Characterization of Air Emissions from Open Burning of Propellant with an Unmanned Aerial System

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INTRODUCTION

Open burning (OB) plumes from ordnance demilitarization are localized and of short duration. Sampling these plumes requires speed and flexibility in positioning. A hexacopter unmanned aerial system (UAS) or "drone" lofted a sampler, named "Kolibri", into the plume to sample the burning propellant emissions. The Kolibri was developed using small commercial sensors, miniaturized pumps, and high power density batteries. The Kolibri includes an on-board Teensy computer and a telemetry system for sampler control from the ground and data transmittal software.

MATERIALS

Three different propellant types were sampled at two sites

- M119A2-155 – single based, lead sheets
- M67-105 – single based
- M17 – triple based, lead carbonate
- MK-90 - rocket motors

UAS "DRONE"

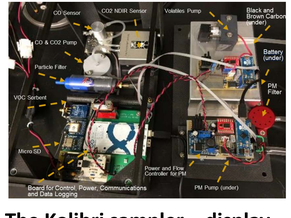
- DJI Matrice M600, 6-rotor
- Weight 9.1 kg (20 lbs)
- Max payload weight 6 kg (13.2 lbs)
- Flight time 16-20 minutes

The NASA UAS – a six rotor system with the Kolibri sampler after being in the plume. Note the black filter.

KOLIBRI EMISSION SAMPLER

- Built by EPA's Office of Research & Development
- Sensors to measure CO and CO_2
- Miniature samplers for $PM_{2.5/10}$, HCl, VOCs, SVOCs, Cr(VI), metals, and inorganic halogens.
- Other capabilities can be added such as real time particle size distributions.

The Kolibri sampler.



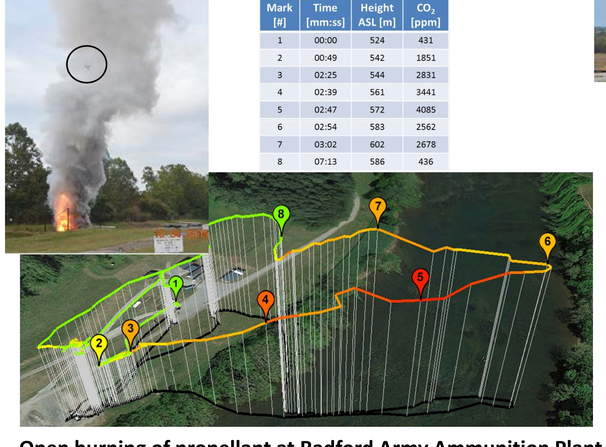
The Kolibri sampler – display of internals.

SUMMARY

An Unmanned Aerial System or 'drone" was used to sample emissions from open burning (OB) demilitarization operations at two Army ammunition plants. These are the first characterizations of OB emissions using an aerial drone. The sampling package (termed "Kolibri") is the most comprehensive system of drone-based emission samplers existing. The UAS/Kolibri system successfully sampled 57 plumes over 22 days for a comprehensive array of pollutants.

FLIGHT DATA

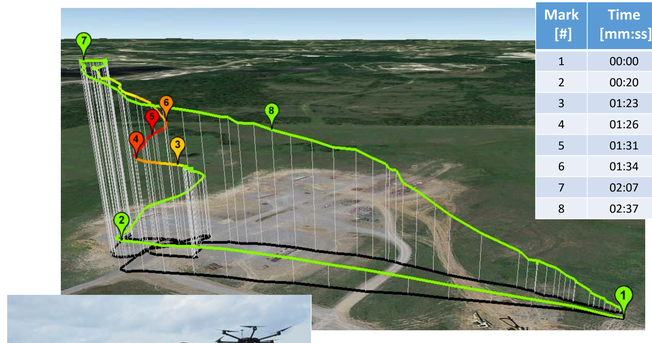
Mark [#]	Time [mm:ss]	Height ASL [m]	CO_2 [ppm]
1	00:00	524	431
2	00:49	542	1851
3	02:25	544	2831
4	02:39	561	3441
5	02:47	572	4085
6	02:54	583	2562
7	03:02	602	2678
8	07:13	586	436



Open burning of propellant at Radford Army Ammunition Plant

FLIGHT DATA

Mark [#]	Time [mm:ss]	Height ASL [m]	CO_2 [ppm]
1	00:00	254	416
2	00:20	259	408
3	01:23	289	2427
4	01:26	290	3778
5	01:31	297	4599
6	01:34	304	3075
7	02:07	331	408
8	02:37	302	410



Open burning of propellant at McAlester Army Ammunition Plant

FINDINGS

- **First-ever drone measurements of open burning demilitarization emissions**
- **Cost effective, safe, accurate, and representative measurements on a comprehensive array of emissions**
- **Relative standard deviations on measurements were low, lending confidence to the methods**

Acknowledgments

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