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Application of Mounting Personal PID VOC Sensors to Small Unmanned Aircraft Systems to Aid First Responders

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A background graphic consisting of a network of light blue and green nodes connected by thin lines, set against a dark blue gradient background. The nodes are scattered across the frame, with a higher density on the left side.

Application of Mounting Personal PID VOC Sensors to Small Unmanned Aircraft Systems to Aid First Responders

Cheri Marcham, PhD, CIH, CSP, FAIHA

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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
 - Why not send in drones instead?



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?

sUAS Platforms Used



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



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

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

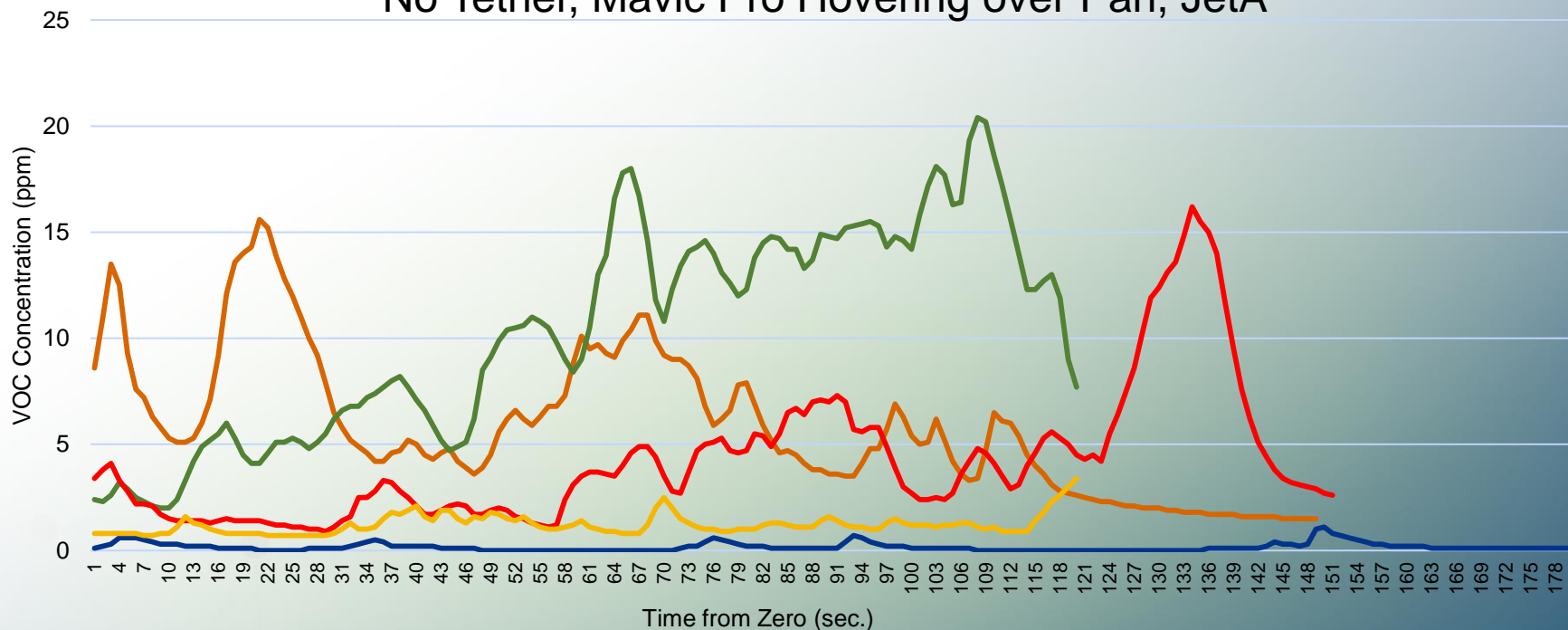


No Tether



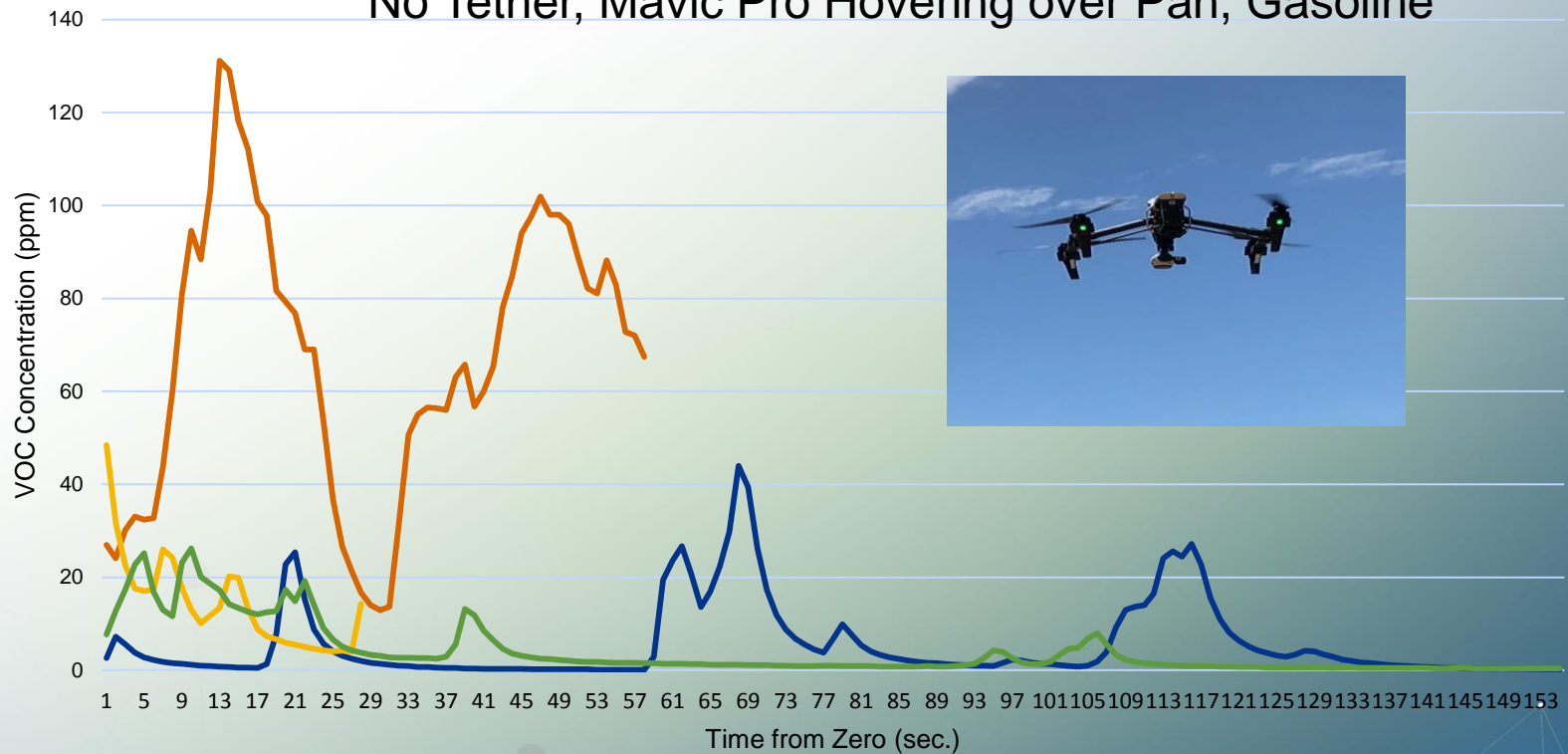
- Ripples on the surface

No Tether, Mavic Pro Hovering over Pan, JetA



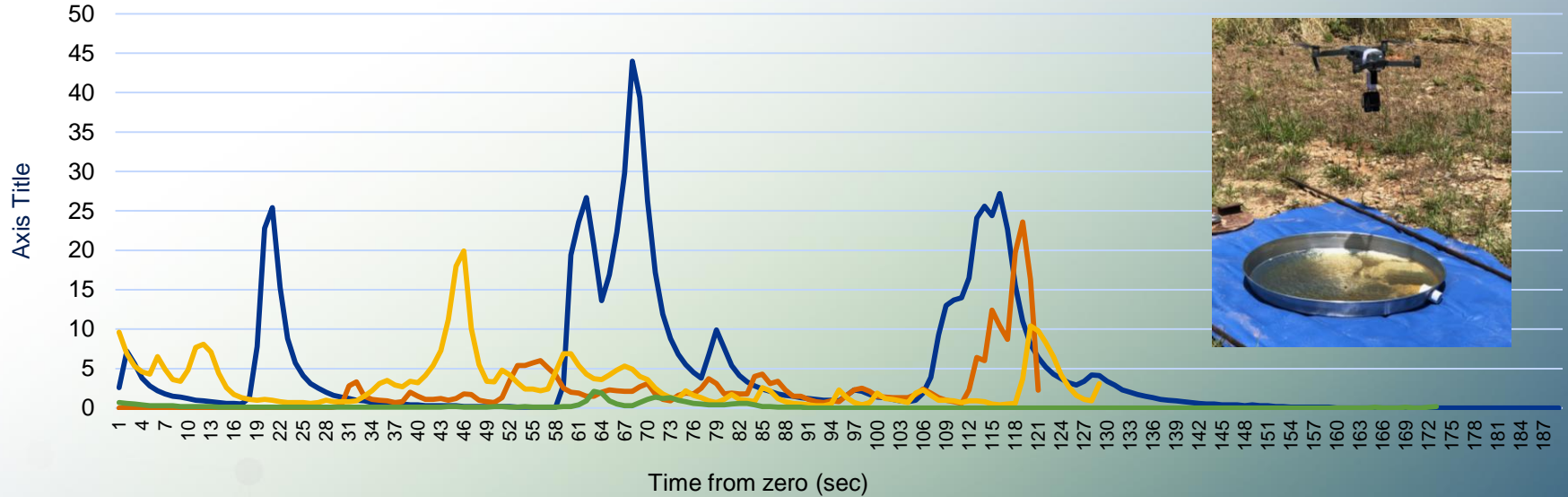
- Stationary meter over pan at 2' (mean 0.15 ppm)
- Mounted on Mavic 16" hover (mean 5.82 ppm)
- Mounted on Mavic 2' hover (mean 10.3 ppm)
- Mounted on Mavic 3' hover (mean 4.22 ppm)
- Mounted on Mavic 5' hover (mean 1.22 ppm)

No Tether, Mavic Pro Hovering over Pan, Gasoline



- Stationary meter over pan (mean 3.7 ppm)
- Mavic hover 3 feet (mean 67.4 ppm)
- Mavic hover 5 feet (mean 14.2 ppm)
- Mavic hover 10 feet (mean 4.1 ppm)

No Tether, Inspire 1 Hovering over Pan, Gasoline



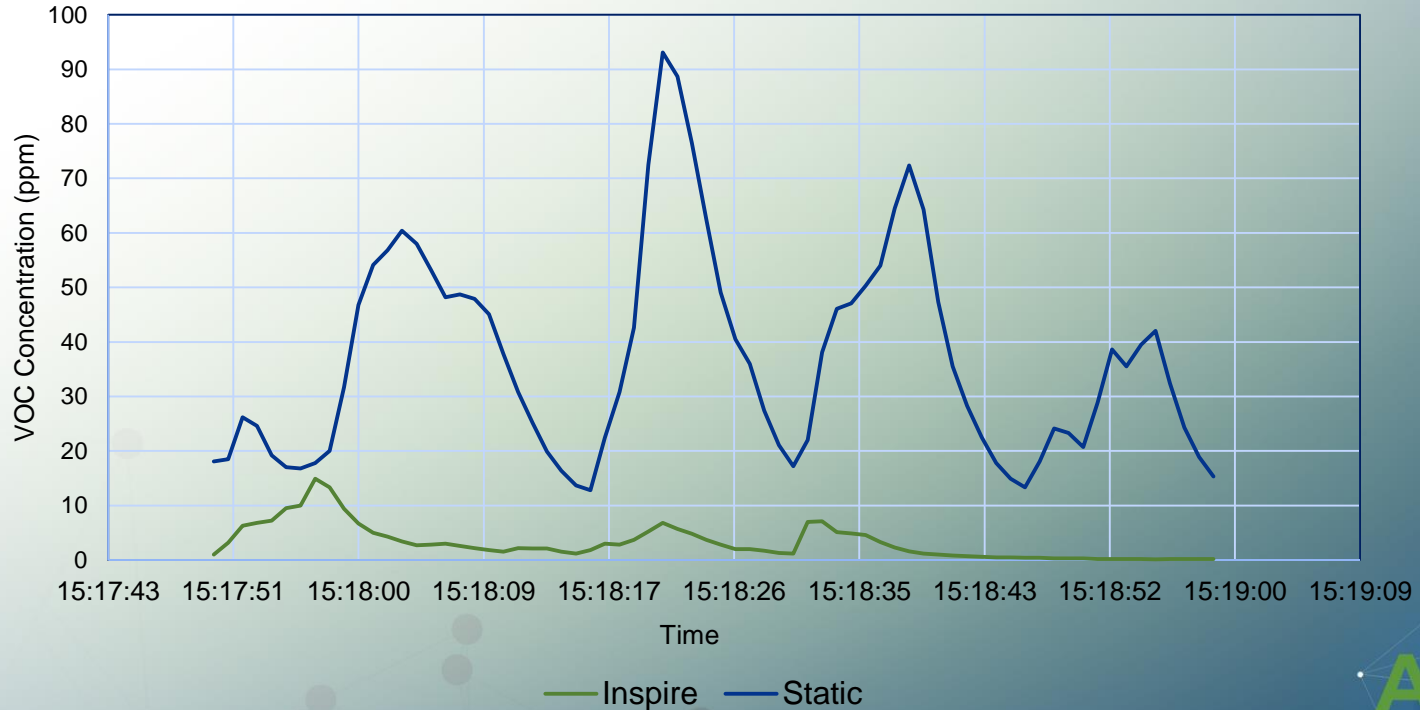
- Stationary meter over pan (mean 3.7 ppm)
- **Inspire hover 3 feet (mean 2.25)* (statistically lower P=.02)**
- Inspire hover 5 feet (mean 3.1)
- Inspire hover 10 feet (mean 0.175)

No Tether Circular Pattern Around the Pan

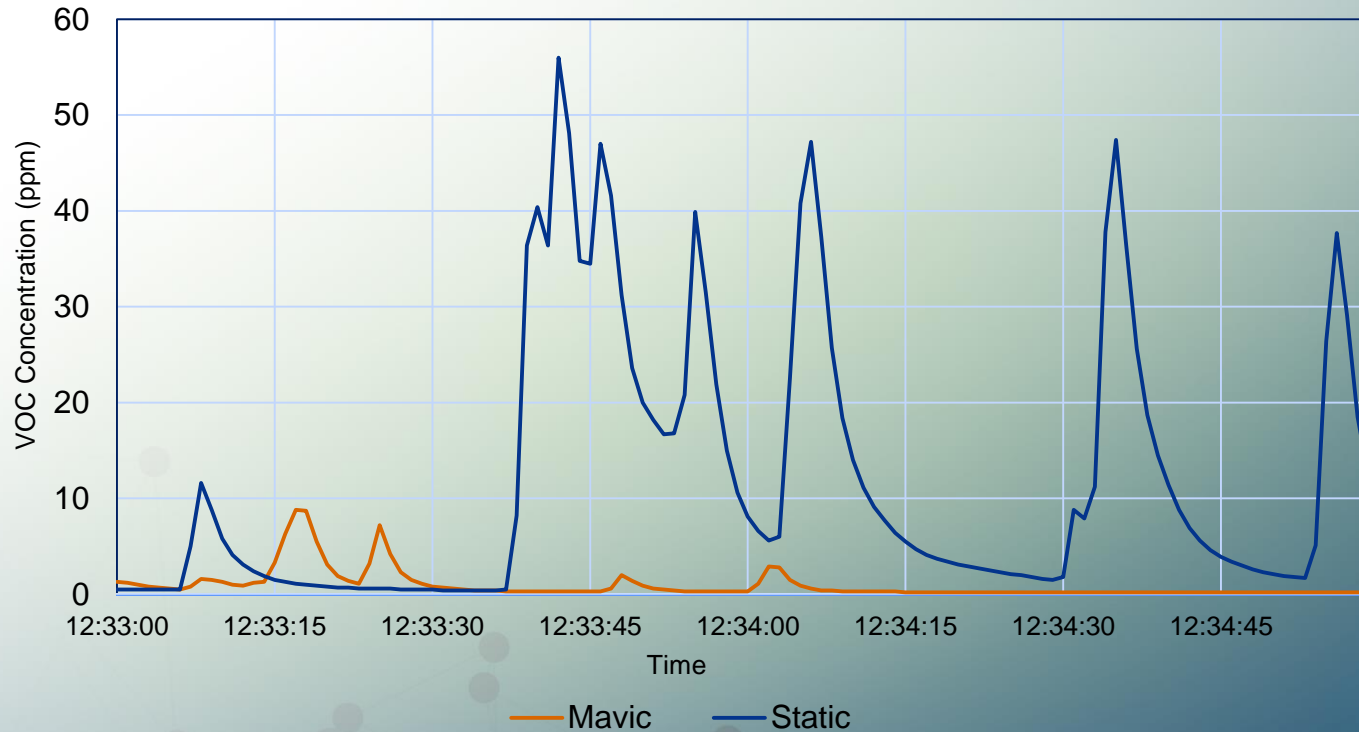


- Goal was to collect data to generate 3D concentration map

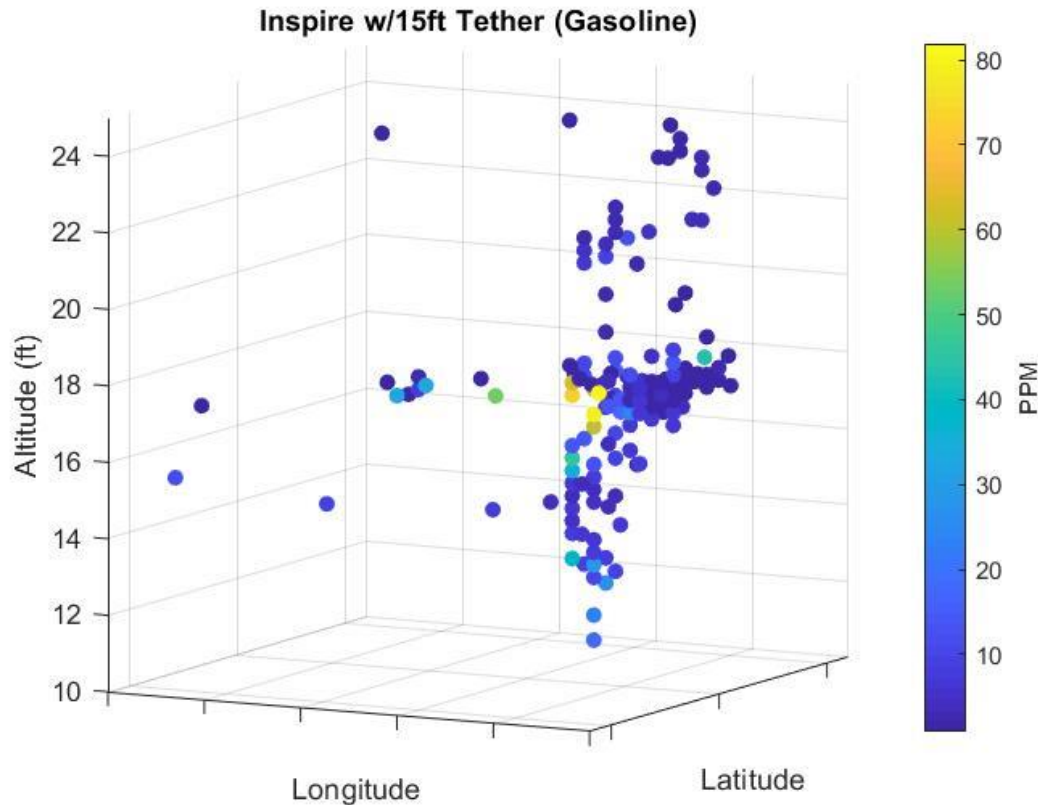
Velcro Harness-Mounted on Inspire 1 3' High, 5' Radius



Velcro Harness-Mounted on Mavic Pro 5' High, 5' Radius



3D Concentration Plot



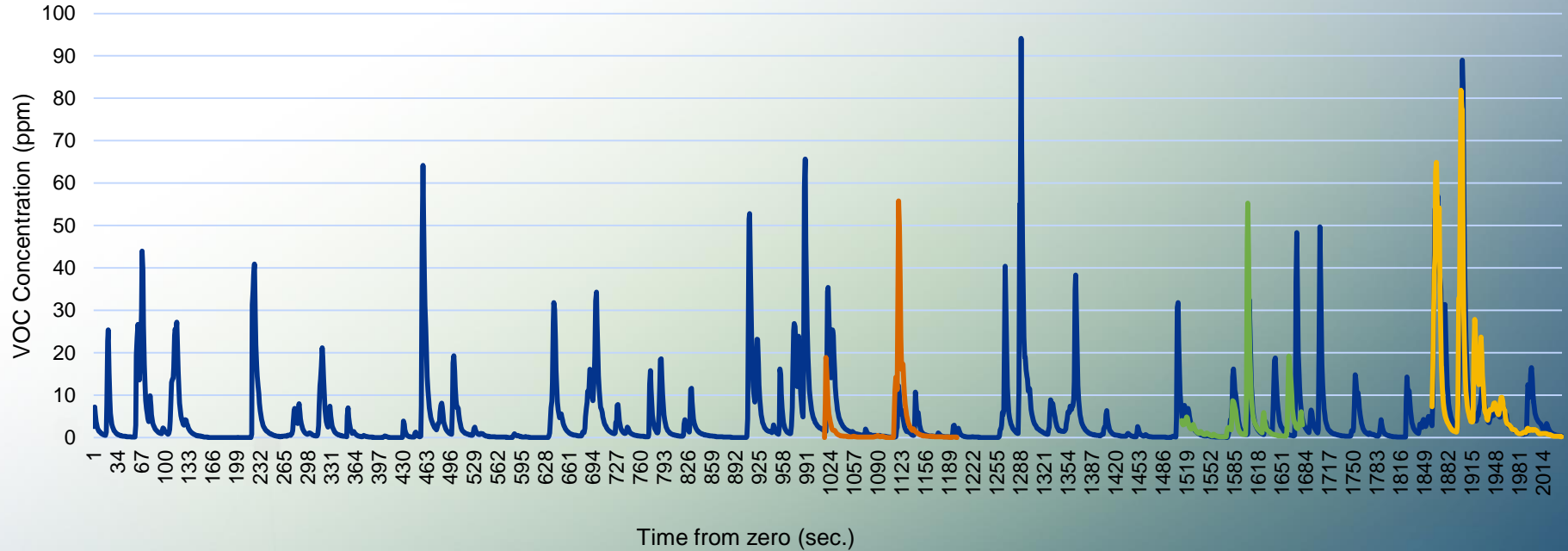
By combining:

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

Tether, 15, 30, 45 Feet



Inspire 1 over Gasoline, with Tether, Run 1



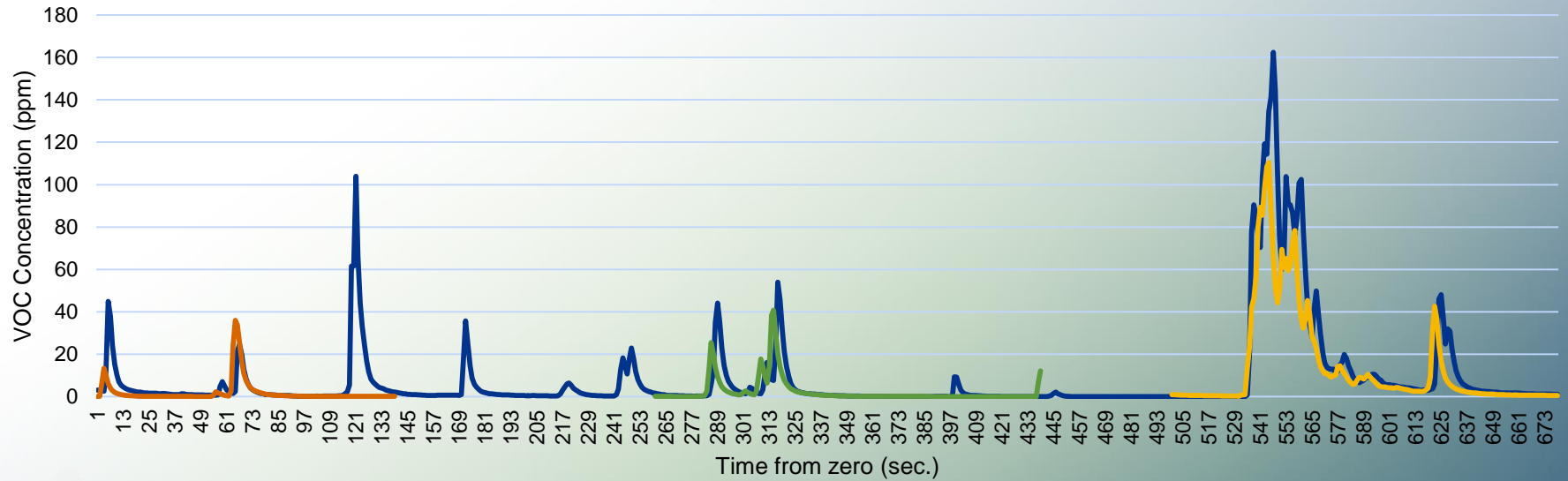
— Static Over Pan

— Hung on Inspire with 30' tether

— Hung on the Inspire with a 45' tether

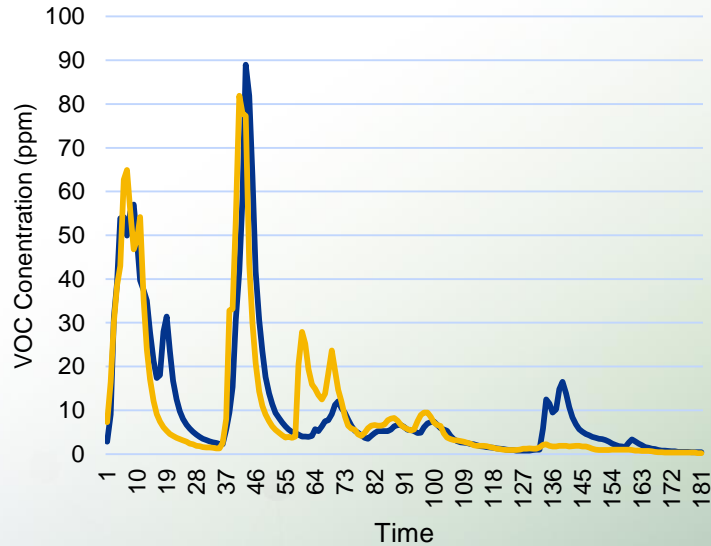
— Hung on Inspire with 15' tether

Inspire 1 over Gasoline, with Tether, Run 2



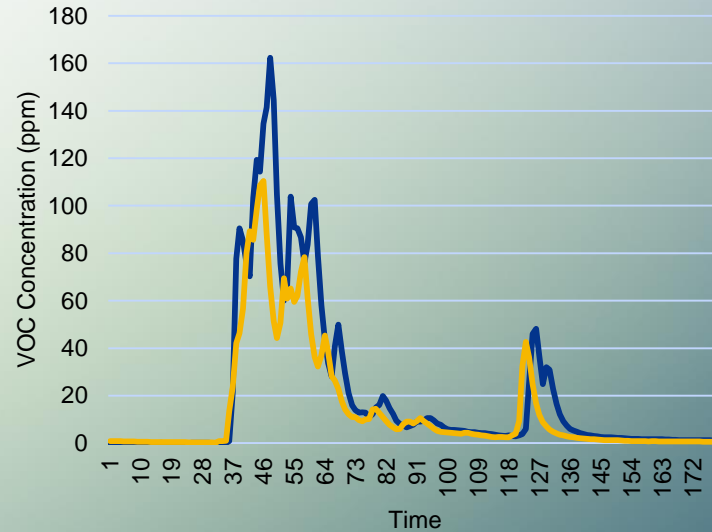
- Static over pan
- Hung on Inspire with 45' tether
- Hung on Inspire with 30' tether
- Hung on Inspire with 15' tether

Inspire 1 over Gasoline, 15' Tether, First Run



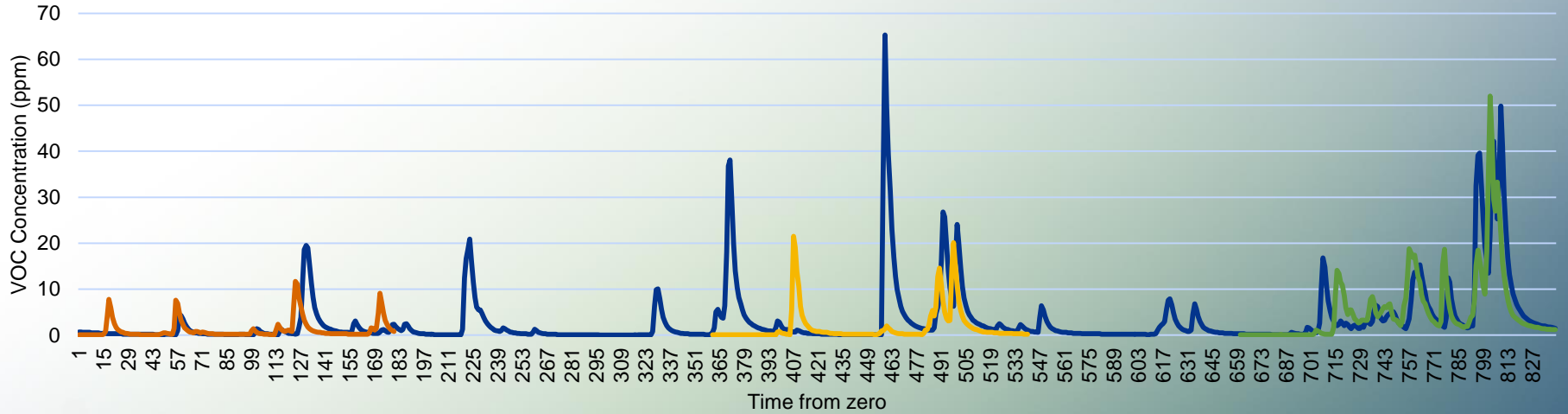
- Static over pan
- Hung on Inspire with 15' tether

Inspire 1 over Gasoline, 15' Tether, Second Run



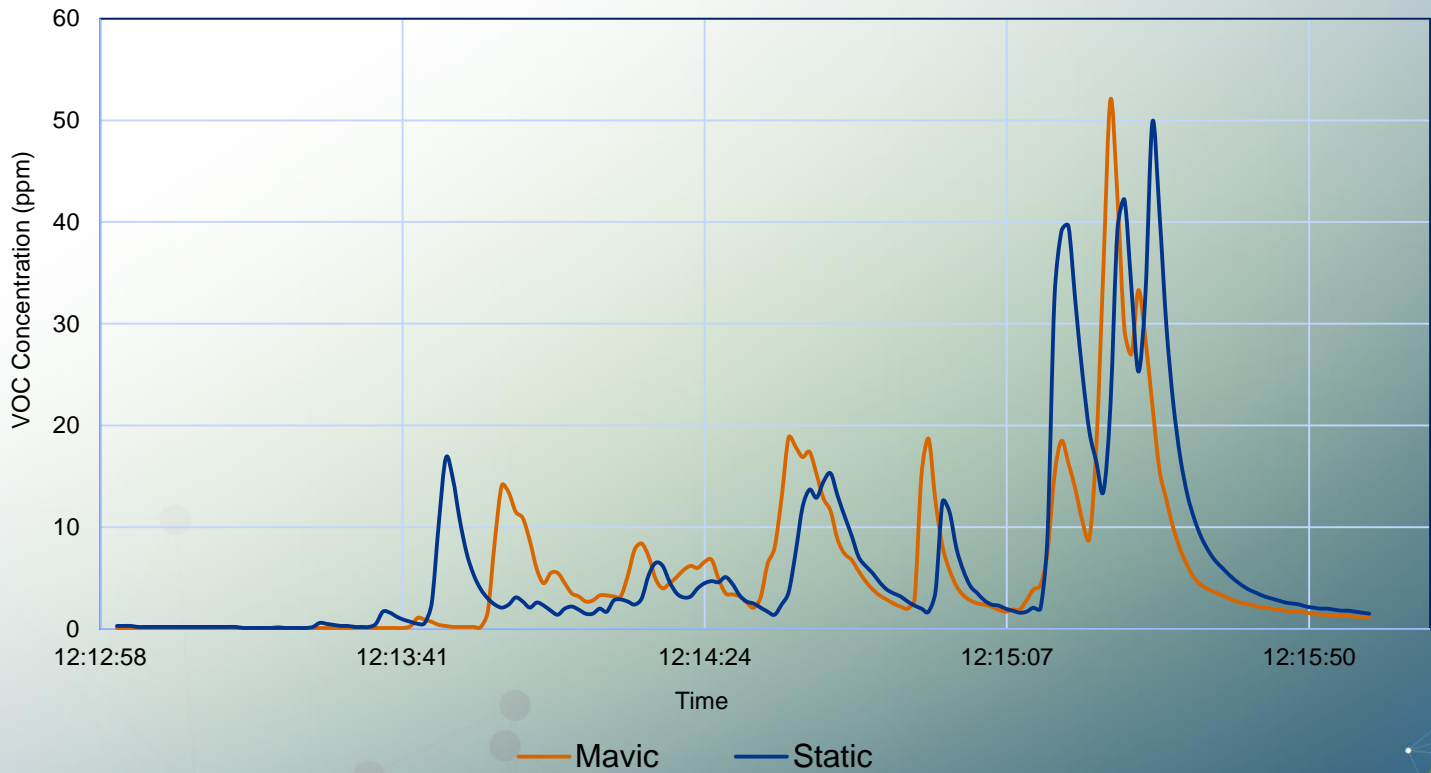
- Static over pan
- Hung on Inspire with 15' tether

Mavic Pro with Tether, Gasoline

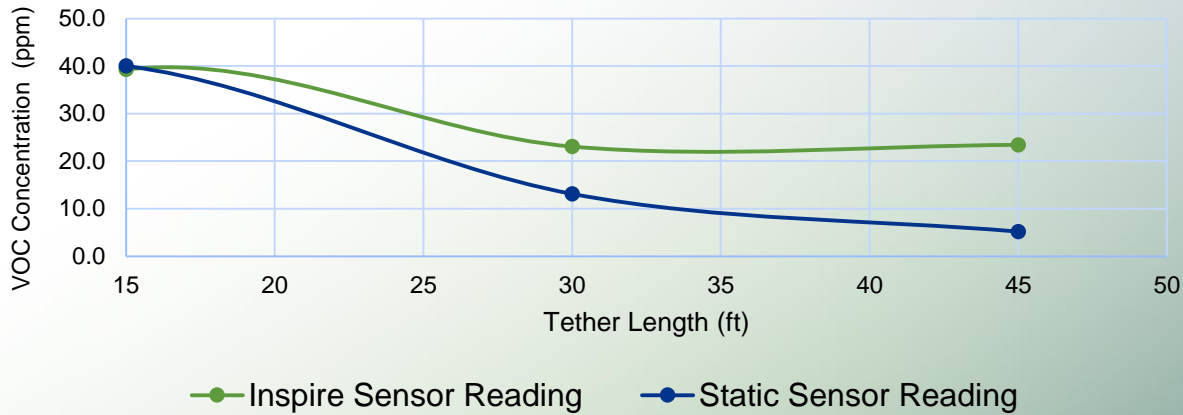


— Over Pan — Mavic with 45' tether — Mavic with 30' tether — Mavic with 15' tether

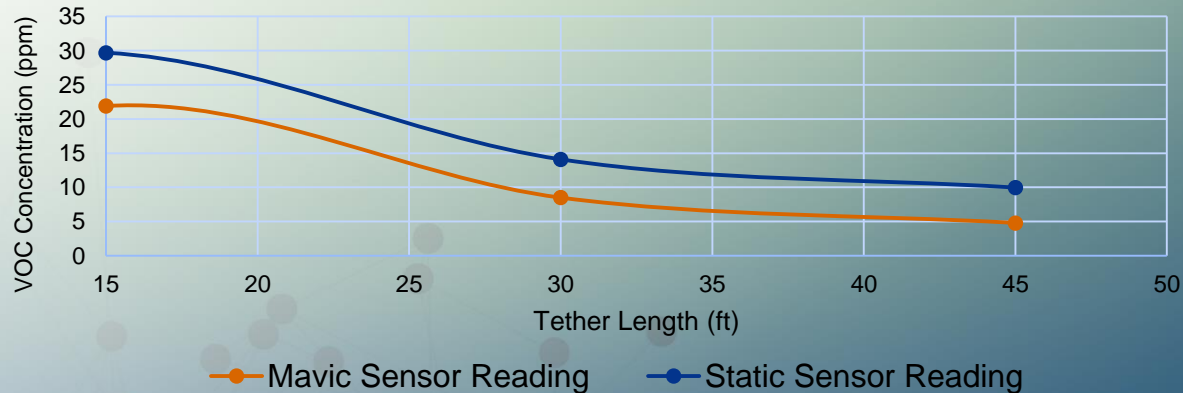
Mavic Pro with 15 Tether, Gasoline



Influence of Tether, Inspire 1



Influence of Tether, Mavic Pro



Results/Conclusions



- If the sensor is mounted directly on the drone, and the drone 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

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.

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 could be visibly seen on the surface, potentially elevating measured exposure levels, thus interfering with the ability to accurately measure potential emergency responder exposure levels.

Results/Conclusions



- With the sUAS platforms used for this experiment, 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

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.

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):
Scott Burgess, Brandon Breault, Joe Cerreta,
Josh Marcham, Patti Clark, Cheri Marcham**

A network diagram consisting of numerous light blue circular nodes connected by thin, light blue lines, set against a dark blue background with a green-to-blue gradient. The nodes are scattered across the left and top portions of the slide.

Questions?

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