New Air Quality Measurement Method: Low-Cost Sensors on UAV’s

Jasper H. Bowles¹, Avinash M. Krishnan², Marc D. Compere², Kevin A. Adkins³, Marwa M.H. El-Sayed¹

¹ Department of Civil Engineering, Embry-Riddle Aeronautical University
² Department of Mechanical Engineering, Embry-Riddle Aeronautical University
³ Department of Aeronautical Science, Embry-Riddle Aeronautical University

Abstract

- Air pollution is a global concern due to its detrimental impacts on humans and the environment. However, detecting atmospheric pollutants is costly and time-intensive.
- The Environmental Protection Agency (US EPA) utilizes filter-based, stationary techniques to measure ground-based particulate matter (PM) in the atmosphere.
- The development of low-cost sensors has helped in combatting the high cost associated with achieving these measurements.
- Low-cost sensors are light, small, still allowing for measurements of atmospheric pollutants.
- We propose placing low-cost air quality sensors on Unmanned Aerial Vehicles (UAVs).
- Sampling will be conducted seasonally in diverse areas, and PM concentrations will be compared to those using the EPA’s methods.

Introduction

- The EPA measures harmful atmospheric pollutants, named as criteria pollutants, namely: ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, lead, and PM.
- Criteria pollutants are measured in over 4000 locations (Figure 2) in the US by regulated EPA collection devices.
- These collection devices are operated and maintained by state agencies to determine compliance with National Ambient Air Quality Standards (NAAQS).

Objective

- Goal: Develop the technology for placing low-cost sensors on UAV’s while achieving reliable measurements for all criteria pollutants.
- Motivation: Detect PM and other criteria pollutants at various elevations in diverse areas (remote and congested cities).

Methodology Development

Site Selection

- Flights are conducted at three sites, namely: Daytona Beach (Suburban), Coe Field (Rural), and Orlando (Urban) (Figure 4).
- Diverse sites allow for contrasting PM concentration measurements at different geographical points.

- Daytona Beach (Suburban)
- Coe Field (Rural)
- Orlando (Urban)

Selection of Low-Cost Sensors

- Three air quality low-cost sensors are selected for comparison:
  - (1) PMS7003, (2) SDS011, and (3) OPC-N2.

<table>
<thead>
<tr>
<th>Air Quality Low-Cost Sensors</th>
<th>PMS 7003</th>
<th>SDS011</th>
<th>OPC-N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>30</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Price ($)</td>
<td>24.97</td>
<td>29.99</td>
<td>39</td>
</tr>
<tr>
<td>Dimensions (mm)</td>
<td>48 x 37 x 12</td>
<td>71 x 70 x 23</td>
<td>75 x 60 x 63.5</td>
</tr>
<tr>
<td>Accuracy (µs/100)</td>
<td>0.83-0.89</td>
<td>0.87-0.9</td>
<td>0.84</td>
</tr>
<tr>
<td>Power Supply Voltage (V)</td>
<td>4.5-5.5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Working Current (mA)</td>
<td>&lt;100</td>
<td>220</td>
<td>180</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>1 year</td>
<td>1 year</td>
<td>1 year</td>
</tr>
</tbody>
</table>

Future Work

- Trial flights for the OPC-N2 and Vaisala AQ4000 sensors will commence in January 2021.
- Collocation of different air quality sensors will take place to test the performance of other sensors as well.

Acknowledgments

We would like to thank the EPA for providing their data to the public as well as ERAU for funding this research.

References
