Characterization of Emission Factors from Demilitarization Operations (OB/OD/SF) by In-Plume Aerial Sampling

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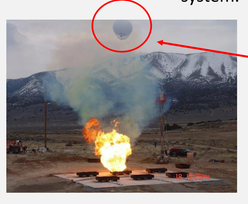
Tethered Aerostat and Flyer

5 m diameter, helium-filled, tethered aerostat.

The EPA "Flyer": An unmanned, telemetry-controlled sampling system.



Tethered aerostat downwind of OB

Open burning of propellant

Tethers/winches downwind

Aerostat/Flyer

Open detonations

INTRODUCTION

The Department of Defense undertakes munition demilitarization operations to maintain safety of its ordnance stockpiles. These operations include open burning (OB), open detonation (OD), and rocket static firing (SF) of ordnance, all of which require pollutant emission factors (EFs) to comply with facility air permits. These EFs are the primary data inputs for dispersion, deposition, and exposure models and are necessary to estimate exposure risk and environmental contamination.

Eight campaigns have been undertaken using aerial emission sampling of plumes from OB/OD/SF since 2010 to determine EFs. The plumes were sampled using instrumentation systems developed by the U.S. EPA's Office of Research and Development and deployed on a tethered, helium-filled aerostat and on other agencies' unmanned aerial systems (UASs), AKA "drones." OB/OD/SF sources result in lofted, high intensity, localized, and short duration plumes that have minimally predictable paths due to wind velocity fluctuations. Gathering air samples of these plumes is extremely challenging.

Analytes sampled by the Flyer and Kolibri samplers.

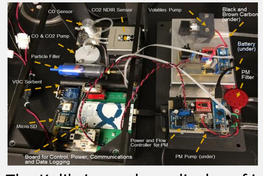
Analyte	Instrument/Method	Frequency
CO_2	NDIR[a]	Continuous
CO	Electrochemical cell	Continuous
$PM_{2.5}$	Impactor/Teflon filter/gravimetric	Batch
PM by size	DustTrak	Continuous
Metals	Filter	Batch
Volatile Organic Compounds (VOCs)	SUMMA Canister, Tenax sorbent	Batch
Polycyclic Aromatic Hydrocarbons (PAHs)	Quartz filter PUF/XAD-2/PUF	Batch
Black carbon	Micro Aethalometer, AE51 and MA350	Continuous
Elemental carbon/ Organic carbon/Total carbon	Quartz filter	Batch
Carbonyls	DNPH cartridge	Batch
Carbohydrates	Teflon filter	Batch
NO and NO_2	Electrochemical cell	Continuous
Energetics	Quartz filter	Batch
Dioxins (PCDD/PCDF)	Quartz filter, PUF	Batch
HCl	Treated filter	Batch

SUMMARY

Lightweight, remotely-controlled emission sampling systems were developed for aerial emission sampling. The sampling systems were lofted into combustion plumes using helium-filled, tethered aerostats and Unmanned Aerial Systems (UASs) or "drones." Emissions were sampled from open burning (OB), open detonation (OD), and rocket motor static fire (SF) plumes resulting from demilitarization operations at two U.S. Army ammunition plants and one Canadian Defence facility. Emission factors were determined for use in air permits and safety measures. The sampling packages, termed the "Flyer" and "Kolibri" for the aerostat and UAS, respectively, represent unique, innovative sampling systems for a comprehensive array of pollutants in an extremely challenging environment.

NASA UAS and Kolibri

The Kolibri sampler.



The Kolibri sampler – display of internals.

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

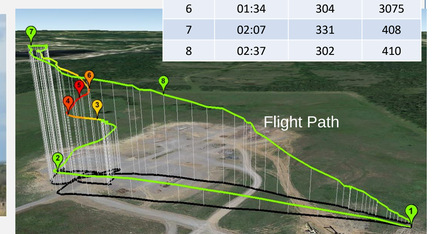
UAS "drone"

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

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



3D UAS Flight path, colored by the plume concentration

Acknowledgments/Disclaimer

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