Nighttime Fire Observations with Unmanned Aircraft Systems

National Oceanic and Atmospheric Administration (NOAA) and Black Swift Technologies (BST) have been collaborating on an unmanned aircraft system (UAS) engineered to help in forecasting fire growth, plume rise and dispersion under dynamically changing weather and fuel moisture conditions (Figure 1).

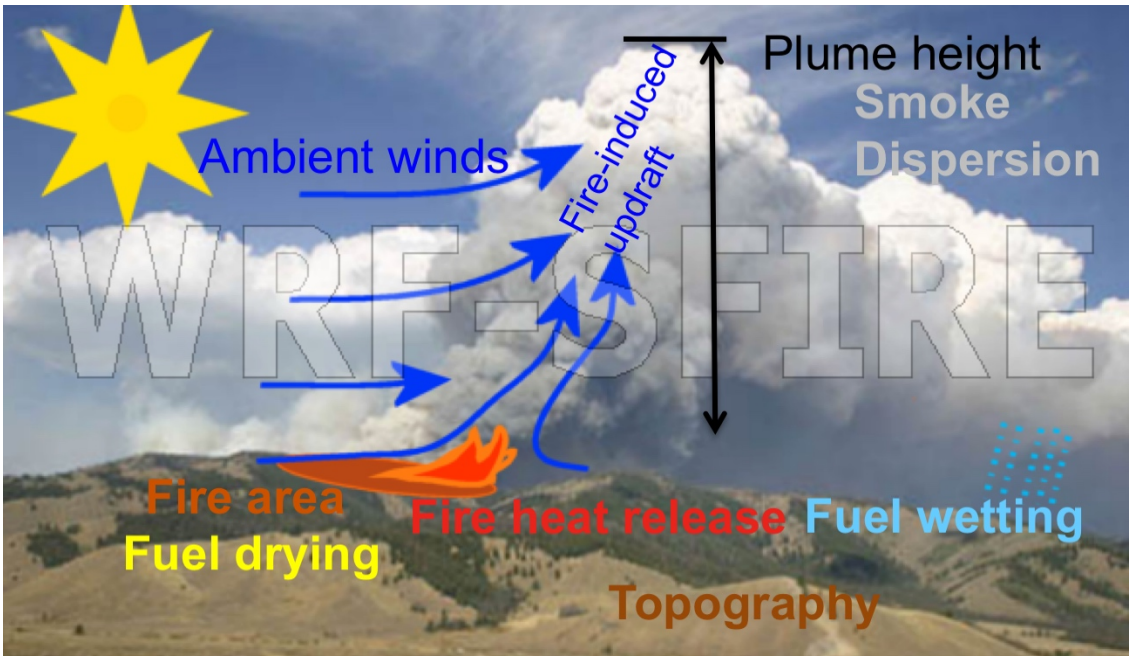

Figure 1: NightFOX leverages operational fire and smoke observations to give incident commanders essential information in a timely and effective manner.

The program, titled NightFOX (Nighttime Fire Observations eXperiment), uses Black Swift's S2™ UAS as the unmanned aerial platform carrying the specialized instrument packages comprising the wildfire UAS Observation Systems (UASOS).

The Black Swift S2 (Figure 2) is a tightly integrated system consisting of an airframe, avionics, and multiple sensors capable of research-quality measurements of CO2, CO, aerosol, RH, p, and T in wildfire plumes, and multispectral high-resolution maps of wildfires (Figure 3). The UAS will be operated by the University of Colorado's Integrated Remote & In Situ Sensing Program (IRISS) in close collaboration with NOAA.

Figure 2: The Black Swift S2 is a fixed wing UAS capable of long duration flights (e.g. >2 hours) in demanding atmospheric environments including high-altitude wildfire environments.

This system can be used to characterize nighttime combustion efficiency, smoke, fire perimeter, and fire radiative poser at high spatial resolution to inform, test, and improve fire weather forecasting.

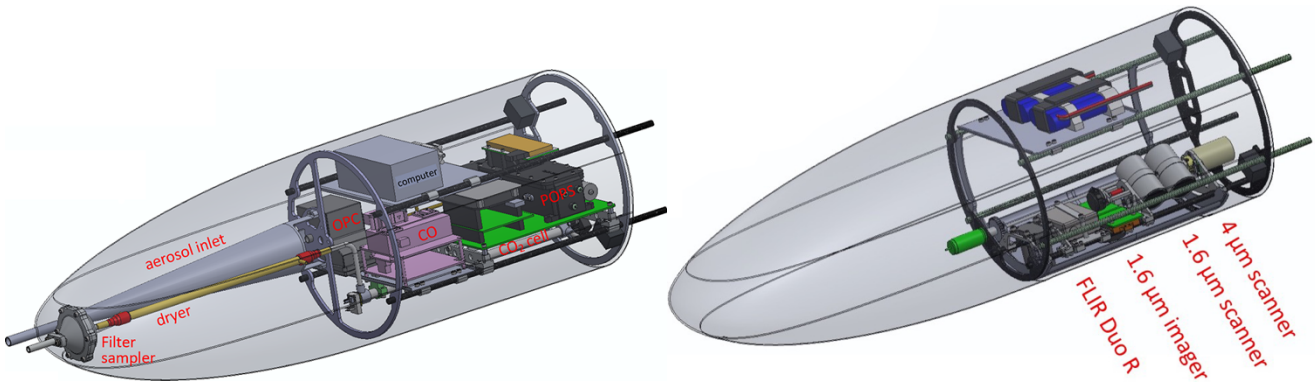

Figure 3: Custom In-Situ Instrument Packages designed to measure modified combustion efficiency (MCE), aerosol loading, fire extent (perimeter), and spatially resolved fire radiative power (FRP).

A UAS observation system is uniquely suited for nighttime measurements. Wildfires burn differently at night and there is a need for nighttime MCE (Modified Combustion Efficiency). Nighttime deployments also avoid any potential airspace conflicts with manned aerial firefighting efforts. Additionally, fire extent and radiative power at night are needed for accurate fire and plume model forecasts.

The ultimate goal of NightFOX is to perform nighttime in situ measurements of wildfire plumes and remote measurements of wildfire properties (Figure 2), and use of the measured data for fire weather forecast improvement. Due to safety concerns, manned aircraft flights are limited to daytime operations due to dangers associated with nighttime operations. Ground observations using a mobile laboratory provide detailed chemical information on fire plumes, but lack information on plume spatial (vertical and horizontal) distribution to put the point measurements in context. UAS observations are the only technology capable of this task. UAS observations can indeed provide useful information for firefighting efforts by accurately detecting fire perimeter and identifying fire hotspots, but have not attempted to make measurements relevant to studying fire emissions or incorporate observations into fire forecast models.

“The FireFOX initiative holds the potential to significantly advance the integration of UAS-based observations of wildfires into fire-weather modeling and forecasting,” says Dr. Ru-Shan Gao, Principal Investigator, Chemical Sciences Division, Earth Systems Research Laboratory, NOAA. “Having a UAS like the Black Swift S2 capable of carrying the necessary instruments routinely through harsh environments adds an invaluable contribution to the calibration and validation of data collected from ground- and satellite-based methods.”

The collected data will also provide otherwise missing data for studying the impact of North American wildfires on the atmosphere and human health, and ultimately supporting better land management decisions and practices, thus contributing to NOAA OAR’s core mission “ (to) advance understanding and prediction of the Earth System to enhance society's ability to make effective decisions.

“NOAA is interested in a UAS observational system that can use be used for fire-related measurements, and so in a sense what we want to know is when and where does the fire flow and ultimately what kind of fire and air quality will result regionally,” notes Dr. Gao. “We want to monitor the fire and incorporate the remote and in situ measurements into a fire forecast model so ultimately we'll be able to do better fire forecasts that will help firefighters better fight the fire and keep human and property losses to a minimum.”