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New Technologies for Air Monitoring

State-of-the-Science

Peter Preuss

Chief Innovation Officer

Office of Research & Development

U.S. Environmental Protection Agency

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A typical regulatory monitor

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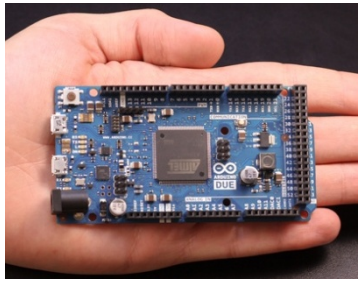
New low-cost monitor

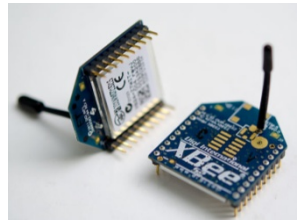
Many dimensions to sensor technology development

- Smartphone / Tablet in widespread use
- Miniaturized environmental sensors
- Batteries/Alternative power sources
- Introduction of low cost controls and communications
- Crowd-funding supporting do-it-yourself (DIY) innovation

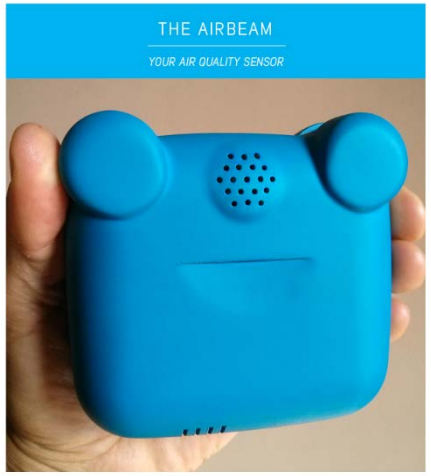
e.g., fitbit activity tracker



e.g., Arduino microprocessor



e.g., Kickstarter



Airbeam

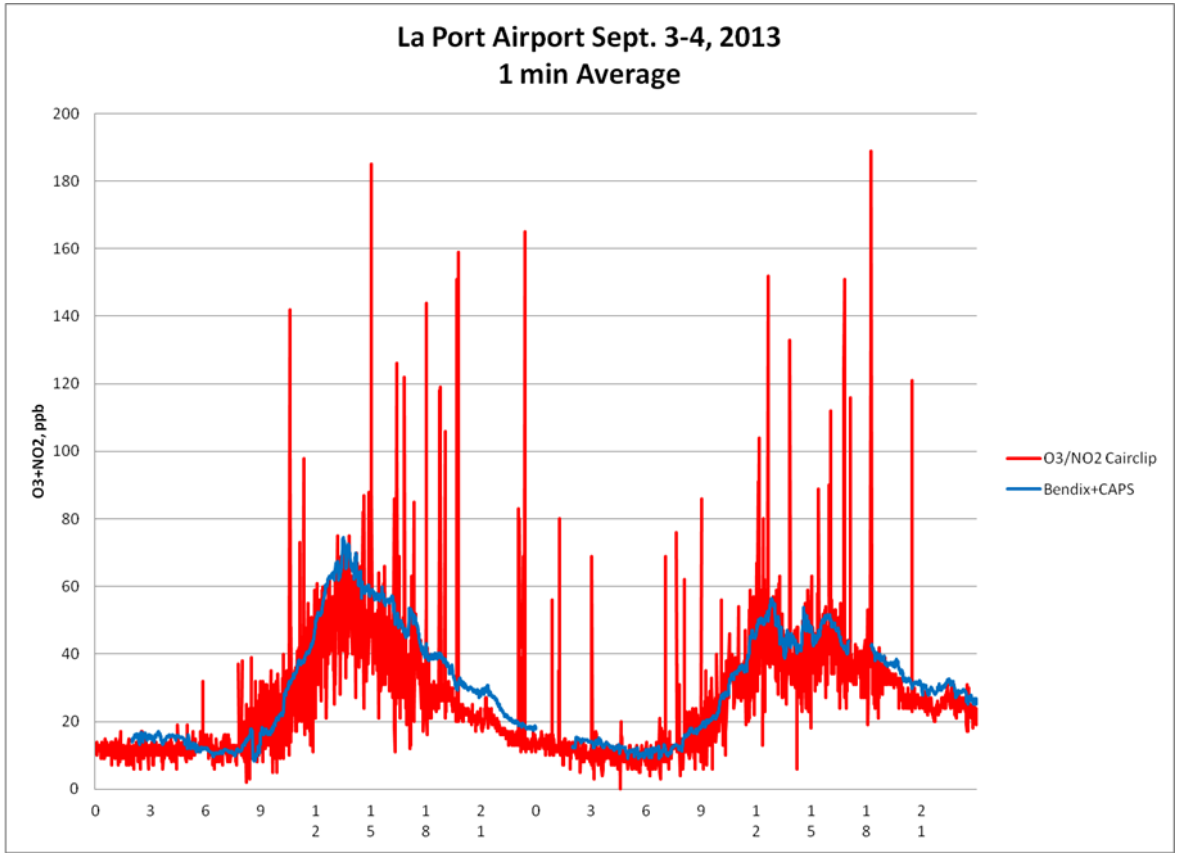
New Challenges

How to:

- Ensure data quality
- Manage and disseminate data
- Interpret what results mean for public health
- Communicate findings

Whose data is it?

- Privacy, data rights, data policies



"Village Green" air monitoring park bench

- Measures ozone and $PM_{2.5}$
  - Instruments under the red park bench
- Solar power
- Wireless transmission of data
- Public website updated minute-by-minute
- Engages community
- Installed in Washington D.C., Philadelphia, Durham and more
- On continuum between large stations and low cost sensors

Village Green air monitoring station at the National Zoo in Washington D.C.

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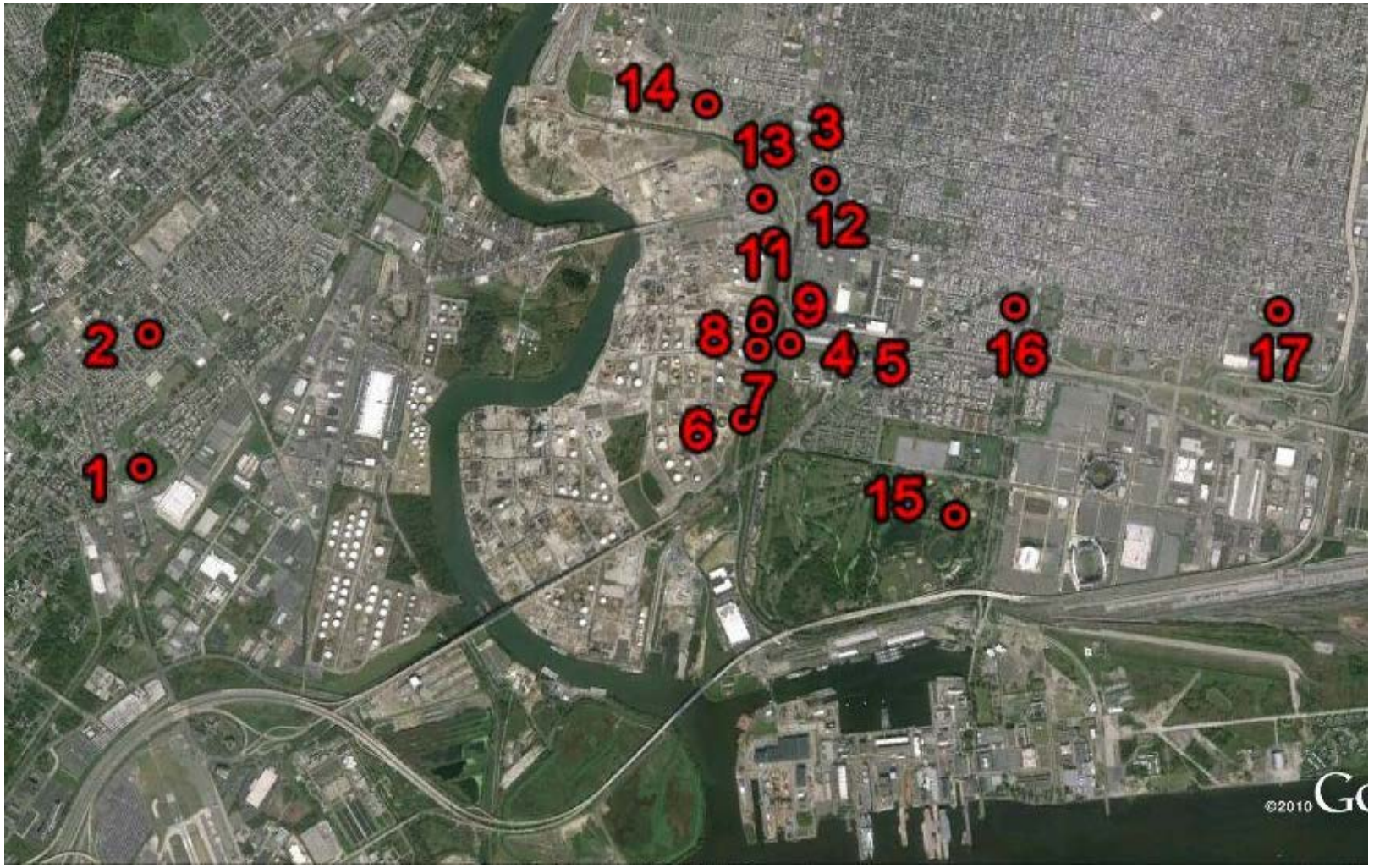
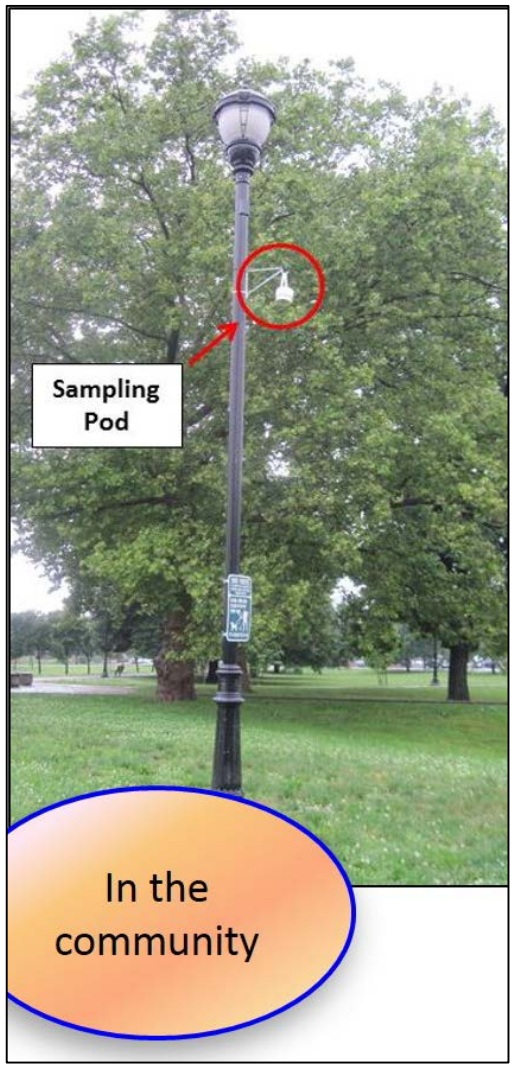
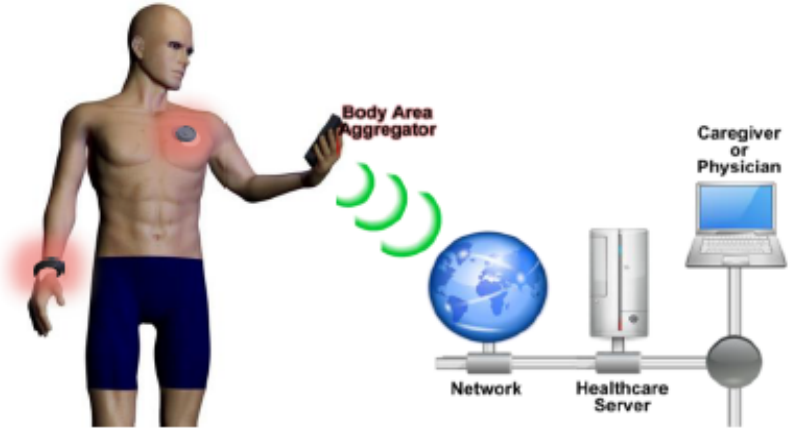
Philadelphia oil refinery fenceline and community monitoring





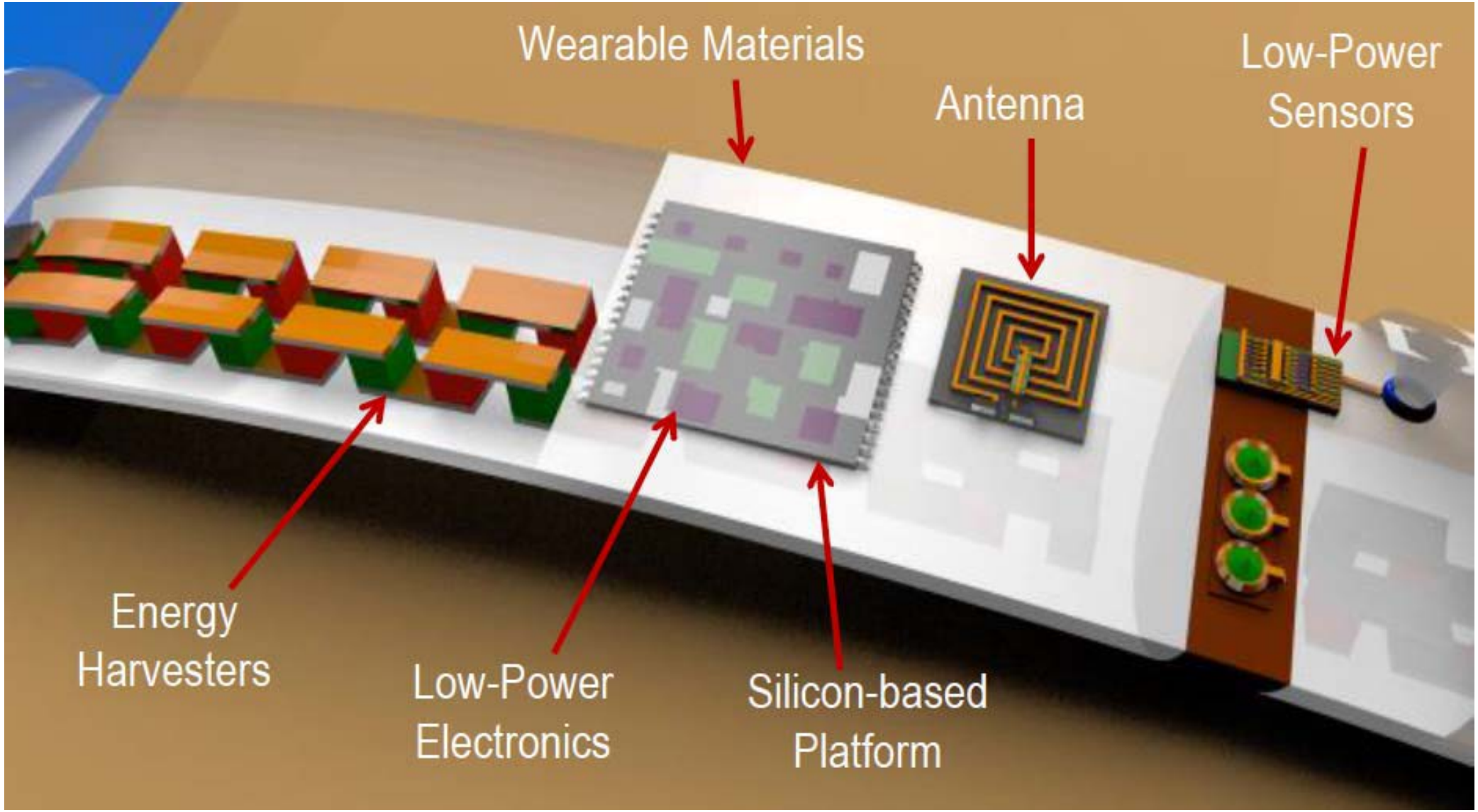
ASSIST:
Advanced Self-Powered Systems of Integrated Sensors and Technologies
An NSF Nanosystems Engineering Research Center



Nanotechnology enabled miniature, self-powered, wireless wearable sensors for **Personal Health** and **Personal Environment** monitoring




Ideally use energy harvesting to completely power wearable sensors



Sensor Performance Characteristics

- Evaluating sensor performance involves many parameters
- Testing in the lab and field is complex

Considerations:

1. Linearity (range)
2. Precision of measurements
3. Lower detectable limit
4. Resolution (noise)
5. Response time (lag and rise time)
6. RH and temperature influence
7. Interference equivalent

Laboratory evaluation of NO_2 and O_3 Sensors

- Open call for potential collaboration (2012-2013)
- O_3 and NO_2 focus
- 9 research groups brought devices for evaluation
- Variety of devices
- Cooperative effort to evaluate devices – evaluation data provided to developers only

Find out more:
http://www.epa.gov/research/airscience/next-generation-air-measuring.htm

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Laboratory example
AGT Sensor: Ozone FEM Comparison

- Ozone measurement – lab study
  - Highly correlated with Federal Equivalent Method (r^2=.98)
  - Good precision
  - Maintained good performance under hot, humid and cold conditions

DISCLAIMER Mention of trade names or commercial products does not constitute endorsement or recommendation for use

Laboratory example
Cairpol-Cairclip: NO_2 FEM Comparison

- Nitrogen dioxide (NO_2) measurement – lab study
  - Highly correlated with Federal Equivalent Method (r^2=.99)
  - Good precision
  - Maintained good performance under hot, humid and cold conditions

DISCLAIMER Mention of trade names or commercial products does not constitute endorsement or recommendation for use

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Field Examples
Particulate Matter (PM) sensors

- Technology for PM is more difficult
- 8 different PM sensors tested for 30 days at outdoor location
- Performance varied widely*
- Best performer in this initial test:
  - * Met One 831 (r^2=.77)

Dylos

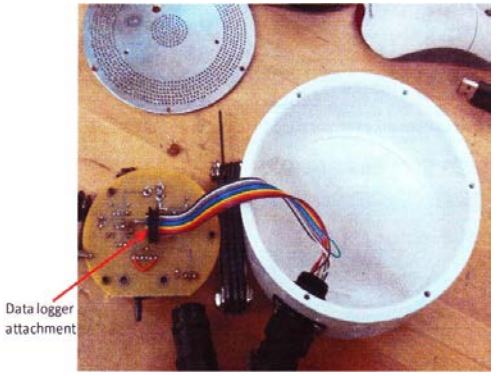
Met One 831

Preliminary results: we have not used replicate sensors and have not repeated this study

Examples
Volatile Organic Compounds (VOC) sensors

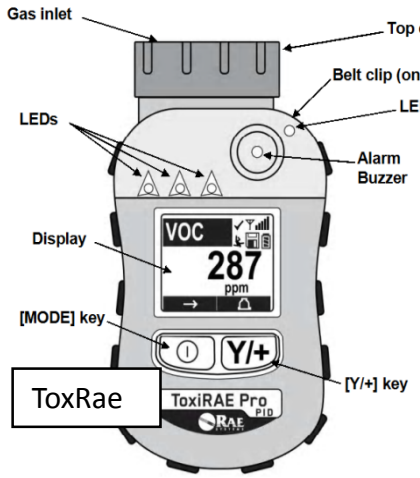
- Preliminary testing of VOC sensors
  – wide range of sensitivities

APPCD

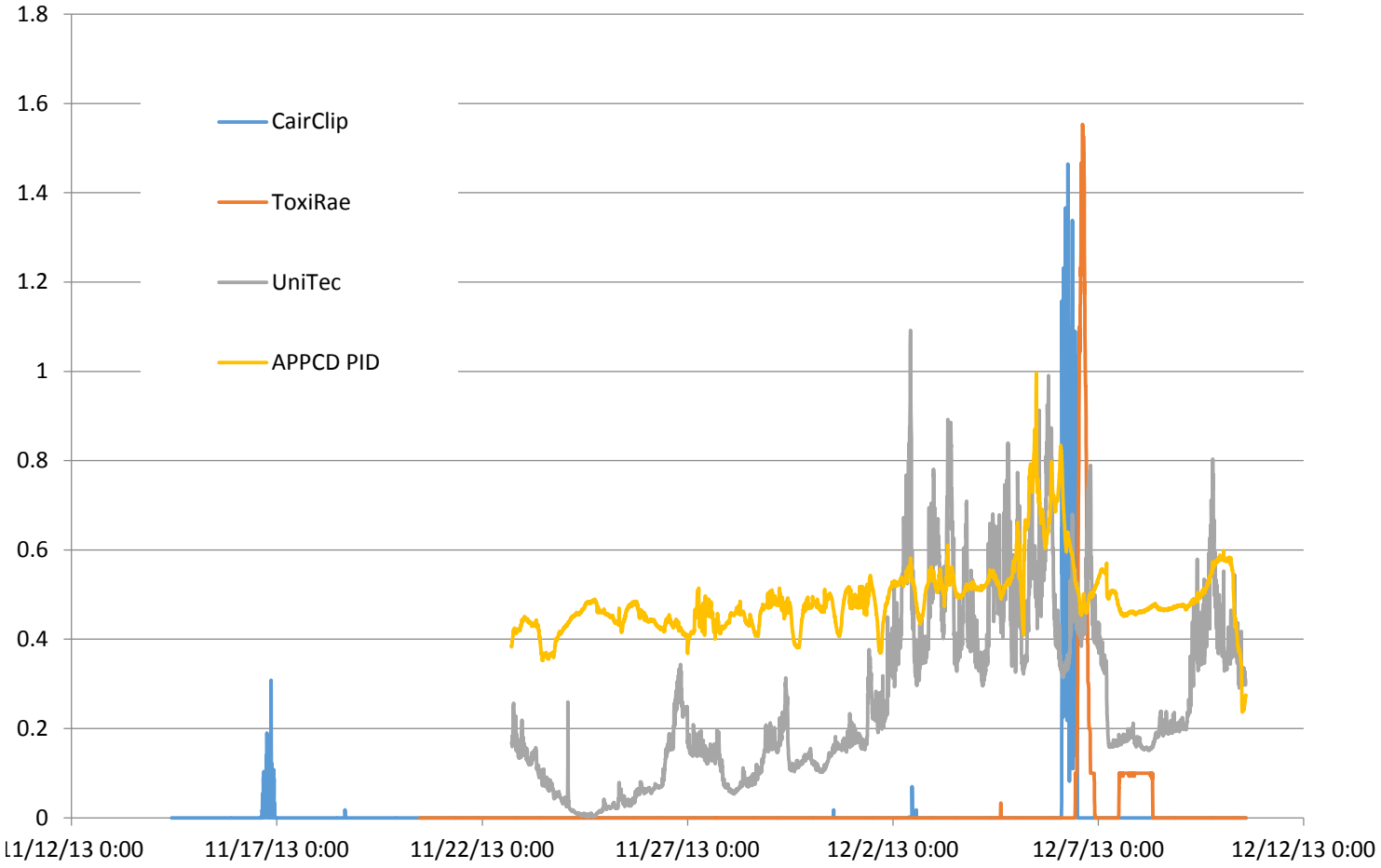


CairClip

UniTec

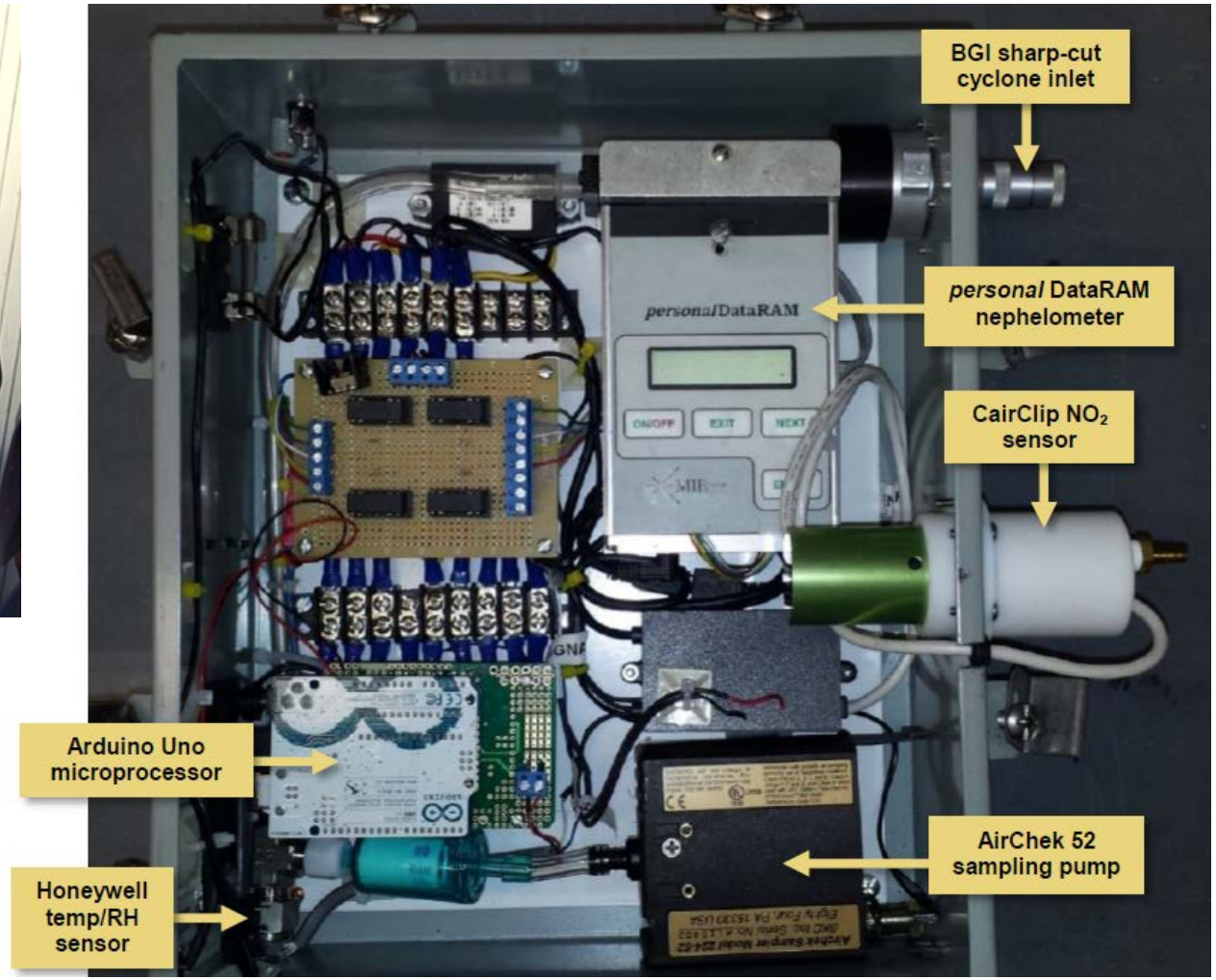


ToxRae



Ironbound Community, Newark NJ

- EJ community members conduct air monitoring with EPA
  - NO_2 sensor
  - $PM_{2.5}$
- High quality instruments and data



Instruments in “briefcase-sized” package

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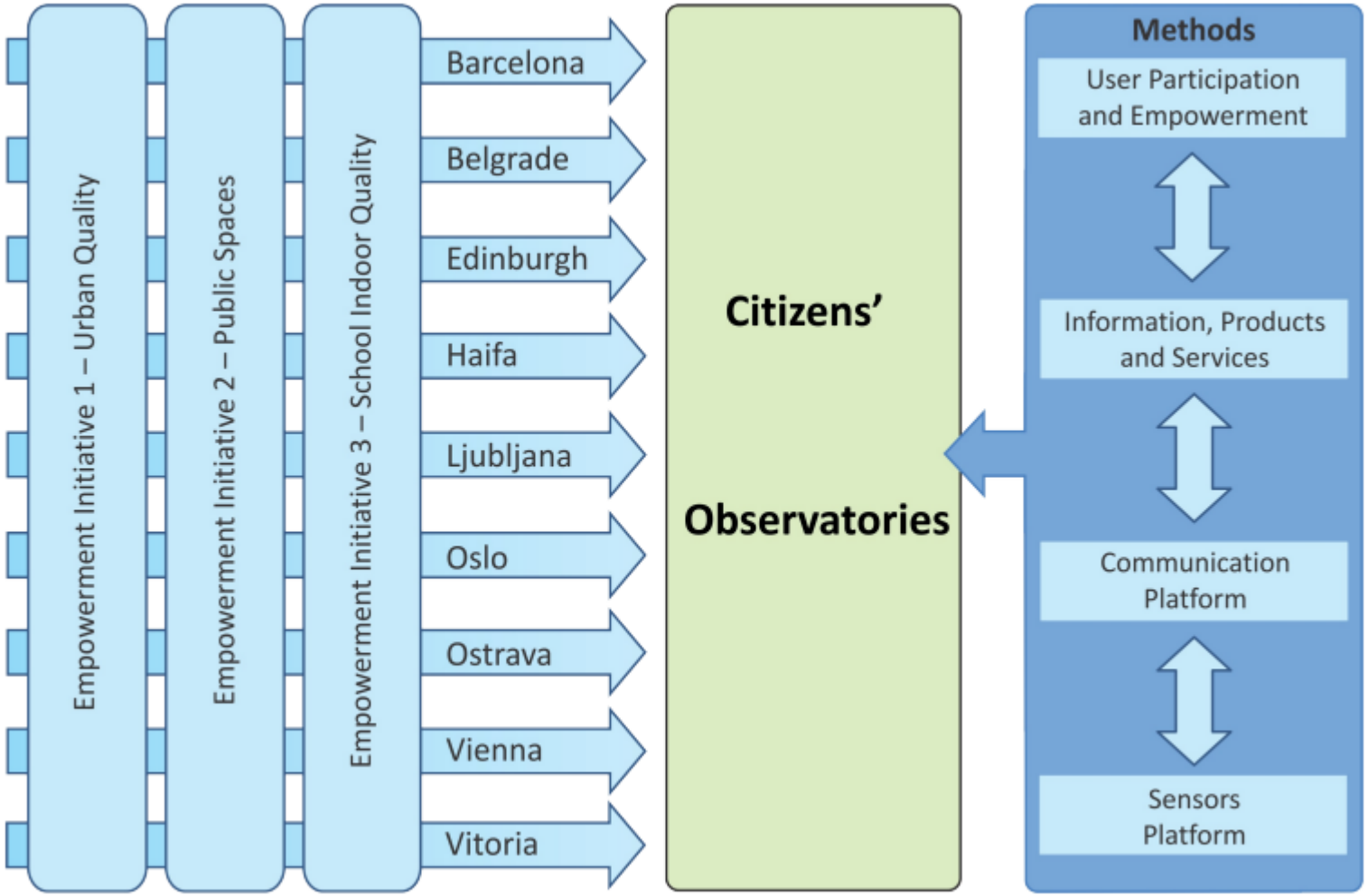
CITI-SENSE EU: Development of sensor-based Citizens' Observatory Community for improving quality of life in cities

- Developing Citizens' Observatories with a variety of microsensors
- Integrating data analysis across data types and cities
- Empowering citizens to influence community policy & decision making
- Contributing to GEOSS



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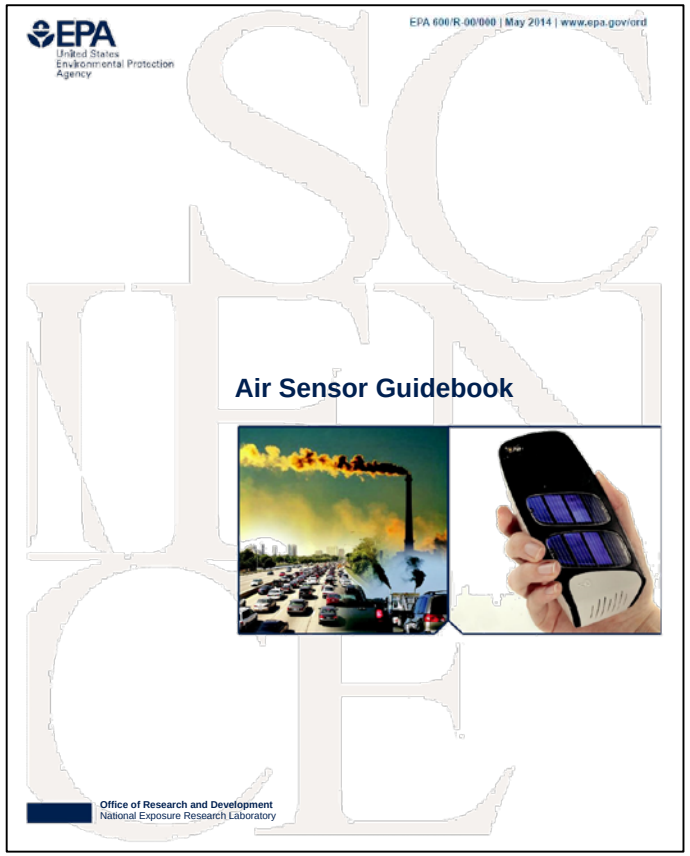
Air Sensor Citizen Science Toolbox EPA Measure • Learn • Share

Citizen Science Toolbox -

Provides guidance for the public on effectively using sensors to collect local air quality data



Air Sensor Guidebook -

Defines what sensor users need to understand if they are to collect meaningful air quality data

Find out more:

http://www.epa.gov/research/airscience/next-generation-air-measuring.htm

Challenges in use of low-cost sensors

- Moving from sensors to sensor systems
- Privacy issues
- Managing the data
- Visualizing the data
- Interpreting the data
- Communicating results

What's next?

- EPA STAR grants for community air monitoring ($4.5M)
- Small Business Innovation Research grants for air monitoring
- Region 2 equipment loan program
- Village Green expansion into more cities
- Water sensors
  - Nutrient Sensor Challenge

Find out more: