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Viability and Application of Mounting Personal PID VOC Sensors to Small Unmanned Aircraft Systems

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Marcham, C.L., Burgess, S.S., Cerreta, J., Clark, P.J., Solti, J.P., Breault, B., & Marcham, J.G. (2021). Viability and application of mounting personal PID VOC sensors to small unmanned aircraft systems. *Collegiate Aviation Review International, 39*(1),1-24. http://ojs.library.okstate.edu/osu/index.php/CARI/article/view/8083/7440

Small Unmanned Aerial Systems in Emergency Response

- Current sUAS Uses
  - Search and rescue
  - Thermal imaging
  - Evaluating structural stability
  - Spread of wildfires
  - Storm damage

Small Unmanned Aerial Systems in Emergency Response

- Crash Sites/Chemical Spills
  - Unknown exposures require full protection for responders until airborne concentrations can be characterized (using direct reading hand-held instruments)
  - Why not send in sUAS instead?

Research Opportunities

Interdisciplinary approach between Department of Flight and Graduate Studies/Occupational Safety Management teams

Provided a graduate student and an undergraduate student the opportunity for research

Research Questions

Is it possible to remotely evaluate potential emergency responder exposures using sUAS, or does the rotor wash from the sUAS cause too much interference?

What is the optimal configuration of mounting the VOC sensor on the sUAS to obtain accurate exposure data?

Air Monitoring Equipment Used

ION Cub personal VOC detector, with a 10.6 eV PID lamp and datalogger

sUAS Platforms Used

DJI Inspire 1 with Ion Cub PID attached with a short tether

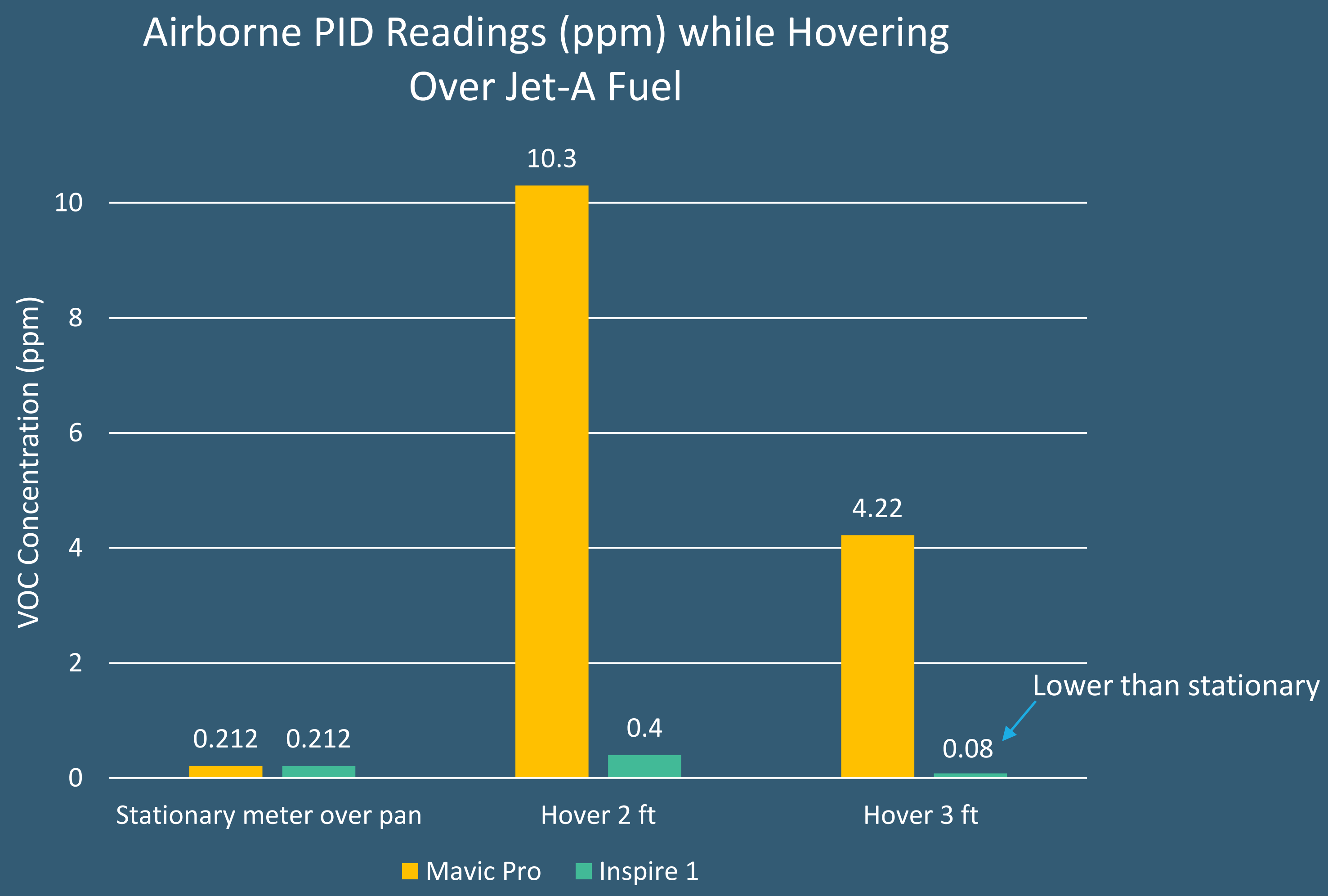
DJI Mavic Pro with Ion Cub PID attached directly below the sUAS

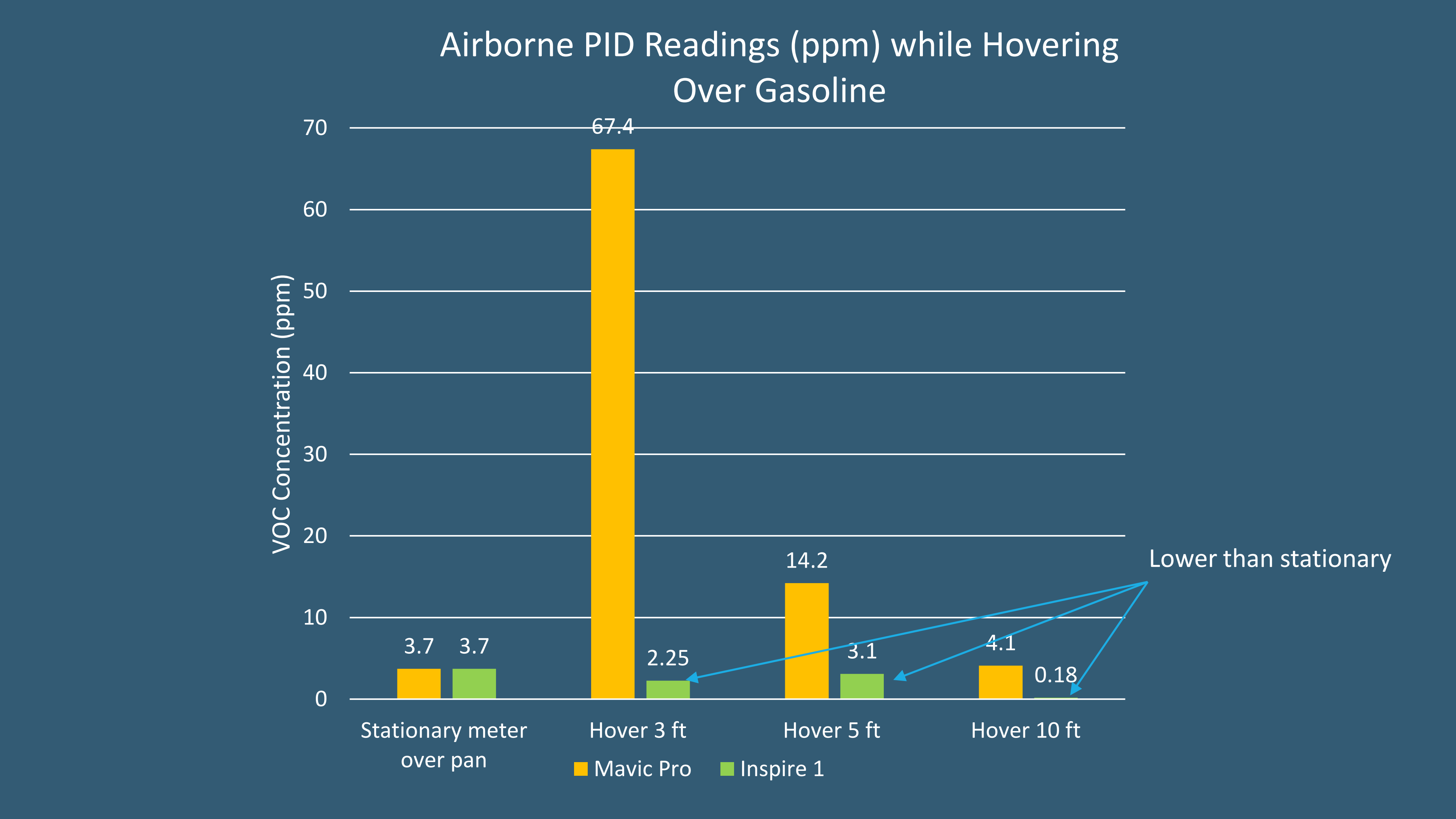
Mock Spill Scenario

- Jet-A and Gasoline
- Steel Pan
- Personal PID
- Kestrel 5500 Weather Meter
    - wind direction and velocity
    - temperature
    - wet bulb
    - dew point
    - pressure
    - relative humidity

No Tether

- Ripples on the surface


Airborne PID Readings (ppm) while Hovering Over Jet-A Fuel
VOC Concentration (ppm)
0
2
4
6
8
10
0.212
0.212
10.3
0.4
4.22
0.08
Lower than stationary
Stationary meter over pan
Hover 2 ft
Hover 3 ft
Mavic Pro
Inspire 1



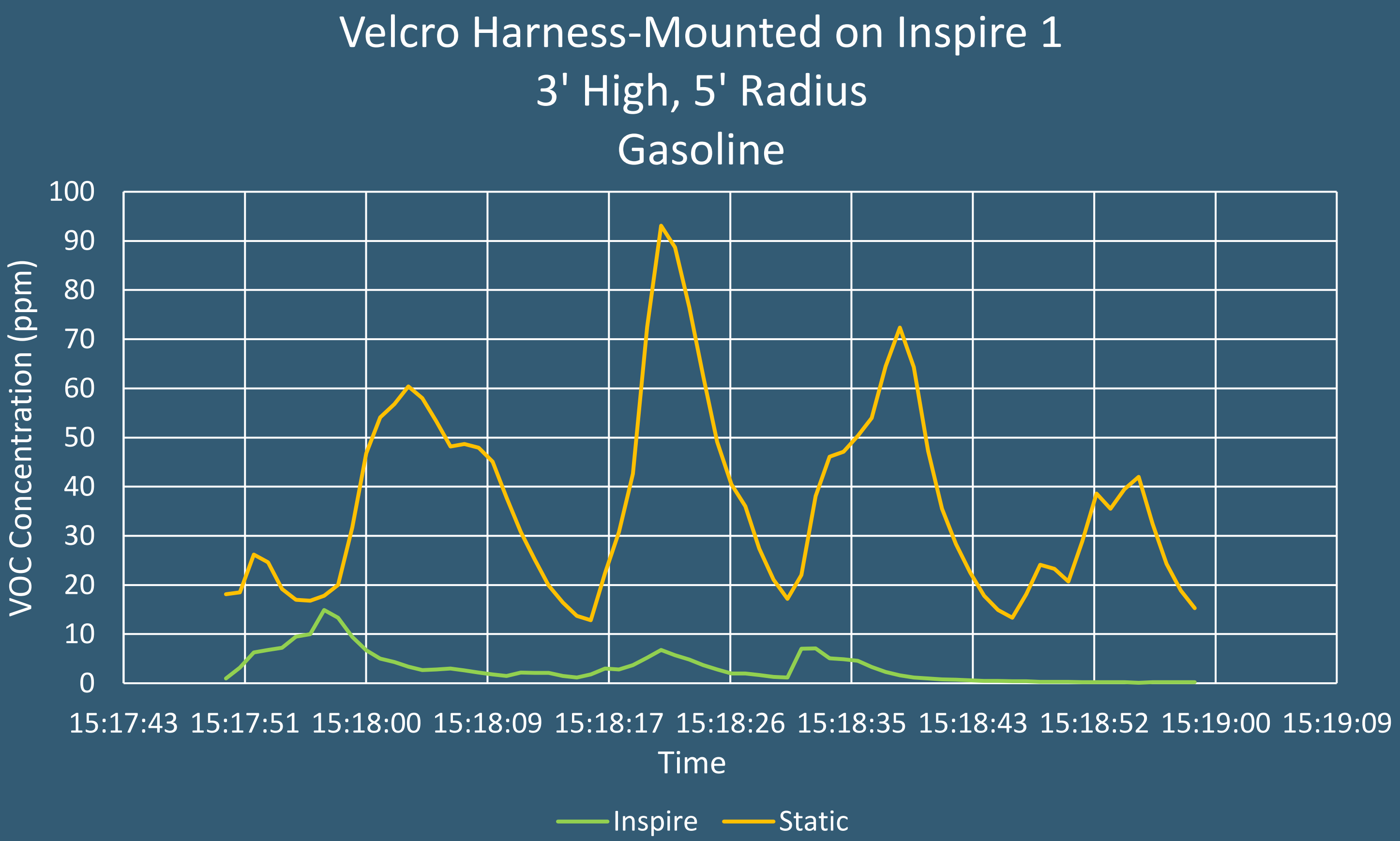
Airborne PID Readings (ppm) while Hovering Over Gasoline
VOC Concentration (ppm)
70
60
50
40
30
20
10
0
3.7
3.7
67.4
2.25
14.2
3.1
4.1
0.18
Lower than stationary
Stationary meter over pan
Hover 3 ft
Hover 5 ft
Hover 10 ft
Mavic Pro
Inspire 1

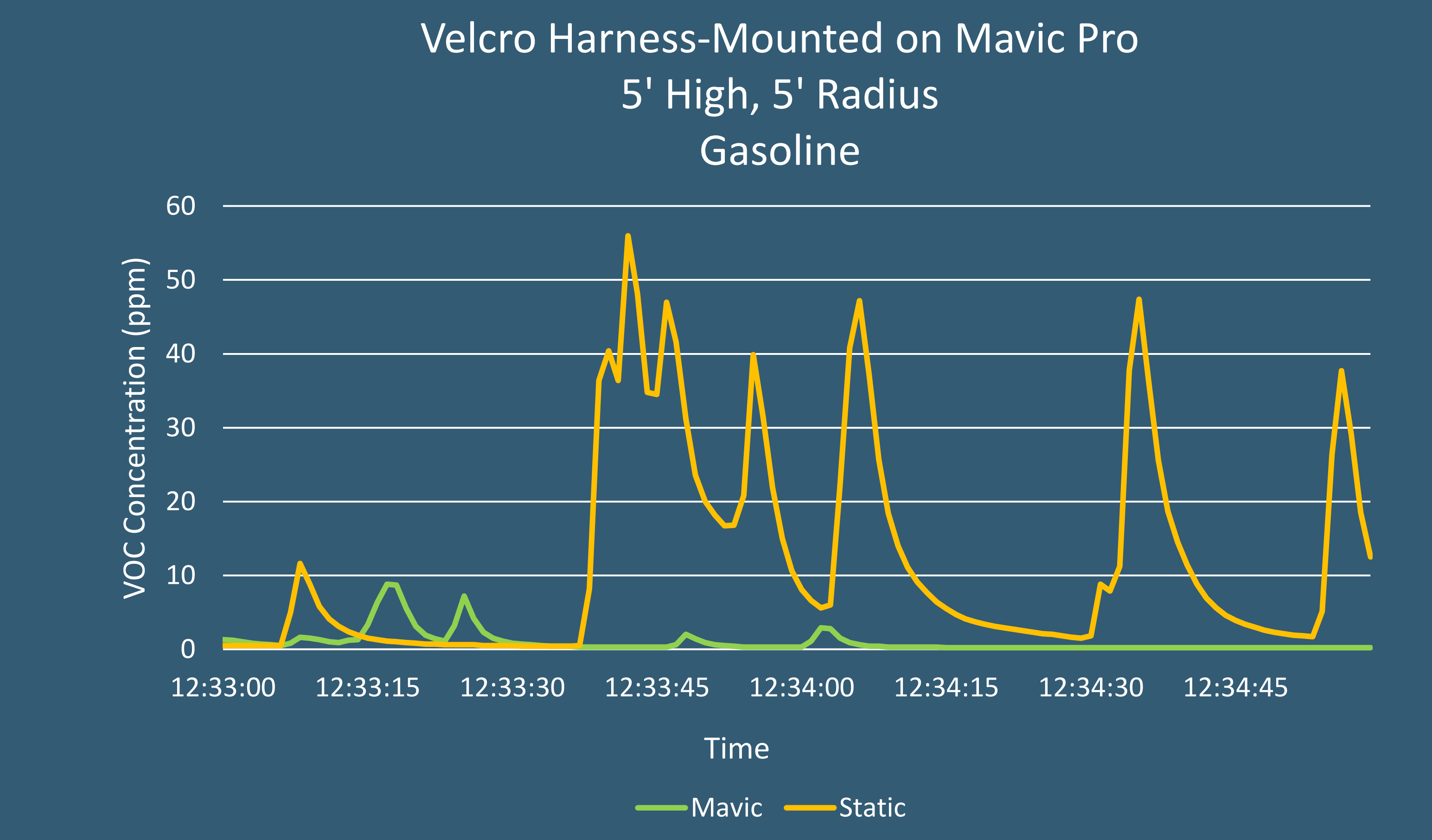
Results/Conclusions

- If the sensor is mounted directly on the sUAS, and it hovers directly over the spill, it depends on the drone configurations as to whether the vapor concentrations detected are higher or lower than ambient levels without the drone present

No Tether Circular Pattern Around the Pan

Goal was to collect data to generate 3D concentration map

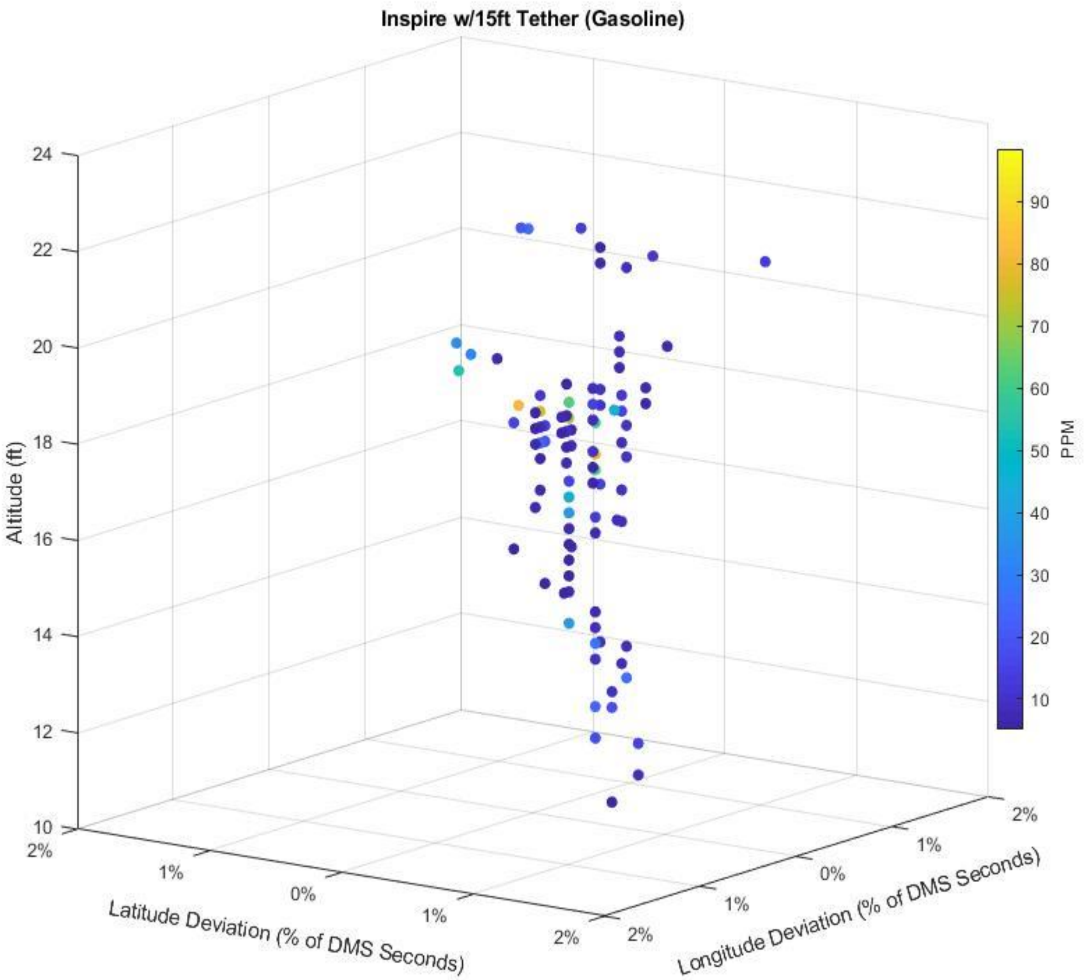

Velcro Harness-Mounted on Inspire 1
3' High, 5' Radius
Gasoline
VOC Concentration (ppm)
100
90
80
70
60
50
40
30
20
10
0
15:17:43
15:17:51
15:18:00
15:18:09
15:18:17
15:18:26
15:18:35
15:18:43
15:18:52
15:19:00
15:19:09
Time
Inspire
Static



Velcro Harness-Mounted on Mavic Pro
5' High, 5' Radius
Gasoline
VOC Concentration (ppm)
0
10
20
30
40
50
60
12:33:00
12:33:15
12:33:30
12:33:45
12:34:00
12:34:15
12:34:30
12:34:45
Time
Mavic
Static

3D Concentration Plot

- By combining:
  - time points of PID concentrations
  - time points of sUAS GPS location (adjusted for tether length)



Results/Conclusions

- If the sensor is mounted directly on the drone, and the drone is **not** directly over the spill, the vapors from the spill did not always reach the sensor and were not always detected.

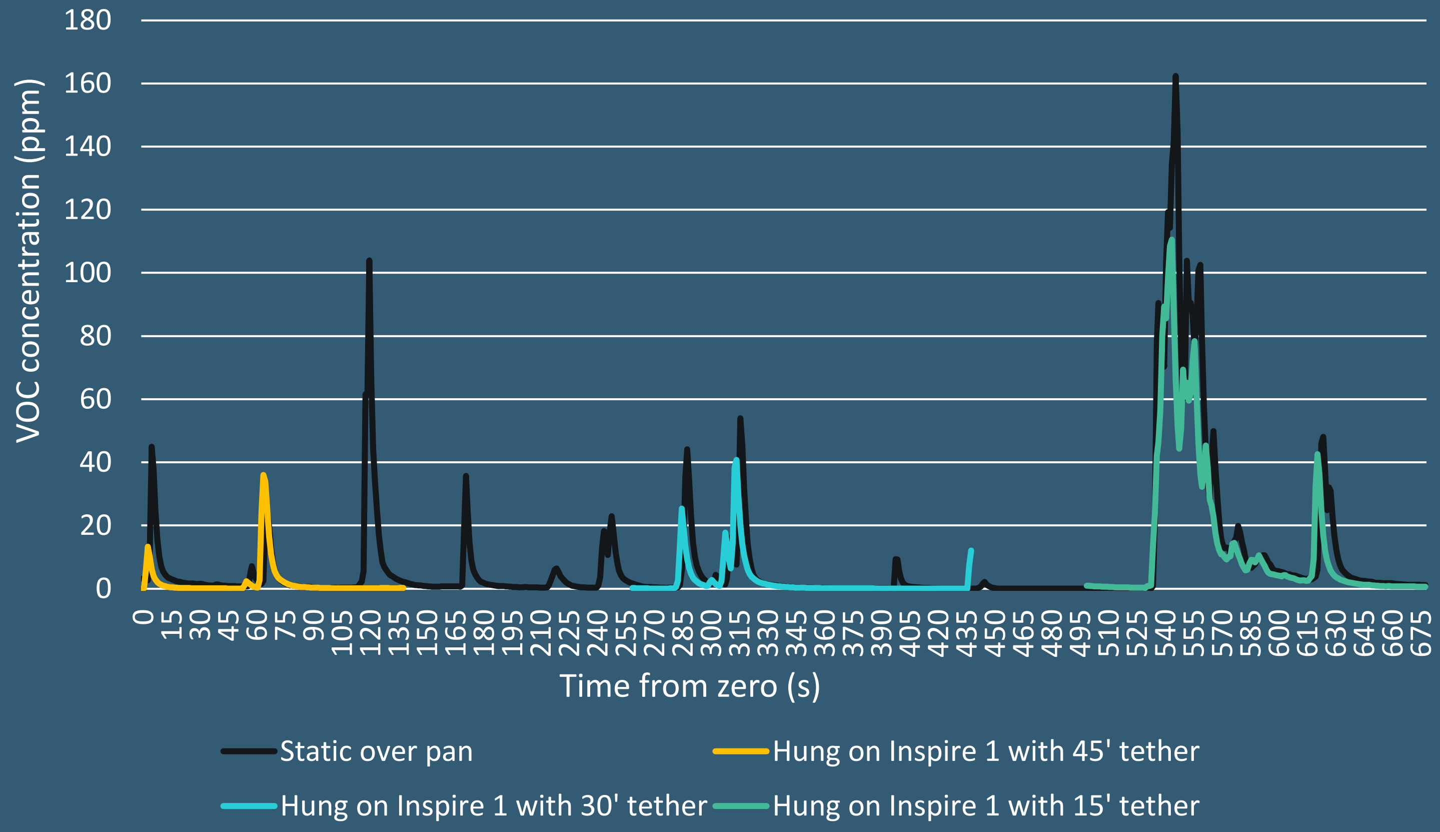
Tether

15 Feet

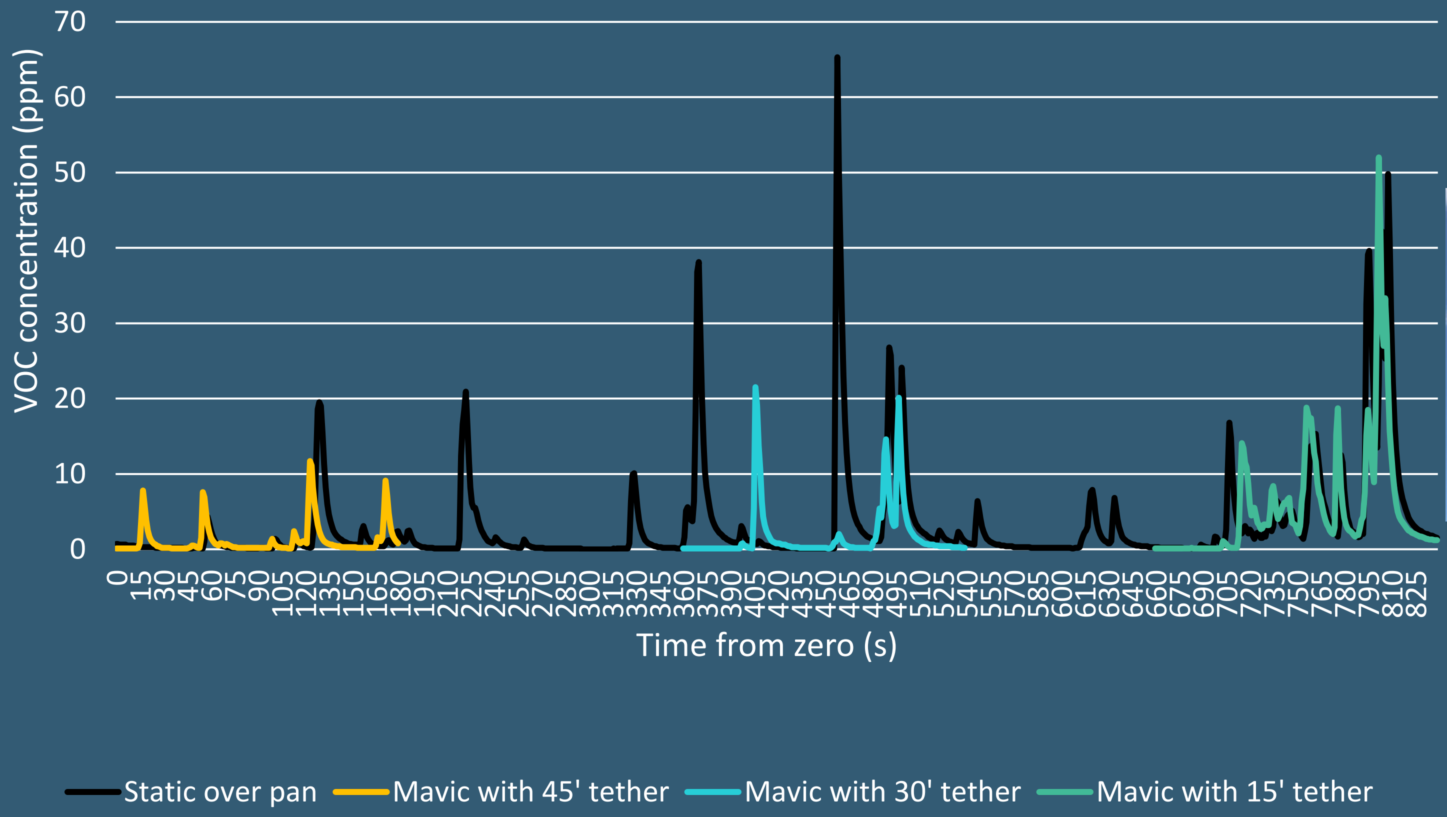
30 Feet

45 Feet

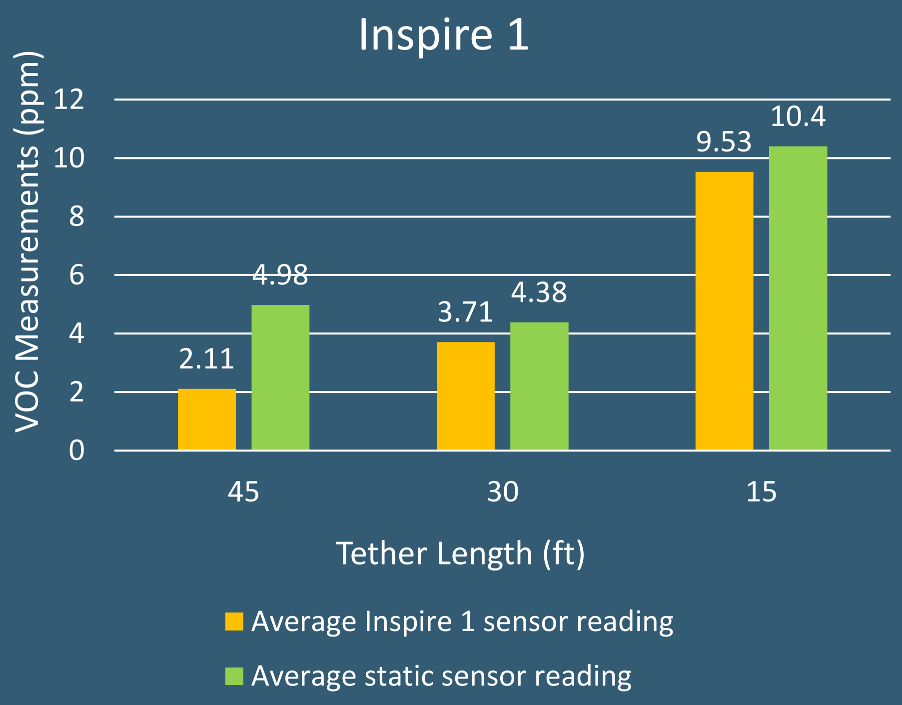
Inspire 1 over Gasoline, with Tether

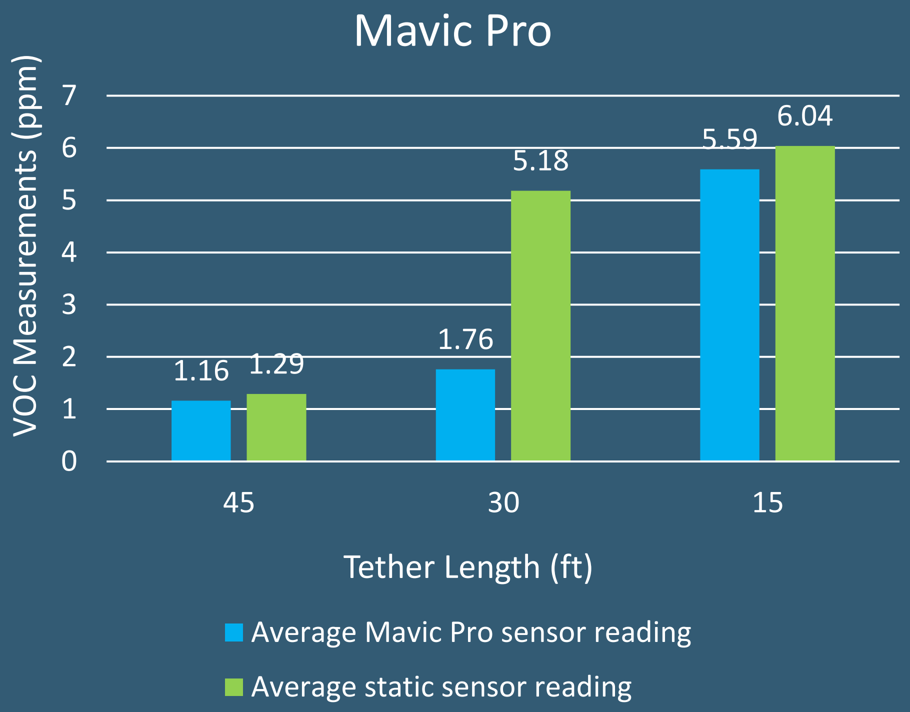


Mavic Pro with Tether, Gasoline



Influence of Tether





Results/Conclusions

- The hanging sensor data at 15, 30, and 45 feet below the sUAS provided similar readings to the static sensor data.
- However, even with the use of a 30’ tether, a ripple from the rotor wash was noticeably visible on the surface, potentially elevating measured exposure levels, thus interfering with the ability to accurately measure potential emergency responder exposure levels.

Results/Conclusions

- With a 15 foot tether, there was a strong similarity between the sensors, but the concentration was also at the highest point, so estimating potential responder exposure is impacted.
- The UAS operators reported that using a shorter tether was more stable than the longer tethers.
- Using a 15 foot tether could be useful if the intent is to detect the presence of a spill, but not to determine responder exposure.

Results/Conclusions

- With the sUAS platforms used, a 45 foot tether provided the optimal length of separation from the rotors to be able to estimate exposures above the spill.
- However, using a tether that long is potentially limiting because of the potential for interference by ground objects and the potential impact of wind on the hanging sensor.
- The UAS operators reported a lot of drift in the operation of the UAS, and it was hard to keep the aircraft level.

Further Studies Needed

- Full characterization of the impact of rotorwash for each type of UAS
- Optimization of the placement of the VOC sensor

Research Team (left to right):
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Questions?

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