A Small UAS Payload for Infrared Remote Measurement of Wildfire Intensity – NightFOX

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MOTIVATION

As large fires get more complex, wildland firefighters and wildfire modelers want accurate measurements of fire intensity and spread. **However:**

- Satellite observations are coarse and infrequent
- Aircraft observations are complex and expensive
- Fire forecasts lack detailed input data

What do we do? Let's use **small Uncrewed Aerial Systems (sUAS)** to link the measurement chain from satellites suites to the ground. Hence, the Nighttime Fire Observations eXperiment – **NightFOX**.



Fire practitioners increasingly use UAS technology for situational awareness. Credit: USDA Forest Service

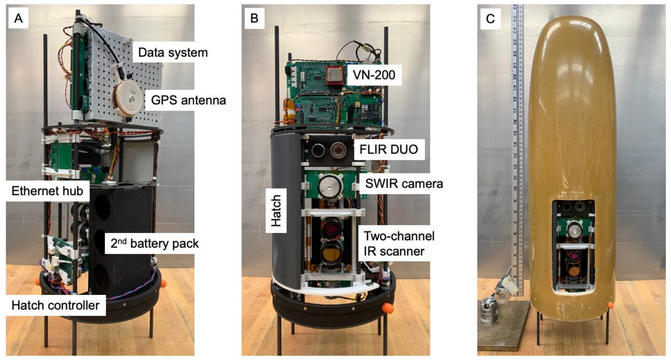
BANDPASS	OPTICAL INSTRUMENT DETAILS
Visible	FLIR Duo R, 90° x 51° FOV, 1920 x 1080 pixels
SWIR	Custom camera, 23° x 23° FOV, 1.0-1.7 µm, 64 x 64 pixels
Near IR (1.6 µm)	Custom scanning scope, 1° FOV, 1610 ± 60 nm, ± 30° scan across the flight track
Mid IR (4 µm)	Custom scanning scope, 1° FOV, 3960 ± 40 nm, ± 30° scan across the flight track
Thermal IR	FLIR Duo R, 57° x 44° FOV, 7.5-13.5 µm, 160 x 120 pixels

SOURCES

https://modis.gsfc.nasa.gov/about/specifications.php
https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/

Thornberry, T. D., Gao, R. S., Ciciora, S. J., Watts, L. A., McLaughlin, R. J., Leonardi, A., Rosenlof, K. H., Argrow, B. M., Elston, J. S., Stachura, M., Fromm, J., Brewer, W. A., Schroeder, P., & Zucker, M. (2023). A Lightweight Remote Sensing Payload for Wildfire Detection and Fire Radiative Power Measurements. Sensors , 23(7), 3514. https://doi.org/10.3390/s23073514

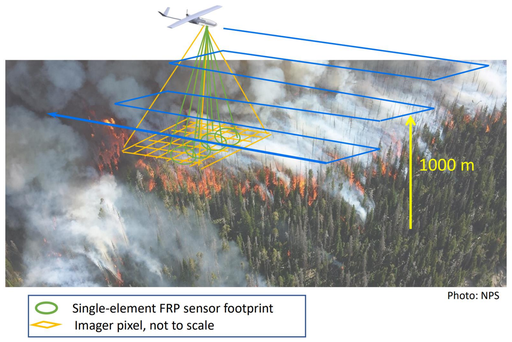
INSTRUMENT PAYLOAD



BLACK SWIFT TECHNOLOGIES S2 sUAS



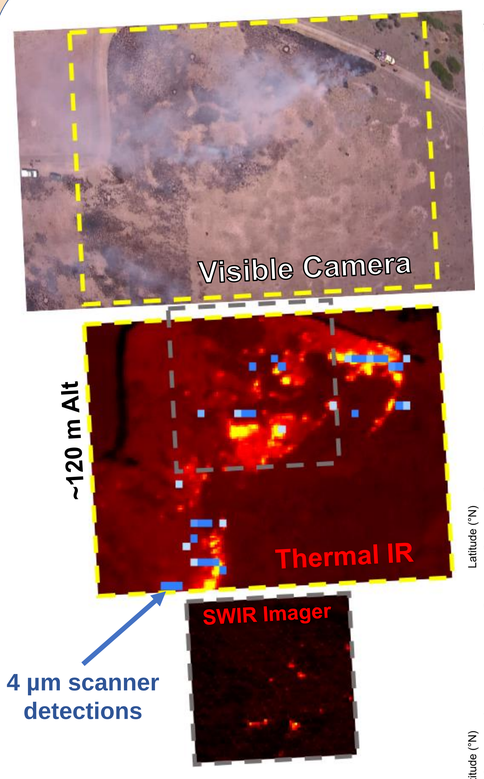
DEPLOYMENT CONCEPT



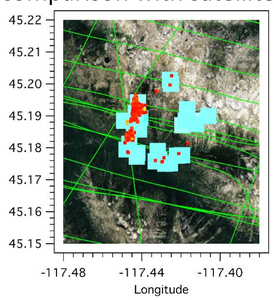
Our payload remotely observes fire radiative power with narrow-band IR single-element scanners and fire extent with wide-band IR imagers.

DATA PRODUCTS

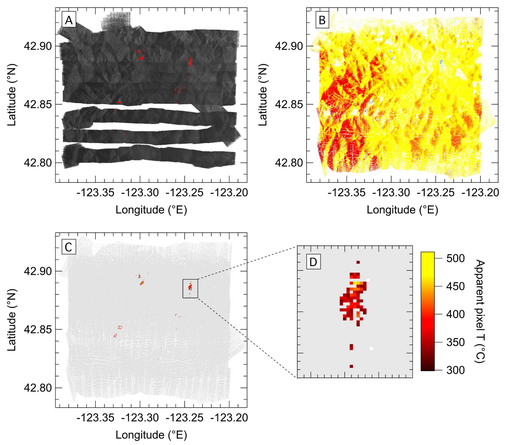
Wide angle imagers provide broad spatial views for coordinating other measurements. The single-element scanners closely match MODIS and VIIRS fire detection bands, allowing for direct comparison with satellite measurements.



Rabbit Mountain Rx Burn, 31 July 2019. sUAS platform. Part 107 restrictions limited flight altitude to 120 m.



Granite Gulch Fire, 7 August 2018. Aircraft-mounted 4 µm scanner fire detections (small ■) vs. VIIRS fire detections (large blue ■). Average VIIRS I4 pixel brightness temp 48 °C. Average 4 µm scanner fire detection pixel temp 357 °C. 1440 m average altitude, ranging from 1000 - 2000 m during scans.



Data from the SWIR Imager (A), 1.6 µm scanner (B), & 4 µm scanner (C) during the Milepost 97 Fire, 27 July 2019. Daylit terrain is visible in (A) and (B). Fire detections are shown as blue pixels in (B).

PAYLOAD FACT SHEET

NF Payload Weight:	< 2 kg
NF Sensor Resolution, 1 km Flight Alt:	Scanners: ~ 18 m MWIR Imager: ~ 7 m
Comparable Satellite Sensor Resolution:	VIIRS: 375 m MODIS: 1 km
BST S2 Endurance:	Up to 2 hours
BST S2 Cruise Speed:	18 m s^{-1}
Comparable VIIRS channels (CWL)	I3 (1.61 µm), M10 (1.61 µm) I4 (3.74 µm), M13 (4.05 µm)
Comparable MODIS channels (bandpass)	6 (1.628 - 1.652 µm) 21, 22 (3.929 - 3.989 µm)

NEXT STEPS

We seek to further demonstrate the capabilities of this payload by measuring the radiative power of active wildfire via UAS from the 1 km design altitude. Any and all suggestions for collaboration or connection with fire practitioners are appreciated.

ACKNOWLEDGEMENTS

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