AIR QUALITY COMMUNITY ACTION NETWORK (AQ-CAN)

MICHAEL OGLETREE
AIR QUALITY PROGRAM MANAGER
DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT
CITY & COUNTY OF DENVER
SEPTEMBER 19, 2018
AGENDA

• Benefits/challenges of air sensors
• Current status CDPHE + DDPHE
• Why?
• Phase 1 & Phase 2
  • Lunar Outpost – Technology Presentation
• Network diagram/description
• Data - state vs sensor collocation
• Data - triplicate sensor collocation
• Data – adjustment factors
SENSORS VS REFERENCE INSTRUMENTS

• Benefits
  • Lower cost
    • About 1/10 the cost
  • Potential for greater density of network
    • Small footprint
    • Solar/battery + cellular communication
  • Hyper-local data set
    • Actionable

• Challenges
  • Data quality
  • Data management
  • Data communication
  • Resources to manage servicing of the network once deployed
STATE MONITORING NETWORK (CDPHE)

• Currently 5 regulatory sites run by CDPHE in City & County of Denver (CCD) boundary
  • I-25 Globeville
  • LaCasa
  • CAMP
  • National Jewish Health
  • I-25 Denver
  • 31 per square mile density
AIR QUALITY COMMUNITY ACTION NETWORK (AQ-CAN)

• Currently 12 sensors deployed
• PM1, PM2.5, & PM10*

• Current locations
  • State sites
  • Construction sites
  • Schools
    • Swansea Elementary
    • Garden Place Academy
    • Fairview World School

• With state sites density of 9 per square mile
WHY DEPLOY SENSORS AT SCHOOL IN DENVER?

• Reduce inequitable exposure to poor air pollution to public school children in Denver

• Denver families spend an average of $3,100 a year on asthma-related medical costs, resulting in more than $30 million spent annually.

• The City of Denver will use cutting-edge air pollution sensor technology to create a city-wide air quality monitoring program at public school buildings, resulting in better informed policy decisions using environmental, health, and economic data.
PHASE 1 (FEB 20 – AUG 20, 2018)

- $100,000 budget
- 10 Schools
  - 3 Tests: Behavior change, Buy-in, Data communication
- Development of sensor technology with local aerospace engineering start up Lunar Outpost
- Development of air sensor platform with TD Environmental
- Collaboration with Bloomberg Philanthropies
  - Frog Design – Mayo Nissen – Innovation Coach
  - Delivery Associates – Minza Zahid – Implementation Coach
  - UsCreates – Experience design consultants
- Primary stakeholder collaboration with Denver Public Schools
PHASE 2 (JAN 2019 – DEC 2021)

• $1 - $5 million budget
• 40+ DPS Schools
  • Elementary, Middle, High
• $8k budget for each school to use for programming
• Menu of options for reducing exposure of kids as well as limiting local sources of pollution
  • Anti-idling
  • Walking school buses
  • Education
  • Behavior change
• Reduce asthma incidents at DPS schools leading to improved live long health and economic benefits for DPS families
LUNAR OUTPOST

The Next Leap
Our mission is to develop technology that enables a presence on the Lunar surface, while creating Earth analogs that drive innovation and have positive impact.
Lunar Outpost uses developed technologies in terrestrial markets
1. These technologies fill an immediate need and have a positive impact
2. Drive near-term revenue generation

Current Terrestrial Application: Air Quality (AQ) Monitoring IOT Sensor Technologies
Commercial Products

Air Quality Systems

Canary-E  Canary-S  Canary-X
### Flexibility ingrained into product lines

#### Canary-E
- POE
- Data flexibility ->
- System health info ->
- Watchdog enabled ->
- On-board storage ->

#### Canary-S
- Solar option ->
- Cellular, any network
- Very low power
- GPS ->
- Encrypted data ->

#### Canary-X
- Cellular, WiFi, Bluetooth, POE
- Walk up interface
- Optimized airflow
- Higher resolution gas sensors

---

**Base Model:** PM1, 2.5, 10, temperature and humidity

-> means applicable to next tier

---

**Big Boi**

Additional sensors: VOC, CO, Ozone, NO2, H2S, and custom packages
Base Model Sensors

• Redundant Particulate Matter
  – PM1.0, 2.5, and 10
  – Binning 0.3-1.0, 1.0-2.5, 2.5-10
  – Efficiency 98%>= 0.5um

• Temperature
  – -40-80C +/- 0.5C

• Humidity
  – 0-100 +/-2% RH
Additional Sensors

• **Gases – ppb resolution**
  • Total VOC (PiD) (0.5 ppb)
    – Ozone
    – NO₂
    – H₂S
    – CO
Additional Sensors

• Ultrasonic Anemometer
  – **Wind Speed:** 0 to 75 m/s (0 to 168 mph)
    Resolution: 0.01 m/s
    Accuracy: ± 2% ± 0.1 m/s (30 m/s), ± 3% (75 m/s)
  – **Wind Direction:** 0 to 360 degrees
    Resolution: 0.1 degree
    Accuracy: ± 2 degrees
Performance

• **Size**
  – 7x6x8.5in
  – <5lb

• **Power**
  – 72 hour battery life (Canary-S)
  – Power over Ethernet (PoE) (Canary-E)

• **Communication**
  – 2G/3G, 4G LTE upcoming (Canary-S)
  – 256 bit Advanced Encryption Standard

• **Data**
  – Database agnostic
  – Message 1/min
Fenceline Monitoring

• Anemometer + Sensor = Source Triangulation
THANK YOU

Julian Cyrus – COO
(973) 738–3885
julian@lunaroutpost.com
TESTING NETWORK DESCRIPTION

Reference Instrumentation
- I-25 Globeville
  - Grimm EDM 180
- LaCasa
  - Grimm EDM 180
- National Jewish Health
  - Teledyne API 640

Sensors
- I-25 Globeville
  - Canary-S v1.0
  - Deployed in triplicate
  - CS2, CS3, & CS4
- LaCasa
  - Canary-S v1.0
  - CS5
- National Jewish Health
  - Canary-S v1.0
  - CS1
COLLOCATION (GRIMM) ~50 DAYS – 1HR AVG

Grimm vs Canary-S

y = 1.5192x + 0.4123
R² = 0.8831
COLLOCATION (T640) ~40 DAYS – 1 HR AVG

T640 vs Canary-S

y = 1.1032x - 0.1663
R² = 0.8514
Triplicate Collocation ~31 Days – 1 HR AVG

y = 0.9578x - 0.3343
R² = 0.9901

y = 1.0152x - 0.5709
R² = 0.9973

y = 1.0382x - 0.0193
R² = 0.9878
### Data Correction - Multivariable Regression

#### Grimm (LaCasa) vs. Canary-S (CS5)

- **Equation:** \( y = 1.6293x + 0.7712 \)
- **\( R^2 \):** 0.7988

#### Canary-S (CS5) adjusted vs. Grimm (LaCasa)

- **Equation:** \( y = 1.0292x + 0.2889 \)
- **\( R^2 \):** 0.9084

### Reference To Compare

<table>
<thead>
<tr>
<th>PM2.5 Total Atmospheric (La Casa NCORE)</th>
<th>Adjustment Sensor 1</th>
<th>Adjustment Sensor 2</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>humidity (La Casa Collo (CS5))</td>
<td>tempf (La Casa Collo (CS5))</td>
<td></td>
</tr>
<tr>
<td>x1Coeff</td>
<td>x2Coeff</td>
<td>x3Coeff</td>
<td>Intercept</td>
</tr>
<tr>
<td>23</td>
<td>0.35736079</td>
<td>-0.01726246</td>
<td>-0.13366448</td>
</tr>
<tr>
<td>21</td>
<td>0.48861630</td>
<td>0.00636227</td>
<td>-0.12068125</td>
</tr>
<tr>
<td>19</td>
<td>0.49186459</td>
<td>0.00347038</td>
<td>-0.12531322</td>
</tr>
<tr>
<td>17</td>
<td>0.49186459</td>
<td>0.00347038</td>
<td>-0.12531322</td>
</tr>
<tr>
<td>16</td>
<td>0.49186459</td>
<td>0.00347038</td>
<td>-0.12531322</td>
</tr>
<tr>
<td>15</td>
<td>0.48926374</td>
<td>0.00562000</td>
<td>-0.12167970</td>
</tr>
</tbody>
</table>

(Mockup)
WHAT’S NEXT?!

Continue working with schools to identify air pollution patterns and put programs in place to reduce exposure and reduce local pollution sources.

Continue refine the sensor technology and work with the data platform developer on ways to correct data utilizing regional reference instrumentation.

Win the grand prize of $5 million in October. Scale to encompass the schools within Denver that are most impacted by air pollution.
THANKS!

For more info contact:
Michael Ogletree
Air Quality Program Manager
Denver Dept. of Public Health & Environment
Michael.Ogletree@DenverGov.org