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Research Results

TPF-5(494) Tethered Unmanned Aerial System (UAS) for Situational Awareness and Emergency Response Pilot and Evaluation

Improving an incident responder's monitoring capabilities.

Rural

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Project Title: Tethered Unmanned Aerial System Research

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WHAT WAS THE NEED?

Understanding situational awareness during an incident is crucial to providing a safe operating environment for our response teams. Using a drone (UAS) to autonomously transmit both high resolution and thermal imaging video to operators at the District Transportation Management Centers and Headquarters Emergency Operations Center was a novel way to provide valuable, real time crucial information to decision makers. Providing drone video via the California Department of Transportation (Caltrans) Mobile Satellite services enabled another critical path toward reliability and redundancy in emergency response events. A key problem with conventional drones was the limitation of flight time due to battery constraints. Battery management was a critical component of drone flight and often required multiple, very expensive battery sets to keep a drone in the air for long durations. The operational flight time for a drone was up to 40 minutes, and the drone had to come down for a battery changeout. During this battery changeout, information was not sent to the command centers and situational awareness was degraded. The proposed drone used in this pilot project was tethered to the ground. By tethering the drone, power and control could be provided from a ground base station. This enabled a long duration, non interrupted flight and eliminated frequent information outages to the operation centers. Additional key advantages to tethered drones were that they could extend up to 150 feet, were in a very portable, lightweight suitcase format, and could accept a variety of power sources including a utility wall socket, portable solar panels, a small generator, battery inverter, or an onsite vehicle.

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WHAT WAS OUR GOAL?

The goal was to determine whether a tethered drone system could provide continuous, reliable, real time situational awareness during emergency incidents by eliminating the frequent outages caused by battery powered drone operations. The Western States Rural Transportation Consortium (WSRTC) has engaged in numerous Transportation Pooled Fund (TPF) projects—such as TPF 5(241) and TPF 5(494)—that have delivered significant value to Caltrans and the traveling public. Building on this success, WSRTC partnered with Caltrans District 2, Caltrans District 3, the Office of Radio Communications Engineering, and the Washington State Department of Transportation to support testing across a wide range of operating environments and field conditions. This collaboration provided diverse deployment scenarios and technical expertise, enabling a thorough evaluation of the equipment. The results of this evaluation helped determine whether the technology was suitable for broader, enterprise level deployment across multiple transportation agencies nationwide.

WHAT DID WE DO?

The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center at the University of California, Davis (UC Davis) procured Fotokite units and distributed them to the Washington State Department of Transportation (WSDOT) and Caltrans. Training for Department of Transportation (DOT) personnel was completed in August 2023.

Over a two year period, researchers and field staff documented real world deployments, flight logs, hardware issues, livestream performance, and setup times. During the evaluation, the research team observed how each agency used Fotokite for traffic monitoring, incident response, surveys, and livestreaming. The research team also recorded operational benefits, challenges, and user feedback, compiling issue timelines along with recommendations to support smoother future deployments.

WHAT WAS THE OUTCOME?

The commercial firm Fotokite's drone proved highly useful for long-duration monitoring, offering continuous flights for more than 24 hours and high-quality aerial video. Caltrans used the system for traffic surveillance, fog operations, mock bridge inspections, multi-vehicle collisions, and extended closures. The Washington State Department of Transportation (WSDOT) successfully deployed Fotokite for traffic operations during a major Costco opening and in several unscheduled incidents requiring elevated views. Both agencies found the system easy to operate and appreciated that Federal Aviation Administration (FAA) Part 107 certification was not required.

However, multiple limitations reduced overall effectiveness. Setup time often took 15–20 minutes, making it incompatible with WSDOT's rapid-response workflow. Hardware issues including overheating, camera failures, water ingress, and motor malfunctions resulted in frequent repairs with long turnaround times. Remote Identification (RID) errors caused user lockouts and distracting alerts.

Caltrans experienced livestream instability, and the system lacked user-controlled video resolution, limiting Traffic Management Center (TMC) integration. Overall, reliability improved over time but remained dependent on vendor support.

WHAT IS THE BENEFIT?

Should the Fotokite tethered UAS prove cost-effective and maintainable, it is considered in addition to Caltrans' Standard Plans and Specifications. A successful system can significantly improve Incident Responder's monitoring capabilities with a corresponding improvement in situational awareness, effectiveness, and safety. These benefits are achieved without the current problem of short UAS battery life and flight time.

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IMAGES



Image 1: Fotokite Sigma Drone and Portable Transport Case



Image 2: Fotokite Sigma Drone on a Mission Connected via Starlink Antenna

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