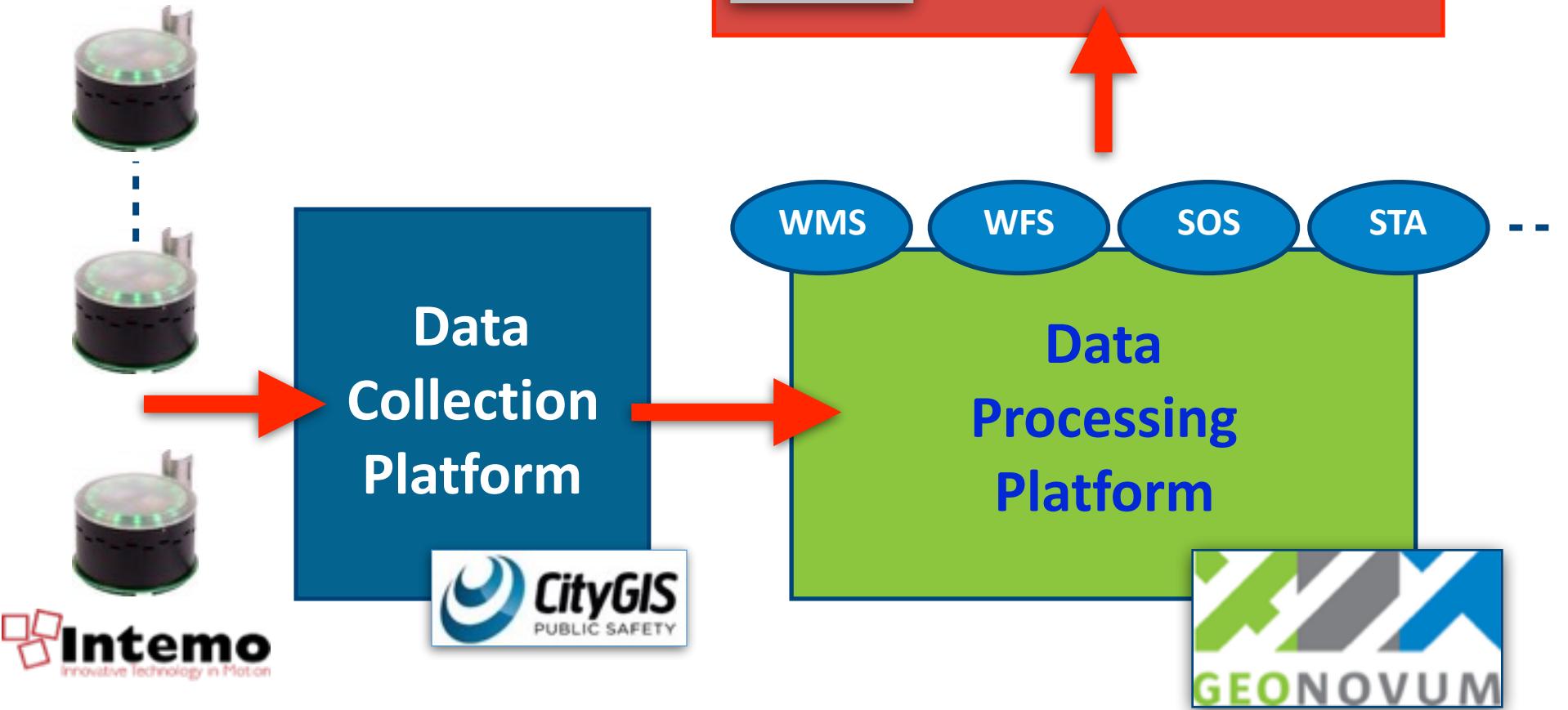
STA

Radboud Universiteit

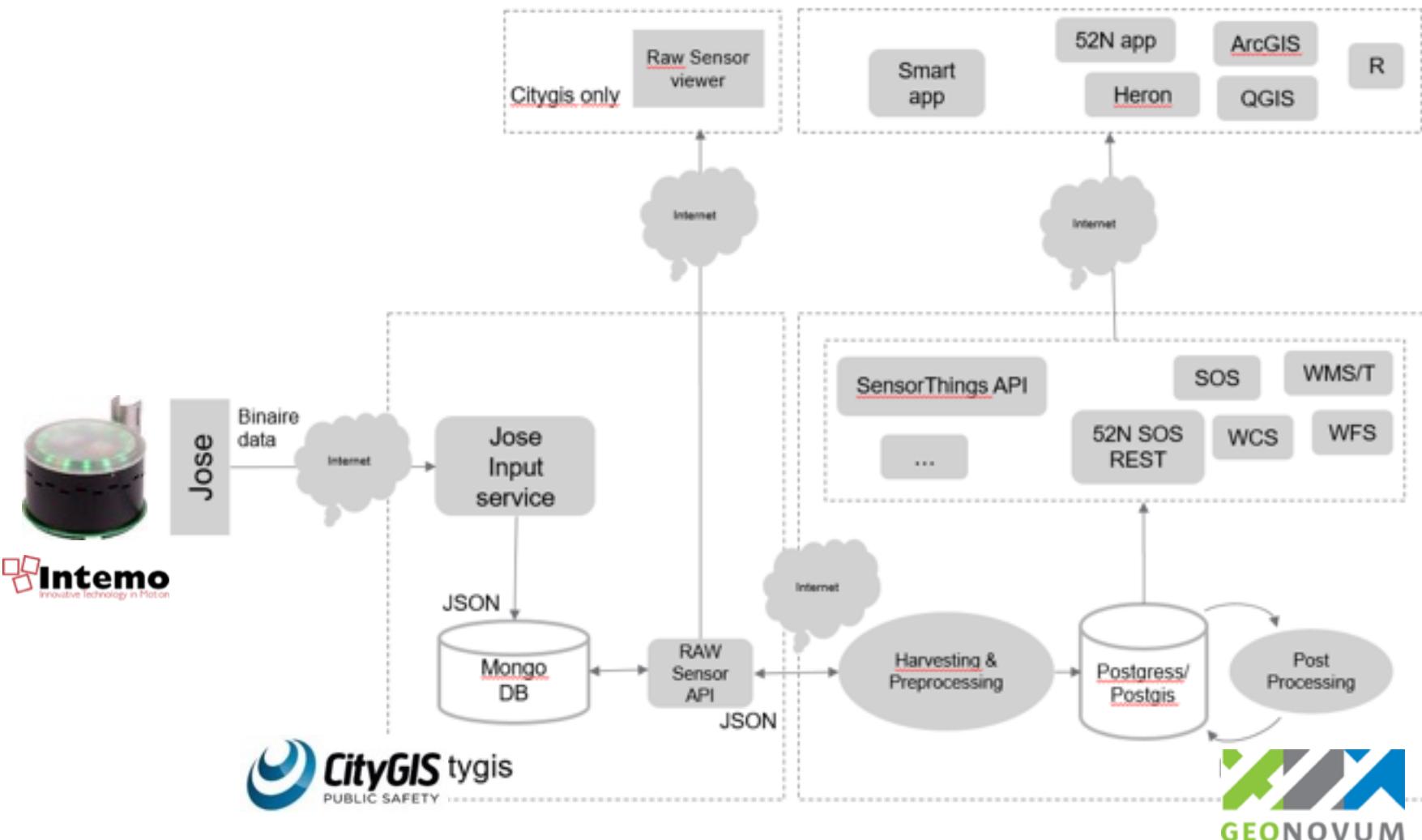


Data Infrastructure

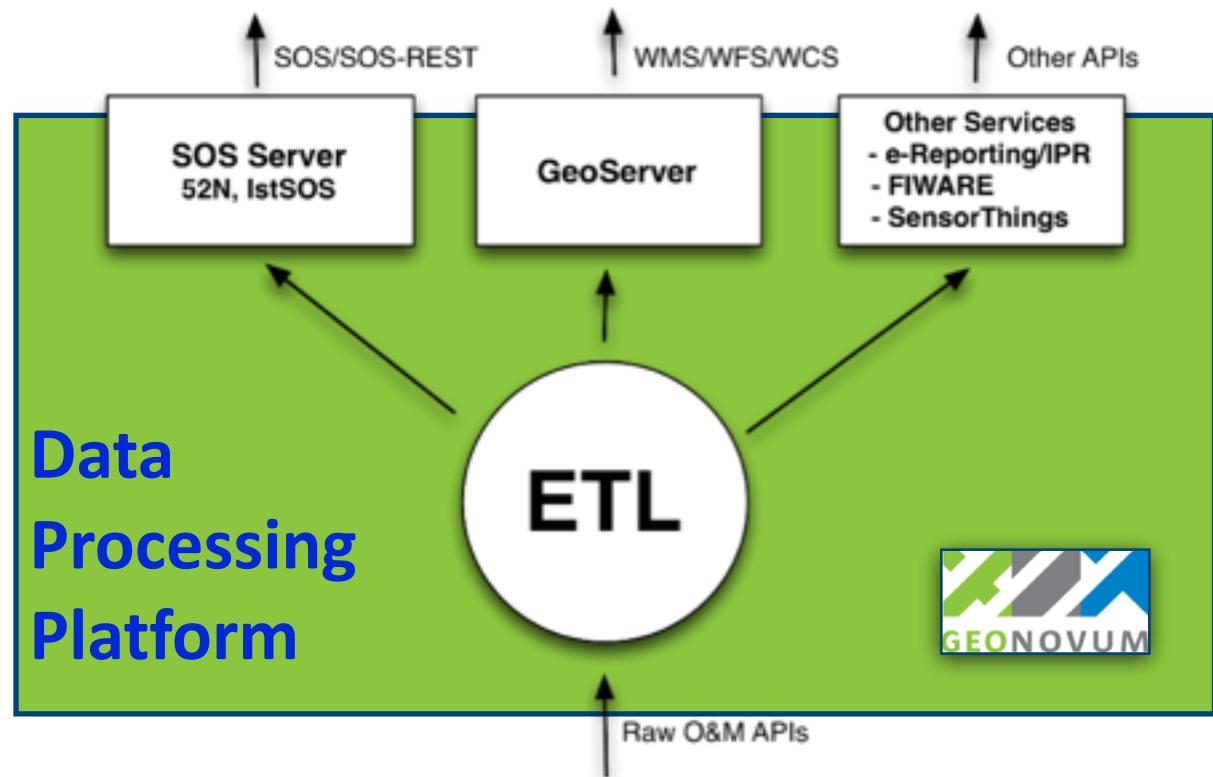
The Big Picture



Data architecture: geospatial data infrastructure



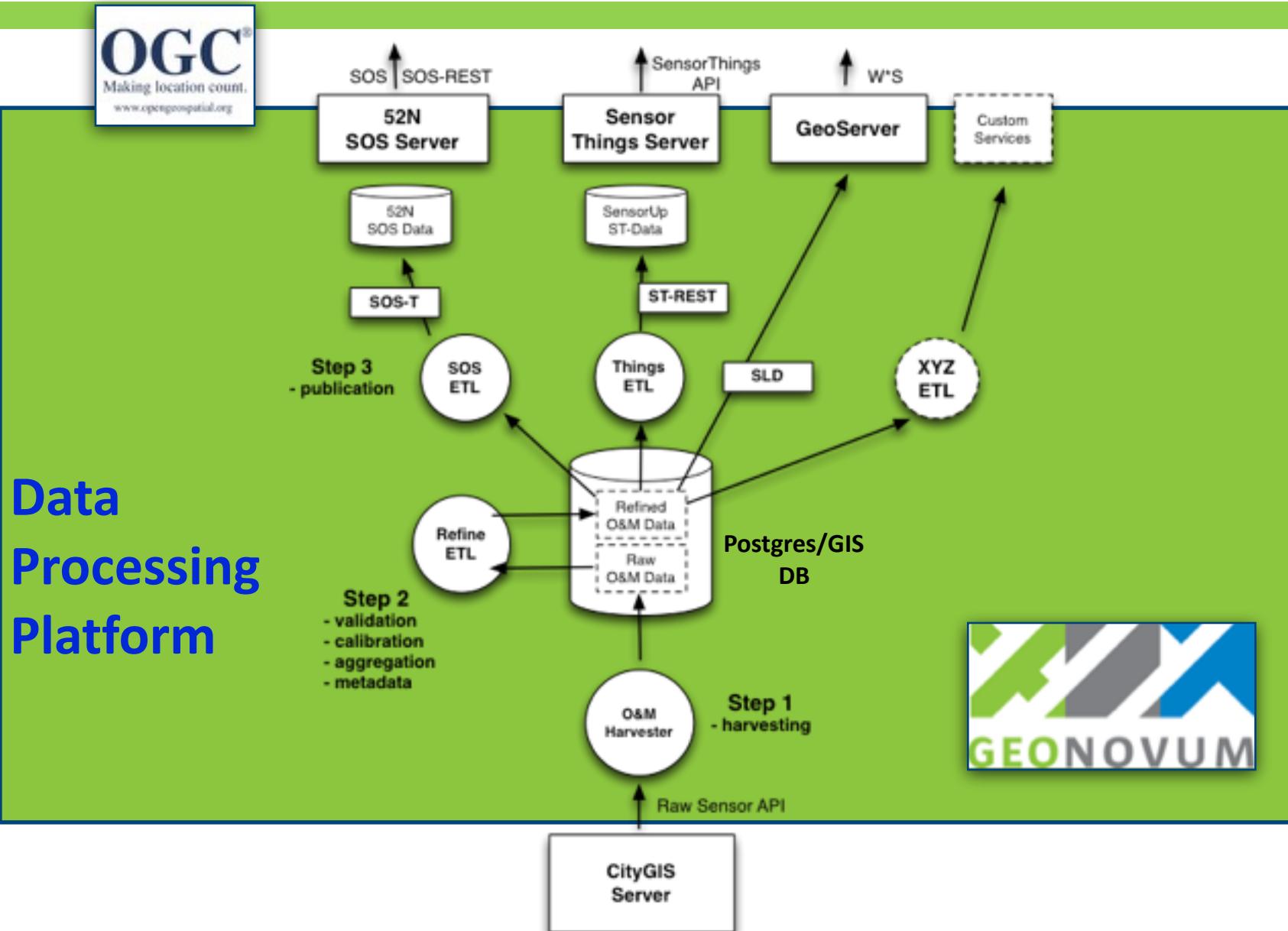
Data Architecture with ETL



ETL =
Extract Transform Load

- Raw Source APIs:
 - RIVM LML Files
 - Smart Emission Raw API
 - MQTT/UltraLight

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)

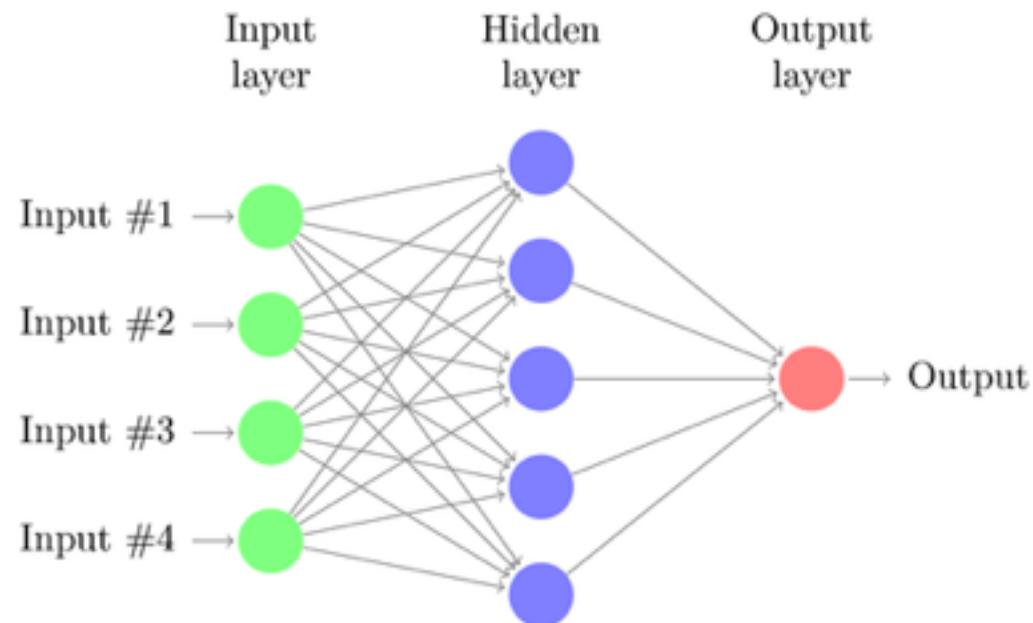


Rijksinstituut voor Volksgezondheid
en Milieu
Ministerie van Volksgezondheid,
Welzijn en Sport

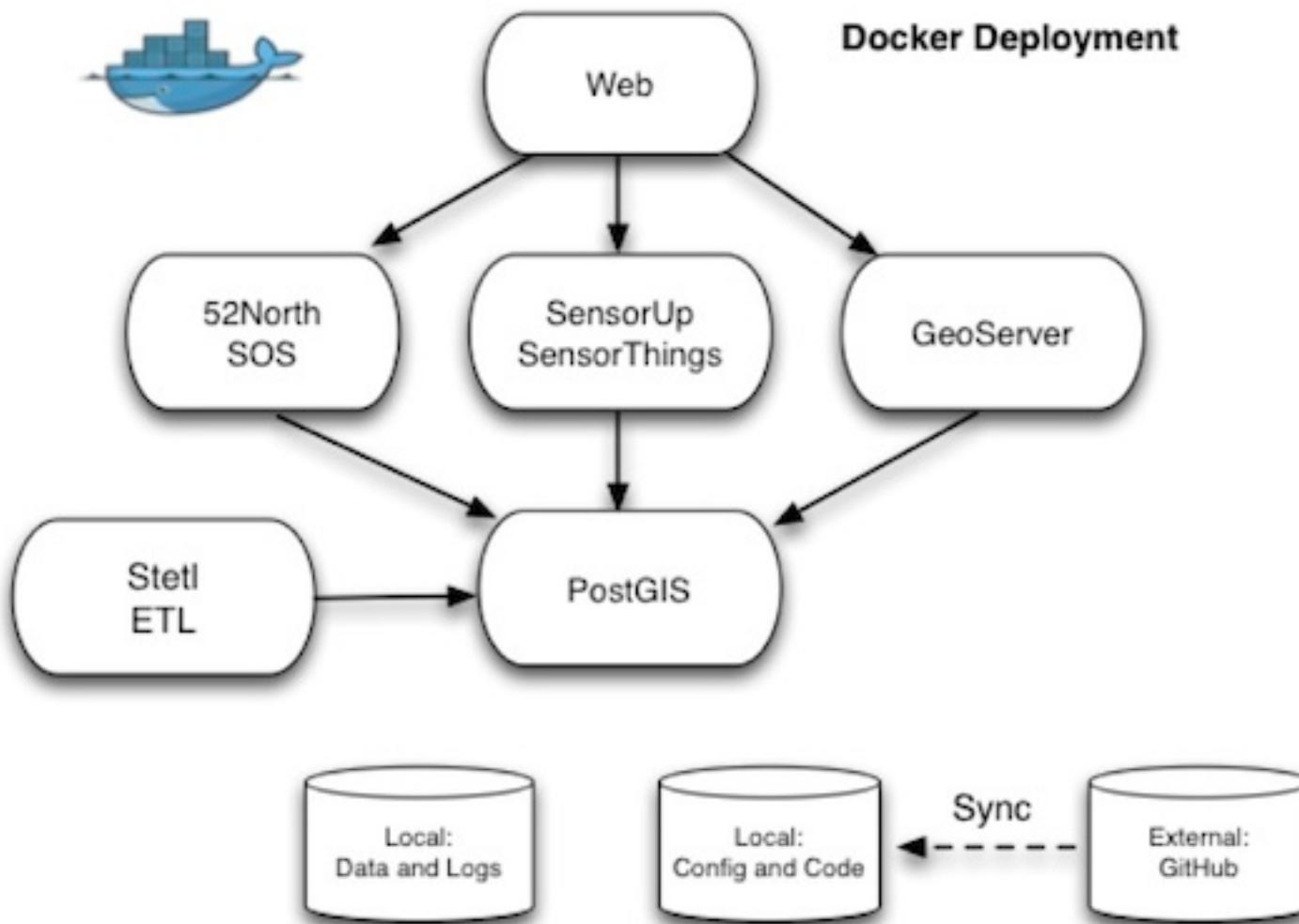


ETL Implementation Details

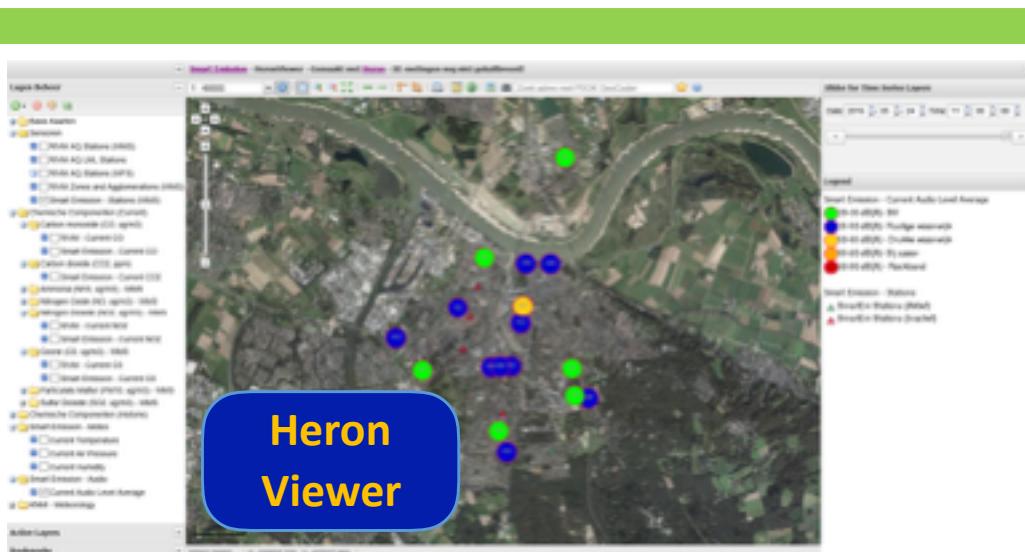
- Python
- Stetl “Streaming ETL” - base ETL framework: <http://stetl.org>
- Docker deployment
- Crontab scheduling
- Open Source: <https://github.com/Geonovum/smartermission/tree/master/etl>
- Artificial Neural Networks (ANN) for Gas Calibration (by Pieter Marsman)
 - R (preprocessing)
 - sklearn <http://scikit-learn.org>



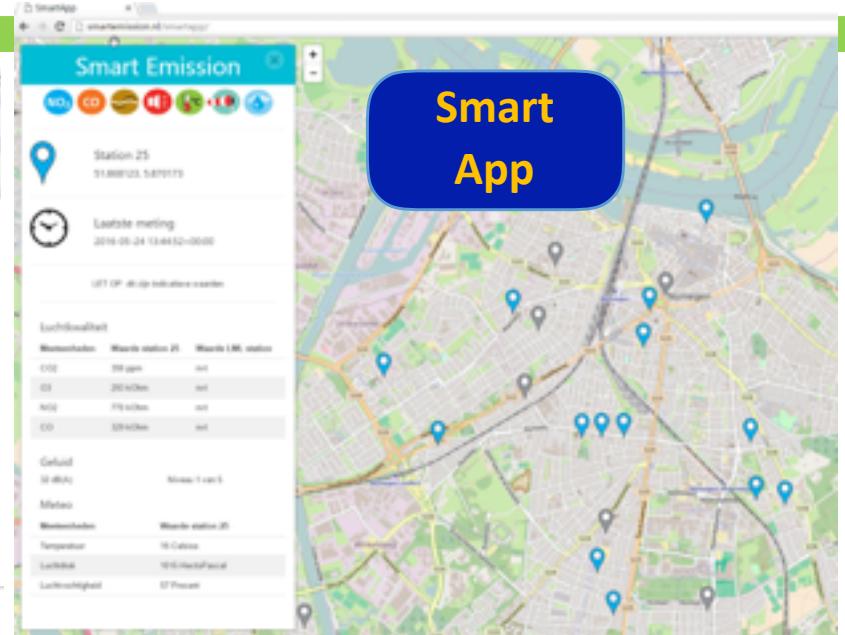
Deployment with Docker



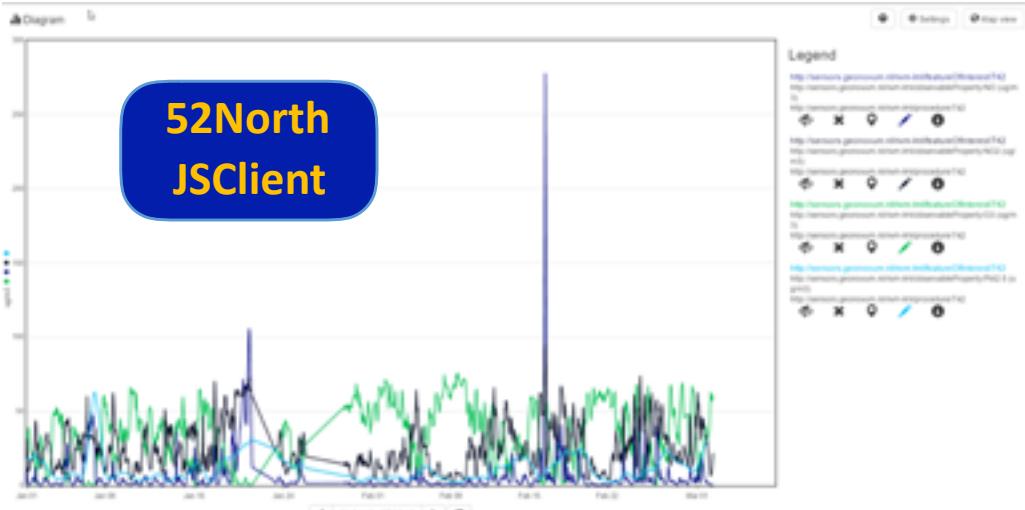
Clients for data exploration and processing



Heron
Viewer



Smart
App



52North
JSClient



ESRI

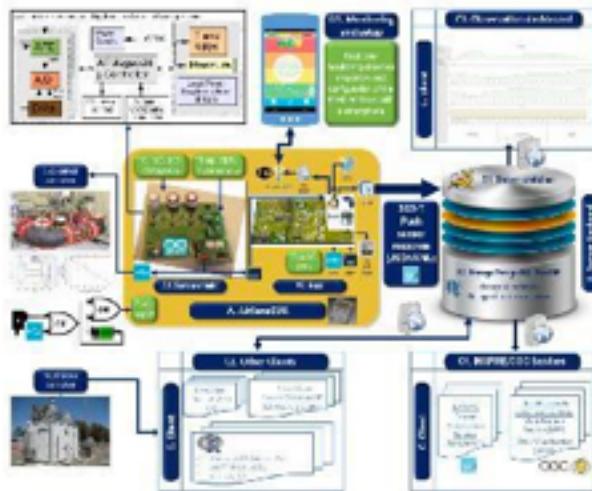


<http://data.smartemission.nl> (data platform)



JRC AirSensEUR

JRC TECHNICAL REPORT



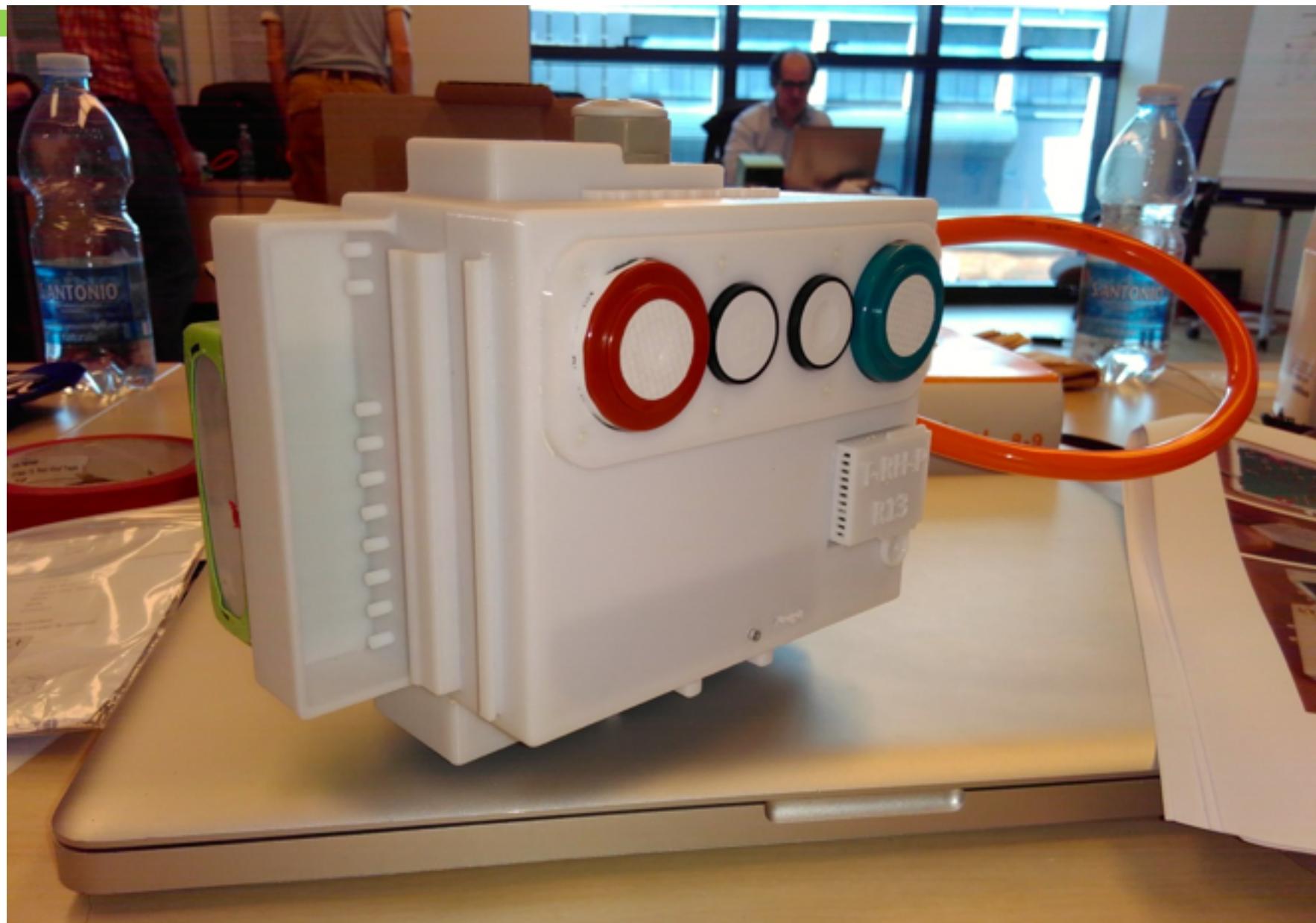
**Interlude:
AirSensEUR
Workshop
JRC Ispra
23-25 mei 2016**

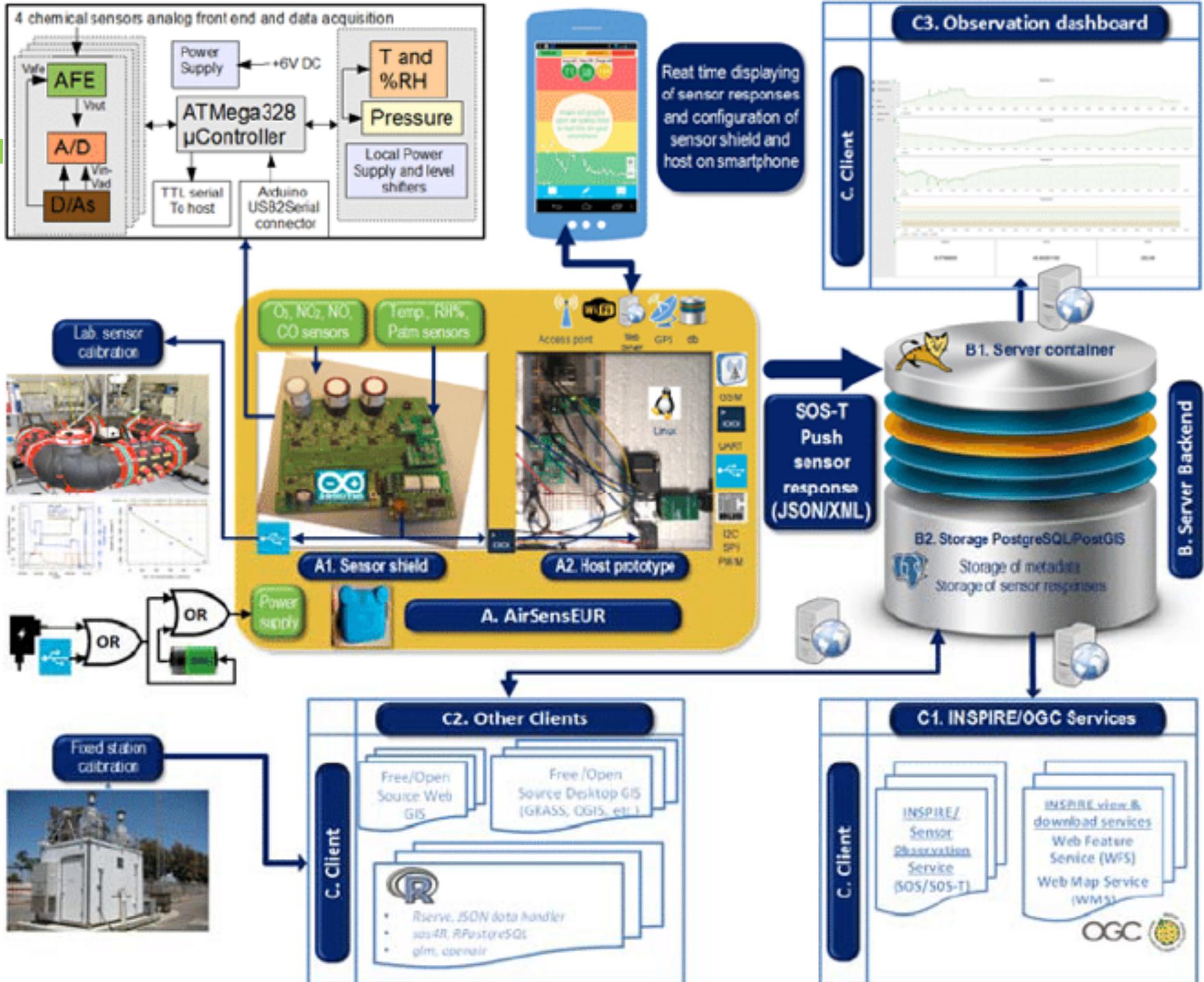
AirSensEUR: an open data /software /hardware multi-sensor platform for air quality monitoring. Part A: sensor shield

Michel Gerboles, Laurent Spinelle and Marco Signorini

2015

Report EUR 27469 EN







ChemSensorBoardImpl.cpp — Disk Browser 1 (ChemSensorBoard)

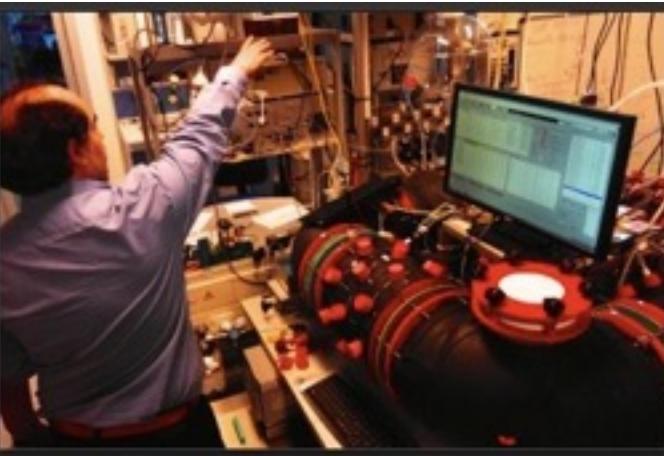
```
File Path : ~/project/sensors/airsenseur/app/Fir  
emSensorBoard.h  
ADS694R.cpp  
ADS694R.h  
ADC16S626.cpp  
ADC16S626.h  
ChemSensorBoard.ino  
ChemSensorBoardImpl...  
ChemSensorSampler.cpp  
ChemSensorSampler.h  
CommProtocol.cpp  
CommProtocol.h
```

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

airsenseurtech

Vafe → AFE → Vout

A/D





OGC SensorThings API

OGC SensorThings API

Showcase Modern Standard

(REST) API-based: HTTP Verbs

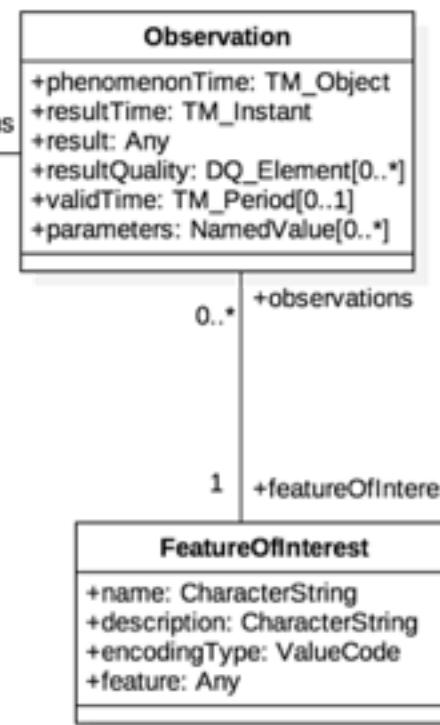
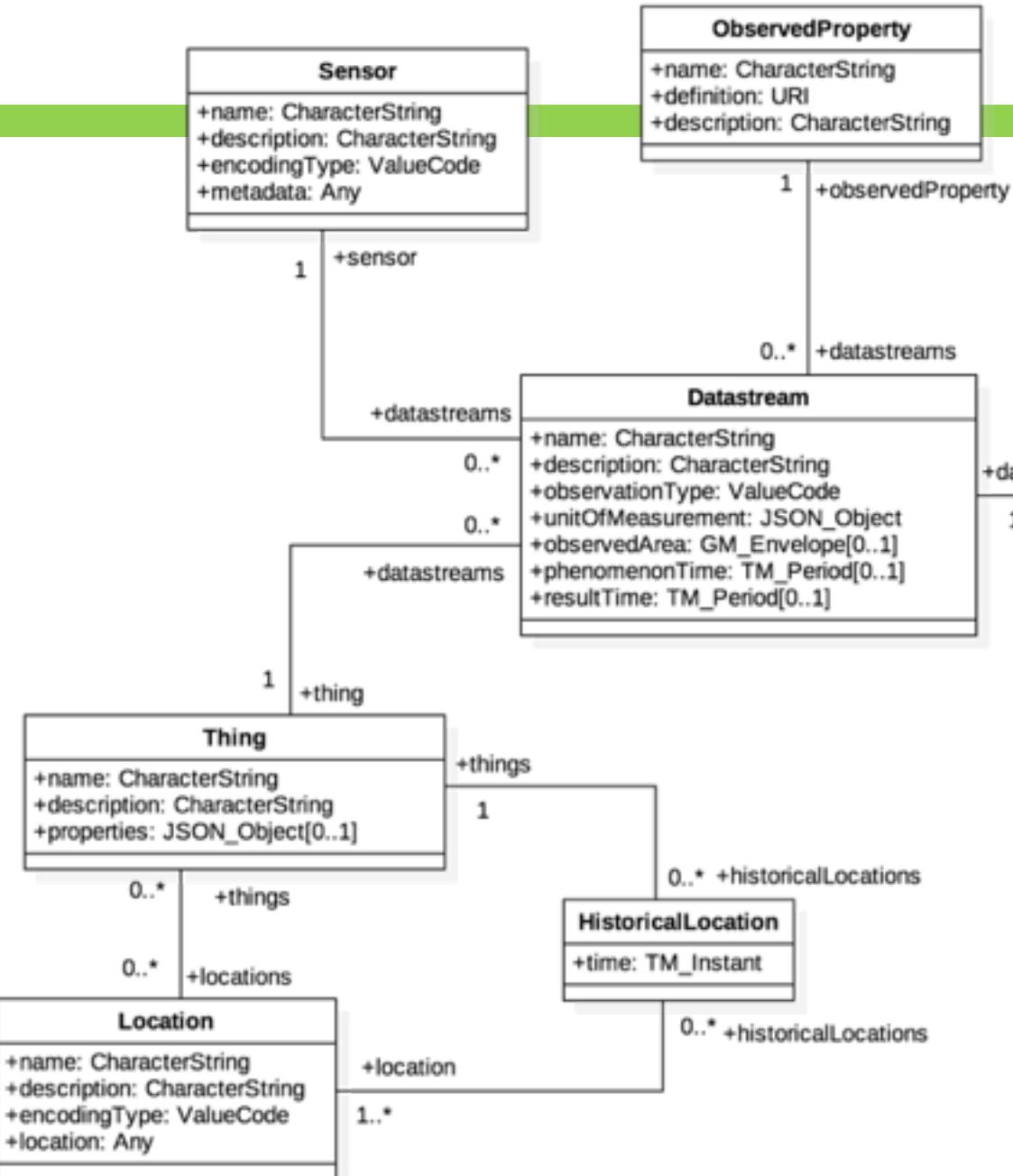
Data Model First Class Citizen

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)
- Facilities 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 AirSensEUR?
- 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

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Radboud Universiteit



GEMEENTE Nijmegen



GEONOVUM

Intemo
INNOVATIVE TECHNOLOGY IN MOTION

CityGIS
PUBLIC SAFETY

Rijksoverheid voor Volksgezondheid en Milieu
Afdeling voor Volksgezondheid, Veiligheid en Sport

With Smart Emission towards sustainable cities



Air Quality



Noise disturbance



Light pollution



Climate adaptation



Heat stress