Lessons Learned in implementing the 2015 Ironbound citizen science study

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Ironbound Citizen Science Air Monitoring Project

First project of its kind

Instruments developed by addressing concerns and needs expressed by local organizations

PM & NOx

One week unattended operation

Instruments released to Citizen Monitoring Groups

Citizen groups have custody of instruments

Citizen group determine sampling locations

Training given to Citizen Science groups in basic maintenance and operation of samplers

Data analysis done by EPA-ORD
Ironbound Citizen Science Air Monitors (CSAM) Project

- Developed and designed by EPA-ORD
- Built by ORD’s Contractor
- Supported by EPA R2 DESA
- Data Analysis by EPA-ORD
4 CSAM samplers assembled
Practical Considerations

• Safety
• Getting samplers/monitors “from here to there”
• Ease of assembly & operation
• Stability
• Durability/Ruggedness – “field ready”
• Size and weight
• Instrument Design
• Reliability
• Comparison w/ established reference analyzers
• Level of support (Federal/State/Local)
Safety

Safety of the operator

Time of sampling (day/night)
Location of sampling (traffic, loading/unloading)
Size, weight, & complexity of instrument to be deployed

Safety of the public

Tripping hazards
Falling hazards
Electrical or moving parts hazards

Safety of the monitor/sensor

Theft/vandalism
Rain/Snow/Cold/Heat
Field ruggedness
Getting Samplers/Monitors “From Here To There”

CSAM Arrival
@ Edison, NJ
Getting Samplers/Monitors “From Here To There”

Boxes unpacked.

4 complete CSAM units.

Note lack of boxes/containers to transfer samplers to contractors (ICC) or to ship samplers from site to site.
Ease of Assembly

4 CSAM samplers assembled.
Video of Lack of Tripod Stability. Mouse Over the Picture and Press Play
Pelican 1660 cases

5/8" marine plywood, sanded, painted, with added mounting hardware and handhold cutouts (4 units)
Inside view of Pelican 1660 cases
Inside view of one Pelican 1660 cases

Sampler Case

Battery Case

Tool kit

Batteries

Tripod mounting hardware

R2 DESA Solution Addressing Sampler Transport & Stability
R2 DESA Solution Addressing Sampler Transport & Stability

Tool kit contents
R2 DESA Solution Addressing Sampler Transport & Stability

4 CSAM samplers in van, out for delivery
Size & Weight

CSAM + Case = 90+ pounds

Bulky tripod – poor materials and workmanship

2nd story work or stair climbs would be dangerous with one person operation
Durability/Ruggedness

CSAM sensors arrived with:
- broken parts,
- bent electronic pins,
- loose screws,
- missing/loose standoffs
Durability/Ruggedness

Broken Parts
Loose Screws
Durability/Ruggedness

Loose standoff
Loose pump cutoff switch
Durability/Ruggedness

Missing Standoff
Durability/Ruggedness

Missing standoff screw
Arduino board loose & bouncing around sampler
Arduino board loose & bouncing around sampler
R2 DESA Repairs for Durability/Ruggedness
Cable tie to secure SS tee that was knocking Arduino board off its mounting pins.

Installation of retaining rings to secure Arduino board.
Note misaligned particulate sampler/sharp cut cyclone head for particulate monitoring.
Note misaligned particulate sampler/sharp cut cyclone head for particulate monitoring.
Closeup of misaligned particulate counter/sharp cut cyclone head for particulate monitoring.

All 4 samplers arrived misaligned and would not stay aligned with even small amounts of movement or transport.
NO₂ Sensor

Dead Volume

Instrument Design
Installation of mounting bracket to ensure stable coupling of the particulate counter and the sharp cut cyclone.
Detail of installed mounting bracket.
SKC Certificate of Compliance

This certificate certifies that the equipment listed below is in accordance with factory specifications.

SKC testing equipment is traceable to NIST Standard number 82100005965.

Description: AirChek Sampler
Model Number: 224-52
Serial Number: A116546

Date of Service: 28-May-99

Scott Marshall
Quality Assurance Administrator
ASQ-CQA
Reliability

CSAM #4 Particulate Matter Flow @ Jan 29, 2015
Immediately Prior to Initial Deployment

Average Flow = 1569.4 cc/min
Standard Deviation = 3.436 cc/min
Reliability

CSAM #4 Particulate Matter Flow @ March 10, 2015
Prior To Pump Replacement

Average Flow = 2061.67 cc/min
Standard Deviation = 397.732 cc/min
During the course of the study, pumps were replaced 7 times. There were only 4 samplers in the study. Pumps either had unreliable flow, intermittent flow, or stopped altogether.

DNU = Do Not Use
Checking voltages after a pump failed to start. Problem linked to poor connector contact at pump.
Bench testing CSAM samplers overnight.
Comparison w/ Established Reference Analyzers & Standards

Flow Measurements

NO$_2$ measurements

R$_2$ DESA conducted Reference and Equivalent Methods Comparison at NJDEP Ncore station
R2 DESA Comparison w/ Established Reference Analyzers & Standards
NO2 Measurements
<table>
<thead>
<tr>
<th>CSAM UNIT #1</th>
<th>Contractor Determined Zero &amp; Span Points</th>
<th>EPA R2 Determined Zero &amp; Span Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero/Low Voltage</td>
<td>39.42 mV</td>
<td>252.34 mV</td>
</tr>
<tr>
<td>Zero/ Low Setpoint</td>
<td>0 ppb</td>
<td>0 ppb</td>
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<tr>
<td>Span Voltage</td>
<td>2999 mV</td>
<td>4743.36 mV</td>
</tr>
<tr>
<td>Span Set Point</td>
<td>231 mV</td>
<td>188 ppb</td>
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</table>

<table>
<thead>
<tr>
<th>CSAM UNIT #2</th>
<th>Contractor Determined Zero &amp; Span Points</th>
<th>EPA R2 Determined Zero &amp; Span Points</th>
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<tbody>
<tr>
<td>NO2</td>
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<td></td>
</tr>
<tr>
<td>Zero/Low Voltage</td>
<td>42.31 mV</td>
<td>117.02 mV</td>
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<tr>
<td>Zero/ Low Setpoint</td>
<td>0 ppb</td>
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<td>Span Voltage</td>
<td>2711 mV</td>
<td>4796.28 mV</td>
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<tr>
<td>Span Set Point</td>
<td>231 ppb</td>
<td>188 ppb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CSAM UNIT #3</th>
<th>Contractor Determined Zero &amp; Span Points</th>
<th>EPA R2 Determined Zero &amp; Span Points</th>
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<tbody>
<tr>
<td>NO2</td>
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<td></td>
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<tr>
<td>Zero/Low Voltage</td>
<td>67.44 mV</td>
<td>138.35 mV</td>
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<td>Zero/ Low Setpoint</td>
<td>0 ppb</td>
<td>0 ppb</td>
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<tr>
<td>Span Voltage</td>
<td>1307 mV</td>
<td>4861.71 mV</td>
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<tr>
<td>Span Set Point</td>
<td>231 ppb</td>
<td>188 ppb</td>
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</table>

<table>
<thead>
<tr>
<th>CSAM UNIT #4</th>
<th>Contractor Determined Zero &amp; Span Points</th>
<th>EPA R2 Determined Zero &amp; Span Points</th>
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<tbody>
<tr>
<td>NO2</td>
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<tr>
<td>Zero/Low Voltage</td>
<td>36.75 mV</td>
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<td>Zero/ Low Setpoint</td>
<td>0 ppb</td>
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<tr>
<td>Span Voltage</td>
<td>2923 mV</td>
<td>4714.54 mV</td>
</tr>
<tr>
<td>Span Set Point</td>
<td>231 ppb</td>
<td>188 ppb</td>
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</table>

Note difference in span voltages between the contractor determined vs. EPA determined NO2 sensor voltages.
4 CSAM samplers were deployed on the roof of NJDEP’s Ncore station at the Clinton Avenue Firehouse in Newark, NJ.
CSAM Flow Rates During Ncore Collocation Study
(4/7 - 4/14, 2015)

<table>
<thead>
<tr>
<th>Date</th>
<th>CSAM #1</th>
<th>CSAM #2</th>
<th>CSAM #3</th>
<th>CSAM #4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow on Arrival @ Newark Ncore Station (L/min)</td>
<td>Flow on Departure @ Newark Ncore Station (L/min)</td>
<td>Flow on Arrival @ Newark Ncore Station (L/min)</td>
<td>Flow on Departure @ Newark Ncore Station (L/min)</td>
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<td>4/7/2015</td>
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<td>1.5</td>
<td>3.3</td>
<td>1.5</td>
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<tr>
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<td>1.5</td>
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<td>1.5</td>
<td>0.0</td>
<td>1.3</td>
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<tr>
<td>4/14/2015</td>
<td>1.5</td>
<td>0.0</td>
<td>1.5</td>
<td>0.0</td>
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CSAM Units 2 & 4 consistently showed zero flow when we arrived at the station. Resetting and/or adjusting the pump set screw would result in an acceptable flow rate. We would then depart the station. The next time we would arrive at the station, the flow would again be zero for CSAM 2 & 4.
Level of Support

R2 DESA dedicated hundreds of staff hours to make this study succeed.

This was partially due to:

• Citizen Science organization sampler requirements (Particulates, NOx, 1 week unattended operation)
• Custom designed samplers
• Contractor assembly
Practical considerations are critical in the success or failure of any citizen science study.

If possible, use off the shelf and established instruments/sensors with proven track records. This will eliminate “teething pains” with unique instrumentation from vendors/contractors with limited or costly manufacturing and support capabilities.

Comparison with reference sensors/analyzers is critical for drawing conclusions from the ambient data collected. If possible collocate with reference instruments at monitoring stations operated by State/Local agencies.

A successful project requires dedicated resources. Resources for maintenance and operational support need to be built into project planning considerations.