

Changing the Paradigm of Air Pollution Monitoring...Opportunities and Challenges

Presented by David Shelow (EPA OAQPS)
Emily Snyder, Tim Watkins, Eben Thoma, Gayle Hagler, Ron Williams – EPA ORD, and variety of other contributors.



A technology shift is under way.....

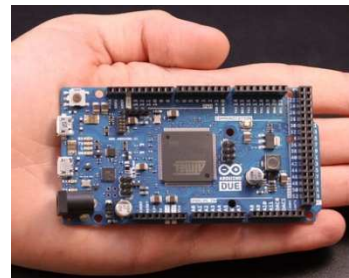
Technology advances are supporting a shift toward new ways of measuring and communicating air quality information

- Smartphone / tablet generation

e.g., fitbit activity tracker

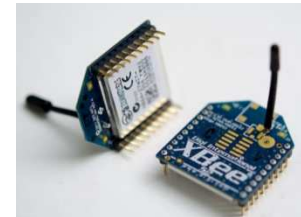


- Miniaturization of sensors



e.g., Arduino microprocessor

- Lower-cost components



- Easy to use

- Crowd-funding supporting DIY innovation

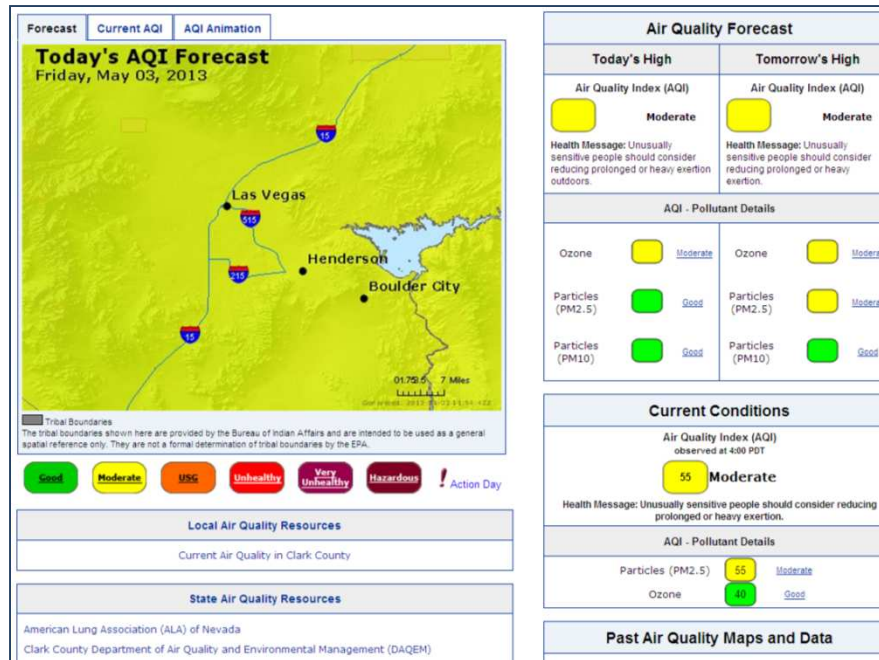


e.g., Kickstarter

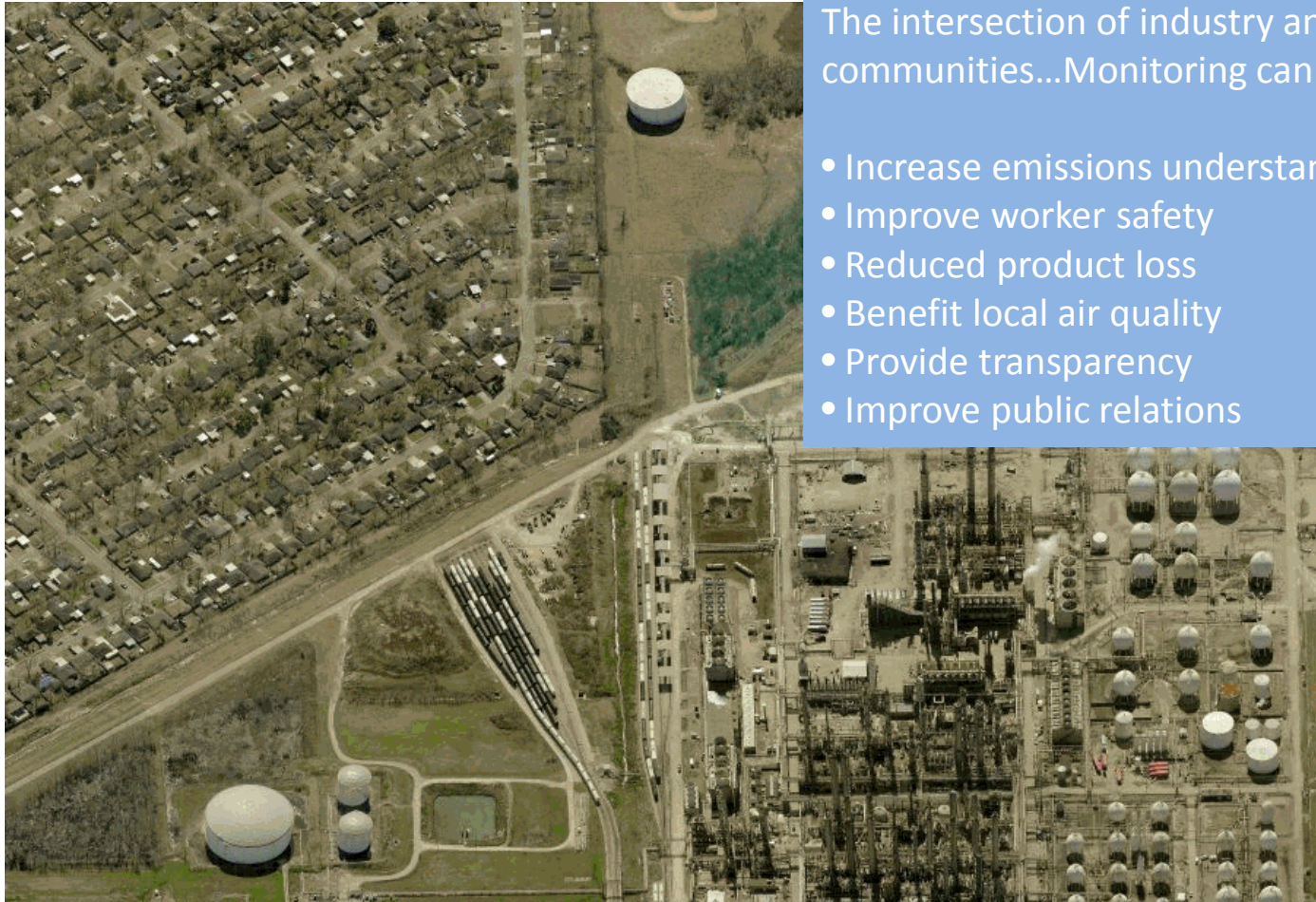
And a cultural shift is under way

Where we are today: government-provided data, AQI on broad time and spatial scales

Public demand for more personalized information – what about *my* exposure, *my* neighborhood, *my* child??



Imagine a different air monitoring landscape...



The intersection of industry and communities...Monitoring can:

- Increase emissions understanding
- Improve worker safety
- Reduced product loss
- Benefit local air quality
- Provide transparency
- Improve public relations

Neighborhood next to industry.....

An aerial photograph of a large industrial facility, likely a refinery or chemical plant. The image shows a dense network of pipes, walkways, and structural steel. Several large, white, cylindrical storage tanks are visible, particularly on the right side. The ground is mostly dirt and gravel. The overall scene is complex and industrial.

Where is the leak?

The key is finding and fixing the big leaks quickly

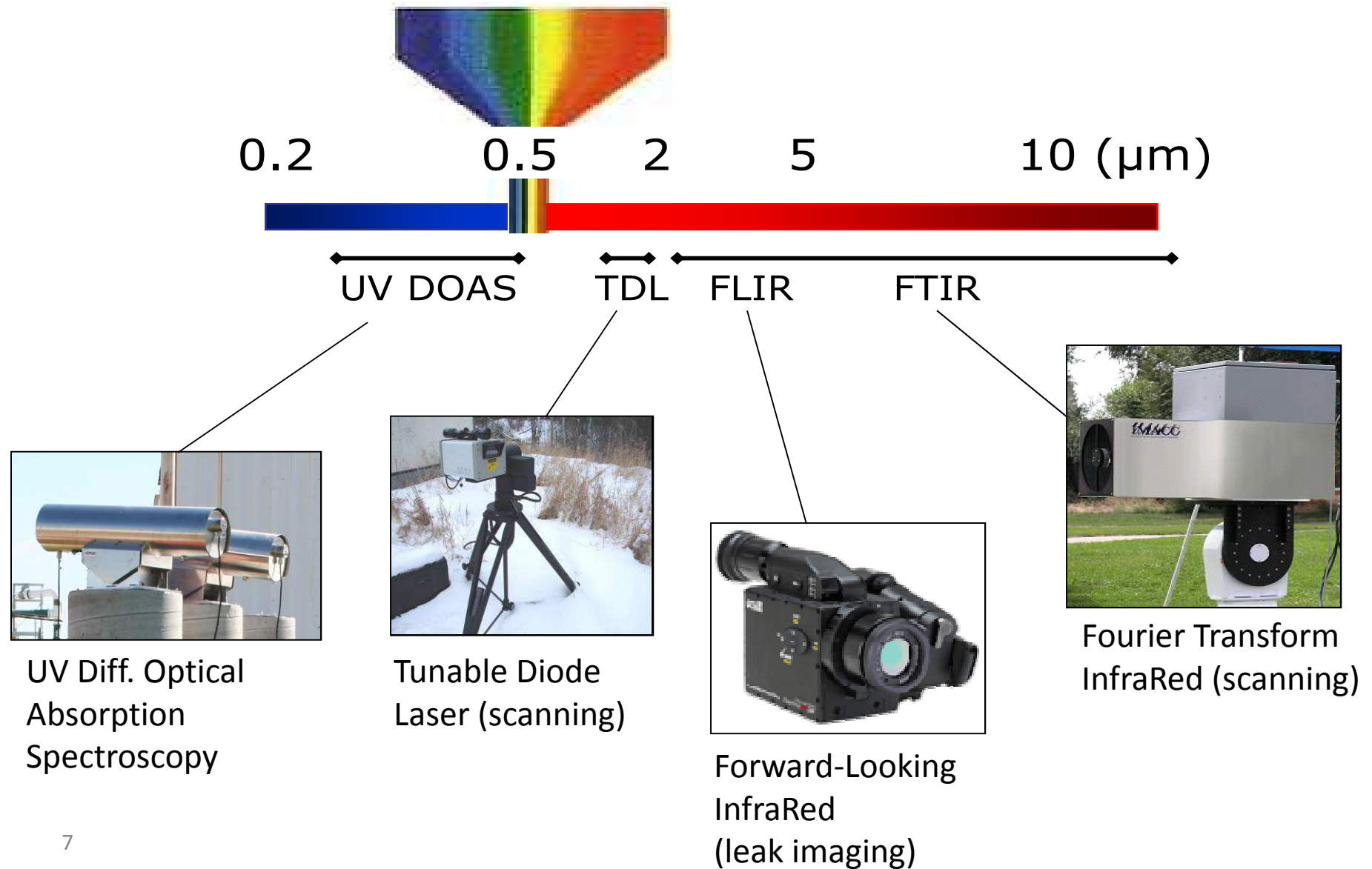
Open-path fenceline systems to detect emissions and direct quick response LDAR

Open-path optical systems

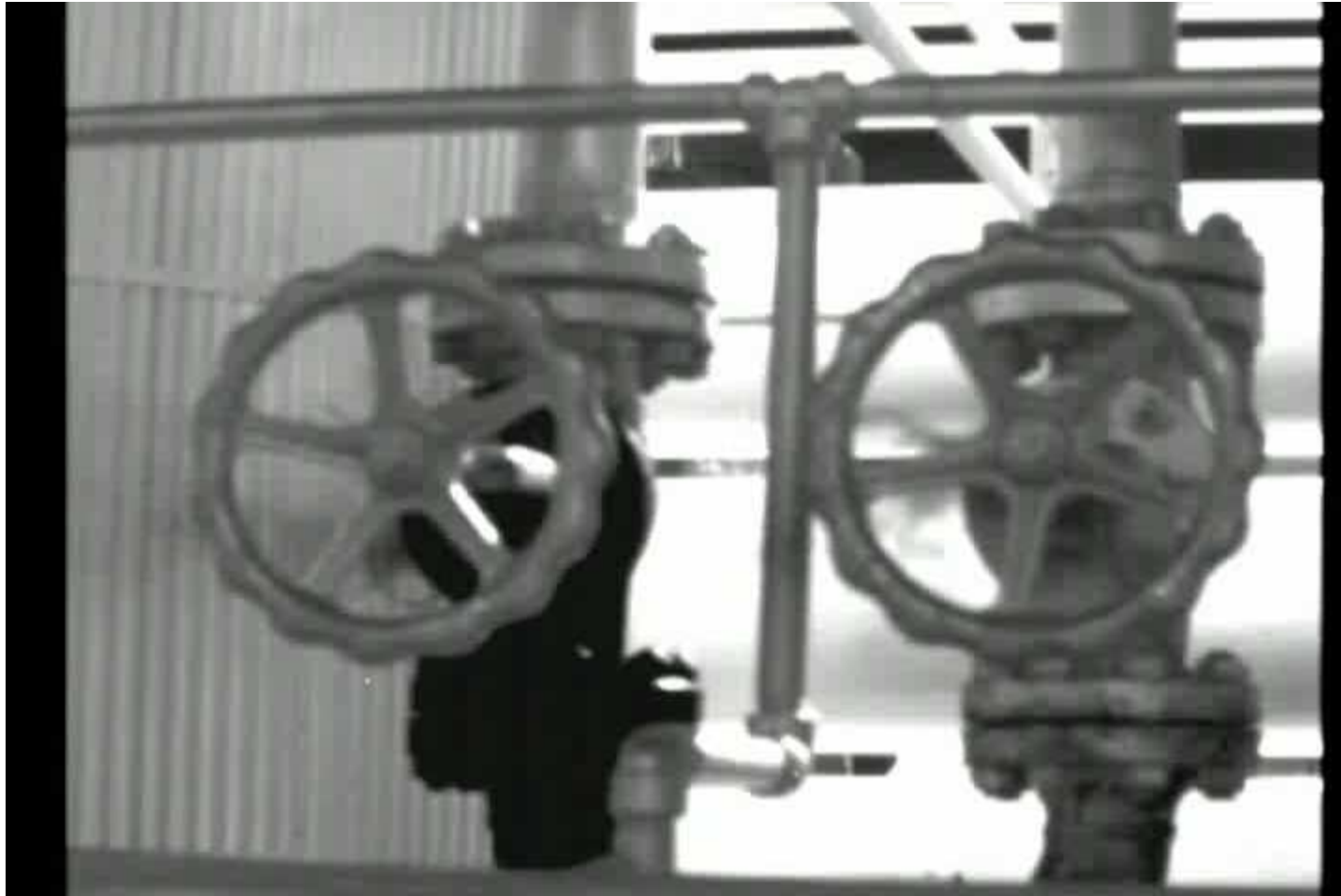
Wind

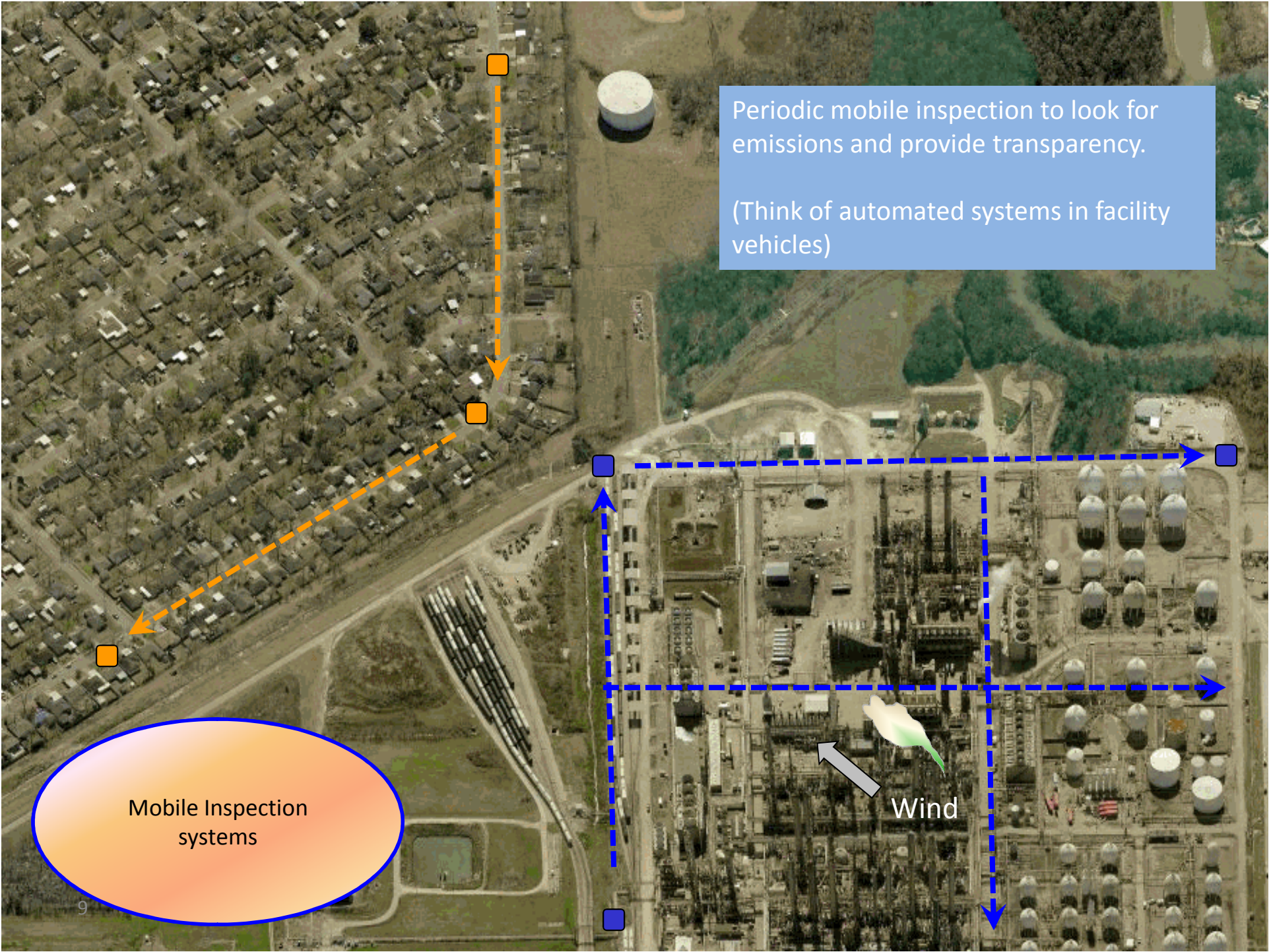


Open-path instruments



Seeing invisible VOC leaks with infrared video FLIR Camera





Periodic mobile inspection to look for emissions and provide transparency.

(Think of automated systems in facility vehicles)

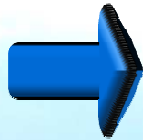
Mobile Inspection
systems

Wind

Off-site assessment with *GMAP-REQ*

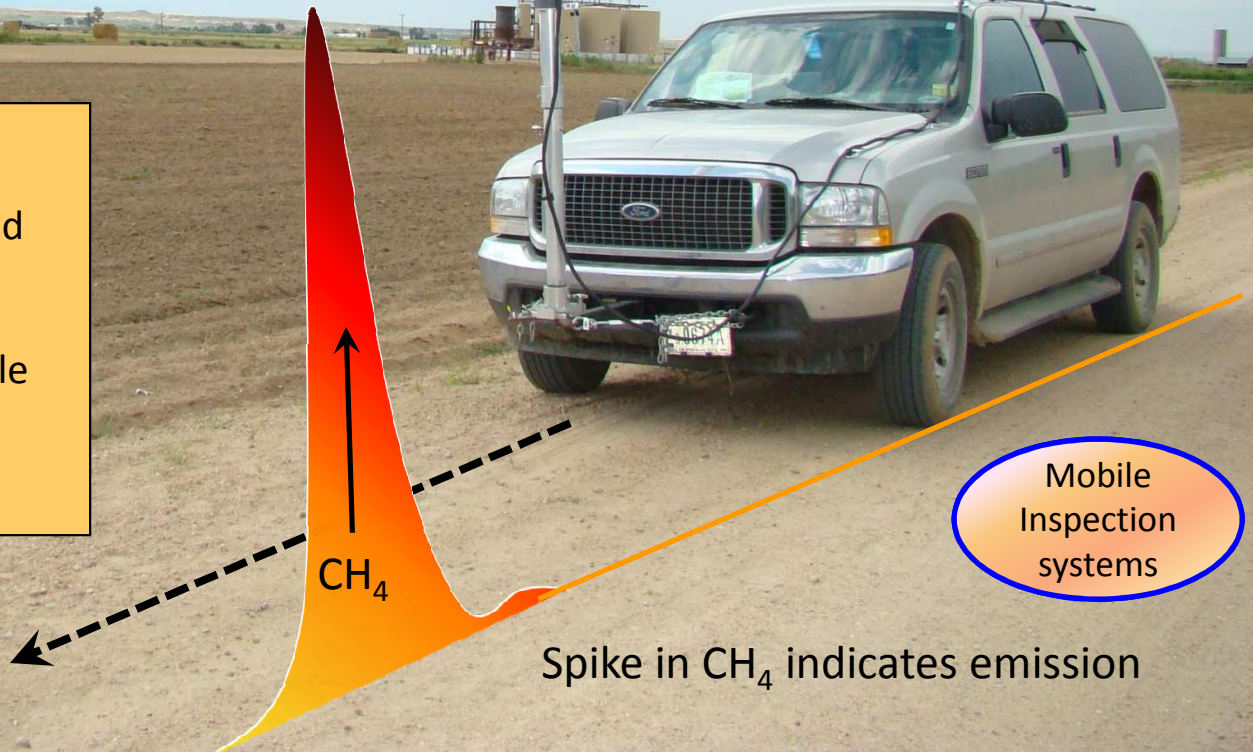
(Geospatial Measurement of Air Pollution – Remote Emissions Quantification)

wind direction



- Position vehicle in the plume
- Acquire methane (CH_4), H_2S and wind data for 20 minutes
- Pull a canister sample for volatile organic compound (VOC) information

driving path



Mobile
Inspection
systems

Spike in CH_4 indicates emission



Emerging low cost sensors provide a variety of new solutions for 24-7 coverage

■ Fenceline with passive and active sensors

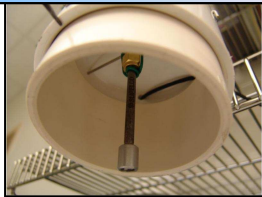
■ In-plant sensor networks

Low cost Sensor
Networks

Low cost sensors can provide industry 24-7 observation

Facility fenceline monitoring

Passive Sampling



Low cost
Sensor
Networks

Low-cost
sensors

- Open path
- Fixed monitors





Emerging low cost sensors provide a variety of new solutions for 24-7 coverage

■ Fenceline with passive and active sensors

■ In-plant sensor networks

■ Community monitoring lower cost systems

Low cost Sensor
Networks

Wind

Fixed location sensors examples



Aqmesh.com: AQ
electrochemical
sensors



Prototype PID sensor package
(pres. temp. , RH., VOC)

Fixed location sensors examples



Unitec Srl - Via A. Volta, 25/B. 35030 Veggiano (PD) - Italy
Tel +39 049 9006911 - Fax +39 049 9006935 - P. Iva 01497740389 - Privacy
Cap. Soc. Euro 200.000,00 - interamente versato - Reg. Imprese Padova n. 01497740389 - R.E.A. Padova n. 320424

Progettazione web: Evoluzione WEB

Fixed Sensor Specifications

SENSOR *	RANGE (@0°C ATM)	PRECISION	LOW DETECTION LIMIT	RESOLUTION	BACKGROUND NOISE	ACCURACY	RESPONSE (T90)
CARBON MONOXIDE (CO)	0-100 mg/m ³ 0-80 ppm	< 2% f.s.	0.1 mg/m ³	0.1 mg/m ³	0.1 % f.s.	+/- 0.5 mg/m ³	< 3 sec.
NITROGEN DIOXIDE (NO ₂)	0-500 µg/m ³ 0-400 ppb	< 2% f.s.	0.1 µg/m ³	0.1 µg/m ³	0.1 % f.s.	+/- 10 µg/m ³	< 3 sec.
OZONE (O ₃):	20-500 µg/m ³ 10-200 ppb	< 10% f.s.	20 µg/m ³	1.0 µg/m ³	0.1 % f.s.	+/- 10 µg/m ³	< 3 sec.
BENZENE (C ₆ H ₆)	0-100 µg/m ³ 0-30 ppb	< 2% f.s.	0.1 µg/m ³	0.1 µg/m ³	0.1 % f.s.	+/- 1 µg/m ³	< 3 sec.
NITROGEN OXIDES (NOX)	0-800 µg/m ³ 0-500 ppb	< 2% f.s.	0.1 µg/m ³	0.1 µg/m ³	0.1 % f.s.	+/- 10 µg/m ³	< 3 sec.
METHANE (CH ₄)	0-300 µg/m ³ 0-400 ppb	< 2% f.s.	0.1 µg/m ³	1 µg/m ³	0.1 % f.s.	+/- 10 µg/m ³	< 3 sec.
OPERATIVE CONDITIONS	Temperature: -20°C to 50°C Relative Humidity: 5 to 95% (non condensating)		ZERO/SPAN DRIFT		< 2.5% / 6 months < 2.5% / 3 months (for O ₃)		

* OTHER SENSORS AVAILABLE ON REQUEST.

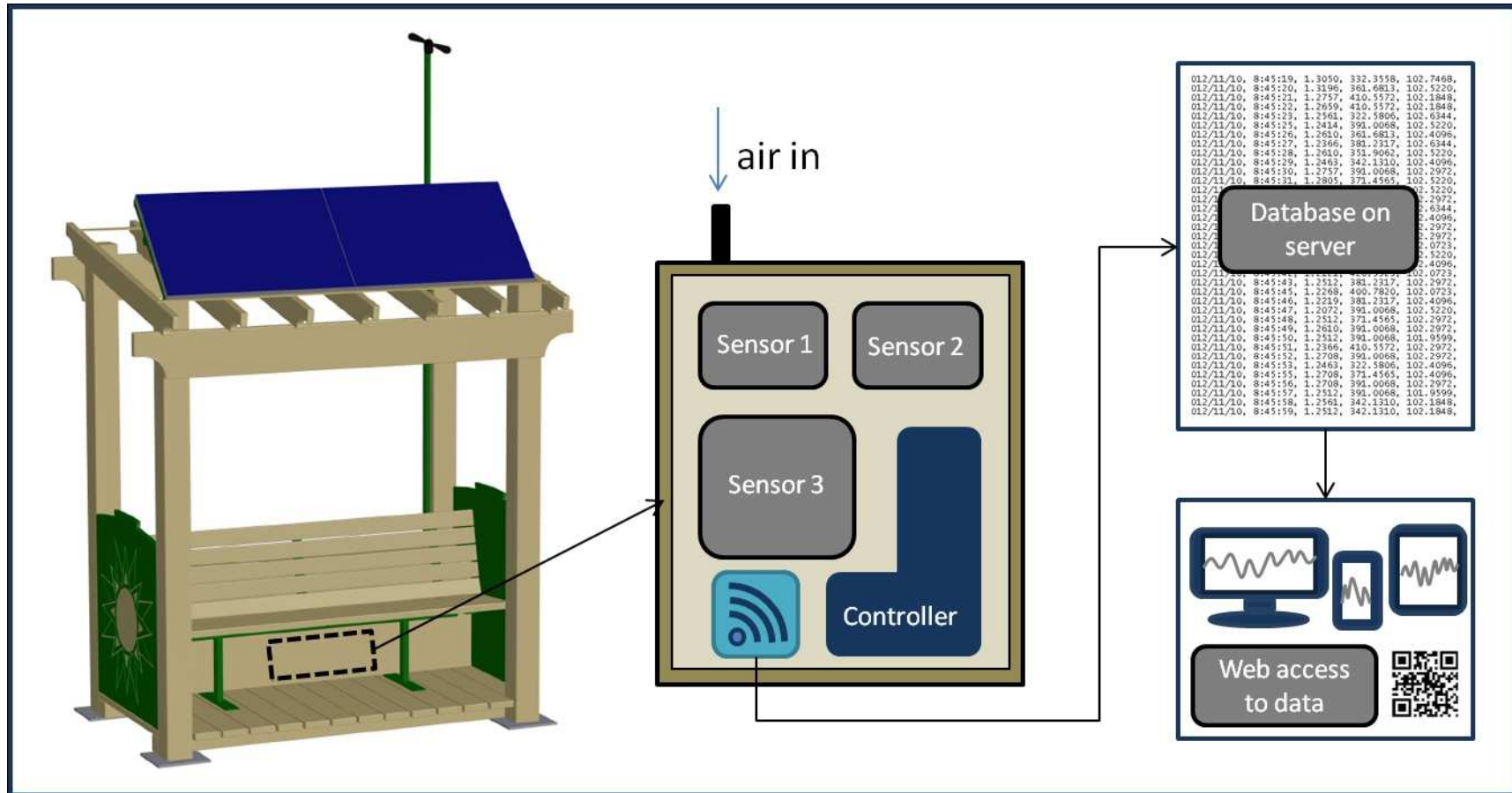


UNITEC srl
VIA C. COLOMBO, 37/E
44100 FERRARA (ITALY)

TEL. +39 0532.731123
FAX +39 0532.730537

WWW.UNITEC-SRL.COM
INFO@UNITEC-SRL.COM

Village Green Project design



Let's take it another step forward...citizen
monitoring/crowdsourcing

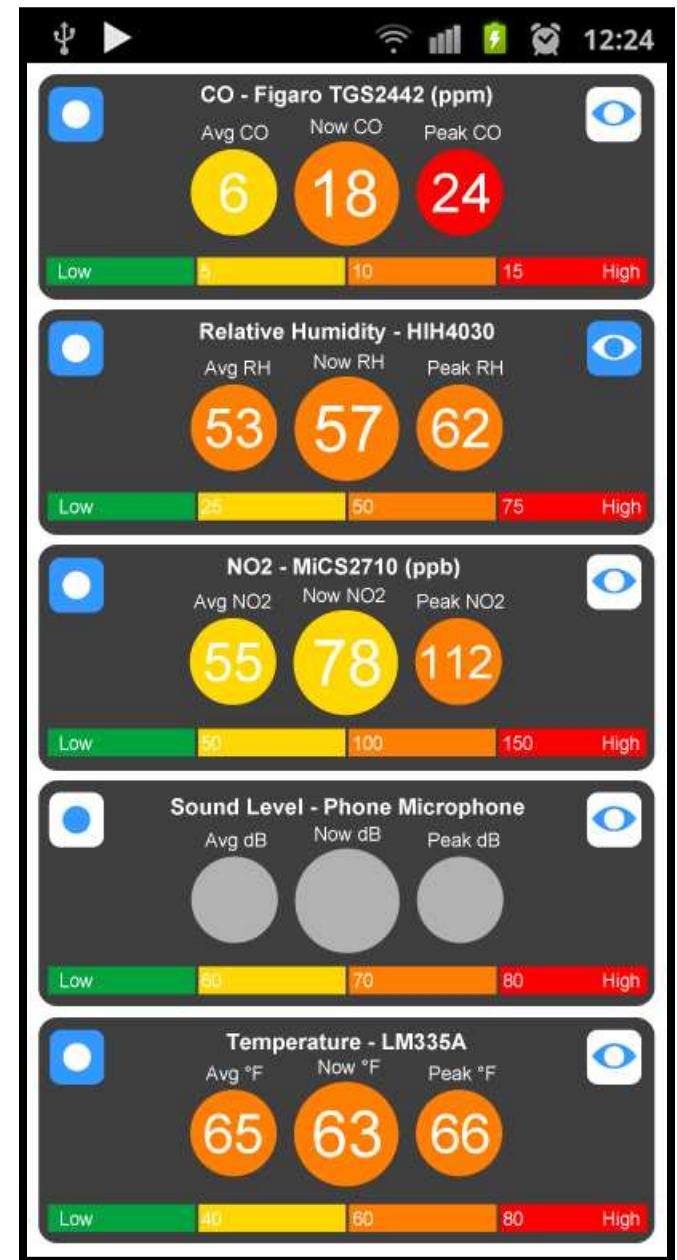
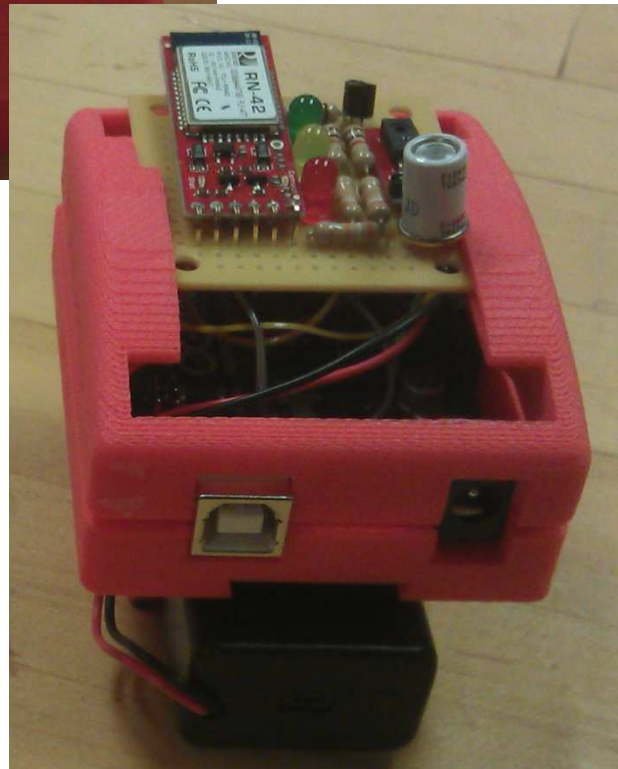
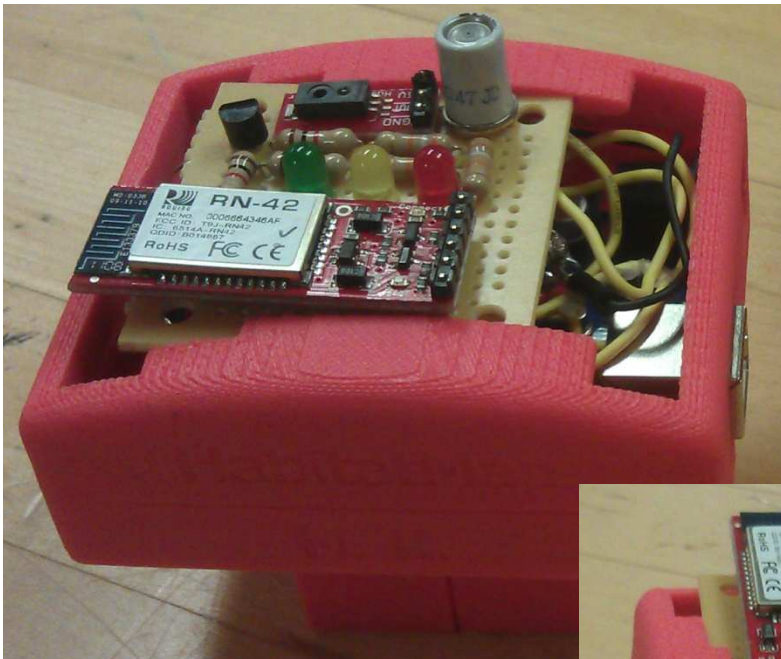


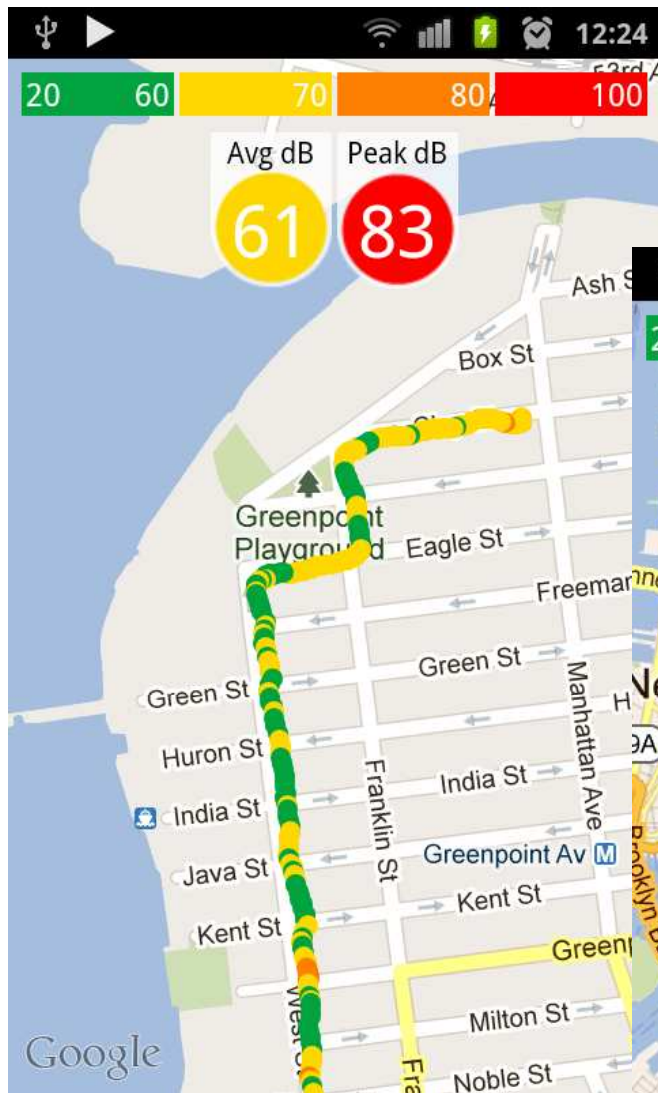
Michael Heimbinder, Habitat Map, Brooklyn NY



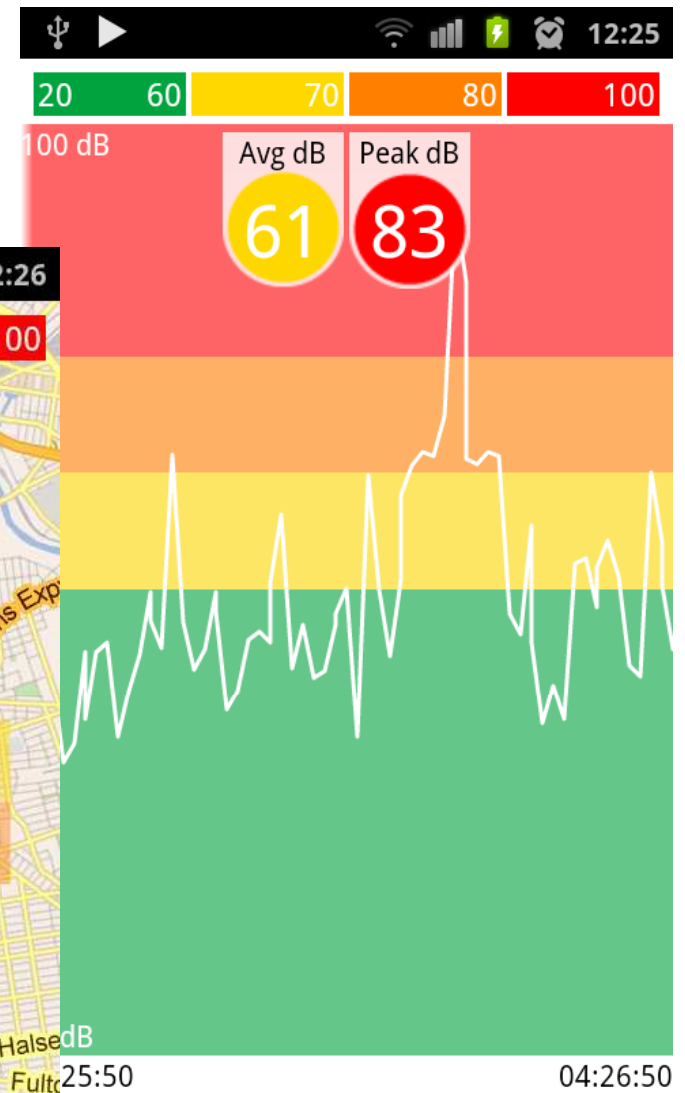
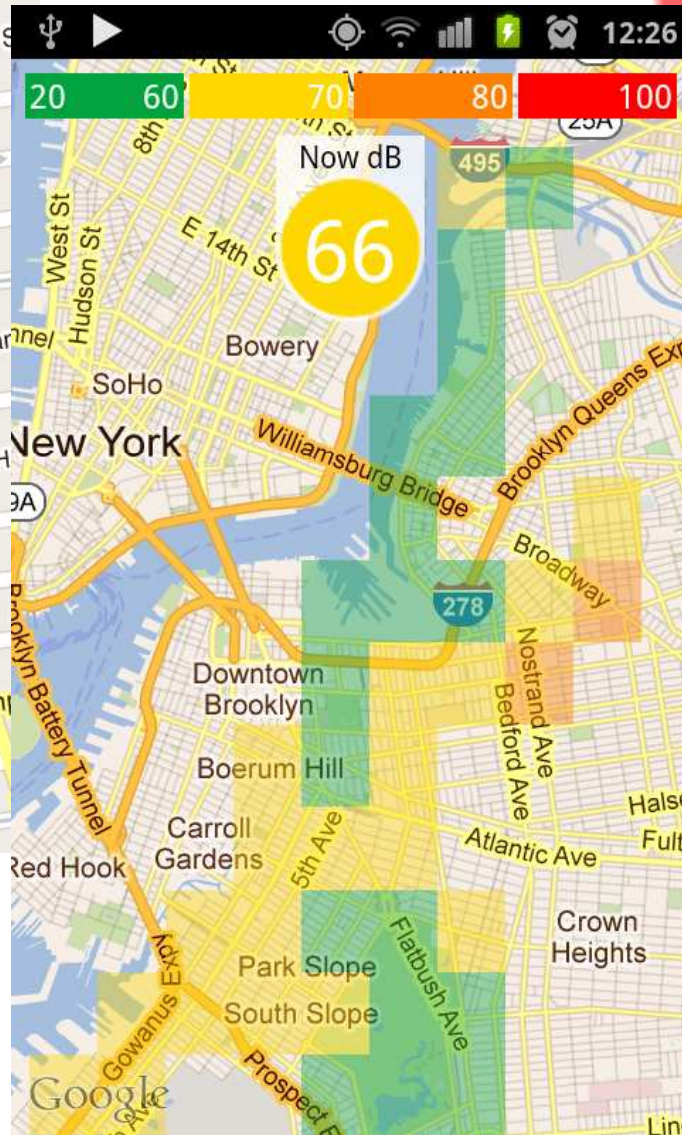
Share Your Air!

Michael Heimbinder, Habitat Map, Brooklyn NY



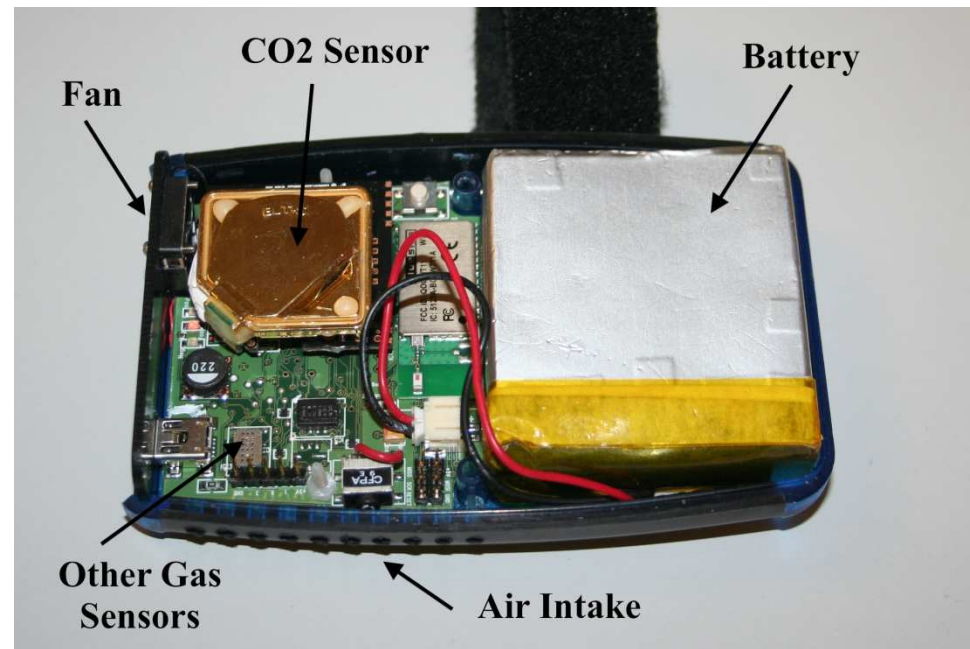


Michael Heim binder,
Habitat Map, Brooklyn NY



M-Pod Components

Mike Hannigan - Univ. of Colorado



Sensor	Gas Measured	Technology
e2v, MICS-2614	Ozone	Metal Oxide Semiconductor
ELT, S100	Carbon Dioxide	Non-Dispersive Infrared
e2v, MICS-5526	Carbon Monoxide, and VOC	Metal Oxide Semiconductor
e2v, MICS-4514	Carbon Monoxide, VOC, and Nitrogen Dioxide	Metal Oxide Semiconductor
Sensirion, SHT21	Temperature, and Humidity	Digital Humidity and Temperature Sensors

How big is it?



Some Specs:

Lifetime on a charge = 10 - 18 hrs

Cost to construct = \$350

Wearable Monitors



Wear Air (*CMU*):
VOC sensor

Let's take it even further...personal monitoring

What if we can monitor our health response to air pollution.....

Advanced Self-Powered Systems of Integrated Sensors and Technologies

Veena Misra

North Carolina State University

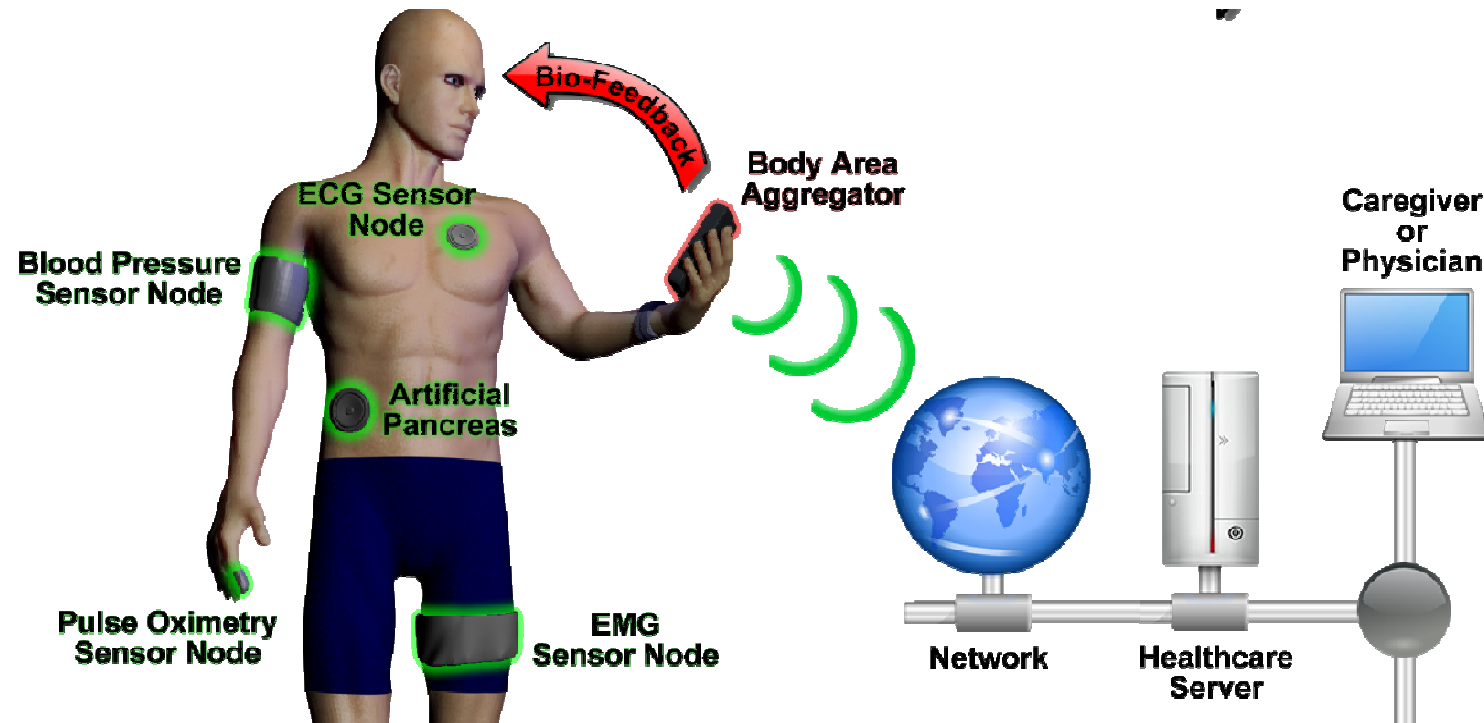
NC STATE UNIVERSITY



東京工業大学
Tokyo Institute of Technology

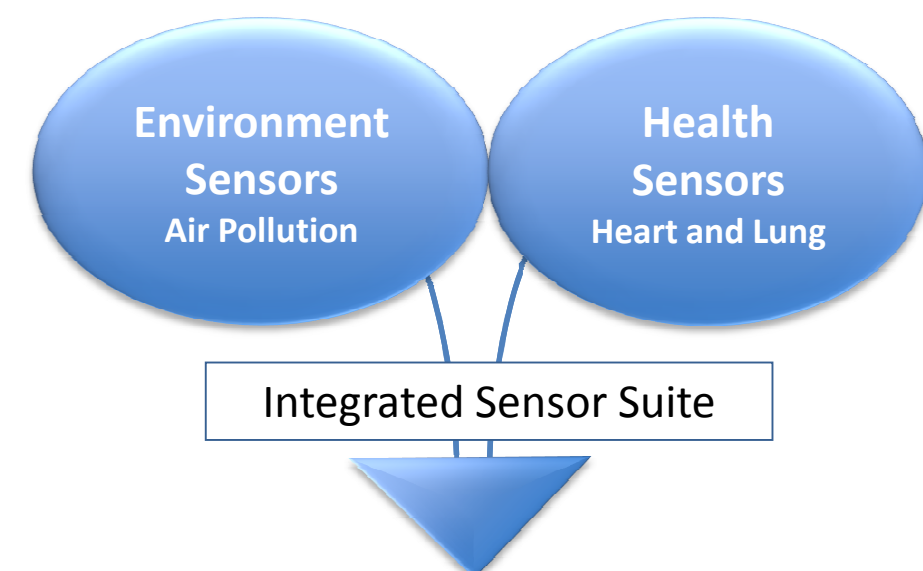


Health response



Courtesy of Veena Misra

Exposure tracking



Application	Body	Environment
Asthma	EKG, EEG, EMG, wheezing, Pulse Ox, Skin- cond, cortisol	NO ₂ , CO, Ozone, VOCs,
Heart Disease		Particulates Noise Heat Stress Light Stress



Long-term monitoring of selected environmental and health parameters

Impact:

- Exposure Sciences
- Chronic Disease
- Health care costs and policy

Courtesy of Veena Misra

Other wearable devices.....



Conscious Clothing –
measuring breathing
rates/volume and heart rates

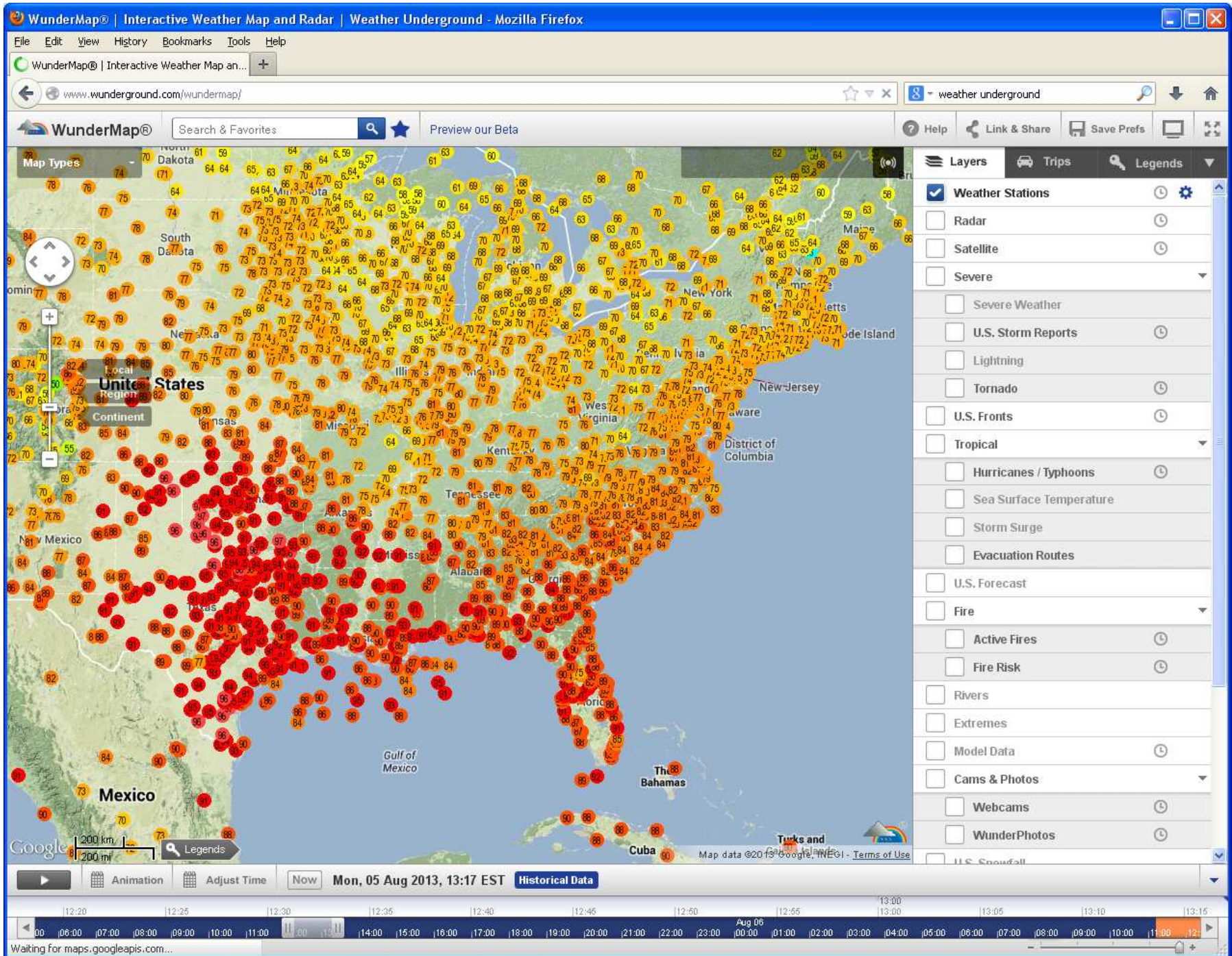
**Winner of My
Health/My Air
contest**

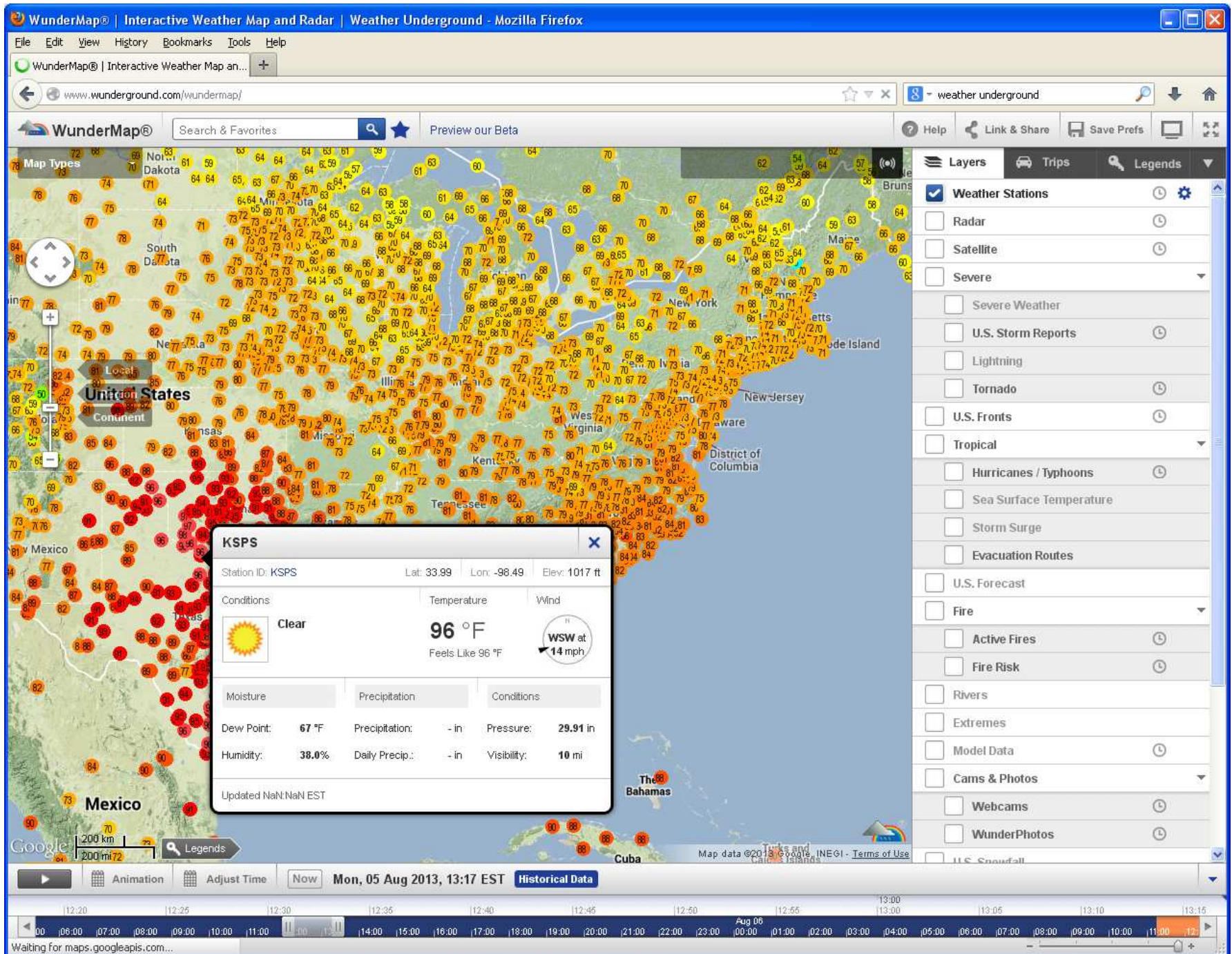
Challenges

- Data Quality
- Sensors for Air Toxics vs Criteria Pollutants
- Levels of detection
 - Fenceline vs Ambient concentrations
- Large data sets
- Health Messaging – what does the data mean?
- Acute Rfc (Inhalation Reference []) values
 - Chronic vs Acute

How can we, EPA, help?

- EPA Hosted NGAM Workshops
- Work with sensor manufacturers
- Community Tool box
 - Acute Rfc values communication
- Sensor Evaluation studies
 - Chamber studies
 - Pilot studies with FRM/FEM's
- Information Clearinghouse websites





In Summary

- Supplement regulatory monitoring programs
- Empower communities
- Enhance source compliance monitoring
- Personal exposures and response monitoring
- A cultural and technological shift is coming and we need to help guide it to become the next generation air monitoring.

Disclaimer

- The contents do not reflect the views or policies of the Agency. The engineering and equipment descriptions contained here are illustrative and mention of trade names or commercial products do not constitute endorsement or recommendation for use.

Websites

- <http://www.epa.gov/research/airscience/next-generation-air-measuring.htm>
- <http://www.citizenair.net>
- <http://communitysensing.org>
- <http://aircasting.org>
- <http://citizensensor.cc>