AQ-SPEC
Air Quality Sensor Performance Evaluation Center
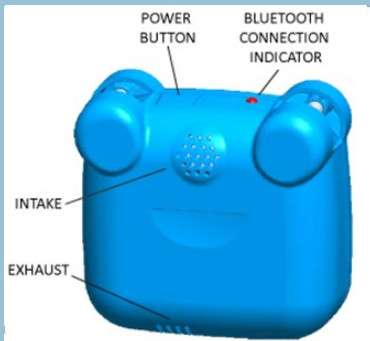
POWER BUTTON
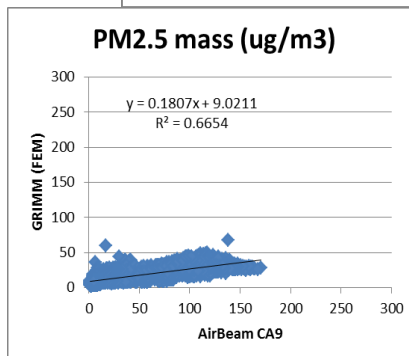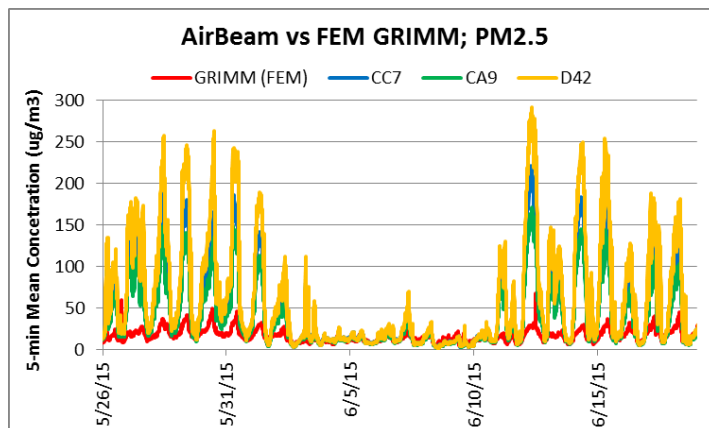BLUETOOTH CONNECTION INDICATOR
INTAKE
EXHAUST

Evaluation Summary

- Overall, the three AirBeam sensors showed very low accuracy, compared to FEM GRIMM for a concentration range between 0 to 50 μg/m³. When GRIMM PM$_{2.5}$ mass conc. exceeded 50 μg/m³, AirBeam sensors plateaued at a concentration reading of 300 μg/m³.

- The AirBeam sensors exhibited good precision during various T-RH combinations at low PM$_{2.5}$ concentration.

- The AirBeam sensors showed substantial intra-model variability.

- Data recovery was 100% from all units.

- For PM$_{2.5}$ mass conc., the AirBeam sensors moderate to strong correlations with the FEM GRIMM from both the field (R² ~ 0.65-0.70) and laboratory studies (R² > 0.87).

- The three sensors carried the March 2015 AirBeam firmware

Field Evaluation Highlights

- Deployment period 04/30/2015 - 06/19/2015: the three AirBeam sensors had an average coefficient of determination R² of 0.66, compared to the PM$_{2.5}$ mass concentration monitored by FEM GRIMM.

- The units showed > 99% data recovery, but substantial intra-model variability.

AirBeam vs FEM GRIMM; PM2.5

PM2.5 mass (ug/m3)

$y = 0.1807x + 9.0211$
$R^2 = 0.6654$

Coefficient of Determination (R²) quantifies how the three sensors followed the PM concentration change by FEM.

An R² approaching the value of 1 reflects a near perfect agreement, whereas a value of 0 indicates a complete lack of correlation.

Laboratory Evaluation Highlights

Accuracy

$$A\,(\%) = 100 - \frac{|\overline{X}-\overline{R}|}{\overline{R}} * 100$$

Steady State (#)	Sensor mean (µg/m³)	FEM GRIMM (µg/m³)	Accuracy (%)
1	147.9	11.5	-1086
2	243	25.4	-757
3	296.2	48.7	-408

When GRIMM $PM_{2.5}$ exceeded 50 µg/m³, AirBeam sensors plateaued at their maximum reading of 300 µg/m³.

Accuracy was evaluated by a concentration ramping experiment at 20 °C and 40%. The sensor's readings at each ramping steady state are compared to the reference instrument.

Negative % means sensors' overestimation by more than two fold. The higher the positive value (close to 100%), the higher the sensor's accuracy.

Precision ($PM_{2.5}$)

Low Concentration

Relative Humidity ■ 15% ■ 40% ■ 65%
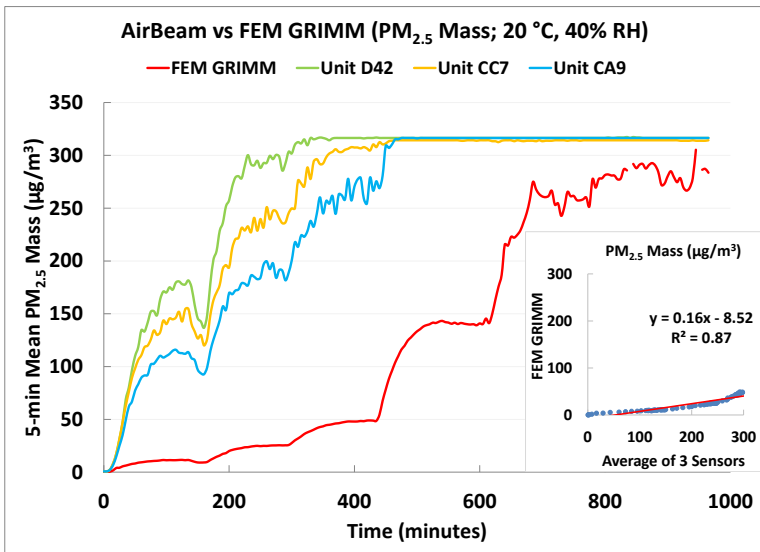
(bar chart: 35 °C, 20 °C, 5 °C vs PRECISION (%) from 95 to 100)

- Overall, the three AirBeam sensors showed good precision for almost all combinations of T and RH at low $PM_{2.5}$ concentration.
- At medium to high GRIMM $PM_{2.5}$, sensors' precision could not be estimated, because the sensors were only reporting their maximum measurement value of 300 µg/m³.

100% represents high precision.

Sensor's ability to generate precise measurements of ozone concentration at low, medium, and high pollutant levels were evaluated under 9 combinations of T and RH, including extreme weather conditions like cold and dry (5 °C and 15%) cold and humid (5 °C and 65%), hot and humid (35 °C and 65%), or hot and dry (35 °C and 15%).

Coefficient of Determination

AirBeam vs FEM GRIMM ($PM_{2.5}$ Mass; 20 °C, 40% RH)

— FEM GRIMM — Unit D42 — Unit CC7 — Unit CA9

(graph: 5-min Mean $PM_{2.5}$ Mass (µg/m³) vs Time (minutes))

(inset: $PM_{2.5}$ Mass (µg/m³), FEM GRIMM vs Average of 3 Sensors, y = 0.16x - 8.52, R^2 = 0.87)

The three AirBeam sensors showed strong correlations with the corresponding FEM $PM_{2.5}$ data (R^2 = 0.87) at 20 °C and 40% RH from 0 - 50 µg/m³.

For count conc. ramping experiment results, please see full length lab reports.

Climate Susceptibility

From the laboratory studies, temperature and relative humidity had minimal effect on the AirBeam performance.

Observed Interferents

N/A