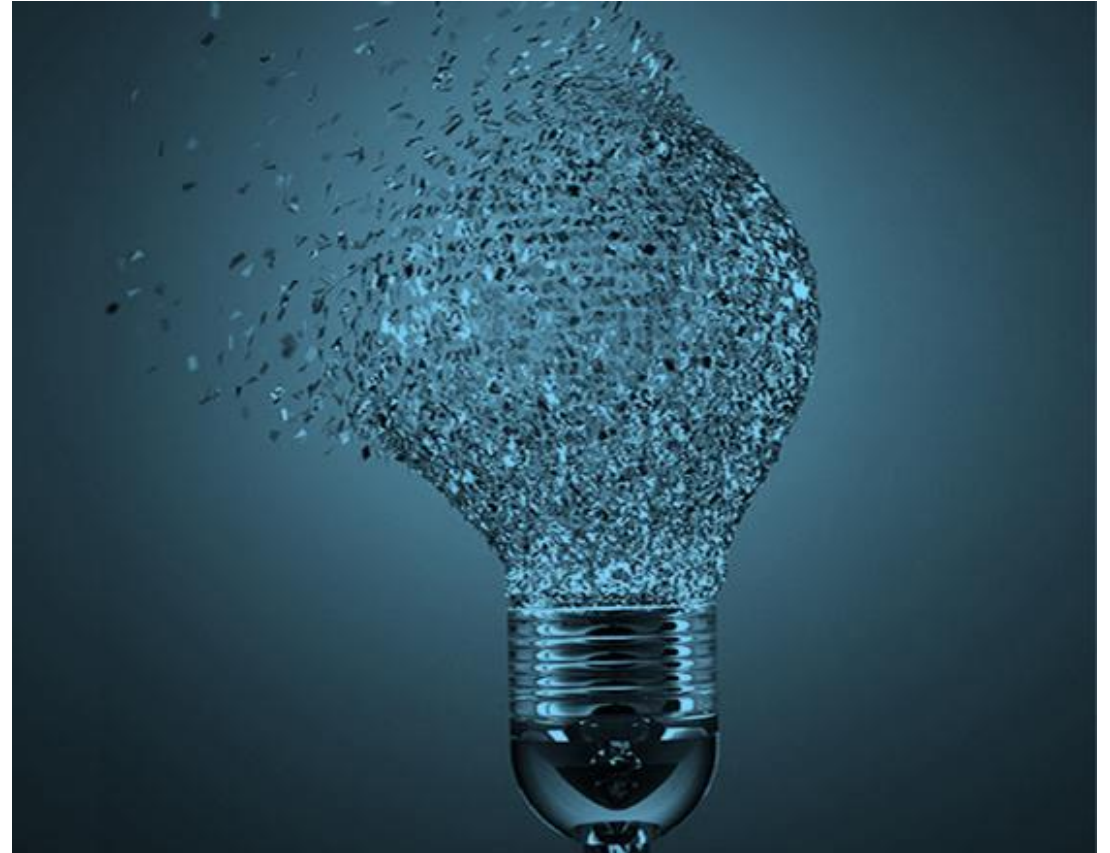


NEXT-GENERATION COMPLIANCE

BETTER, FASTER, CHEAPER

NEXT GENERATION COMPLIANCE

- What can technology offer the regulated entities?
- How do we define next-generation?
- What do we need to move into next generation compliance?
- How can we work with the EPA and other regulators?



WHAT IS NEXT GENERATION COMPLIANCE?

- High resolution data
 - Continuous or semi-continuous measurement
 - Spatially resolved
 - Very low detection limit
- Use data analytics to improve compliance profile, reduce spend on replacement and optimize maintenance



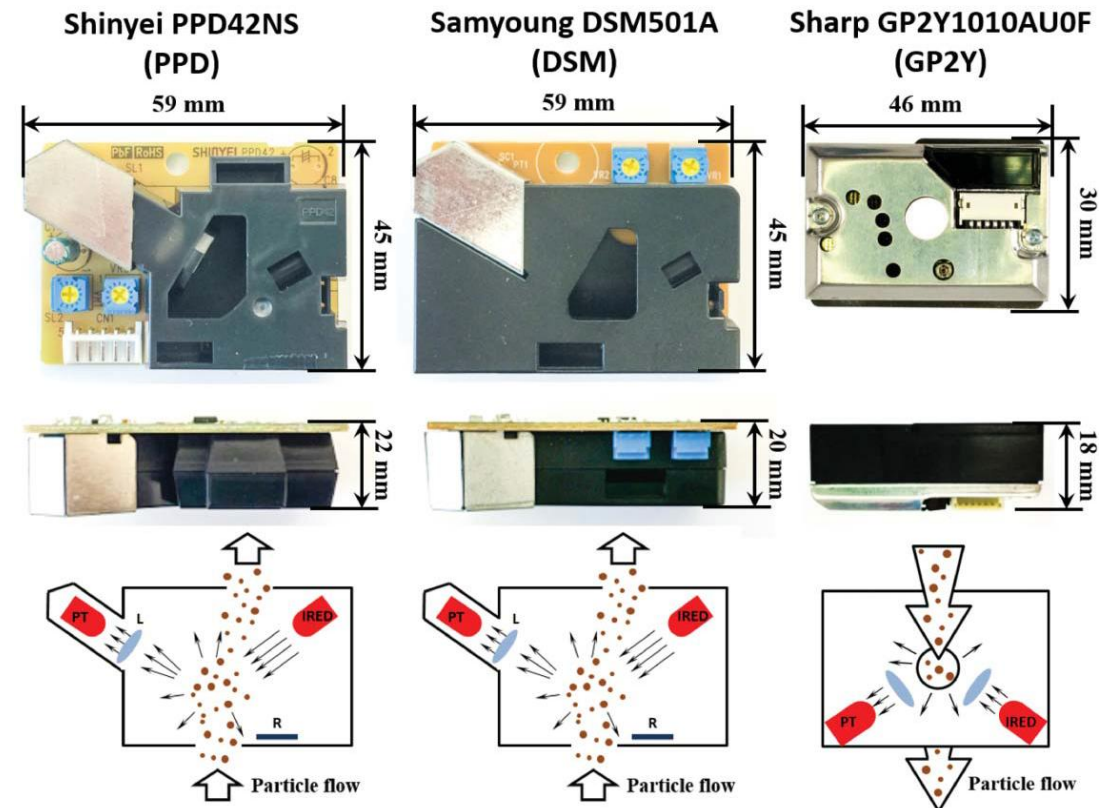
SPATIALLY RESOLVED DATA: OPTICAL REMOTE SENSING

- Truck mounted Solar Occultation Flux (SOF) measurement device
- SOF uses the interference of chemicals in UV light to measure mass of chemical in the column
- Simultaneous wind speed measurements allow an estimate of mass flux through the column
- Downwind measurements used to estimate emissions from entire plant
- Specific locations coupled with wind direction help pinpoint leaking units



MICROSENSORS – SMALL, INEXPENSIVE SENSORS TO MONITOR SPATIAL TRENDS

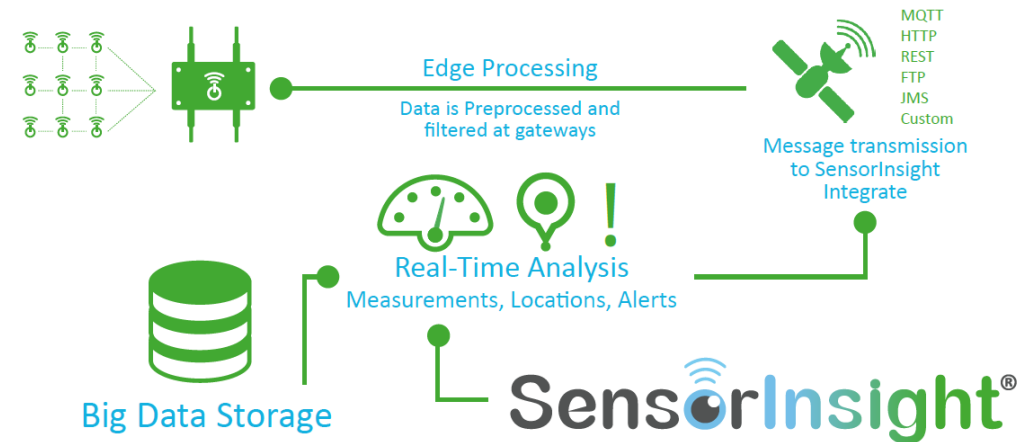
- Current state of the art: 1 – 10 Federal reference methods testing the air quality in a metropolitan area
- New microsensors: Place 10's or 100's or 1000's of sensors across a metropolitan area to better understand microenvironments
 - Microsensors have stability, accuracy and precision issues
 - Numerous types of microsensors on the market
 - EPA on record stating that FRMs required for attainment classification



Source: Wang, Y. et al. Laboratory Evaluation and Calibration of Three Low-Cost Particle Sensors for Particulate Matter Measurement. *Aerosol Science and Technology*, 49:1063–1077, 2015

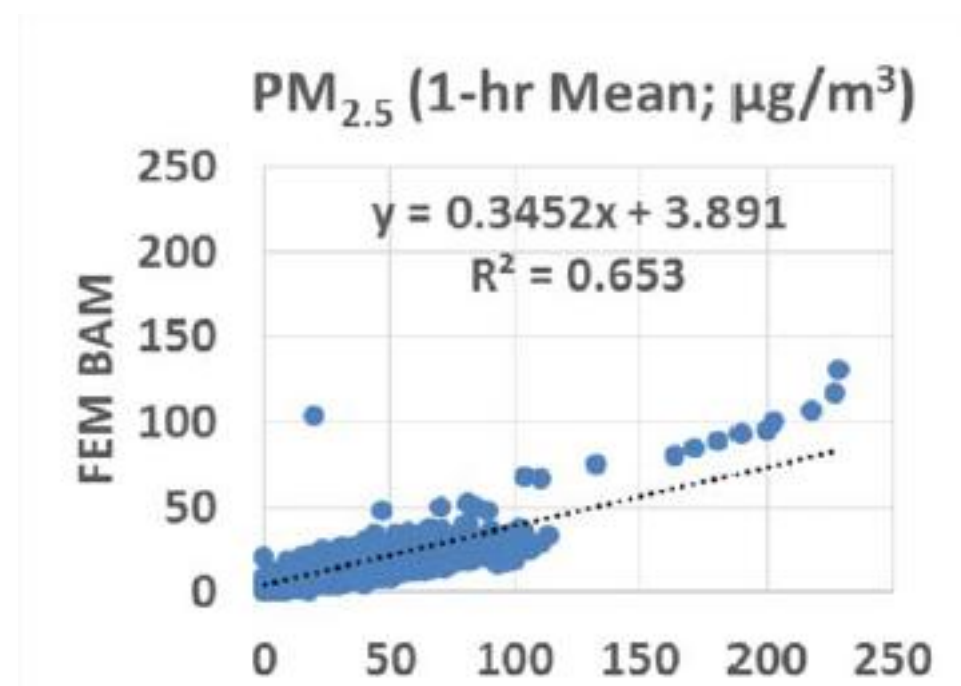
MICROSENSORS – NOT ACTUALLY SO INEXPENSIVE

- The sensor itself costs between \$10 and \$200
- In addition, the sensor has to communicate with the outside world
 - Something to translate the signal into a number
 - I/O device to transmit the signal to a gathering device
 - A gathering device
- The current price of a complete unit is closer to \$500
- Unit lifetime less than two years



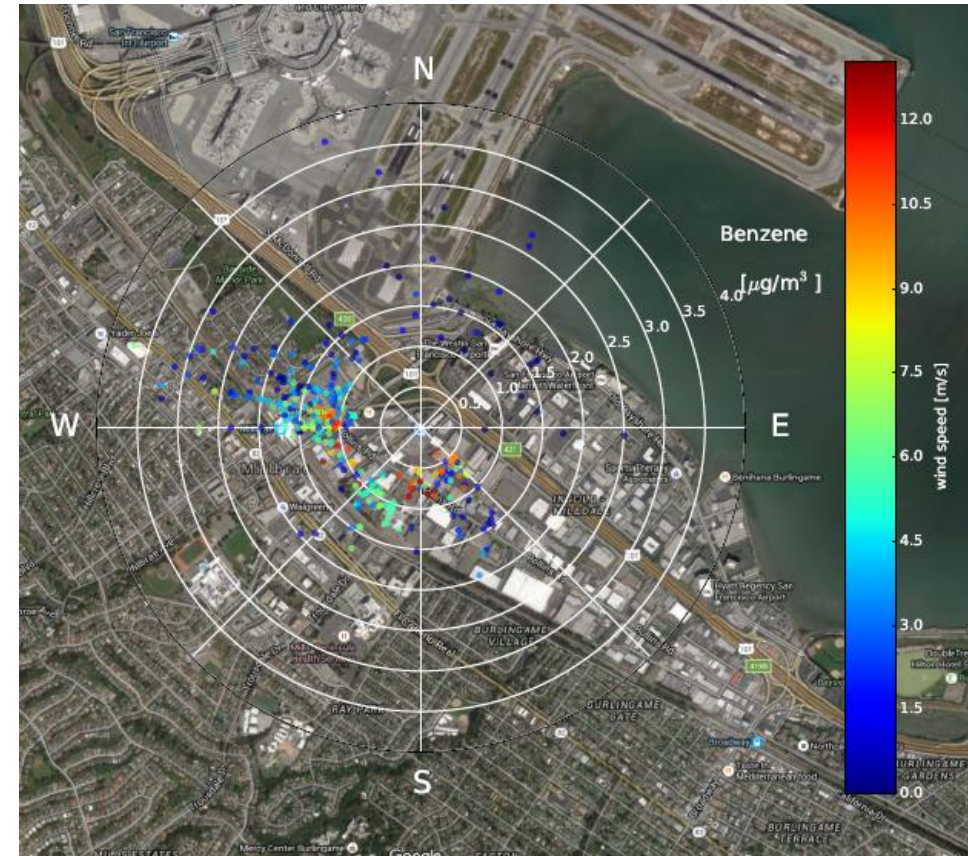
HOW WELL DO THE MICROSENSORS TRACK FRMS?

- Little data on how well the microsensors track federal reference methods (FRMs)
- Microsensors may be impacted by humidity, temperature, co-pollutants, and previous measurements
- Difficult to determine when microsensors will drift, which introduces additional uncertainty
- Recent results indicate wide variability, although good auto-correlation
 - Indicates that the same sensor brands have similar systematic issues

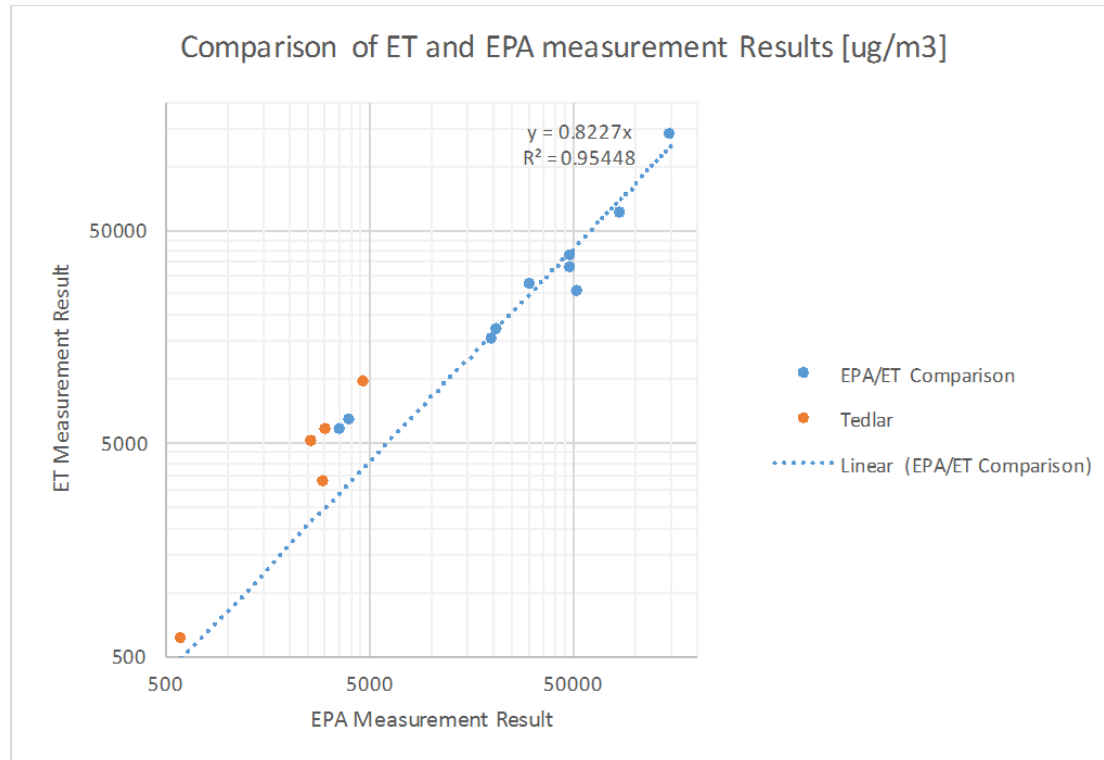


MOBILE INSTRUMENTS TO TRACK TOXIC AIR CONTAMINANTS AT PPT LEVELS

- Enhanced cavity ring-down spectroscopy has detection limits in the part per trillion range for benzene, TCE, and developing others
- Currently takes samples every 10 minutes, with the goal of sampling every minute
- Excellent correlation with EPA methods such as TO-15, with potentially lower detection limits
- Can track airborne plumes or subsurface water contamination



TCE SOIL GAS SIDE BY SIDE WITH ENHANCED CRDS



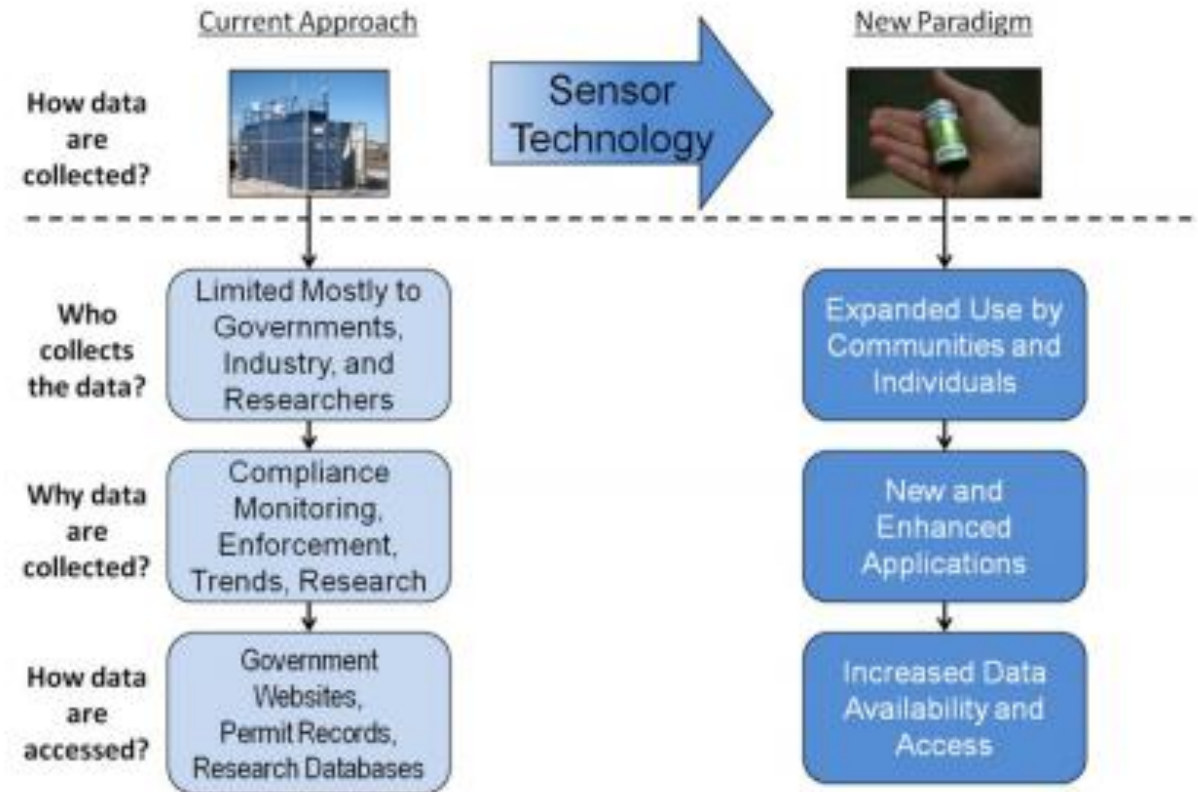
- Measurements performed at contaminated site under EPA supervision
- All samples simultaneous TO-15 (analyzed by EPA Region 9 Laboratory) and E-CRDS
- Excellent agreement over broad dynamic range

ADVANCED MONITORING: ALTERNATIVE OPACITY MONITORING

- EPA Alternative Method 082, Digital Camera Opacity Technique (DOCT), can be used in lieu of EPA Method 9
- Use of a digital camera to capture images of the plume
 - Images are then analysed using software to determine the opacity
 - Location, time stamp allows the determination of sun relative to observer
- DCOT now required by the Ferroalloys NESHAP (final rule issued June 2015)
 - “DCOT is appropriate for the final rule because it provides more objective and better substantiated opacity readings.” FR Vol. 80, No. 125
- Cell phone app for Method 082 enables citizen enforcers

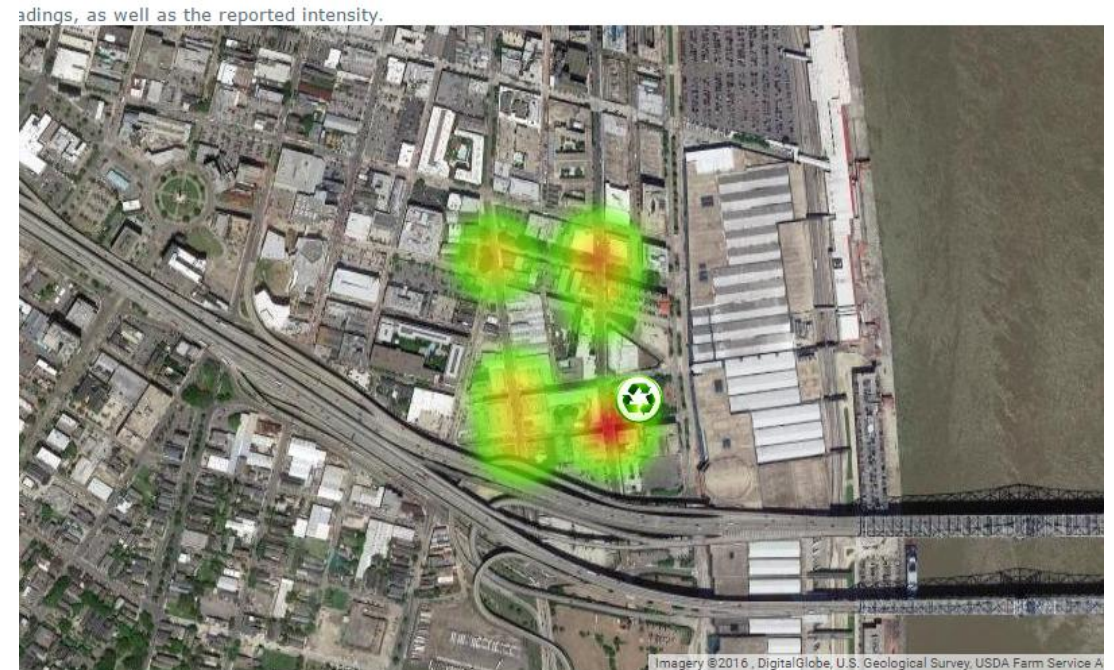
ADVANCED MONITORING: SENSOR SCALE PILOT PROJECT

- Pilot project for communicating instantaneous air quality data
- EPA program testing a new air quality scale that uses data provided by sensors obtaining measurements in short-term increments (as little as one minute)
- Goal is to enable individuals to use this data as an additional tool for planning outdoor activities
- 1-minute ozone and PM data for 7 US cities
- Feedback will be accepted through the end of August 2016
- EPA's goal is to finalize and make the scale available for use with sensors later in 2016



CROWD-SOURCING ODOR MEASUREMENTS

- Cell phone application allows time and location stamp for community odor observers
- Application allows odor gradations (strong, moderate, weak) and odor identification (floral, fishy, garbage)
- Application gathers wind speed, direction for data analysis
- Allows community to understand odor issues and industry to determine specific times and locations of odors



DATA ANALYTICS – HOW DO YOU USE ALL OF THAT DATA?

- Large data sets can help us draw conclusions that may otherwise be difficult to infer
- Increasing sensor technology results in more data to evaluate
- Can large data sets be used to predict ozone episodes and result in time-dependent emissions restrictions?
- Can large data sets reduce testing requirements by using sensor technology to reduce likelihood of failure
 - Sensors in baghouses indicate bag ruptures
 - Can larger data sets predict bag defects?

$$\mathbf{X} = \begin{pmatrix} x_{11} & x_{12} & \dots & x_{1p} \\ x_{21} & x_{22} & \dots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \dots & x_{np} \end{pmatrix} .$$

PARAMETER EMISSIONS MONITORING SYSTEM (PEMS) VS. DATA ENABLED EMISSIONS MONITORING (DEEM)

- PEMS (1990's)
 - Monitor easy to measure parameters to determine emissions and reduce testing requirements
 - Pressure
 - Temperature
 - Flow rate
 - Systems never really worked
 - Insufficient data
 - Unable to show compliance with emissions limits
- DEEM (2020's)
 - Use data analytics and modern sensors to tie emissions to a wide variety of parameters
 - Establish model of emissions based on analytics
 - Reduce need to replace components by more accurately predicting failure rates and modes
 - Minimize expensive source testing

WHAT DO WE NEED TO GET TO NEXT GENERATION COMPLIANCE?