# RUBIX S&I Senses & Instrumentation

Waste . Industry . Composting . Water . Rendering

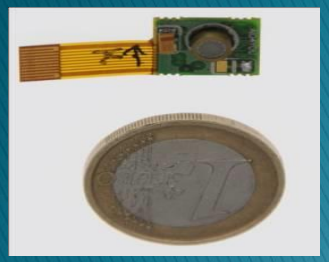
## Nouvelle Génération de Barrettes de capteurs virtuels miniaturisés en réseau pour smartphone et Big Data pour analyse

*(gaz, odeurs, lumière, bruit, allergènes, vibration, particules ..)*

dans l'environnement extérieur

*Des exemples de corrélation entre mesures analytiques et sensorielles*.

Fimeale Capteurs du 9 novembre 2017



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# RUBIX S&I

COMMENT UTILISER LA PUISSANCE DE LA COMBINAISON DE BARRETTES DE CAPTEURS ET DES SMART PHONE POUR CARTOGRAPHIER ET SUIVRE LA QUALITE DE L'AIR EXTERIEUR DANS DES VILLES.

AMENONS L'ANALYSE et L'INTELLIGENCE LA OU SE TROUVE L'ECHANTILLON

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# RUBIX S&I

Mapping of a nordic ( Danemark) city using an arrays of stand alone gas sensors and Virtual Sensors Arrays Systems mounted on smart phone aiming at measuring gas and odors on line indoor and outdoor

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# *What is RUBIX S&I Fields of Expertise ?*

1> Development , manufacturing and sales of sensing modules for indoor and outdoor, Air VOC, Odor and in general chemicals and physical nuisances on line analysis ( gas, odor, noise, light, radiations, RH, T°, vibration …)

2> Development of customized sensing modules with various gas or physical sensors with holistic data processing for industrial use ( smoldering fires, household appliances, Indoor air of cars & plane, oils & gas, cosmetics and personal care, Intelligent houses ..) including various form factors and reference design aiming at the mobile phone and wearable industry.

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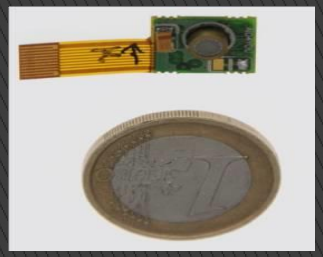
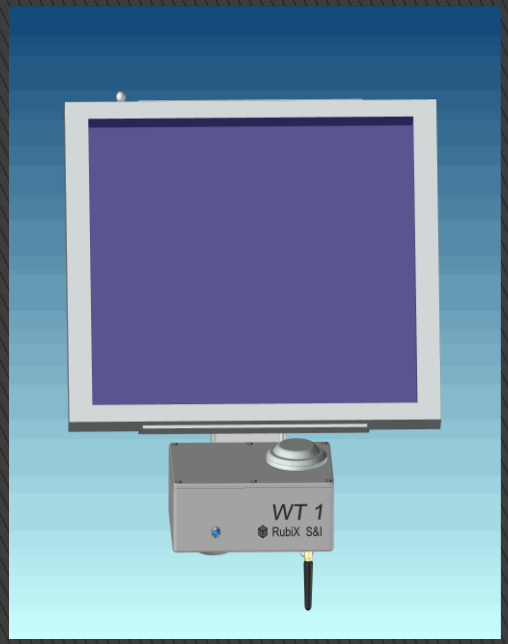
# TECHNOLOGIES & PRODUCTS :






## Outdoor

## Indoor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# *RUBIX POD*

With its RubiX POD, RubiX S&I enables companies to collect objective (measured by sensors) and subjective (according to people own perception) data.

- Temperature
- Moisture
- Light (intensity, color, flicker)
- Noise (40 to 20,000 Hz, measurement of perception by octave)


- Odors (Data banks of odors in the clouds, 4 sensors allowing sources identification)
- Indoor air quality (6 gas sensors sensitive to VOC, H2S, CO2, CO, FA and BTX)
- Particles (allergens, chemicals and biologicals)
- Vibrations, Pressure

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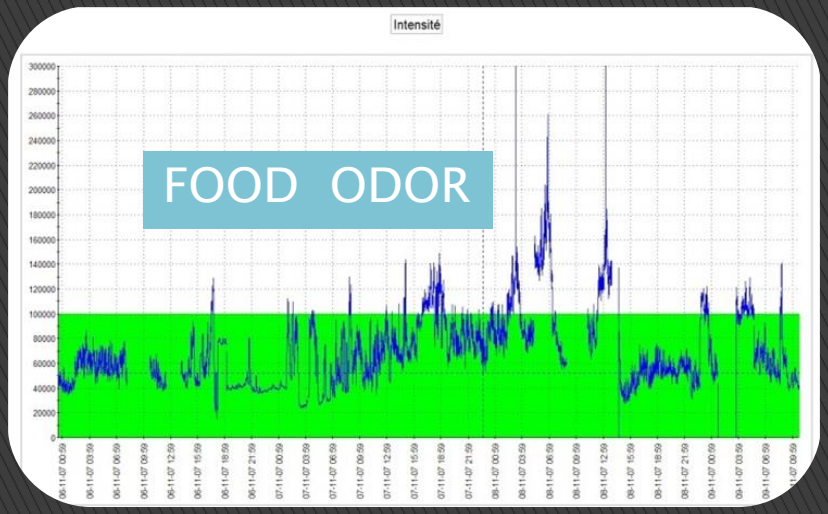
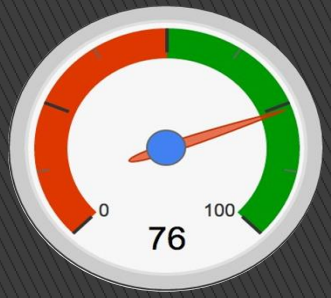
# *A unique management of alarms and comfort factors (objective data)*

## Control Panel and Comfort Meter




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 70-b3-d5-9b-a0-00-01-14 | 48 % | 21.61 °C | 47 dB | 267 lux | 0 ppm | 0 | 0 |
| 70-b3-d5-9b-a0-00-01-58 | 51 % | 21.62 °C | 46 dB | 312 lux | 0 ppm | 0 | 0 |

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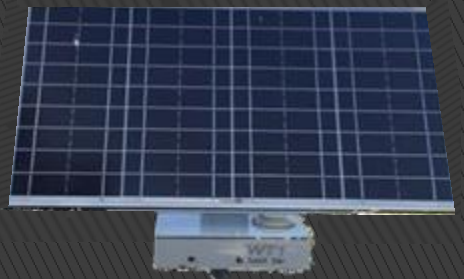
# E-Noses – WT1 – E-noses

## Continuous monitoring of olfactory nuisances and gas emissions

- WT1 E-nose
- Odor diagnosis complementary approach
- Continuous emission measurement
- Dynamic 3D odor mapping
- Real-time alert and sampling
- Control of odor treatment facilities

- Waste
- Industry
- Composting
- Water
- Rendering



Single or multi-site(s), local or remote monitoring

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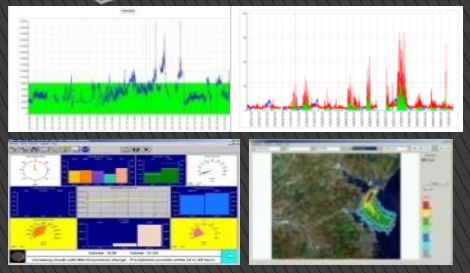
# WT1 – Cloud based Global architecture

Monitoring center

Field-installed measuring device

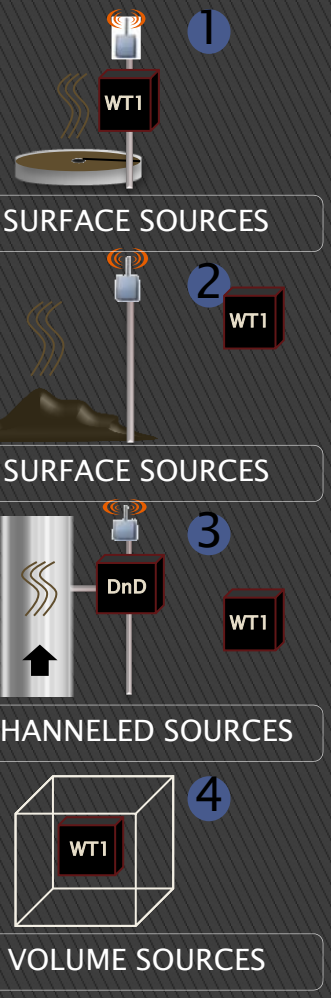
RUBIX SOFTWARE
DISPERSION
SOFTWARE
WEATHER SOFTWARE



LORA or
GPRS

WEATHER
STATION

WT1 – WT2
ANALYZER
SOURCES TO BE MONITORED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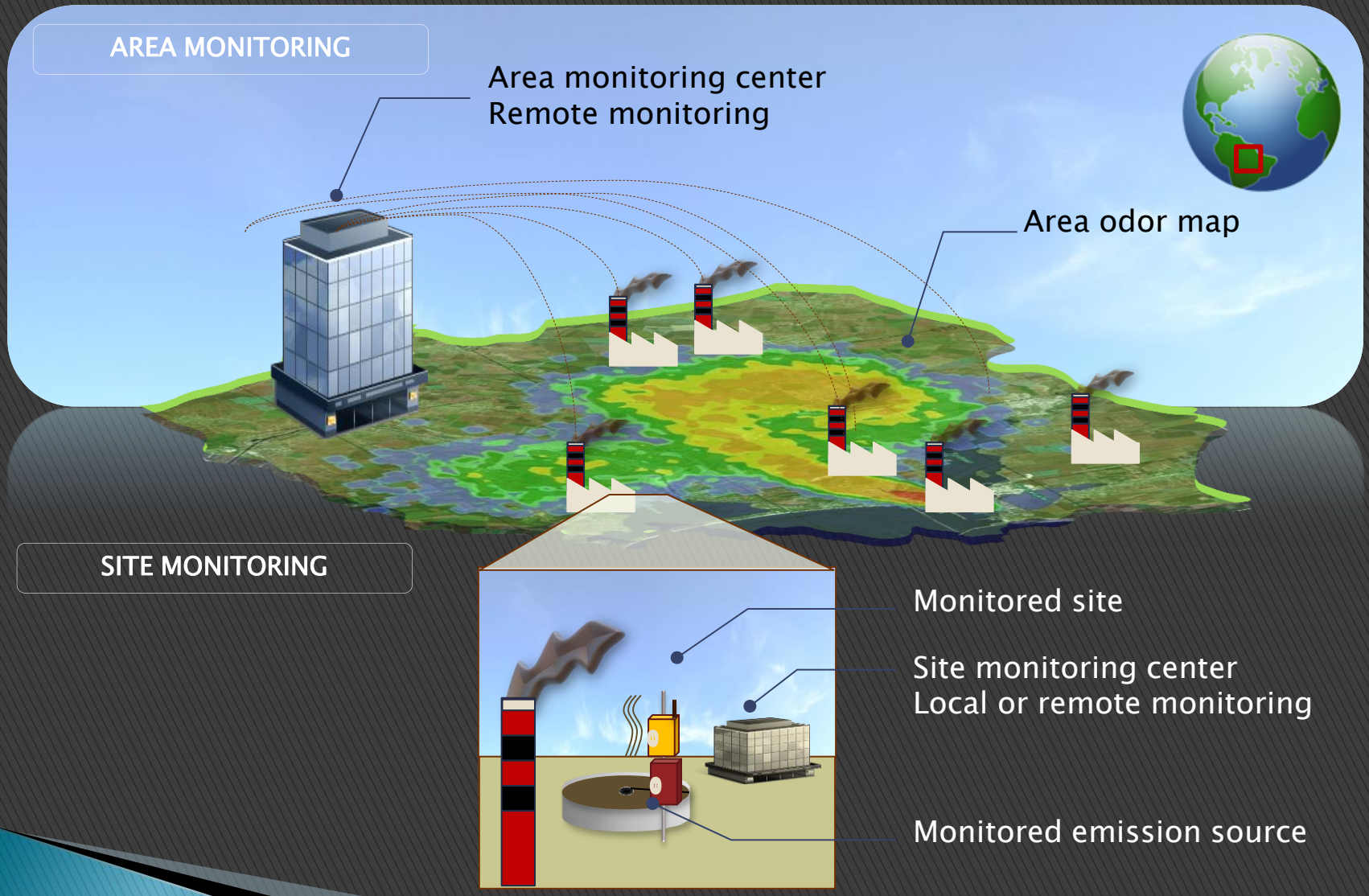
# WT 1 or WT2 Anywhere *Overall Architecture*

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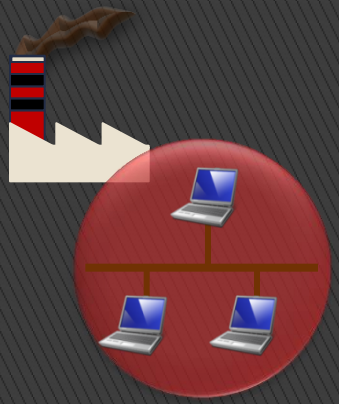
# WT 2Anywhere in the Cloud

## Overall Architecture



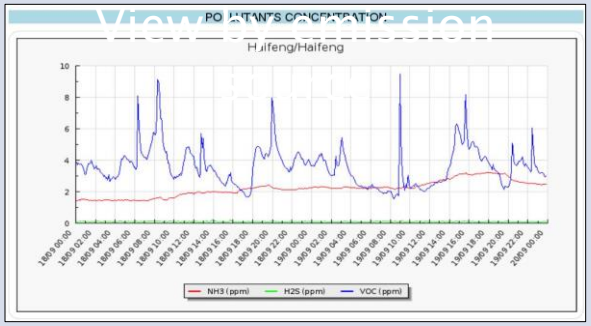
### Site monitoring data



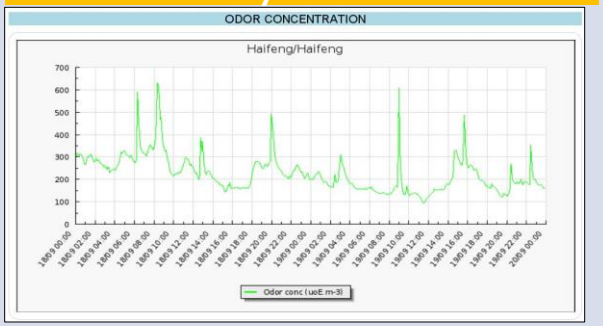
Site monitoring center

- Each site displays its own data
- No access to other sites data

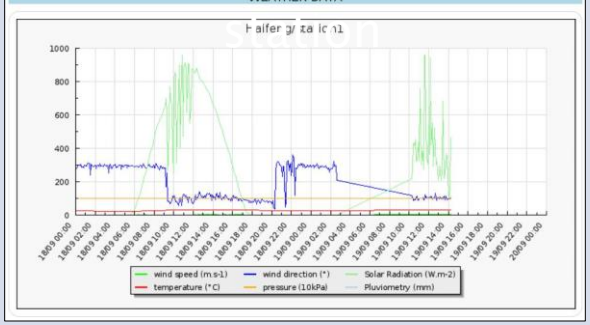
**Pollutant gas concentration**



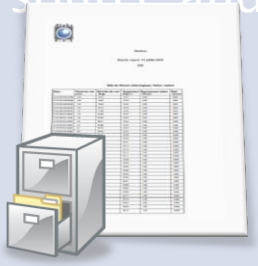

**Odor concentration**
View by emission




**Weather data**
From local weather station




**Daily dispersion reports**
View by emission source and pollutant



- Odor
- VOC
- $H_2S$ or RSH
- $NH_3$

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S&I PROPERTY

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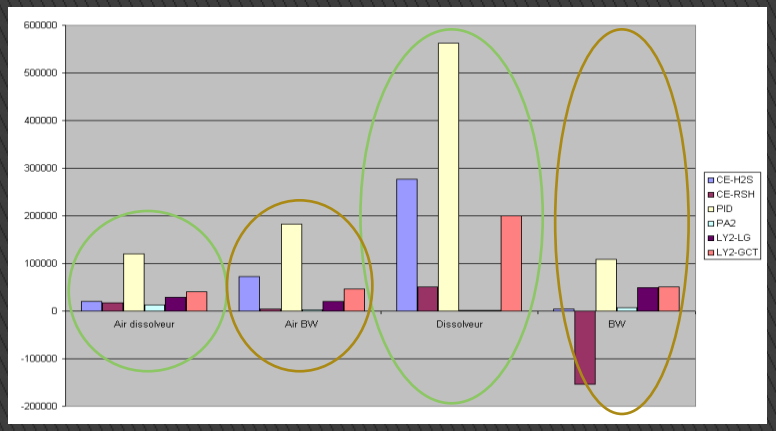
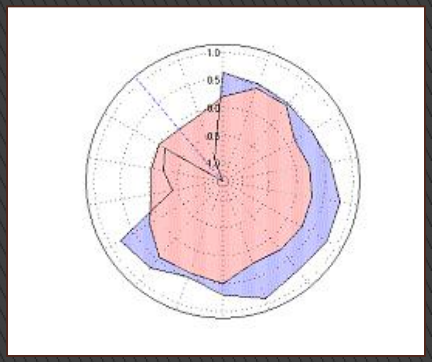
# IDENTIFICATION OF SOURCES

## Electronic nose results

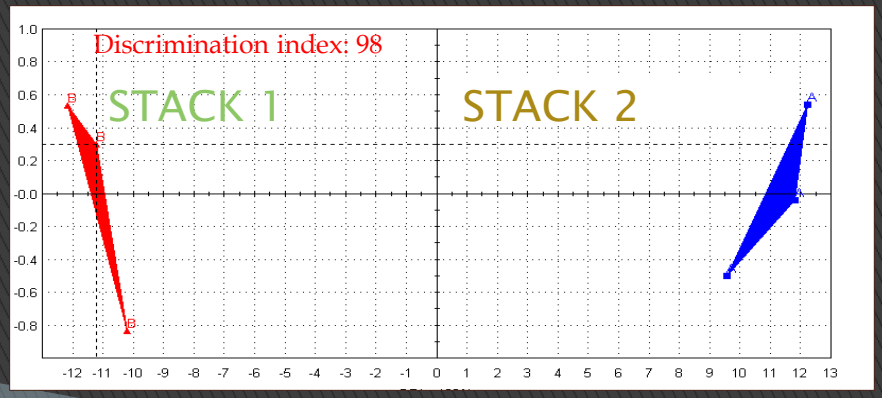
- ⇨ Ambiant air has been collected near the two sources to define a « blank » considered as reference with acceptable odor.
- ⇨ On-line monitoring was conducted by collecting gas each two seconds. The sensor responses define a specific & different chemical profiles.



Radar plot representation: Discrimination of the 2 stacks sources

- ➢ A radar plot representation gives a simple representation of the chemical & olfactive profiles.
- ➢ The profile of the two sources is very different as shown on the following PCA

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# Gas micro-sensors

Development program to develop micro gas sensors for improving :

- Sensitivity to specific gas (C2 H2…)
- Selectivity within complex matrix
- Speed (measurement every 28 ms)
- Size (smart applications)
- Electrical consumption (autonomy)
- Modulation capabilities
- Cost

# RUBIX S&I
# DATA PROCESSING – MINING

- Pattern recognition knowledge for gas, odors and particles identification :
  - AI ( Artificial intelligence)
  - Multivariate statistics ( PCA, DFA, PLS, SIMCA, ANOVA, SQC , MLR …)
  - Neural Network with “Deep Learning”
  - Self learning algorithms
  - Fuzzy Logic
  - Base line Drift compensation
  - Humidity Drift compensation

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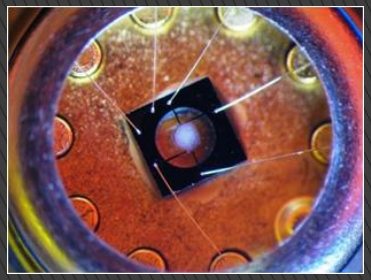
# Gas Sensors and virtual sensors knowledge :

- From MOS to MEMS MOS



6 gas sensors
on a MEMS
Sensors arrays

4 gas sensors
on a MEMS
Sensors arrays

One classical
gas sensors

- From Electro-Chemicals to miniaturized EC

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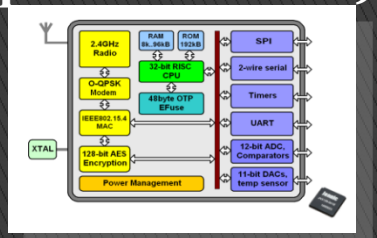
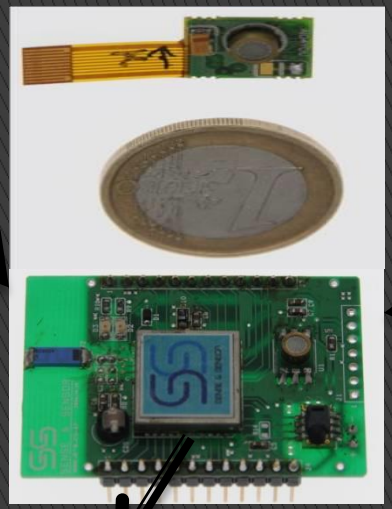
# Technologies
# Wireless E-nose System « WENS »

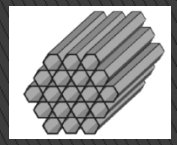
**One chip Zigbee Chip (up to 100 meter)**

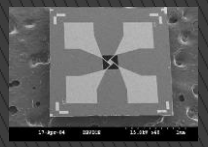


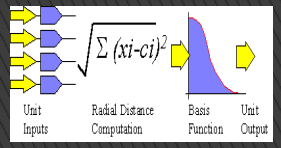

**3.3 Volts 100mV**



**Enose**







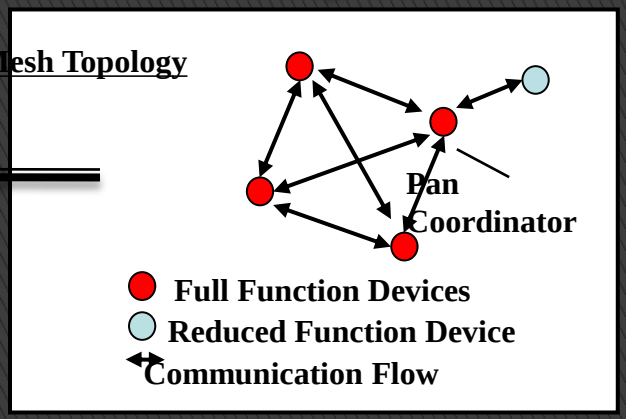

Metro rail station

Airport/plan e

home

Museum

industry




- *Easy system installation*
- *Low cost*
- *Wide range coverage*
- *Gas or odor distribution monitoring*
- *Toxic gas detection*

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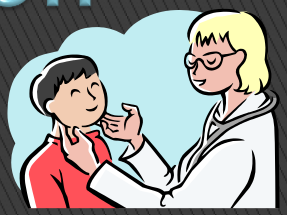
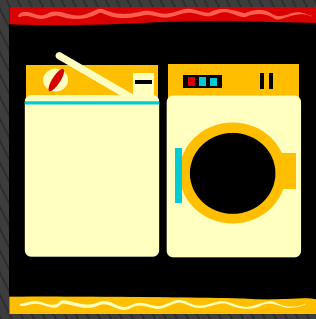
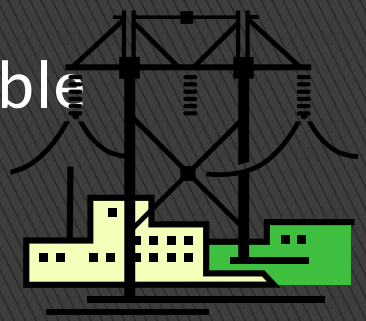
# Customized Industrial solution targets

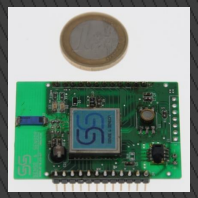


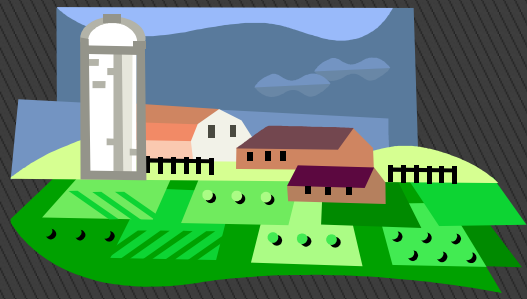
- **Apply RUBIX S&I Enose technologies to industrial application /micro gas sensor**
  - high volume
  - customized development possible





- **Area**
  - Industry, household appliances
  - Energy, transformers,
  - Medical
  - Food
  - IAQ
  - Mobile phone and wearables



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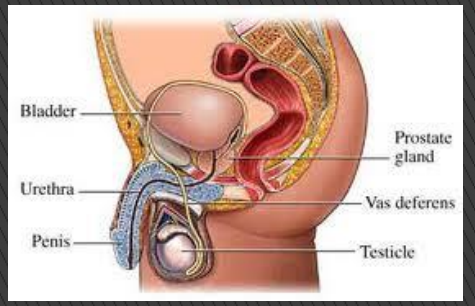
# Non Invasive Personal mobile health monitoring applications

## Samples types : Breath, Urine, Blood

- Detection of Vaginose / Vaginitis
- Detection of Lung Cancer ( breath)
- Detection  of Crohn disease ( breath)
- Detection diabetis ( breath)
- Detection of Ketosis ( breath)
- Detection of prostate cancer ( urine)
- Detection of colon Cancer

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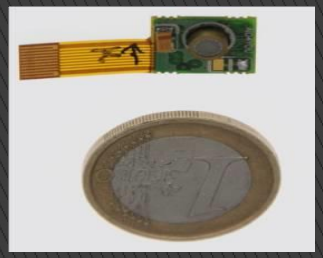
# Mobile Phone applications

**Samples types : Breath, Food , solid or liquid samples**

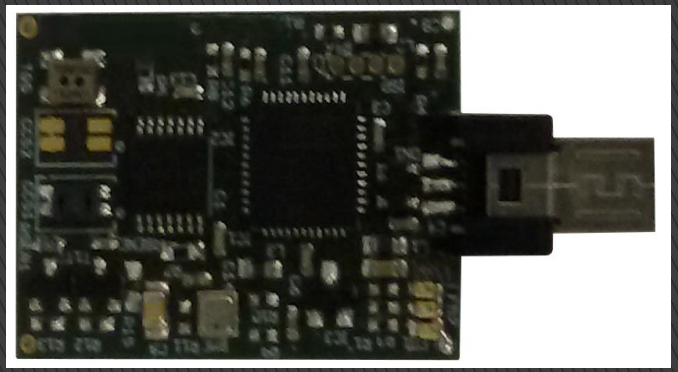
- Detection of Ethanol in breath
- Detection  of overall pollution
- Detection of fish freshness
- Detection of good breath and more…




# DEVELOPMENT

- **VIRTUAL SENSORS ARRAYS SYSTEM AS A SMART PHONE PLUG IN FOR GAS & ODOR DETECTION:**

  - MOS MEMS
  - 2 cm *1 .5 cm
  - MODULATION of VARIOUS PARAMETERS
  - LEARNING CAPABILITIES
  - DATA LOGGER
  - VARIOUS WEB BASED APPLICATIONS

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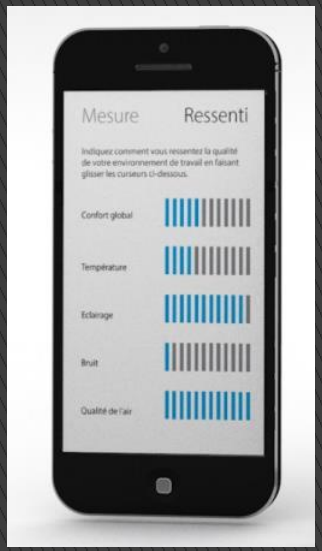
# *An application dedicated to the analysis of perception (subjective data)*

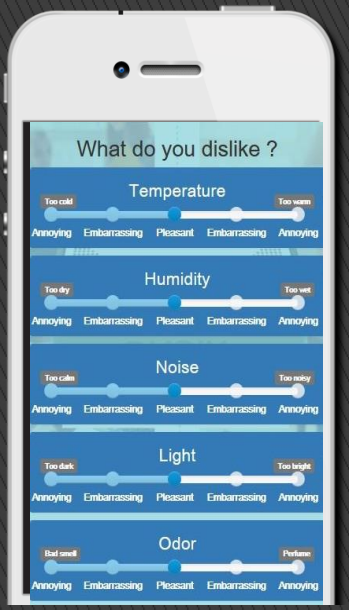
Temperature

Moisture

Air Quality And VOC ( Gas, BTX, Odor origin identification

Feeling

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# Olfactometry

## Principle

- A panel of qualified and selected assessors evaluates the average **dilution factor** $\bar{Z}_{ITE,pan}$ that must be applied to a sample in order to reach the odour detection threshold of the panel.
- By definition, the **odour concentration** ($C_{od.\ threshold}$) at the panel **detection threshold** is **1 $ou_E.m^{-3}$**.
- This value corresponds to the dilution factor for which the odorous sample has a 50% probability to be detected by the population.

$$C_{od} = C_{od.threshold} \times \bar{Z}_{ITE,pan} = 1\ ou_E.m^{-3} \times \bar{Z}_{ITE,pan}$$

$C_{od}$ ($ou_E.m^{-3}$): Odour conc. of the sample

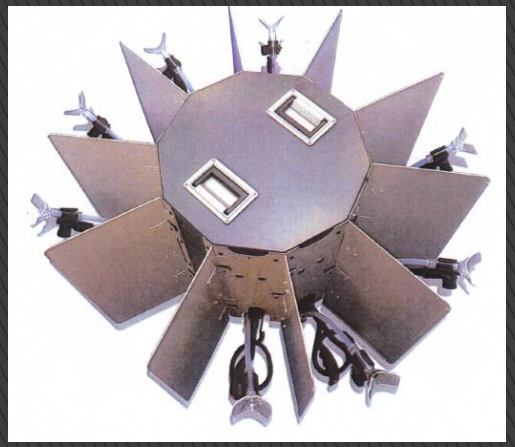
$C_{od\ threshold}$($ou_E.m^{-3}$): Odour conc. at the detection threshold of the panel (1 $ou_E.m^{-3}$)

$\bar{Z}_{ITE,pan}$ : average dilution factor applied to the sample to reach 1 $ou_E.m^{-3}$ (odour detected by 50 % of the panel)

# Olfactometry

## On-field olfactometers

- Portable olfactometers
  - 8 sniffing  ports EN13725 compliant
  - Dilution range from $2^2$ to$2^{16}$ (65536)



- Olfactometer 2 ports
  - From 2 to 30 000 ou

# Sensors & Microsensors

## On-field analysis of odorous molecules

- Specific sensors located at the source (high concentration and on line GC)
  - Monitoring of specific gases concentration (ppm level)
    - H2S, SO2, NH3, SO2…
  - Control of odour treatment facilities by taking chemical thresholds into account

- Specific microsensors located in the environment (low concentration)
  - Monitoring of specific gases concentration (ppb-ppm level)
    - S Box : H2S, RSH
    - N Box : NH3

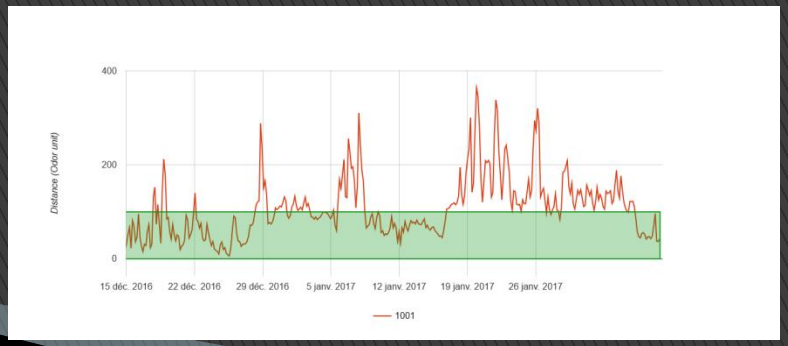
# MAIN RESULTS

## Main results

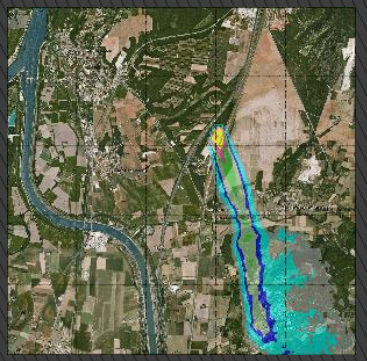
- A 60-day correlation study for odor impact
- 100% correlation between instrumental measurements and side resident perception with the 4D Lagrangian dispersion modeling

| DATE APPEL TELEPH | GARDE ADHEMAR | | GRANGES GONTARDES | | | | DONZERE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M. ARAGONA | M.VINAUD.G | Mme DUHOO | MANEVAL Fils | SEMIAND Jean-Claude | SERMAND Jean-Pierre | GUIGON Robert | REY Léon | Mme MORTIER | MANEVAL Coopérative Frattière |
| | 04 75 98 56 92 | 04 75 04 44 43 | 04 75 53 08 58 06 75 59 70 57 | 04 75 98 58 49 | 04 75 98 50 28 | 04 75 98 54 17 | 04 75 51 61 21 06 22 06 15 13 | 04 75 51 63 18 06 87 74 48 67 | 04 75 51 77 16 06 63 01 55 72 | 04 07 65 04 15 |
| 18/07/2009 | Absent | Absent | Fort à partir de 07 h 30 | Absent | Non | Absent | Non | Non | Absent | |
| 19/07/2009 | | | Fort dimanche matin | | | | | | | |
| 20/07/2009 | Léger à 08 h | Non | Non | Non | Non | Non | Non | Non | Absent | |
| 21/07/2009 | Non | Non | Non | Absent | Non | Non | Non | 8 H. 00 fort (OM) | Absent | |
| 22/07/2009 | Non | Non | Non | Non | Non | Non | Non | 7 H. 30 fort (OM) | Absent | |
| 23/07/2009 | Non | Non | Non | Non | Absent | Non | Non | Non | Absent | |
| 24/07/2009 | Non | Non | Non | Non | Non | Non | Non | Non | Non | |
| 25/07/2009 | Absent | Absent | OUI très fort 19h/23h | Non | Absent | Non | Non | Non | Absent | |
| 26/07/2009 | | | | | | | | | | |
| 27/07/2009 | Non | Absent | Non | Non | Non | Non | Non | OUI 7h à 8h odeurs déchets | Non | OUI 8h à 9h odeurs déchets |

Daily record of neighborhood complaints




Odor dispersion plume
(Fast-forward)

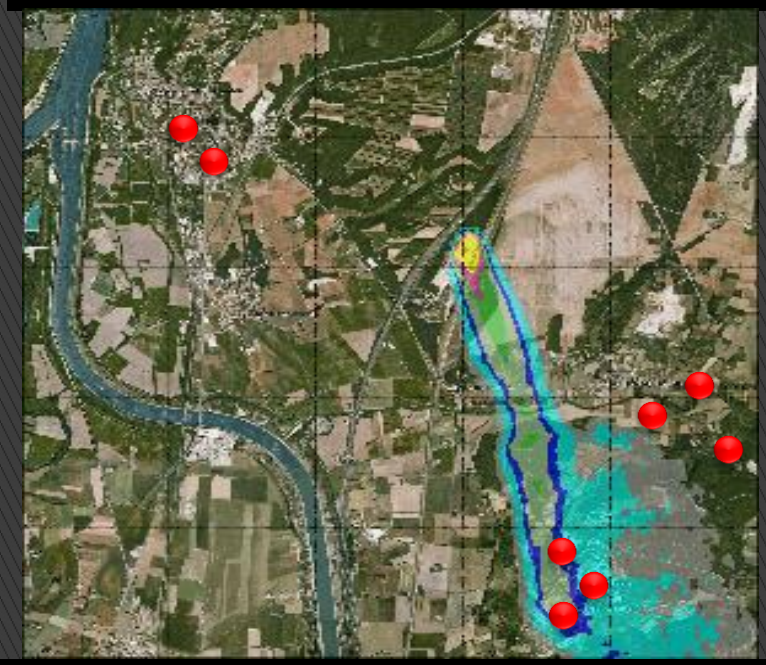


Odor units
$ou_E.m^{-3}$

# WT1 Results

## 4D Dispersion Software

Dynamic and continuous modeling of the odor/pollutant dispersion



Concentration at points of interest

$OU_E/m^3$

20

10

5

2

1

0.1

0.01

**Odor Concentration**

$OU_E$ = European Odor Units

**Discrimination thresh**
Clearly perceived by 50% of the population

**Recognition threshol**
Recognized by 50% of the population

**Detection threshold**
Detected by 50% of the population

**No odor detected**

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# CONCLUSION

- PLUS :
  Very good Correlation between MOS MEMS SmartPhone Plug In :
  - And olfactometry ( 13725)
  - And on line GC and on line static gas sensors particularly for BTX and mercaptants
  - Allows big data correlation with sensory perception
  - Allows dispersion towards localised data collection point
  - Very good correlation with olfactometry Correlation Factor R2 > 0,9)

- WEAKNESSES :
- Training is still needed
- Full transferability in development
- RSD on gas measurement > 50 % at low concentration

# Q&A


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