STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT DOCUMENTATION PAGE

TR-0003 (REV 04/2024)

1. REPORT NUMBER	2. GOVERNMENT ASSOCIATION NUMBER	3. RECIPIENT'S CATALOG NUMBER
WA-RD 950.1	N/A	N/A

4. TITLE AND SUBTITLE

Evaluation of the Fotokite Tethered Unmanned Aerial System for DOT Operations in Network-Deprived Areas

5. REPORT DATE

June 30, 2025

6. PERFORMING ORGANIZATION CODE

AHMCT Research Center, UC Davis

7. AUTHOR

Anh P. Duong, Ty A. Lasky, Iman Soltani

8. PERFORMING ORGANIZATION REPORT NO.

UCD-ARR-25-06-30-01

9. PERFORMING ORGANIZATION NAME AND ADDRESS

AHMCT Research Center
UCD Dept. of Mechanical & Aerospace Engineering
Davis, California 95616-5294

10. WORK UNIT NUMBER

N/A

11. CONTRACT OR GRANT NUMBER

T3372-AC

12. SPONSORING AGENCY AND ADDRESS

Washington State Department of Transportation
Research Office MS 47372, Transportation Building
Olympia, WA 98504-7372
Doug Brodin, Project Manager, 360-705-7972

13. TYPE OF REPORT AND PERIOD COVERED

Final Report 02/23-06/25

14. SPONSORING AGENCY CODE

WSDOT

15. SUPPLEMENTARY NOTES

N/A

16. ABSTRACT

The Washington State Department of Transportation (WSDOT) Southwest Region operates a 60-mile section of Interstate 5 (I-5) without network communication to support camera implementation for incidents. WSDOT has other highways that operate without network communication or cameras. The WSDOT Incident Response Team (IRT) program consists of roving pickup trucks that help drivers in need and assist the Washington State Patrol (WSP) with incidents and collisions that occur on state highways and interstates. WSDOT needs to obtain accurate and timely scene information from major incidents or road closures. This must include easily shareable incident scene video feeds for partner agencies, Emergency Operation Center (EOC), and media outlets. WSDOT's IRT seeks means to rapidly deploy resources without interfering with crews on scene. WSDOT prefers to provide a drone (Unmanned Aerial System, UAS) to one of their drivers that operates primarily in an urban setting, and one that operates in a rural setting where our current camera coverage is limited. The AHMCT Research Center procured and evaluated Fotokite UASs for DOT operations in network-deprived areas. This effort was a partnership between WSDOT, the California Department of Transportation (Caltrans), and the AHMCT Research Center. This is the research project final report.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Uncrewed Aerial System, Drone, Incident response, Active tether	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. SECURITY CLASSIFICATION *(of this report)*	20. NUMBER OF PAGES	21. COST OF REPORT CHARGED
Unclassified	123	N/A

DISCLAIMER

This document is disseminated in the interest of information exchange. The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This publication does not constitute a standard, specification or regulation. This report does not constitute an endorsement by the Department of any product described herein.

For individuals with sensory disabilities, this document is available in alternate formats. For information, call (916) 654-8899, TTY 711, or write to California Department of Transportation, Division of Research, Innovation and System Information, MS-83, P.O. Box 942873, Sacramento, CA 94273-0001.

Advanced Highway Maintenance and Construction Technology Research Center

Department of Mechanical and Aerospace Engineering
University of California at Davis

Evaluation of the Fotokite Tethered Unmanned Aerial System for DOT Operations in Network-Deprived Areas

Anh P. Duong, Ty A. Lasky &
Iman Soltani: Principal Investigator

Report Number: WA-RD 950.1
AHMCT Research Report: UCD-ARR-25-06-30-01
Final Report of Contract: T3372-AC

June 30, 2025

California Department of Transportation

Division of Research, Innovation and System Information

Executive Summary

The Washington State Department of Transportation (WSDOT) and the California State Department of Transportation (Caltrans) collaborated to procure a portable tethered drone system, known as Fotokite, with the purpose of enhancing situational awareness and improving traffic monitoring in rural areas where there are no cameras or infrastructure for cameras. Over the span of two years, Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center personnel monitored the deployment of Fotokite in the southwest region of Washington State and in Caltrans districts (mainly Districts 2, 3, and 6) of California to determine whether Fotokite is suitable for both DOTs' operations.

Fotokite proved to be valuable with its live-streaming capabilities, and the newly introduced remote control camera released in 2025 was well received by users. WSDOT especially values the ability to operate Fotokite without requiring Federal Aviation Administration (FAA) Part 107 certification (as of June 2025) for their operators, which allows more personnel in their fleet to deploy the drone for a bird's-eye view of incidents. In addition, both DOTs appreciate the system's ease of use, including a user-friendly control interface and the requirement for only one mandatory operator. However, there are drawbacks for both DOTs.

For WSDOT, Fotokite has been underutilized due to the lack of major incidents requiring its deployment since purchase. WSDOT has concerns about the size of the Fotokite portable unit and considers it unsuitable for rapid incident response. For example, in rapid incident response scenarios that typically last about an hour, setting up and establishing the live stream with the Fotokite portable unit can take approximately 15 to 20 minutes. This is due to the multiple steps involved in deploying and connecting the system. First, the unit must be removed from a truck loaded with other equipment, then the incident scene is assessed, and the Fotokite is positioned appropriately. The operator opens the case, retrieves a power cable from the truck, and connects it to the Fotokite. After powering on, the system takes time to boot up, and sometimes the battery needs additional time to charge and become ready. Next, the tablet must also boot up and establish a Wi-Fi connection with the Fotokite. Once connected, the Fotokite is deployed, and the operator may need some time to maneuver it to achieve the optimal vantage point. Finally, the livestream is initiated, which can take a moment to begin transmitting footage.

WSDOT finds value in using Fotokite for long-duration traffic management. Fotokite was used to monitor a Costco opening for approximately five hours, to share footage with multiple agencies during an accident via the Fotokite-provided livestream link, and for operational studies.

For Caltrans, Fotokite has been used in many applications, such as traffic surveillance, speed zone surveys, use as a portable CCTV camera during major incidents or newsworthy events, microwave path surveys, and situational awareness by utilizing the livestreaming functionality to relay footage to the Traffic Management Centers (TMCs) and other agencies as needed. Caltrans has concerns with the inability to control livestream resolution. If resolution could be lowered and made controllable, Caltrans could feed Fotokite streaming into the WOWZA server, which would, in turn, improve footage distribution and smoother operation.

Other concerns include the lack of a permanent solution for remote ID control issues, which cause user lockouts, delayed livestreaming, and distracting error messages. There is also a heavy reliance on the Fotokite vendor for troubleshooting. More importantly, there is no ten-year performance data for Fotokite as it was first introduced in 2019. The vendor stated that the product lifespan is five (5) years, and it will not be warranted beyond that period.

Overall, Fotokite's livestreaming capabilities and remote-control camera function as intended when a reliable network connection is available. Since Fotokite cannot influence cellular network performance, the vendor has recommended using Low Earth Orbit (LEO) satellite networks in rural areas for smoother livestreaming.

Each unit in this report includes a summarized timeline of the issues experienced, along with solutions and recommendations where applicable. If the vendor continues to actively support users in troubleshooting, Fotokite deployment can become smoother and improve over time.

The results from this evaluation are specific to WSDOT and Caltrans operations. Future users of the Fotokite system may experience different outcomes as the robustness of the Fotokite portable unit continues to improve.

Problem, Need, and Purpose of Research

The WSDOT operates a 60-mile section of Interstate 5 (I-5) in the southwest region without network communication to support camera implementation for incidents. WSDOT has other highways that operate without network communication or cameras. The WSDOT Incident Response Team (IRT) program consists of roving pickup trucks that help drivers in need and assist the Washington State Patrol (WSP) with incidents and collisions that occur on state highways and interstates.

WSDOT needs to obtain accurate and timely scene information from major incidents or road closures, including easily shareable incident scene video feeds for partner agencies, Emergency Operation Center (EOC), and media outlets. WSDOT's IRT seeks means to rapidly deploy resources without interfering with crews on scene. WSDOT prefers to provide a drone (uncrewed aerial system [UAS]) to one of their drivers who operates primarily in an urban setting, and one who operates in a rural setting where current camera coverage is limited.

The following are WSDOT's long-term goals:

- *Any selected solution must require a limited amount of training to deploy. It is preferable to avoid the need for FAA Part 107 certification.*
- *User friendly and easy to deploy with one employee.*
- *Ease of maintenance. Most maintenance repairs can be completed in house with a quick turnaround.*
- *The product needs to transmit real-time data back to the various locations where subject matter experts can use the information to make informed tactical decisions.*
- *System must be easily transportable to locations outside of the primary service area.*
- *The system should be easily repositioned to obtain the best vantage point.*

Like WSDOT, Caltrans wants to evaluate a UAS system that can offer the values listed above.

As a result, the objective of this research was to procure and evaluate Fotokite UASs for DOT operations in network-deprived areas.

Overview of Methodology

The research included the following tasks:

- *Task 1: Manage project*
- *Task 2: Procure systems*
- *Task 3: Document system setup*
- *Task 4: Exercise and evaluate systems*
- *Task 5: Develop final report*

Major Results and Recommendations

The key deliverables of this project include:

- *Fotokite systems*
- *Video of system installation and training*

- *Video of select system testing*
- *Testing and evaluation results documented in this final report*

Major results

WSDOT Southwest Region Operation

Initially, Fotokite was procured with the intention of supporting major incidents during heavy winters and mudslides on the highway. However, such incidents have not occurred as of June 2025 when the system was purchased, which has led to Fotokite being underutilized. Additionally, Fotokite is not compatible with rapid incident response. In WSDOT operations, a fleet of rapid incident response trucks, each operated by one person, patrols the southwest region to assist drivers. These incidents typically take about an hour or less to resolve. Since the Fotokite system requires approximately 15 to 20 minutes to set up and establish a livestream connection, the driver does not have sufficient time to deploy the system while also attending to the incident. Spending 15 minutes setting up equipment for an incident that may last less than an hour is not ideal. For example, deploying a Fotokite portable unit requires the driver to remove the unit from a truck crowded with other equipment, then position it in an appropriate launch area since the Fotokite can only move vertically (up and down) and not laterally. Next, the pilot opens the case and retrieves a power cable from the truck to power the Fotokite. The system then needs time to boot up, and sometimes the battery has to be charged before it is ready. The controller tablet has to also boot up and communicate with Fotokite via Wi-Fi, and the upstream internet connection needs to be available to begin live streaming. Most of these tasks are handled by a single person on the scene. If the pilot did not have to perform extra steps such as unloading the Fotokite, opening the case, and connecting cables, the setup process could potentially be much faster.

Moreover, the southwest region of WSDOT is already well-equipped with cameras in highly populated areas, further reducing the need to deploy Fotokite.

WSDOT has found value in using Fotokite for long-duration traffic management and operational support. For example, the system was used to monitor a Costco opening for approximately five (5) hours and to share accident scene footage with other agencies when necessary.

However, WSDOT has the following reservations:

1. *Software updates can be complicated, sometimes requiring vendor remote access to resolve issues.*

2. *The bulky size of the Fotokite system makes it inconvenient for rapid response incidents, especially considering the typical 15 to 20 minutes setup time to livestream.*
3. *There is a heavy reliance on the vendor for troubleshooting. Most of the issues encountered during the two-year evaluation period were resolved through vendor intervention, either by providing troubleshooting instructions or by requiring the unit to be sent back for repairs.*

Caltrans Operation

Fotokite was utilized by Caltrans for various operations, including traffic surveillance, speed zone surveys, as a portable CCTV camera during major incidents or newsworthy events, for microwave path surveys, situational awareness, long-term operation monitoring, extended closures, and time-lapse imaging. In addition, since Caltrans incorporated a LEO satellite network using the Starlink high-performance flat dish with Fotokite, its livestreaming capabilities were successfully expanded into extremely rural areas.

Caltrans values Fotokite's livestreaming functionality, the new remote control camera feature introduced in early 2025, and its long flight time of over 24 hours, provided there is a ground power supply. These features help Caltrans relay footage to multiple TMCs throughout California.

However, Caltrans has the following reservations:

1. *There is* **no user-controlled resolution** *setting for live streaming. This limitation prevents Caltrans from feeding the livestream directly into its server, which would support broader footage distribution and a faster incident reporting process. The current high-resolution stream often results in discontinuous footage and cannot be easily reset on the Caltrans server.*
2. *Remote ID issues have caused user lockouts, delayed livestream footage, and led to distracting error messages. Although the vendor has mitigated these issues throughout the evaluation period, these concerns have not been fully resolved due to the vendor needing to comply with FAA remote ID requirements.*
3. *Similar to WSDOT, Caltrans is concerned about the heavy reliance on the vendor for troubleshooting and support.*

Recommendations

AHMCT has the following recommendations when operating Fotokite:

- *Since the AHMCT team has documented issues, causes, solutions, and recommendations throughout the two-year evaluation period in Chapter 3 of this report, users should refer to Chapter 3, particularly Table 3.1, as a*

resource. This troubleshooting resource excludes the remote ID issues, which remain mitigated but unresolved.

- *To improve operation in rural areas, Fotokite should be paired with a LEO satellite network to support livestreaming.*
- *Users should be aware of Fotokite's power, network, and equipment requirements before operation. These requirements are detailed by the AHMCT team in Chapter 2 under the subsection titled "Fotokite Setup".*

Table of Contents

Figures

Tables

Acronyms and Abbreviations

Acronym	Definition
AHMCT	*Advanced Highway Maintenance and Construction Technology Research Center*
ATIRC	*Advanced Transportation Infrastructure Research Center*
Caltrans	*California Department of Transportation*
DOT	*Department of Transportation*
DRISI	*Caltrans Division of Research, Innovation and System Information*
EOC	*Emergency Operation Center*
FAA	*Federal Aviation Administration*
IRT	*Incident Response Team*
UAS	*Uncrewed Aerial System*
WSDOT	*Washington State Department of Transportation*
WOWZA	*A Streaming Engine Brand*
ID	*Identification*
RID	*Remote Identification*
TMC	*Traffic Management Center*
LEO	*Low Earth Orbit*
CCTV	*Closed-Circuit Television*
WSP	*Washington State Patrol*
AC	*Alternating Current*
DC	*Direct Current*

Acronym	Definition
RGB	*Red Green Blue*
UC	*University of California*
HQ	*Headquarter*
LTE	*Long Term Evolution*
VAC	*Volts Alternating Current*
GFCI	*Ground Fault Circuit Interrupter*
VDC	*Volts Direct Current*
AWG	*American Wire Gauge*
LFP	*Lithium Iron Phosphate*
OEM	*Original Equipment Manufacturer*
SIM	*Subscriber Identity Module*
USB	*Universal Serial Bus*
IR	*Infrared Radiation*
CMOS	*Complementary Metal-Oxide-Semiconductor*
HFOV	*Horizontal Field of View*
LWIR	*Long Wave Infrared*
IP	*Ingress Protection*
GPS	*Global Positioning System*
COA	*Certificate of Authorization*
USA	*United States of America*
GB	*Gigabyte*
SSD	*Solid State Drive*

Acronym	Definition
DJI	*A Drone Company Brand*
MOSFET	*Metal-Oxide-Semiconductor Field-Effect Transistor*
QR	*Quick Response*
PM	*Postmile*
RMA	*Return Merchandise Authorization*
ESC	*Electronic Speed Controller*
IMU	*Inertial Measurement Unit*
SR	*State Route*
VZW	*Verizon Wireless*
RVS	*Relative Value of Service*
PCB	*Printed Circuit Board*

Acknowledgments

The authors thank the California Department of Transportation (Caltrans), Washington State Department of Transportation (WSDOT), and Fotokite staff for their support, particularly Andre Chavez and Jeremiah Pearce with Caltrans Division of Research, Innovation and System Information; Paul Yamashita and Shima Afshari Wollman with Caltrans District 6; Michael Southwick, Jacob Sorensen, Tony Leingang, and Tyler Branch with WSDOT Southwest Region; and Alexander Zhitelzeyf, Chris Arnold, Esther Lee, and Pete Evans with Fotokite. The authors acknowledge the dedicated efforts of the AHMCT team who have made this work possible.

Chapter 1: Introduction

Problem

Many rural areas in California and the southwestern region of Washington State lack CCTV coverage. As a result, responding to incidents in these locations can be challenging due to the absence of quick situational assessments. In addition, certain scenarios, such as dam inspections, highway monitoring, and areas affected by natural disasters, cannot be fully captured without an aerial perspective. To address these challenges, the Washington State Department of Transportation (WSDOT) and the California State Department of Transportation (Caltrans) are seeking an uncrewed aerial system (UAS) that can provide live, shareable video feeds for network-deprived areas and locations without existing CCTV infrastructure. Therefore, the Advanced Highway Maintenance and Construction Technology (AHMCT) team was tasked with evaluating the Fotokite UAS, a tethered drone that has the potential to provide the capabilities sought by the DOTs.

Objective and Scope

The AHMCT Research Center procured and evaluated Fotokite UASs for DOT operations in network-deprived areas. This effort was a partnership between WSDOT, Caltrans, and the AHMCT Research Center.

Research Methodology

The research included the following tasks:

- **Task 1: Manage project** – *The AHMCT team coordinated meetings and communication between the DOTs and Fotokite, provided quarterly and summary reports, and kept track of repair timelines and downtimes.*
- **Task 2: Procure systems** – *The AHMCT team ensured that the DOTs received the equipment purchased from Fotokite and coordinated any additional purchases.*
- **Task 3: Document system setup** – *The AHMCT team documented how to operate the Fotokite system in California and Washington separately in this report as the two states have different internal rules.*
- **Task 4: Exercise and evaluate systems** – *The AHMCT team worked with the DOTs to track Fotokite system deployments, evaluated field performance,*

documented any issues that arose, and coordinated with Fotokite to provide solutions.

- **Task 5: Develop final report** – *The AHMCT team delivered this report, summarizing the evaluation from the initial Fotokite training through to the changes that have occurred since.*

Overview of Research Results and Benefits

The key deliverables of this project include:

- *Fotokite systems, along with associated Red Green Blue (RGB) camera, transport case, and tablet*
- *List of procured systems, including serial numbers*
- *Raw video footage of system installation and training*
- *Raw video footage of select system testing*
- *Testing and evaluation results documented in this final report*
- *Final report*

Chapter 2:
System Procurement and Setup

Fotokite Training

After the first four systems were delivered, AHMCT arranged training sessions for WSDOT and for Caltrans/AHMCT. The training was provided by Pete Evans, Director of the North American Market for Fotokite at the time. The training focused on primary setup and system operation. The training began with a PowerPoint presentation by Fotokite, and numerous questions were asked by the DOT attendees. Following the presentation, the attendees received hands-on flight training with their two Fotokite systems. The training lasted between two and three hours at each site. A copy of the Fotokite training presentation is available upon request, along with video from the hands-on flight training.

WSDOT Training

The WSDOT training was held on August 24, 2023, from 9:00 am to about 11:30 am, in Vancouver, Washington. The WSDOT training is illustrated in Figures 2.1 and 2.2.

Attendees

- *Mike Southwick*
- *Matt Calderone*
- *Rachel Suitter*
- *Jacob Sorensen*
- *Mike Dyer*
- *Rob Brusseau*
- *Tyler Branch*
- *Dianna Brewer*
- *Vince Fairhurst*

Figure 2.1: Pete Evans presenting Fotokite training material to WSDOT

Figure 2.2: Hands-on Fotokite training at WSDOT

Caltrans/AHMCT Training

The Caltrans/AHMCT training was held on August 23, 2023, from 1:00 pm to about 3:30 pm, at the Advanced Transportation Infrastructure Research Center (ATIRC) on the University of California (UC) Davis campus. The Caltrans/AHMCT training is illustrated in Figures 2.3 to 2.10.

Attendees

- *District 2*
  - *Jeremiah Pearce*
  - *Keith Koeppen*
  - *Kenneth Shipley*
- *SatCom*
  - *Ferdinand Milanes*
  - *Earnesto Fermin*
  - *Eric Ho*
- *HQ*
  - *Dean Campbell*
  - *Rachel Jenkinson*
- *DRISI*
  - *Sean Campbell*
  - *Andres Chavez*
  - *Nathan Loebs*
- *AHMCT*
  - *Anh Duong*
  - *Ty Lasky*
- *UC Merced*
  - *Brandon Stark*

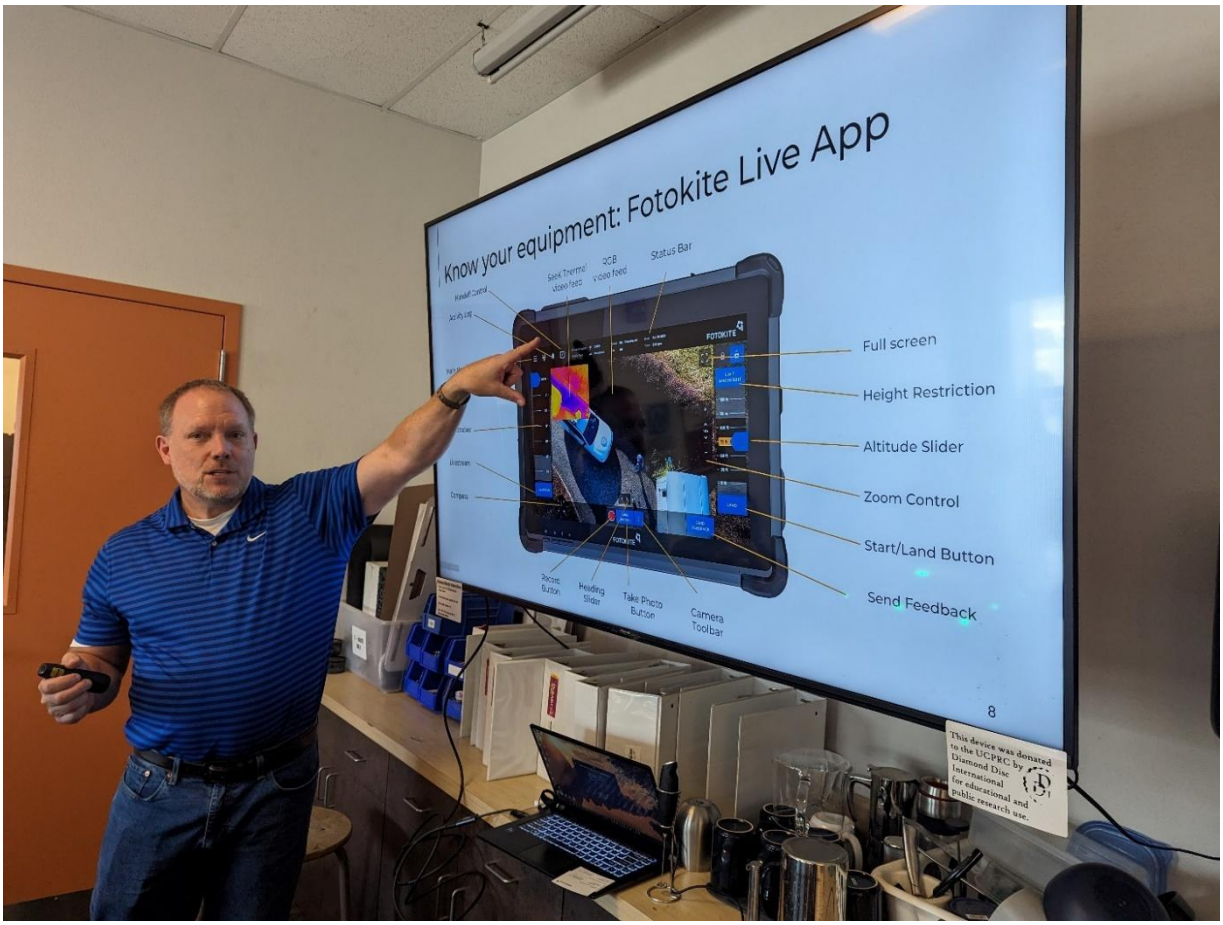

Figure 2.3: Pete Evans presenting Fotokite training material to AHMCT/Caltrans

Figure 2.4: Caltrans/AHMCT attendees during Fotokite training presentation

Figure 2.5: Pete Evans illustrating the user interface

Figure 2.6: Pete Evans demonstrating how to use one Fotokite system while Anh Duong prepares the second system

Figure 2.7: Caltrans/AHMCT attendees viewing the Fotokite system in flight

Figure 2.8: Fotokite systems in flight at the ATIRC facility

Figure 2.9: Andres Chavez controlling the Fotokite system during training at ATIRC

Figure 2.10: Keith Koeppen controlling the Fotokite system during training at ATIRC

Fotokite Procurement

The procurement included five (5) units. Caltrans operates two (2) units, primarily deployed in District 2 (Shasta County) and District 6 (Fresno County) in the State of California. WSDOT also operates two (2) units, mainly deployed in the southwest region of Washington State. The fifth unit serves as a float, used for testing purposes and as a backup when other units are undergoing repairs. Documentation for the units is summarized in Table 2.1.

Table 2.1: Information of the Fotokite units procured and their distribution

Fotokite and Name Given (if any)	Drone Unit Serial Number	Cradle Unit Serial Number Corresponding to the Drone Originally	Cradle Unit Serial Number Corresponding to the Drone at the end of the Evaluation	Rugged Tablet Serial Number (Exchangeable throughout the Evaluation)
Fotokite 1 (Jake's unit, WSDOT)	*E392K*	*G267B*	*G267B*	*BJW5FD3*
Fotokite 2 (back up, WSDOT office)	*E331K*	*G244B*	*G244B*	*5JW5FD3*
Fotokite 3 (Wildcat)	*E396K*	*G214B*	*G2028XH*	*7JW5FD3*
Fotokite 4 (Hornet)	*E376K*	*G269B*	*G269B*	*2KW5FD3*
Fotokite 5 (Gunrock)	*K2019PF*	*G2028XH*	*G214B*	*6LM8FD3*

Fotokite units 1, 2, 3, and 4 were received by the AHMCT team between the end of June and the beginning of July 2023. As soon as these units and their accessories were received, they were sent to DOT personnel by the AHMCT team. Two units were sent to WSDOT, and the other two were sent to Caltrans. Fotokite unit 5 was received separately by the AHMCT team around October 20, 2023. This unit was used as a float for testing, research, and as a backup in case any DOT unit required repair.

Throughout this report, the Fotokite units are referred to by their drone unit serial number and cradle unit serial number. At a certain point during the evaluation (specified later in this report), the Fotokite cradles were exchanged among drone units due to a cradle malfunction. As a result, the AHMCT team added a column in Table 2.1 to inform users of any changes from the originally assigned units.

Fotokite FAA Registration

When Fotokite units were first procured in 2023, remote identification (RID) regulations had not yet been mandated. However, in 2024, the Federal Aviation Administration (FAA) began requiring all drone units weighing more than 0.55 pounds to comply with RID standards. In response, the AHMCT team worked with state DOTs to re-register Fotokite units in accordance with the updated FAA regulations. Table 2.2 summarizes the registration information before and after the implementation of the RID mandate.

Table 2.2: Fotokite units FAA registrations before and after RID mandate

Drone ID	Old registration number	New registration number	Remote ID
E392K (WSDOT)	*FA3PCL4CH7*	*FA3C3YHHP9*	*1898B003000***G267B**
E331K (WSDOT)	*FA3PCL97LT*	*FA3C3YLCTW*	*1898B003000***G244B**
E396K (Caltrans – Wildcat)	*FA3PCLAYNN*	*FA3ACWPWXF*	*1898B0030***G2028XH**
E376K (Caltrans – Hornet)	*FA3PCLETRF*	*FA3CYMLHHX*	*1898B003000***G269B**
K2019PF (Caltrans – Gunrock)	*FA3MCRHKAK*	*FA3AWLM4KF*	*1898B003000***G214B**

Note: The last 5 or 7 digits in the remote ID is the ground base serial number corresponds to the drone (i.e., drone K2019PF pairs with ground base G214B).

FAA registration is valid for three (3) years. Since these units were re-registered at the beginning of March 2024 to comply with the RID mandate, they should be re-registered in 2027.

Fotokite Setup

Fotokite consists of the following:

1) **Cradle Unit**: *Maintains communication between the controller tablet and the Fotokite via Wi-Fi, maintains LTE connection for live streaming, and supplies power to the drone unit.*
2) **Drone Unit**: *Tethered to and powered by the cradle unit. Capable of flying up to 150 feet in altitude. Equipped with cameras offering optical zoom ranges of 0.5–1x and 2.3–4.6x, as well as digital zoom ranges of 1–2.3x and 4.6–16x.*
3) **Controller Tablet**: *Pilot(s) uses the tablet to operate Fotokite, configure the carrier network, and view system specifications and status. The tablet also stores captured photos and video footage.*

Figure 2.11: Fotokite cradle and drone unit

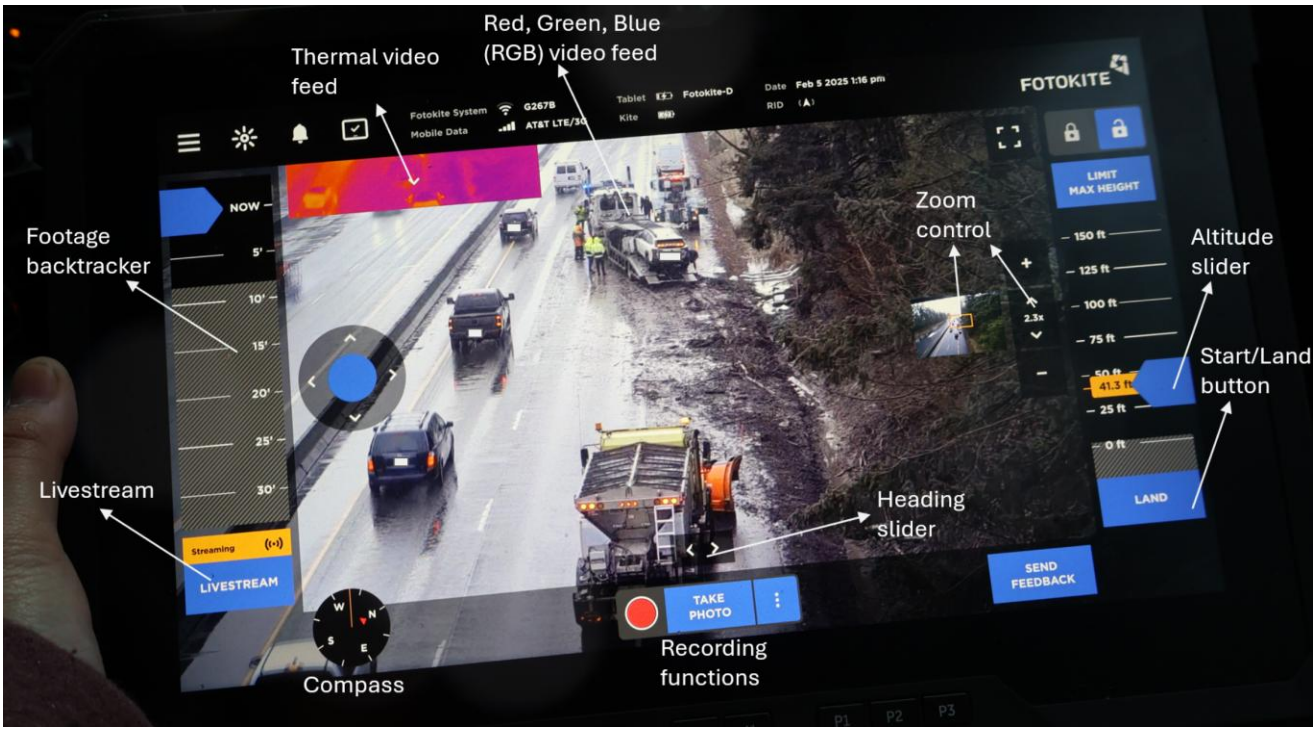

Figure 2.12: Fotokite controller tablet and its user interface

To operate the Fotokite, users need to be aware of:

- *The Fotokite's power requirement*

- *Network and bandwidth requirement for live streaming*
- *Equipment requirement*

The details of each requirement are summarized in the following sections.

Power Requirement

Fotokite alternate current (AC) and direct current (DC) requirements according to the vendor are listed in Tables 2.3 and 2.4.

Table 2.3: Fotokite AC power supply requirements

Power Specification	Value
Nominal Input Voltage (AC)	*110 - 230 (50-60Hz) VAC*
Operational Input Current	*Peak 3.5A*
Operational Input Current: Continuous	*2.6A*
Operational Input Current	*Idle 1.8A*
Idle Power Consumption (not flying)	*220 - 260W*
*Maximum Power Consumption in Flight**	*300 - 400W*
*Min Ground Fault Circuit Interrupter Rated Current***	*15A*

Note: Information courtesy of Fotokite.

** If connecting to an inverter or generator, always ensure you are connecting to a power source rated for a minimum 900W continuous output.*

*** Rated Ground Fault Circuit Interrupter (GFCI) Cable is included with every new Fotokite System.*

Table 2.4: Fotokite DC power supply requirements

Power Specification	Value
Nominal Input Voltage (DC)	*12 - 24 VDC*
Operational Input Current	*Peak 55.0A*
Operational Input Current	*Continuous 50.0A*

Table 2.4: Fotokite DC power supply requirements

Power Specification	Value
Operational Input Current	*Idle 6.7A*
Peak Idle Power Consumption (not flying)	*40 - 80W*
Maximum Power Consumption in Flight	*400 - 500W*
*Sleep Mode Input Power Consumption**	*0.25W*
*Max Path to Power Resistance Required***	*0.065 Ohm*
*Circuit Breaker / Fuse Min Current Rating****	*60A*

Note: Information courtesy of Fotokite.

**The Fotokite Roof Mount System enters Sleep Mode after 5 minutes running without alternator (car battery voltage reading < 12.4V) and exits Sleep Mode once the alternator is running (car battery voltage reading > 13.1V). The battery saving feature is not currently supported for 24V vehicles.*

***A low-resistance path of power is required. Use 6 AWG wire (silicone sheath and a high strand count preferred) at a maximum length of 16ft (5m) from the battery or power supply.*

****A 60A circuit breaker or fuse is required to be installed as close to the power supply as possible.*

It is recommended that Fotokite users should always ensure that their power source meets the system's power requirements. GFCI power cables are provided with the Fotokite system to prevent electrical shock coming from the high-power requirements.

Fotokite Powered by an EcoFlow Portable Power Station

In December of 2023, the AHMCT team conducted a compatibility test between a portable battery brand EcoFlow Delta 2 Max portable power station and Fotokite. Notable specifications for the portable power station are listed in Table 2.5.

Table 2.5: EcoFlow Delta 2 Max portable power station specifications

Item	Specification
Weight	*Approximately 23 kg (50 lbs)*

Table 2.5: EcoFlow Delta 2 Max portable power station specifications

Item	Specification
Dimension	*19.6 x 9.5 x 12 in (497 x 242 x 305 mm)*
Capacity	*2,048Wh*
AC Output	*Pure sine wave; 2,400W total (surge 4,800W) 120V ~ 50/60Hz*
AC Output (bypass mode)	*100-120V ~ max. 15A 50Hz/60Hz (Duration time <3 hours when current exceeds total 12A)*
AC Input Power	*Maximum of 1,800W 15A*
AC Input Voltage	*100-120V~ maximum of 15A*
Battery Type	*Lithium Iron Phosphate (LFP)*
Cycle Life	*3,000 cycles to 80% + capacity*
Protection Type	*Over Voltage Protection, Overload Protection, Over Temperature Protection, Short Circuit Protection, Low Temperature Protection, Low Voltage Protection, Overcurrent Protection*
Optimal Operating Temperature	*20°C to 30°C (68°F to 86°F)*

With a full capacity of 2,048Wh, and the Fotokite consistently drawing between 300W and 400W, the EcoFlow portable power station powered the Fotokite for 4 hours, 52 minutes, and 30 seconds. The timer began when the takeoff button was pressed and stopped upon landing. The flight was conducted in a controlled environment indoors. The table below presents the battery percentages of each item at the start and end of the flight.

Table 2.6: Battery percentage of each item after a 4 hours 52 minutes flight using the EcoFlow portable power station

Item	Battery Percentage at the Start	Battery Percentage at the End

Table 2.6: Battery percentage of each item after a 4 hours 52 minutes flight using the EcoFlow portable power station

Fotokite	*N/A, powered by EcoFlow Power Station*	*N/A, powered by EcoFlow Power Station*
Tablet	*99%*	*87%*
EcoFlow Power Station	*98%*	*10%*

In addition, the battery displays an estimation of the remaining power in hours or minutes. In this test run, the battery percentage estimation given by the battery was correct.

Figure 2.13: Fotokite powered by EcoFlow portable power station

In addition to portable power stations, the Fotokite can also be powered by a generator that meets its power requirements.

Figure 2.14: Fotokite powered by a Honda generator. Note that the cable shown in the photo was not provided by Fotokite; WSDOT used an alternative cable due to a malfunction with the original. Photo courtesy of WSDOT

Fotokite Powered by Vehicles

Throughout the evaluation, Fotokite units were powered by DOT vehicles. Around September 2024, WSDOT raised concerns that their newer model vehicles were unable to power the Fotokite for longer than 30 minutes. It was later discovered that the WSDOT newer trucks were unable to power the Fotokite because the auxiliary battery switch on the trucks was malfunctioning and the idle kill switch was not disabled. In this case, these issues were related to the WSDOT vehicle, not the Fotokite system. The vendor and the AHMCT team have the following suggestions and recommendations for users:

Regarding Fotokite performance with new trucks (in this case, the WSDOT Ford F-350), Fotokite recommended:

- *The OEM factory wiring and inverter for the F-350 provides 400W. Adding an aftermarket inverter may help support the amount of current the Fotokite is drawing. Fotokite requires a minimum continuous 600W and 1000W surge AC power supply.*
- *Fotokite has used the following inverter in their trucks with good success and recommends it:*
    - *BougeRV Pure Sine Wave Inverter 2000W – Converts DC 12V to AC 110V, features built-in Bluetooth for mobile app, ON/OFF/ECO operating modes, and is suitable for off-grid solar systems, RVs, and home backup power. This inverter can be purchased off-the-shelf.*

AHMCT recommended:

- *AHMCT opinion: Theoretically, the 3000W inverter that WSDOT installed should support the Fotokite system.*
- *Possible error sources:*
    - *Bad inverter*
    - *Faulty or undersized wiring, or wiring that is too long (~85 Amps (1000W/12V) is required at 12 Volts)*
    - *The F-350's 12V alternator system may not be able to meet the current requirements (unlikely due to dual alternators)*
- *AHMCT suggestion: Monitor the current and voltage input/output at the inverter.*

Ultimately, the issue WSDOT experienced was caused by a malfunctioning auxiliary battery switch and/or an active idle kill switch. Once the faulty battery switch was replaced and the idle kill switch was disabled, the Fotokite could once again be continuously powered by the vehicle, provided it has fuel.

Other than the issue reported by WSDOT, there have been no other reports of Fotokite experiencing problems when powered by a vehicle if the inverter was a pure sine invertor rated at a minimum of 1000W of continuous power. The Fotokite has been successfully powered by gasoline cars, hybrid cars, and electric vehicles. For example, the 2022–2023 Ford F-150 was used to power the Fotokite, consuming approximately two-fifths of its gas tank over a flight duration of about 2 hours and 30 minutes.

Figure 2.15: Fotokite cradle powered by a Caltrans vehicle

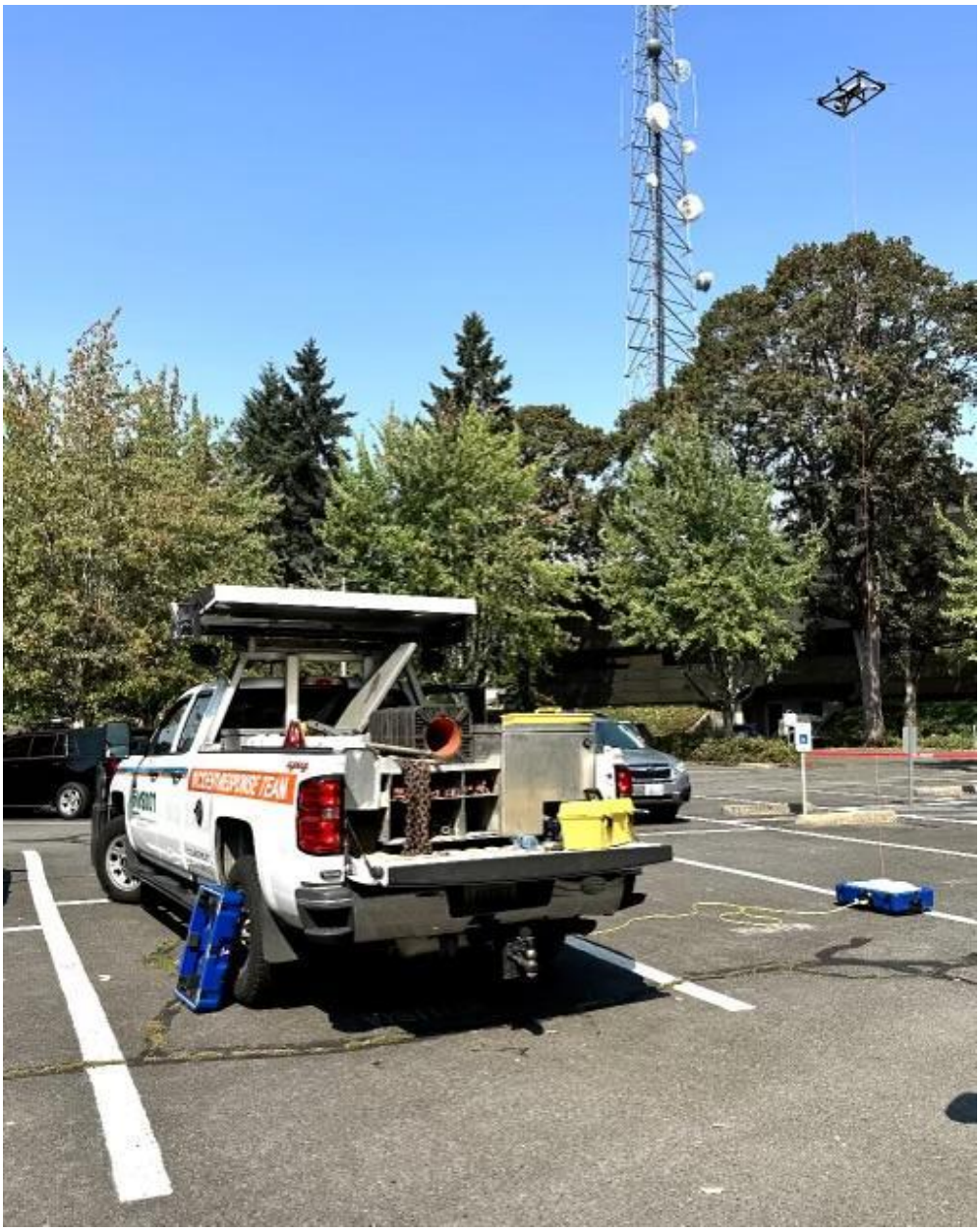

Figure 2.16: Fotokite cradle powered by a WSDOT vehicle. Photo courtesy of WSDOT

Network and Bandwidth Requirement

Fotokite requires cellular service (LTE) to enable its live streaming functionality. The bandwidth requirements for live streaming are:

- *Bandwidth: 2 Mbit/s or higher*
- *Data usage: Up to 0.6 GiB per hour*
- *Latency: Less than 200 ms*

Cellular coverage is included for the lifetime of the unit but is limited to diagnostic access and software updates. Advanced features, such as remote livestreaming and remote camera control, are not included by default and must be purchased separately. The included livestreaming service is set to expire in July 2026, which coincides with the end of the unit's warranty. After this date, users may supply their own cellular service and integrate an independent livestreaming solution into the unit. Alternatively, users could purchase cellular and livestreaming services directly from Fotokite.

For this project, a three-year live streaming subscription was purchased in late June 2023. Initially, Fotokite only offered its own LTE service. However, starting in 2025, Fotokite began offering assistance with configuring user-provided LTE services for an additional fee. Remote camera control functionality also became available in early 2025.

To access Fotokite's livestreaming and remote camera control features, users must contact the company directly for pricing as these services are billed separately. When using a personal SIM card, users are responsible for any associated cellular service costs.

Some users have reported choppy livestream quality when using Fotokite's LTE service. In response, Fotokite implemented an automatic resolution adjustment feature that lowers the streaming resolution when LTE connection quality degrades. Overall, cellular signal quality is outside of Fotokite's control.

For rural or low-coverage areas, Fotokite recommends using a Low Earth Orbit (LEO) satellite internet service or actively monitoring cellular signal latency if using LTE service.

Fotokite provided the following (unedited) guidance for monitoring cellular signal latency:

"Its very hard for us to track because there is poor visibility on their internal routing on our end, but simply running in cmd: ping 8.8.8.8 or tracert 8.8.8.8 . When connected to the Fotokite Wifi should give you some information about the current ms. If you perhaps you can follow up with your results when you are not livestreaming running these commands and we can have a look further. This might explain the livestream connection issues you have been experiencing."

In addition, Caltrans inquired whether Fotokite could allow users to manually control footage resolution to improve livestreams for Caltrans Traffic Control Management (TMC). Caltrans TMC prioritizes continuous video feed over high image quality. Although Fotokite has implemented automatic resolution adjustment, this feature does not meet Caltrans's specific needs. As of June 2025, Fotokite has not implemented user-controlled resolution settings.

Equipment Requirement

To set up the complete Fotokite system, the following components are required:

- **Fotokite portable unit**, *which includes the communication cradle and drone*
- **Fotokite controller tablet**
- **A power source** *that meets Fotokite's power requirements (e.g., vehicle, generator, or portable battery)*
- **Power inverter with outlets** *(recommended capacity: 1000W)*
- **Dell tablet charger** *for charging the Fotokite controller tablet*
- **Ethernet cable**
- **User-provided cellular modem**, *if direct communication with a TMC is needed*
- **SIM card** *compatible with the TMC communication system*
- **Recommend: USB drive** *to backup photos and videos from the Fotokite tablet*

Figure 2.17 shows a setup of the Fotokite with the equipment listed above.

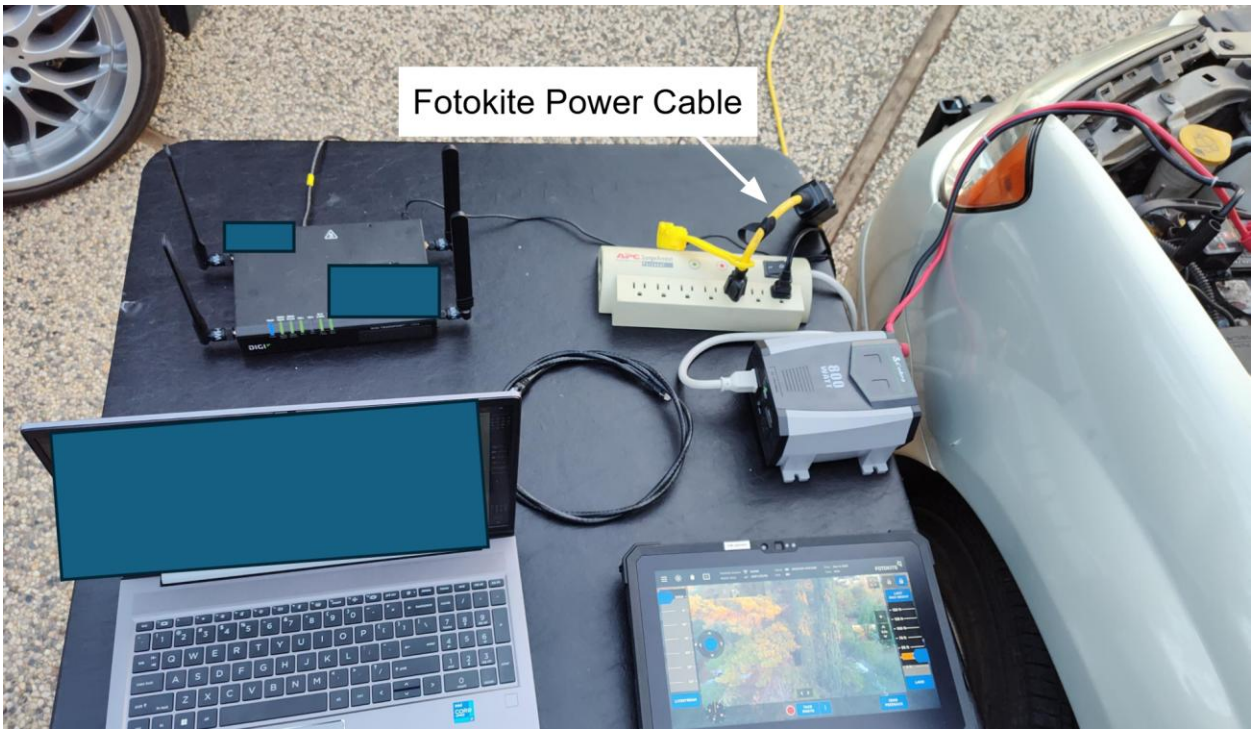

Figure 2.17: Setup for operating the Fotokite. A modem and SIM card for communication with the TMC network are not required if users choose to share

the Fotokite provided live streaming link directly with TMC personnel. Photo courtesy of Caltrans.

How the Fotokite Works

WSDOT Operation

WSDOT primarily used the livestreaming link provided by Fotokite to relay footage to TMCs and other agencies. Figure 2.18 demonstrates how the Fotokite system operates during WSDOT deployments. The system is typically powered by a DOT vehicle, and the field pilot controls the camera to capture the scene. The Fotokite-provided livestream link is then sent to WSDOT TMC for traffic management purposes.

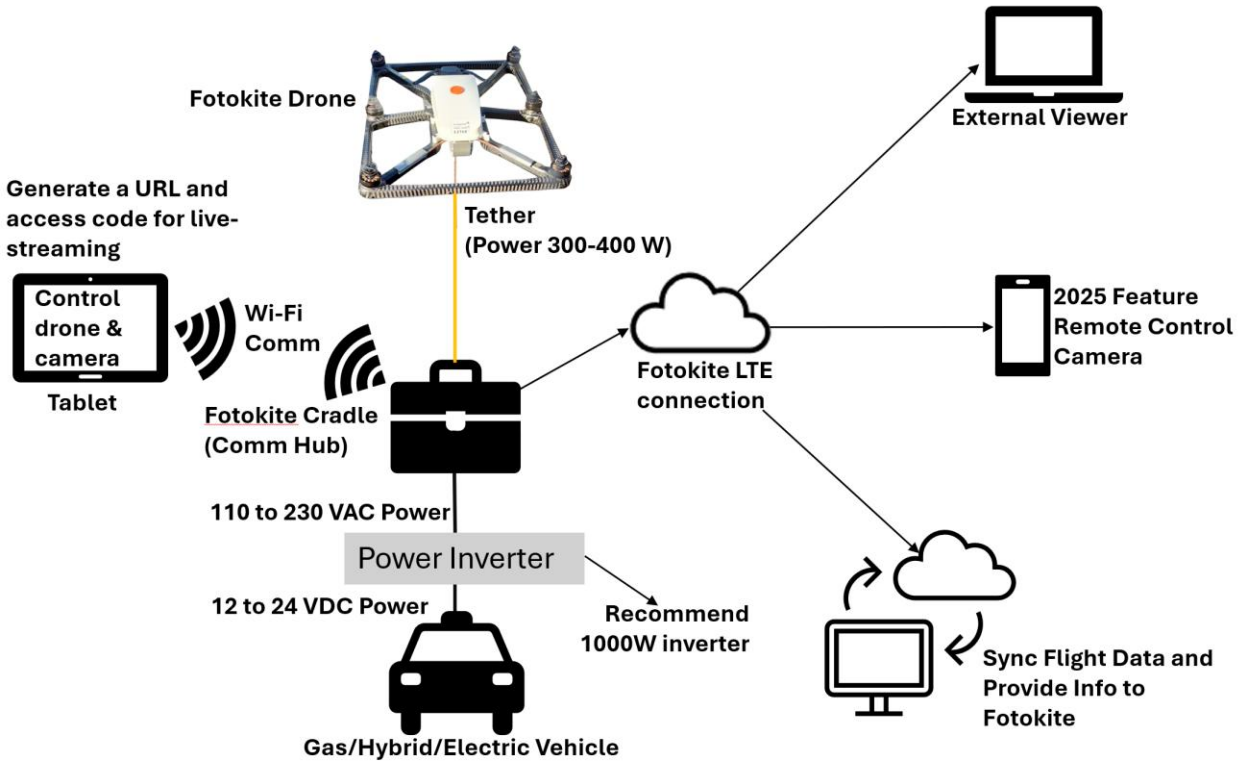

Figure 2.18: The diagram demonstrates how the Fotokite system works for typical WSDOT operation. Note that the abbreviation "comm" stands for "communication"

In addition, since the Fotokite system does not require FAA Part 107 Certification to operate (as of June 2025), it offers flexibility for WSDOT personnel in traffic operations, which adds value for WSDOT.

Caltrans Operation

Caltrans prefers using its own network for live streaming. While Caltrans can also use the Fotokite-provided livestream link like WSDOT, they sometimes embedded their own SIM card into the Fotokite cradle unit to simplify operations and eliminate the need for a separate modem.

Figure 2.19 demonstrates how the Fotokite system operates during Caltrans deployments. The system is typically powered by a DOT vehicle, and the field pilot controls the camera to capture the scene. Since Caltrans prefers to use its own network, an external cellular modem must be connected to the cradle unit to allow Caltrans TMCs access to the live streaming footage on their network. Alternatively, a Caltrans SIM card can be embedded directly into the cradle unit's internal modem, eliminating the need for an external cellular modem.

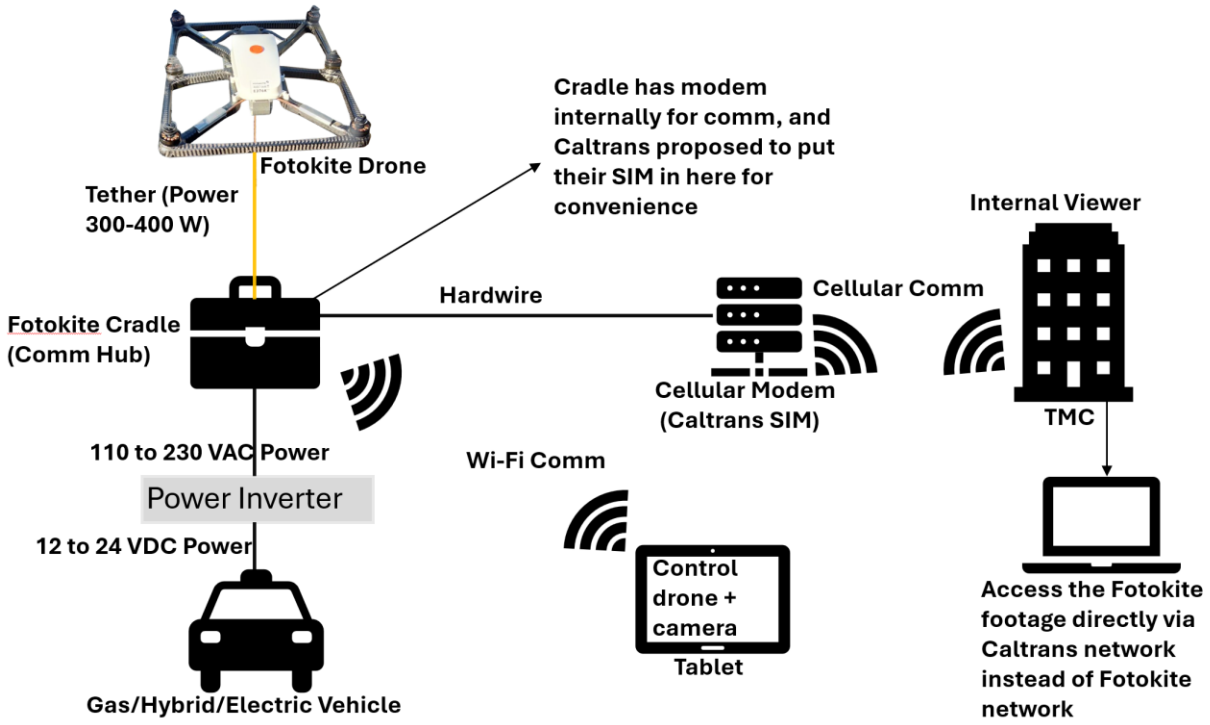

Figure 2.19: The diagram demonstrates how the Fotokite system works for typical Caltrans operation. Note that the abbreviation "comm" stands for "communication"

Although the Fotokite system does not require FAA Part 107 Certification to operate (as of June 2025), Caltrans still requires its personnel to hold the certification prior to operating it. Caltrans prefers to observe the system's performance in the field over a longer period before deciding whether to lift this internal restriction.

Notable Fotokite Specifications

The following specifications from the Fotokite manual are important for users. Note that the content in this section is heavily related to the Fotokite user manual, version 2.17 [1].

Camera Specifications

For this evaluation, the Fotokite units have the second-generation camera offered by Fotokite. Camera 2nd generation camera features:

- *Radiometric Infrared Radiation (IR) thermal camera*
- *Wide angle Complementary Metal-Oxide-Semiconductor (CMOS) camera*
- *Narrow angle CMOS color camera*

The data from these camera sensors are combined to make the following video streams simultaneously available at the same time:

- *Thermal video feed*
- *Zoom color video feed*
- *Overview color video feed*

The dual color camera configuration enables the zoom color video feed to provide 0.5x – 16x hybrid optical and digital zoom. Optical zoom ranges from 0.5x – 1x and 2.3x – 4.6x. Digital zoom ranges from 1x – 2.3x and 4.6x – 16x [1].

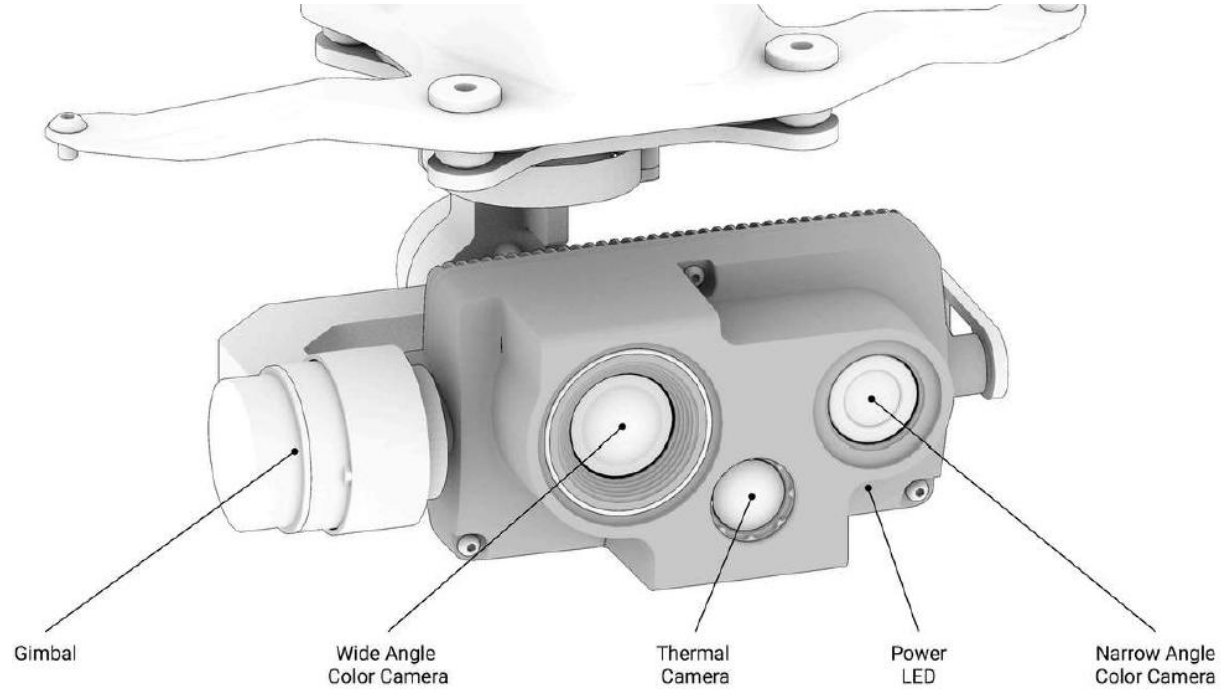

Figure 2.20: Fotokite camera configurations. Photo courtesy of Fotokite [1]

Table 2.7: Camera 2nd generation specifications

Item	Specification
Color camera sensors	*12MP CMOS image sensor, 1/2.3", 30 fps*
Wide angle lens configuration	*2.7 mm HFOV 98°, f/2.8, focus 0.5m - infinity*
Narrow angle lens configuration	*12.5 mm HFOV 28°, f/2.4, focus 10.5m - infinity*
IR thermal camera sensor	*320x240, LWIR, 12 µm pitch, 27 fps*
IR thermal lens configuration	*9.1mm HFOV 24°*

Note: Information courtesy of Fotokite [1].

Fotokite System Specifications

Tables 2.8, 2.9, and 2.10 outline general specifications, transport case and ground station specifications, and flight unit specifications.

Table 2.8: General Fotokite specifications

Item	Specification
Weather rating	*IP55*
Operating temperature	*14F to 104F (-10C to 40C)*
Operating conditions	*Light to medium rain/now, wind up to 25 mph (40 km/h)*
Maximum operating altitude	*6,561 ft (2000 m) mean sea level*
Range	*Max height 150 ft (45 m) with GPS* *Max height 82 ft (25m) without GPS*
Flight time	*24 hours plus*
FAA regulation compliance	*No pilot license, COA, or aircraft certification needed for Public Safety officers, Remote ID (USA) ready*

Note: Information courtesy of Fotokite [1].

Table 2.9: Transport case and ground station (also known as cradle unit) specifications

Item	Specification
Transport case	
Dimensions	*25 x 19 x 13.5 in (635 x 483 x 343 mm)*
Weight	*43 lbs (19.5 kg)*
Nominal input voltage (AC)	*90 – 230 V, 50 or 60Hz*
Operational input current: peak	*6A*
Maximum power consumption (in flight)	*500W*
Ground station (also known as cradle unit)	
Dimensions	*20.16 x 13.67 x 6.26 in (512 x 347 x 159 mm)*

Table 2.9: Transport case and ground station (also known as cradle unit) specifications

Item	Specification
Weight	*22.18 lbs (10.06 kg)*
Backup battery capacity	*870mAh 3-Cell/3S 11.1V LiPo (with integrated heating)*
Internal storage	*500GB SSD*
Satellite navigation system	*U-blox NEO-M8N-0*
Access point frequency	*Dual-band (2.4 GHz / 5.0 GHz) – dual-concurrent Wi-Fi; 802.11 a/b/g/n/ac*
Tether voltage	*300 – 400V*

Note: Information courtesy of Fotokite [1].

Table 2.10: Flight unit specifications

Item	Specification
Dimensions	*19.22 x 13.70 x 4.69 in (488 x 348 x 119 mm)*
Weight	*2.78 lbs (1.26 kg)*
Propulsion	*6 x Fotokite 3350 motors with weather sealing and endurance bearings*
Propellers	*6 x 8.3 in – 8331 DJI mavic pro low-noise quick-release*
Max descent time	*60 seconds (from max height of 150 feet)*
Backup battery	*870mAh 3-Cell/3S 11.1V LiPo (with integrated heating)*

Note: Information courtesy of Fotokite [1].

Chapter 3:
System Testing and Evaluation

System Testing

Following the system setup and training sessions from August 23 to 24, 2023, two Fotokite systems were provided to both Caltrans and WSDOT. A flight logging template was also developed. The DOTs began testing and logging at this time. The logging format is as shown in Figure 3.1.

Fotokite Log

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes

Figure 3.1: Flight log format

The AHMCT team reviewed flight logs over a two-year period from June 2023 to June 2025. When issues were identified, the AHMCT team, Caltrans, and WSDOT coordinated with Fotokite support to help find the root cause, develop solutions, and make recommendations. Table 3.2 summarizes the recorded issues, their causes, the implemented solutions, and recommendations for future operations.

Table 3.1: Summary of Fotokite issues, root causes, solutions, and recommendations

Problem	Cause	Solution	Recommendation
Motor malfunction	*Supplier changed the metal-oxide-semiconductor field-effect transistor (MOSFET) board, prompting a recall across all units*	*All units sent back for inspection and repair*	*N/A*
Condensation at lens	*Crack in the lens*	*Camera replaced*	*N/A*

Table 3.1: Summary of Fotokite issues, root causes, solutions, and recommendations

Problem	Cause	Solution	Recommendation
Ground base could not be charged	*Charging circuit did not reach required voltage*	*Ground station battery replaced*	*N/A*
Drone crash causing frame and propellers damaged	*Related to motor malfunction*	*Replaced propellers and conducted flight quality test before sending back to Caltrans*	*N/A*
Unable to sign in to tablet	*Software issue*	*Fotokite remoted in; fixed 1 of 2 tablets; the other was replaced*	*N/A*
Camera lagging	*Poor signal*	*N/A*	*Keep the tablet in close proximity to the Fotokite base. Recommend 10 feet or below*
Tether twisting concerns	*Excessive spinning of the tether*	*Fotokite to develop compensation feature into the flight controller*	*Periodically inspect tether for warping*
Ground base overheating causing premature landings	*Battery and sensor placement issues*	*Backup battery replaced. Fotokite to improve temperature reading (recorded by sensor) accuracy to prevent false landing warning*	*Allow cooling in shade for 30 min on hot days to keep temperature below 65°C (149°F). Monitor the temperature status using the Fotokite tablet*
RID issue	*Code configuration*	*Software updates and fixes provided*	*Send feedback via tablet*

Table 3.1: Summary of Fotokite issues, root causes, solutions, and recommendations

Problem	Cause	Solution	Recommendation
		partial improvement. Fotokite to continue working on a permanent solution	
Fotokite not consistently powered by newer trucks	*Idle kill switch active; auxiliary battery switch malfunctioned*	*Idle kill switch disabled; ensured stable power*	*Monitor the current and voltage input/output at the inverter.*
Camera control failure from tablet	*Loose screw caused skipping on shaft*	*Replaced*	*N/A*
Drone unable to take off	*Internal short circuit in ground station*	*Ground station replaced*	*N/A*
Drone drifted > 8 ft from base in wind	*Magnetometer anomalies. A fault on the cradle unit printed circuit board (PCB) affected GPS transmission and communication*	*Replaced malfunctioning circuit boards, installed a new camera, and reworked most of the cradle unit*	*The drone unit does not have real-time wind monitoring. Since the issue is primarily caused by internal components, there are no applicable recommendations for users*
Mandatory software update during use	*Incomplete update*	*Fotokite support assisted remotely and later completed update in a strong-signal environment*	*Perform updates in strong-signal environments*
Fotokite oscillated near large trucks	*Too close to moving traffic*	*Caltrans developed a launch protocol*	*Caltrans required launch distance from the road to be the flight height + 10 feet*

Table 3.1: Summary of Fotokite issues, root causes, solutions, and recommendations

Problem	Cause	Solution	Recommendation
Tablet screen hard to see in sun	*Glare*	*Print out live streaming QR codes*	*Purchase anti-glare screen cover*
Unstable livestream	*Unknown*	*Cause undetermined (bitrate drop/cutout unclear)*	*Recommend LEO satellite network in rural areas*
Unstable network	*Possibly poor routing*	*Run ping 8.8.8.8 or tracert 8.8.8.8 while connected to Fotokite Wi-Fi for diagnostics*	*Share results with Fotokite support. Recommend LEO satellite network in rural areas*
"External magnetic disturbance detected" error	*Magnetometer did not initialize correctly*	*Yaw error from bad initialization; system recovers on next flight*	*Avoid yawing during ascent on first take-off*
"Mobile data unavailable" error	*Failed to connect to cellular tower*	*N/A*	*Install personal SIM card or use a LEO satellite network*
Livestream feature unavailable	*Not connected to upstream cellular or Wi-Fi signal*	*N/A*	*Use a LEO satellite network in little to no signal areas*
Unable to capture video footage	*Disk full*	*Transfer photos and videos to a drive and delete existing footage.*	*Have a USB drive to back up photos and videos*
Camera functionality issue	*Water ingress damaged the camera*	*Unable to restore the original camera, so a new camera was installed*	*Perform a visual check and clean the camera after operation if needed*

In addition to Table 3.1, which summarizes issues encountered by both Caltrans and WSDOT, the AHMCT team also documented the specific units

associated with each problem. The following sections outline Caltrans' and WSDOT's operations and deployment of Fotokite.

WSDOT Testing

Day-to-Day Operation and Expectations for Fotokite

WSDOT operates an incident response team composed of approximately seven drivers, each assigned to one incident response vehicle. The team's primary responsibility is to quickly respond to accident scenes and monitor the highways. These activities include, but are not limited to, assisting stranded drivers, clearing debris, providing traffic signs for highway patrol, and ensuring safe travel conditions.

The Fotokite is meant to be used in areas with no camera coverage, during major accidents (such as multi-car collisions), and in response to natural disasters, particularly floods and mudslides. However, it has not been utilized frequently as most incidents occur within areas already covered by existing cameras. Additionally, there have not been any significant accidents or natural disasters since the Fotokite was procured in June 2023.

While the Fotokite was successfully used to monitor traffic flow during the Costco opening in Washington, it has not been deployed for any other events. Due to its setup time (approximately 15 minutes), the Fotokite is not ideal for rapid incident response (incidents often take less than an hour to resolve). Incident response personnel typically handle around 20 incidents per day, totaling approximately 440 incidents per month, excluding non-working days. The Fotokite, which travels with the incident response team, is used only once or twice a month, resulting in a usage rate of less than 1%. Similarly, the Fotokite stored in the TMC for emergency response has a usage rate of less than 1%.

Deployed Locations

From June 2023 to June 2025, the most frequent locations for Fotokite deployment by the WSDOT were across the southwest region of Washington State and along Interstate 5. The following is a list of locations where Fotokite has been deployed to date:

- *East of Route 500 PM 16*
- *North of I-5 PM 45*
- *North of Route 411 PM 5*
- *Rush Rd*
- *Kelso Yard*
- *Route 503 PM 10*
- *East of Route 500 PM 4*

- *WSDOT Southwest Region Office*
- *Northbound I-5 PM 2*
- *Northbound I-5 PM 21*
- *Northbound I-5 PM 24*
- *Northbound I-5 PM 25*
- *Northbound I-5 PM 27*
- *Northbound I-5 PM 30*
- *Southbound I-5 PM 31*
- *Southbound I-5 PM 65*
- *Northbound I-5 PM 70*

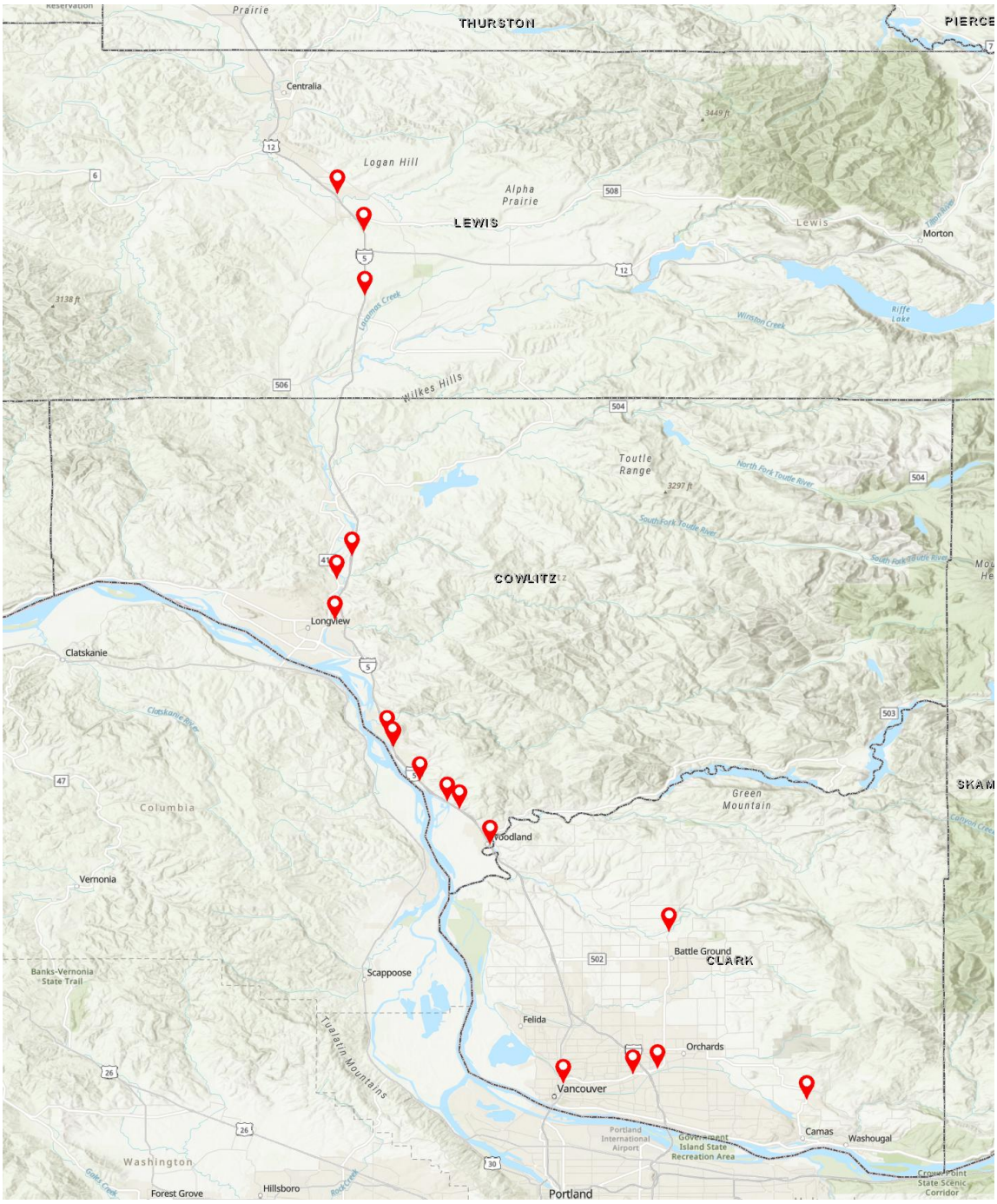

Figure 3.2: Map of WSDOT deployment locations

Issues Encountered with the Units and Solutions

The Fotokite units for WSDOT deployment are E331K drone paired with G244B cradle unit and E392K drone paired with G267B cradle unit. Tables 3.2 and 3.3 detailed the issues the units experienced and solutions to those issues.

Table 3.2: E331K drone and G244B cradle unit timeline summary

Month Year	Summary
July 2023	*Unit received by WSDOT*
August 2023	*On-site training with Fotokite. No issue recorded*
September 2023	*No issue recorded*
October 2023	*No issue recorded*
November 2023	*Condensation at the camera lens caused by a crack. Fotokite team replaced the camera*
December 2023	*Motor failure. Pilot safety landed the unit*
January 2024	*Inspection due to a motor malfunction recall -return merchandise authorization (RMA) was enforced. Fotokite replaced the malfunctioning parts and tested the unit before sending it back to the user. "Opened and all speed controllers replaced. In requalification checkouts before return. Camera replaced" according to the vendor*
February 2024	*Two controller tablets had a software issue which locked out the users. Fotokite team remoted in to reset the software for one of the tablets, and Fotokite replaced the other tablet*
March 2024	*RID feature was introduced, which later caused issues such as user lockout and its consistent error messages were distracting during livestreaming. Fotokite released software updates to improve the RID errors. Was not able to connect to a LTE signal source for 15 minutes, occurred twice in the month. Delay in cellular connection is outside of Fotokite's control. Recommend using LEO satellite network*
April 2024	*No issue recorded*
May 2024	*No issue recorded*
June 2024	*No issue recorded*
July 2024	*No issue recorded*
August 2024	*No issue recorded*
September 2024	*WSDOT new trucks were unable to power the Fotokite for more than 30 minutes. WSDOT new truck(s) idle kill switch was not disabled and/or the auxiliary battery switch was malfunctioned. After the idle kill switch was disabled and/or the auxiliary batter switch was replaced, the issue was resolved*

Table 3.2: E331K drone and G244B cradle unit timeline summary

Month Year	Summary
October 2024	*No issue recorded*
November 2024	*RID errors prevented WSDOT from launching the drone unit. Fotokite remoted in to fix the issue*
December 2024	*No issue recorded*
January 2025	*No issue recorded*
February 2025	*Fotokite power cable malfunctioned, prompting WSDOT to use their own cable*
March 2025	*No issue recorded*
April 2025	*No issue recorded*
May 2025	*No issue recorded*
June 2025	*Remote ID issue and power issue. Remote ID issue fixed itself. The user reset the system and did not experience an issue afterward*

Table 3.3: E392K drone and G267B cradle unit timeline summary

Month/Year	Summary
July 2023	*Unit received by WSDOT*
August 2023	*On-site training with Fotokite. No issue recorded*
September 2023	*No issue recorded*
October 2023	*Motor malfunctioned. Fotokite failed to take off. Fotokite unit was returned for repairs*
November 2023	*One specific motor was then fixed, and Fotokite unit sent back to WSDOT in mid-November*
December 2023	*Drone experienced another motor failure around December 18th. In the second incident, the tablet displayed kite motor error, and the center motors would not function properly*
January 2024	*Inspection due to a motor malfunction recall -return merchandise authorization (RMA) was enforced. Fotokite replaced the malfunctioning parts and tested the unit before sending it back to the user. "Opened and all speed controllers replaced. In requalification checkouts before return" according to the vendor*
February 2024	*Two controller tablets had a software issue which locked out the users. Fotokite team remoted in to reset the software for one of the tablets, and Fotokite replaced the*

Table 3.3: E392K drone and G267B cradle unit timeline summary

Month/Year	Summary
	other tablet. Was not able to connect to a LTE signal source for 15 minutes. Delay in cellular connection is outside of Fotokite's control. Recommend using LEO satellite network. One motor was slower than others upon startup. This issue did not affect the overall flight performance
March 2024	*RID feature was introduced, which later caused issues such as user lockout and its consistent error messages were distracting during live streaming. Fotokite released software updates to improve the Remote ID errors. Live streaming footage was lagging. Delay in cellular connection is outside of Fotokite's control. Recommend using LEO satellite network*
April 2024	*No issue recorded*
May 2024	*No issue recorded*
June 2024	*No issue recorded*
July 2024	*No issue recorded*
August 2024	*"Ground station battery temperature problem" error message. WSDOT allowed the Fotokite system to cool in the shade for about 30 minutes, then relaunched it and experienced no issues afterward*
September 2024	*WSDOT new trucks were unable to power the Fotokite for more than 30 minutes. WSDOT new truck(s) idle kill switch was not disabled and/or the auxiliary battery switch was malfunctioned. After the idle kill switch was disabled and/or the auxiliary batter switch was replaced, the issue was resolved*
October 2024	*No issue recorded*
November 2024	*RID errors prevented WSDOT from launching the drone unit. Fotokite remoted in to fix the issue*
December 2024	*No issue recorded*
January 2025	*No issue recorded*
February 2025	*Fotokite power cable malfunctioned, prompting WSDOT to use their own cable. Excessive yaw issue occurred. "External magnetic disturbance detected" error occurred. Fotokite identified the cause as an initialization bug. To*

Table 3.3: E392K drone and G267B cradle unit timeline summary

Month/Year	Summary
	prevent this issue, users are advised to avoid yawing the unit while ascending
March 2025	*Excessive yaw issue, the unit was sent back to Fotokite for inspection and diagnostic*
April 2025	*Under repairs*
May 2025	*Under repairs. Although the unit was in repair due to excessive yaw, the unit's camera also needed to be rebuilt. There was some water ingress to the compartment that houses the camera control board, which caused the camera issues*
June 2025	*Investigation revealed that the cradle unit required rework due to malfunctioning circuit boards, water ingress, and inadequate GPS transmission and communication. The unit was re-tested after the repairs and returned to WSDOT at the end of June*

Notable issues with the Fotokite units in Washington State and detailed vendor responses are below. Note that vendor responses are provided as-is and have not been written or edited by the AHMCT team.

- *Motor malfunction led to recall of all units.*
    - *Vendor raw response 1: "I had a discussion with our Senior Applications Engineer who was running point on the repair for your unit. The issue was that our electronic speed controller (ESC) board supplier changed a MOSFET on the board without our knowledge and the failure did not exhibit itself for a long enough period that it was passing all of our internal and checkout tests we performed. That problem has been rectified with the supplier and we have beefed up the supplier documentation to avoid any further instances of it in the future."*
    - *Vendor raw response 2: "When E392K was last serviced we only had one of the speed controllers replaced during its first RMA. This was a mistake on our end because we did not fully understand the nature of these failures. We now have established the root cause was a set of MOSFETs on the circuit board were partially populated with a different component by our supplier (SiSS26**L**DN instead of SiSS26DN), which now means our RMA criteria is to check all speed controllers for the correct surface mount components and replace the boards accordingly. To us it is also concerning, but we are confident that we have enough data to now say we are fixing this issue for good."*

- *Vendor raw response 3: "K2019PF is part of a production batch unaffected by the RMA issue – correct"*
- *AHMCT recorded notes: "A Fotokite representative concluded that drone E376K was not affected by the MOSFET issue, so none of the speed controllers have to be replaced."*

- *Remote ID issues have persisted since remote ID was introduced to Fotokite. As of June 2025, although software updates have improved RID issues over the span of one (1) year, the issues have not been fully resolved as users still experience RID error messages from time to time.*
  - *Vendor raw response: "Here is the associated FAA section 89.320 https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-89/subpart-D/section-89.320*
    (h) Message elements performance requirements.
    The reported geometric position of the unmanned aircraft must be accurate to within 100 feet of the true position, with 95 percent probability.
    The reported geometric altitude of the unmanned aircraft must be accurate to within 150 feet of the true geometric altitude, with 95 percent probability.
    The reported geometric position of the take-off location must be accurate to within 100 feet of the true geometric position, with 95 percent probability.
    The reported geometric altitude of the take-off location must be accurate to within 150 feet of the true geometric altitude, with 95 percent probability.
    The remote identification broadcast module must broadcast the latitude, longitude, and geometric altitude of the unmanned aircraft no later than 1.0 seconds from the time of measurement to the time of broadcast.
    The remote identification broadcast module must broadcast the message elements at a rate of at least 1 message per second.
    So the main thing is that we are trying to be very strict with complying to the letter of the law around Remote ID. Important to note the broadcast rate of 1 second. If at any time we have a loss of GPS communication (regardless of it is even 30ms) and we attempt to transmit an RID packet, we currently get a failure. If we emit a remote ID error for a period of time, we go into this Remote ID error state you mentioned.
    One thing the pilot can do is make sure they do not move away from the Fotokite Tablet too far from the System. If the tablet fails to

receive communication with the Fotokite for a period in flight, it will also transmit a remote ID error where the feed is greyed out and you cannot control the system (what you saw 5 times, thanks for sending GUI feedback btw).
We are in the process of modifying the logic around these error states to not lock out the user and also to emit regardless of these edge cases, which from the user side should eliminate any flags that appear. Its important to note that your system continues to be compliant when this happens"

- *AHMCT recorded notes: "The Remote ID issue has been partially addressed in the recent software update, which should help alleviate some of the problems. However, if significant changes to the code logic are made, recertification will be required. The Fotokite team is currently working on securing approval for this action. This issue has been occurring nationwide, likely due to interactions with FAA Remote ID compliance rules.* **Fotokite is actively testing and working to improve the Remote ID issue, with the goal of mitigating it in an upcoming software release.** *The issue has been attributed to signal transmission and timing inconsistencies."*

- *Excessive yaw issue in windy conditions.*
  - *Vendor raw response 1: "Unfortunately we don't have a way to monitor real time wind readings. The way we calculate wind disturbance detection on our end is by looking at the combined velocity from different onboard sensors (IMU, GPS, etc) and compare that to the saturation of the motors, which provides a state estimate of the wind, with a threshold that triggers high wind detection etc. Was the drone triggering high wind warnings when you had these issues? Any videos and times you have would be great to take a look at. One thing to note, if there is poor GPS performance then we trigger High Wind more often than we should, causing false positives. This is something we are hoping to address better in the upcoming update."*
  - *Vendor raw response 2: "***[E392K] [G267B]** *This unit was returned for service to resolve the magnetometer issues it was experiencing in the field. During our initial inspection, we also identified several preventative maintenance tasks that would benefit the kite's overall performance if addressed while it was in our facility. We cleaned and re-greased components in the drivetrain to improve longevity and reduce mechanical friction. Additionally, we cleaned and reapplied thermal compound on critical boards within the kite's power*

transformer. To ensure maximum capacity and reliability, we also replaced the batteries with new units. With maintenance complete, we turned our attention to the magnetometer issues for which the kite was initially returned. Our preliminary functionality test revealed communication problems. Upon investigation, we determined that one of the boards in the power transformer was malfunctioning. Replacing this board resolved the communication issue observed during testing. Testing continued until we encountered camera functionality problems. Our investigation revealed that this issue may have been due in part to water ingress. The water detection sticker in the camera indicated that at some point there was water present in the unit. After considerable effort to restore the original camera, we determined that replacing it with a new unit would be more time-efficient than performing a full rework. Following installation of the new camera, further testing revealed a soft-lock condition caused by velocity readings exceeding acceptable thresholds. This issue proved complex and led us to discover several related problems. We replaced the FCR, one of the kite's primary flight boards. While this did not fully resolve the velocity readings, it did eliminate the magnetometer anomalies. Next, we examined the interface between the main power distribution board and other internal components. We identified soldering issues between the distribution PCB and the motor controllers, as well as a mechanical alignment issue affecting spacing between the distribution board and the flight controllers. During this inspection, we also observed damage to the kite frame at the rivet attachment points. As a result, we replaced the entire frame. We believe that, together with the solder rework, this resolved the velocity reading issue.The unit then proceeded through a complete battery of tests, including bandwidth assessments, stress tests, sensor calibrations, telemetry checks, and flight tests. During the final stage, the unit failed due to an inability to transmit GPS data from the ground station to the rest of the system. This was traced to a fault on a ground station PCB responsible for processing data from the ground station's GPS antenna. Note that ground station GPS does not affect flight performance, but is tested as part of outdoor checks. We replaced the faulty board and, following successful verification, the unit passed all remaining tests."

- *Force software update issue.*
    - *AHMCT recorded notes 1: "Fotokite has confirmed that there are no mandatory updates currently being pushed through the Fotokite application. However, users operating on iOS or Android devices*

should be aware that automatic updates may still occur based on individual device settings. It is recommended that users review their device settings to manage update preferences. For those using the Fotokite-provided tablet, automatic updates should not be enforced by default."

- *AHMCT recorded notes 2: "Once a Fotokite software update is initiated, it must be completed. If the update is interrupted or left incomplete, it will automatically resume the next time the Fotokite application is opened. This can potentially impact field operations in areas with limited internet connectivity as the update may not be able to finish properly. In such cases, the pilot may be unable to launch or control the Fotokite until the update is fully installed."*

- *"External magnetic disturbance detected" error.*
  - *Vendor raw response: "The telemetry is telling me that your GPS readings looked okay, but perhaps the magnetometer didn't initialize properly on the first takeoff. There were no steel structures nearby when you were flying, correct? From what I can gather, this initialization led to a yaw bias error that compounded after approx 4min where the kite believed there was a yaw error that was >30deg of misalignment after 4 minutes. I think this is an initialization bug, because the system goes back to normal after the next flight attempt. To avoid this, you may want to avoid yawing while increasing altitude, as I have seen this help in situations where this issue occurs."*
  - *AHMCT recorded notes: "Significant steel structures can interfere with Fotokite's operation due to the presence of a magnetometer inside the unit. Fotokite has stated that this interference should not significantly impact the unit's flight performance under normal operating conditions."*

- *Camera issues due to water ingression.*
  - *Vendor raw response: "We decided that we're going to swap the camera for a completely new camera. It's persistently having camera issues during testing, so I think the damage from the water ingress may have damaged the camera beyond the point where component*

swaps will resolve it."

What Has Worked for WSDOT and Lessons Learned

After observing WSDOT day-to-day operations, the AHMCT team compiled Table 3.4 to summarize what has worked for WSDOT and the lessons learned from operating the Fotokite.

Table 3.4: What has worked for WSDOT and lessons learned from operating the Fotokite

What Has Worked for WSDOT	Lesson Learned
Features closely resemble the capabilities of TMC cameras, including remote-controlled livestreaming, zoom functionality, good resolution, friendly-user interface, and an advantage point.	*Firmware updates are lengthy and time-consuming. Fotokite team has confirmed that there are no mandatory updates currently being pushed through the Fotokite application. However, users operating on iOS or Android devices should be aware that automatic updates may still occur based on individual device settings. It is recommended that users review their device settings to manage update preferences. For those using the Fotokite-provided tablet, automatic updates should not be enforced by default.*
Ideal for incidents that take more than one hour to resolve, such as mudslides, floods, and multi-car collisions.	*Fotokite is not compatible with rapid incident response due to delay in LTE connection and setup time combined taking 15 minutes for a one-hour incident.*
Ideal for regions that do not have camera coverage.	*The tablet takes a long time to connect to the Fotokite, requiring about 10 minutes each time, which is not ideal for rapid response.*
Operating the Fotokite requires minimal training.	*The size of the Fotokite is too large to be stored in the incident response trucks (daily use equipment is in the trucks) and to move around.*
Personnel do not need to obtain Part 107 Certification (as of June 2025, when this report was concluded).	*Troubleshooting cannot be done independently most of the time.*
Responsive customer service.	*Repair downtime can take 1 to 2 months or longer depending on the issue.*

In addition, WSDOT underutilized the Fotokite since the southwest region of Washington State is well-equipped with cameras. From July 2023 (when the Fotokite was first purchased) to June 2025 (when this evaluation concluded),

there have not been any major incidents requiring constant deployment of the Fotokite, such as heavy winters or mudslides—events for which the Fotokite was originally intended to be used. As a result, there was a less than 1% usage rate of the Fotokite by the conclusion of this evaluation.

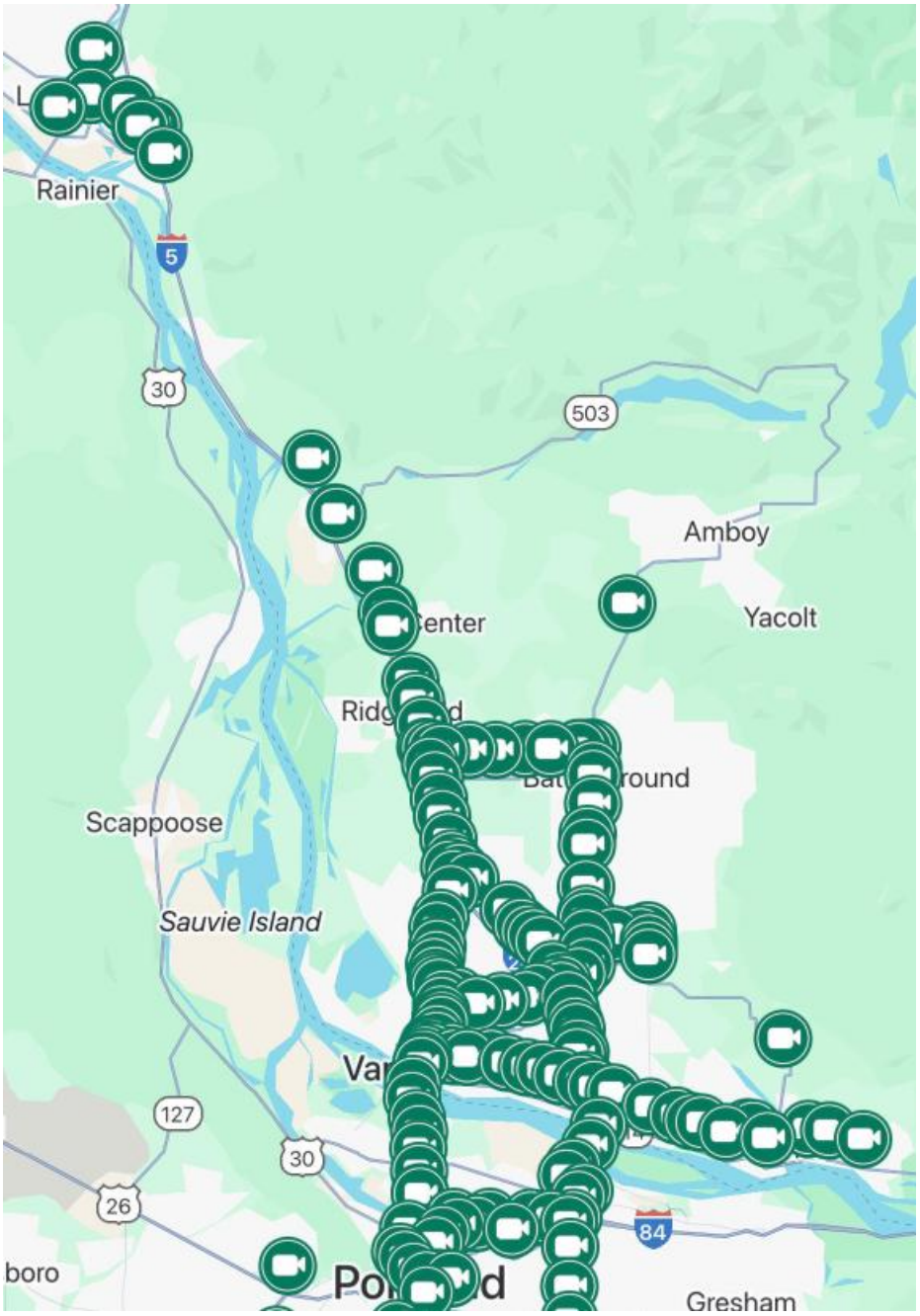

Figure 3.3: Camera infrastructure in WSDOT's southwest region. Cameras are densely equipped in highly populated areas in the region. Photo courtesy of WSDOT

Caltrans/AHMCT Testing

Day-to-Day Operation and Expectations for Fotokite

Caltrans operates multiple TMCs throughout the State of California. However, camera coverage can be limited in some areas due to insufficient infrastructure. During major incidents, such as multi-vehicle collisions or flooding, not having immediate visual information can delay Caltrans' ability to assess the situation, which results in longer delays for the traveling public. It is important that TMCs are made aware of such incidents as quickly as possible so that they can coordinate with the appropriate agencies to resolve the issues.

The Fotokite system is intended for use in areas with limited camera coverage, during significant traffic incidents such as multi-vehicle collisions, and in response to natural disasters, particularly floods and mudslides. Caltrans has successfully deployed Fotokite in some of these scenarios, including multi-vehicle collisions and traffic monitoring during foggy conditions. Additionally, Caltrans District 6 has used Fotokite for traffic surveillance and operations.

However, the deployment of Fotokite has sometimes been hindered by technical issues encountered in the field. These issues are detailed in the section "Issues Encountered with the Units and Solutions." When such issues are addressed, Fotokite effectively supports TMC operations.

Caltrans also requested that Fotokite provide users with the ability to control live streaming resolutions to improve TMC operations. For Caltrans, consistent and stable video streaming is more valuable than high-resolution footage. While the Fotokite team has implemented an automatic resolution adjustment feature that reduces video quality when LTE connection strength decreases, this is not the functionality Caltrans requested. As of June 2025, Fotokite does not offer user-controlled resolution settings.

The Fotokite streaming link automatically refreshes under normal conditions. However, Caltrans accesses the stream through the WOWZA platform, which generates four different types of streaming links. When Fotokite streams at high resolution, the video feed accessed through these links may become unstable, especially in remote areas with low bandwidth connections, leading to interruptions and failure to refresh automatically.

For Caltrans, being able to distinguish objects in the footage is sufficient, and maximum resolution is not necessary. Streaming reliability is the higher priority. If Fotokite were to implement user-controlled resolution settings, it would significantly enhance TMC communication and operational effectiveness.

Deployed Locations

From June 2023 to June 2025, Caltrans deployed Fotokite systems across the northern, central, and southern regions of California. The deployments were

primarily concentrated in Caltrans Districts 2, 3, and 6. The following is a list of locations where Fotokite has been deployed to date:

- *Cameron Park*
- *Rancho Cordova TMC*
- *University of California, Davis*
- *Oliver Avenue in Caltrans District 6*
- *Caltrans District 2 Office*
- *Millux Road in Caltrans District 6*
- *Shasta Lake*
- *I-5/SR-273 Interchange in Redding*
- *Red Bluff Maintenance Station in Red Bluff*
- *Areas in Shasta County*
- *I-5/SR-44 Interchange in Redding*
- *Pollard Flat Interchange in Shasta County*
- *Caltrans District 10 Office*
- *Caltrans District 6 Office*
- *Avenue 12 in Madera*
- *Areas in Fresno County*

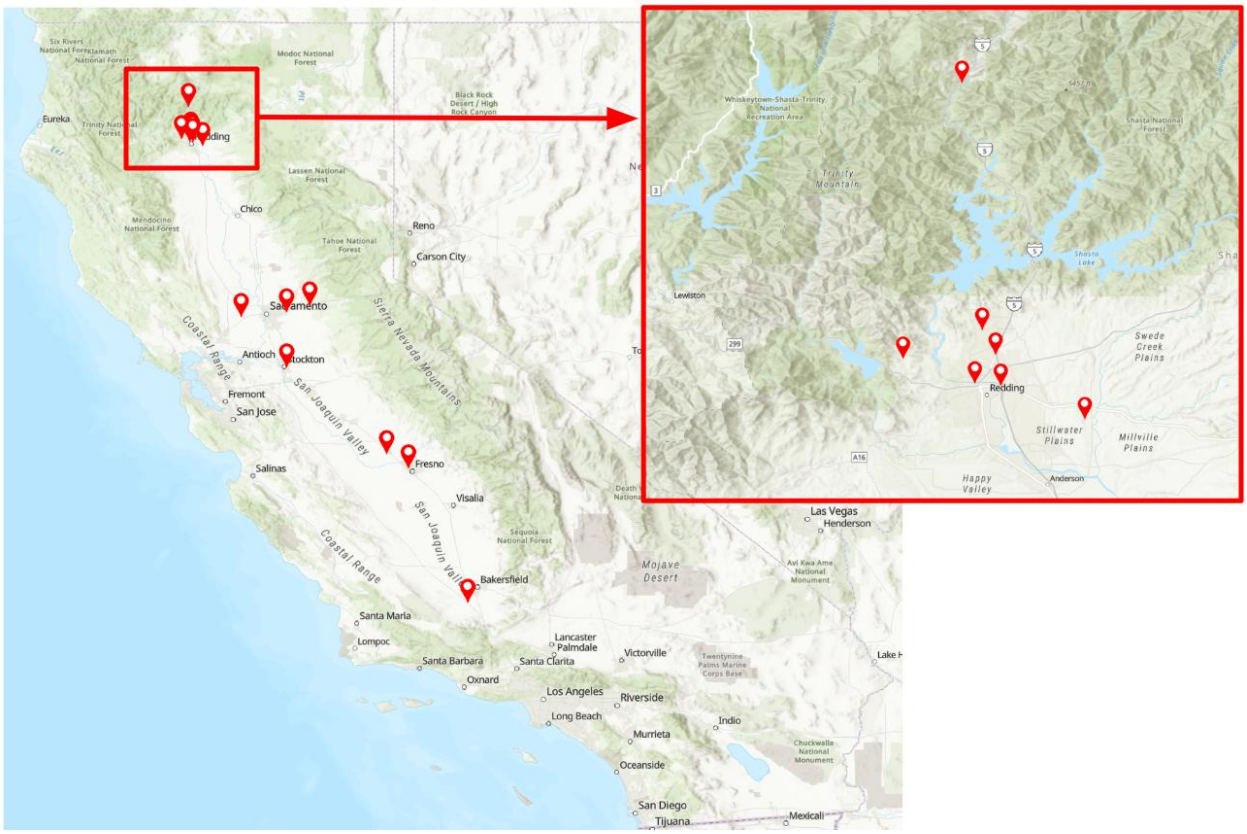

Figure 3.4: Map of Caltrans deployment locations

Issues Encountered with the Units and Solutions

The Fotokite units deployed by Caltrans include the K2019PF drone paired with the G214B cradle unit (named Gunrock), the E376K drone paired with the G269B cradle unit (named Hornet), and the E396K drone paired with the G2028XH cradle unit (named Wildcat). Initially, the K2019PF drone was paired with the G2028XH cradle unit and designated for testing and analysis. Over time, this unit became Caltrans' float unit since the other units periodically required repairs with typical downtimes ranging from one to two months.

In December 2023, the G214B and G2028XH cradle units had to be exchanged due to a malfunction with the G2028XH unit. At that point, the G2028XH cradle was paired with the E396K drone, which had sustained damage from a crash. By pairing the two malfunctioning components together and sending them back to Fotokite for repair, Caltrans was able to limit the system's operational downtime to one unit instead of two. Tables 3.5, 3.6, 3.7, and 3.8 detail the issues the units experienced and solutions to those issues.

Table 3.5: K2019PF drone and G2028XH cradle unit timeline summary, original units pairing

Month/Year	Summary
July 2023	*N/A*

Table 3.5: K2019PF drone and G2028XH cradle unit timeline summary, original units pairing

Month/Year	Summary
August 2023	*N/A*
September 2023	*N/A*
October 2023	*Unit received by AHMCT. Since this unit was received three (3) months later, "K2019PF is part of a production batch unaffected by the RMA issue" according to the vendor*
November 2023	*No issue recorded*
December 2023	*The G2028XH cradle unit was not properly charged. The E396K drone sustained damage from the crash. These two units have been paired together since December 2023. The purpose of pairing them is to ensure Caltrans would be down only one unit instead of two*

Table 3.6: K2019PF drone and G214B (Gunrock) cradle unit timeline summary after cradle units were exchanged

Month/Year	Summary
July 2023	*Unit received by Caltrans. Original pairing was E396K drone and G214B cradle unit*
August 2023	*On-site training with Fotokite*
September 2023	*No issue recorded from the original pairing E396K drone and G214B cradle unit*
October 2023	*No issue recorded from the original pairing E396K drone and G214B cradle unit*
November 2023	*E396K crashed on the roof upside down. The frame and the propellers sustained damages. The drone unit was no longer fly-worthy*
December 2023	*G2028XH cradle unit was not charged properly. Had to swap for G214B cradle unit so that Caltrans could take a functioning Fotokite to District 6. From this point, functioning K2019PF drone was paired with functioning G214B cradle unit; not fly-worthy E396K drone was paired with malfunctioning G2028XH cradle unit. After the change, K2019PF drone oscillated when it was flown near the big trucks passing by on the freeway. Caltrans established a*

Table 3.6: K2019PF drone and G214B (Gunrock) cradle unit timeline summary after cradle units were exchanged

Month/Year	Summary
	protocol that pilots should not fly too close to moving vehicles
January 2024	*Inspection due to a motor malfunction recall -return merchandise authorization (RMA) was enforced. "K2019PF is part of a production batch unaffected by the RMA issue" according to the vendor*
February 2024	*No issue recorded*
March 2024	*RID feature was introduced, which later caused issues such as user lockout and its consistent error messages were distracting during live streaming. Fotokite released software updates to improve the Remote ID errors*
April 2024	*No issue recorded*
May 2024	*District 6 experienced camera lagging issue for K2019PF drone. The lagging issue occurred on the tablet. Lagging issue occurred due to poor LTE connection. Recommend LEO satellite network. District 6 concerned about tether twisting. According to the vendor, when the drone twists 180 degrees or more, the system rotates in the opposite direction to prevent further twisting. Fotokite noted that the drone does not currently compensate for twisting, but flight logs are tracked to develop this feature. G214B cradle unit experienced an overheating issue, causing K2019PF drone to emergency landed. Thus, the AHMCT team conducted testing with another unit to investigate the cause*
June 2024	*No issue recorded*
July 2024	*No issue recorded*
August 2024	*No issue recorded*
September 2024	*No issue recorded*
October 2024	*G214B cradle unit temperature was more than 100°F during a 70°F day. The AHMCT team exchanged this unit with another unit for District 6. The unit was taken back for testing. Remote ID errors occur every 15 to 20 minutes, each lasting a few seconds and repeating at least ten times. While they do not disrupt flight, they briefly limit*

Table 3.6: K2019PF drone and G214B (Gunrock) cradle unit timeline summary after cradle units were exchanged

Month/Year	Summary
	control and affect user experience. Fotokite released software updates to improve the Remote ID errors
November 2024	*No issue recorded*
December 2024	*Camera issue, unable to control the camera from the tablet. Suspect loose screw cause skipping on the shalf. Fotokite team replaced the camera. Cold weather testing. Fotokite was unable to take off due to suspected short circuit. Sent back for service*
January 2025	*Under repairs*
February 2025	*Difficulty of viewing tablet screen during sunny days. Vendor suggested an anti-glare screen cover*
March 2025	*No issue recorded*
April 2025	*No issue recorded*
May 2025	*The tablet would not power regardless of how long the user pressed the power button, prompting the user to plug in the power cable. When the tablet was powered and turned on, it was at 66% battery capacity. Afterwards, the user could not re-create this issue. Fotokite can replace the tablet under warranty upon user request*
June 2025	*No issue recorded*

Table 3.7: E396K and G2028XH (Wildcat) cradle unit timeline summary after cradle units were exchanged

Month/Year	Summary
July 2023	*Unit received by Caltrans*
August 2023	*On-site training with Fotokite*
September 2023	*No issue recorded*
October 2023	*No issue recorded*
November 2023	*E396K crashed on the roof upside down. The frame and the propellers sustained damages. The drone unit was no longer fly-worthy*

Table 3.7: E396K and G2028XH (Wildcat) cradle unit timeline summary after cradle units were exchanged

Month/Year	Summary
December 2023	*Caltrans delivered the unit to UC Davis for the AHMCT team to coordinate repairs*
January 2024	*Inspection due to a motor malfunction recall -return merchandise authorization (RMA) was enforced. Fotokite replaced the malfunctioning parts and tested the unit before sending it back to the user. E396K drone "post-crash Inspection completed, and opened, and all speed controllers replaced" according to the vendor. G2028XH cradle unit "battery replaced - confirmed that charging circuit is healthy" according to the vendor*
February 2024	*Back to Caltrans District 2 after confirming that the crash drone was re-tested and the battery circuit was healthy*
March 2024	*RID feature was introduced, which later caused issues such as user lockout and its consistent error messages were distracting during live streaming. Fotokite released software updates to improve the Remote ID errors*
April 2024	*No issue recorded*
May 2024	*No issue recorded*
June 2024	*No issue recorded*
July 2024	*No issue recorded*
August 2024	*No issue recorded*
September 2024	*No issue recorded*
October 2024	*No issue recorded*
November 2024	*No issue recorded*
December 2024	*No issue recorded*
January 2025	*No issue recorded*
February 2025	*Connection issues that prevented livestream from continuing. Fotokite investigated the issue and determined the cause to be an incomplete software update. Fotokite*

Table 3.7: E396K and G2028XH (Wildcat) cradle unit timeline summary after cradle units were exchanged

Month/Year	Summary
	remoted into the tablet and addressed the software update issue
March 2025	*The controller tablet displayed "Mobile Data Unavailable", despite users have Verizon signal on their phones. This may be due to the Fotokite factory SIM (Telecom26) using different towers. Installing user own SIM card could resolve this. If users are unable to record videos, check if the disk is full. Transfer existing videos to a USB drive before deleting them from the disk.*
April 2025	*No issue recorded*
May 2025	*No issue recorded*
June 2025	*No issue recorded*

Table 3.8: E376K drone and G269B (Hornet) cradle unit timeline summary

Month/Year	Summary
July 2023	*Unit received by Caltrans*
August 2023	*On-site training with Fotokite*
September 2023	*No issue recorded*
October 2023	*No issue recorded*
November 2023	*No issue recorded*
December 2023	*Although the unit had experienced no issue so far, the unit was sent back for inspection due to the RMA*
January 2024	*Inspection due to a motor malfunction recall -return merchandise authorization (RMA) was enforced. A Fotokite representative concluded that drone E376K was not affected by the MOSFET issue, so none of the speed controllers have to be replaced*
February 2024	*No issue recorded*
March 2024	*RID feature was introduced, which later caused issues such as user lockout and its consistent error messages were*

Table 3.8: E376K drone and G269B (Hornet) cradle unit timeline summary

Month/Year	Summary
	distracting during live streaming. Fotokite released software updates to improve the Remote ID errors
April 2024	*No issue recorded*
May 2024	*Testing the integration of a user-provided SIM card into the Fotokite cradle unit*
June 2024	*Operating the Fotokite in the heat revealed that the Fotokite performed premature landings in 90°F conditions. The unit was sent back for inspection*
July 2024	*Under repairs*
August 2024	*Follow-up on the premature landing issue: the ground base battery was replaced, and the yaw axis bearings were repaired to address shaky footage. Remote ID issues remain persistent. Fotokite released software updates to improve the Remote ID errors*
September 2024	*No issue recorded*
October 2024	*Great shakeout pilot. Remote ID error messages appeared briefly about ten times but had minimal impact on the pilot overall*
November 2024	*No issue recorded*
December 2024	*No issue recorded*
January 2025	*No issue recorded*
February 2025	*Issue with the tablet screen not displaying. The tablet had to be replaced*
March 2025	*Fotokite program shut down shortly after booting up. Caltrans contacted Fotokite support to resolve the issue. The tablet display kept freezing up while recording video. Verified video feed after recording, no glitches or issues*
April 2025	*No issue recorded*
May 2025	*No issue recorded*
June 2025	*No issue recorded*

Notable issues for the three Caltrans units and detailed vendor responses are below. Note that vendor responses are provided as-is and have not been written or edited by the AHMCT team.

- *Motor malfunction led to recall of all units.*
    - *The Fotokite team provided Caltrans the same responses as WSDOT. Refer to "WSDOT Testing" section, subsection "Issues Encountered with the Units and Solutions."*
- *RID issues have persisted since RID was introduced to Fotokite. Although software updates have improved RID issues over the span of one (1) year, the issues have not been fully resolved as of June 2025 as users still experience RID error messages from time to time.*
    - *The Fotokite team provided Caltrans the same responses as WSDOT. Refer to "WSDOT Testing" section, subsection "Issues Encountered with the Units and Solutions."*
- *Excessive yaw issue in windy conditions.*
    - *The Fotokite team provided Caltrans the same responses as WSDOT. Refer to "WSDOT Testing" section, subsection "Issues Encountered with the Units and Solutions."*
- *Force software update issue.*
    - *The Fotokite team provided Caltrans the same responses as WSDOT. Refer to "WSDOT Testing" section, subsection "Issues Encountered with the Units and Solutions."*
- *"External magnetic disturbance detected" error.*
    - *The Fotokite team provided Caltrans the same responses as WSDOT. Refer to "WSDOT Testing" section, subsection "Issues Encountered with the Units and Solutions."*
- *Premature landings were linked to the cradle unit overheating error messages. This issue was primarily observed by Caltrans, likely due to the warmer weather in California compared to Washington State.*
    - *Vendor raw response: "After replacing the battery, in a noticeably hotter environment, where temperatures hit close to 100F during the flight session, we see the system stabilizing at temperatures nearly 10C lower than previously, and the system flew for nearly 2.5 hours after being on standby for 4 hours in direct sunlight. We landed the system because the temperatures were stabilizing at approximately 55C. As a note, the threshold for an emergency landing is 65C on the battery, so something was specifically affecting the battery to cause this to happen. Perhaps the internal resistance got*

too high inside the old one, which we are investigating now more deeply."

- *AHMCT recorded notes: "The Fotokite team has identified the root cause of the heating problem. It stems from the aluminum drive train motor, which is located near the battery. The motor heats up in proximity to the battery, causing the temperature sensor readings to become corrupted. To address this, the Fotokite team plans to reconfigure the system layout, introducing a barrier or isolated component to prevent the motor from interfering with the temperature sensor. As the software improves, the temperature recording process should become more accurate, helping to prevent the system from initiating unnecessary premature landings. This software improvement is expected to be released before the summer."*

- *The cradle unit was not properly charged.*
  - *Vendor raw response: "Ground station battery replaced - confirmed that charging circuit is healthy."*
- *The cradle unit experienced a short circuit.*
  - *Vendor raw response: "We are in the final checkout stages for your unit. We identified that the ground station tether must have experienced some internal short leading to the issues we experienced. This is why the unit would never power on once you had your emergency landing. I tested with a new groundstation and the kite is operating without issue."*
- *"Mobile data unavailable" error message.*
  - *Vendor raw response: "sometimes cellular data will drop out, the factory SIM card provider is Telecom26 which uses different towers based on availability, so it may have been going off of a different tower than VZW. This could potentially be resolved by having you install your own SIM card. This would incur a one-time fee for us to configure the cradlepoint, but would reduce the yearly RVS fee because you wouldn't be using our data plan."*
- *Camera issues included shaky footage and loss of camera movement control via the tablet controller.*
  - *Vendor raw response 1: "Regarding unit E376K producing shaky footages, due to shock incurred, the bearings on the yaw axis were slightly misaligned. Fotokite have made some improvements to the reliability around this interface."*
  - *AHMCT recorded notes: "Regarding the camera issues for unit K2019PF/G214B, Fotokite explained that the gimbal set screw might be*

loose and cause the skipping on the shaft. A 1.3 hex driver was needed to tighten the screw. Since the AHMCT team did not have the right tool at the time, the action did not happen. However, Fotokite replaced the camera after this unit was sent in for service."

- *Tablet blackout issue.*
  - *AHMCT recorded notes 1: "AHMCT team and Caltrans had a support call with Fotokite. The discussion was mostly about the tablet issue that Paul experienced in February 2025. The solution was to send Paul a new tablet and send in the malfunctioning tablet for inspection. The vendor was unable to replicate the issue; hence the root cause was not determined."*
  - *AHMCT recorded notes 2: "The tablet was not able to power on despite the user attempting to press the power button many times. As before, the user plugged in the tablet and the screen was able to display (tablet had 66% battery capacity). The user was unable to replicate the issue. The Fotokite team can replace the tablet under warranty, as plugging in the tablet might not be feasible in the field."*

What Has Worked for Caltrans and Lessons Learned

After observing Caltrans day-to-day operations, the AHMCT team compiled Table 3.9 to summarize what has worked for Caltrans and the lessons learned from operating the Fotokite.

Table 3.9: What has worked for Caltrans and lessons learned from operating the Fotokite

What Has Worked for Caltrans	*Lesson Learned*
Features closely resemble the capabilities of TMC cameras, including remote-controlled livestreaming, zoom functionality, friendly-user interface that requires minimal training, and a vantage point.	*Troubleshooting cannot be done independently most of the time.*
Ideal for incidents that take more than one hour to resolve, such as mudslides, floods, and multi-car collisions.	*High-resolution bandwidth constraints prevent Caltrans from obtaining smooth video footage for TMCs.*
Ideal for regions that do not have camera coverage.	*Repair downtime can take 1 to 2 months or longer depending on the issue.*
Live-streaming implementation for traffic incident management.	*Remote ID issues persist as of the conclusion of this report (June 2025).*

Table 3.9: What has worked for Caltrans and lessons learned from operating the Fotokite

Operating the Fotokite requires minimal training.	*Caltrans implements a conservative approach, still requiring personnel to have Part 107 Certification to operate the Fotokite as of June 2025.*
Responsive customer service.	

Overall, Caltrans successfully utilized Fotokite for various applications, including chain control in specific areas, traffic surveillance, situational awareness, accident management, and mock structural inspections.

System Evaluation Conclusions

Based on the testing and evaluation of the Fotokite system, the AHMCT team came to the following conclusions for each respective DOT:

For WSDOT, *specifically the southwest region of Washington State, the Fotokite portable unit system is currently underutilized, largely due to its incompatibility with rapid incident response operations for the following reasons:*

- *The portable unit is too bulky for convenient storage in incident response vehicles, as shown in Figure 3.5.*
- *The region is already well equipped with stationary cameras, reducing the need for additional aerial coverage.*
- *Most incident responses in the region are resolved within an hour, while Fotokite requires approximately 15 to 20 minutes to set up and establish a livestream.*

Since there is only one person per incident response truck, setting up the Fotokite portable unit system delays their ability to respond to issues quickly. However, the system has proven valuable for long-term traffic monitoring and operations. For instance, Fotokite was effectively used to monitor traffic during a Costco opening, which provided TMCs with real-time traffic congestion awareness. If the size and setup time of the Fotokite portable unit system can be reduced, it could become a more viable tool for rapid response scenarios.

Figure 3.5: WSDOT incident response truck storage. Due to the extensive equipment already required for WSDOT personnel's field operations, the size of the Fotokite portable unit can be an inconvenience for storage purposes

For Caltrans, *the Fotokite system is more actively utilized, particularly for traffic surveillance, accident management, and situational awareness due to its ability to stream live footage to TMCs. However, there are limitations:*

- *The system lacks user-controlled video resolution, and its high bandwidth constraints can lead to streaming interruptions within Caltrans TMCs.*
- *Although the Fotokite streaming link automatically refreshes, Caltrans uses the WOWZA platform, which generates four types of streaming links. These links do not support auto-refresh and are prone to interruptions when the video resolution is too high.*

If the Fotokite team can offer user-controlled resolution settings and fully resolve the RID issues, the system could have greater value to Caltrans.

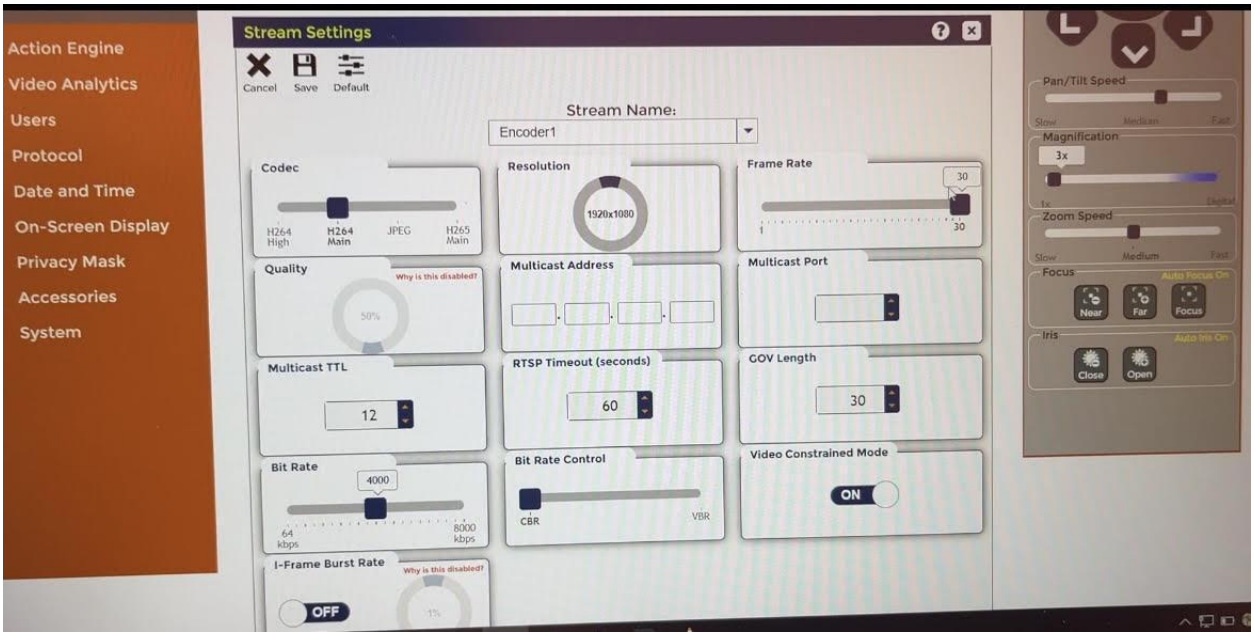

Figure 3.6: Resolution control panel for Caltrans TMC cameras. Since Fotokite does not have this feature, its live streaming footage inside Caltrans TMCs might not be as continuous as that of the existing cameras

Additionally, while the Fotokite team has made progress in addressing RID issues, a permanent fix has yet to be implemented at the time this evaluation concluded due to the strict FAA regulations with which the system must comply.

Fotokite Deployment in the Southwest Region of Washington State

WSDOT has had both scheduled and unscheduled events that required Fotokite deployment. For scheduled events, WSDOT used Fotokite for approximately five (5) hours for traffic management during a Costco opening. For unscheduled events, WSDOT used Fotokite for incident responses that typically lasted longer than an hour during which WSDOT personnel thought Fotokite deployment would be useful. Figures 3.7 and 3.8 provide examples of the Fotokite system field deployment in Washington State.

Figure 3.7: Example of the Fotokite deployment in an unscheduled event. Footage was relayed back to the WSDOT TMC. Photo courtesy of WSDOT

Figure 3.8: Example of the Fotokite deployment in a scheduled event. Footage was relayed back to the WSDOT TMC. Photo courtesy of WSDOT

As shown in Figure 3.8, the Fotokite system experienced a "Ground Station Battery Temperature Problem" error message after being exposed to the sun for several hours (a total flight time of 5 hours). WSDOT personnel allowed the unit to cool in the shade for about 30 minutes and then relaunched it. Fotokite was able to continue flying until the end of the traffic management operation. The error message only occurred once throughout the duration of the flight.

Fotokite Deployment in California

Caltrans has had both scheduled and unscheduled events that required Fotokite deployment. For scheduled events, Caltrans used Fotokite for mock structural inspections and mock traffic surveillance. For unscheduled events, Caltrans used Fotokite to monitor a multi-vehicle car collision on the I-5 highway. Figures 3.9, 3.10, and 3.11 provide examples of the Fotokite system field deployment in California.

Figure 3.9: Example of the Fotokite deployment in an unscheduled event. Footage was relayed back to the Caltrans TMC. Photo courtesy of Caltrans

Figure 3.10: Example of the Fotokite deployment in a scheduled event. Footage was relayed back to the Caltrans TMC. Photo courtesy of Caltrans

Figure 3.11: Mock bridge inspection footage and mock traffic surveillance footage observed inside the Caltrans TMC from the scheduled deployment. Photo courtesy of Caltrans.

Chapter 4:
Deployment and Implementation

Problems and Issues that Affected Product Deployment

As of June 2025, the RID issues, which cause user lockout, delayed livestreams, and distracting error messages, have been mitigated through software updates but not completely resolved.

Solutions to Noted Problems and Issues

Fotokite is actively testing and working to improve the RID issue, with the goal of mitigating it further in an upcoming software release. The issue has been attributed to signal transmission and timing inconsistencies.

Fotokite has indicated plans to roll out software updates in the coming months to further enhance the user flight experience.

Deployment Results

Overall, WSDOT and Caltrans were able to deploy the Fotokite system in both scheduled and unscheduled events with mostly positive results. At times, the system experienced issues in the field that required vendor intervention, either through remote support via the Fotokite tablet or phone calls to guide troubleshooting steps. As long as these issues could be resolved, the Fotokite operated as intended. However, the heavy reliance on vendor support throughout the evaluation period raises concerns. If Fotokite were to go out of business, DOTs may not receive the support they need.

In addition, Fotokite was first introduced in 2019. As of 2025, a 10-year performance overview is not available, so it remains uncertain whether the product lifespan can reach 10 years. Currently, the product lifespan is 5 years, and Fotokite is not warranted beyond that period.

Fotokite User Survey

Pilots who operated Fotokite responded to a survey created by the AHMCT team. The survey included a mix of free response and Likert scale questions. The pilot responses are presented as-is and have not been edited. The pilot responses are anonymous.

To Question 1, "Did you operate the Fotokite in/for your work? If so, approximately how many times?", we received the following answers (unedited):

- *18 to date, with some demonstrations upcoming.*
- *Approximately 22 times.*
- *Yes, four times. Stopped operating after the Department released policy requiring FAA part 107 certification.*
- *Yes, 2 times*
- *10*
- *5*
- *50 times up to date. For test flight, each test takes about 15 minutes. Scene usage averaging about 1 hour 30 minutes*
- *Approx 50-60 times*

To Question 2, "What features of the Fotokite are most important to you?", we received the following answers (unedited):

- *Ability to fly longer than regular drones.*
- *Livestreaming and the new remote operation function mostly, but the flight time not limited to a battery is a close second.*
- *Longer flight times.*
- *Video livestream, unlimited flight time*
- *Extended flight duration.*
- *Video streaming from the field into the TMC.*
- *Camera quality and livestreaming capabilities (critical for TMC and on-the-ground personnel)*
- *The camera quality and live streaming features*

Question 3, "How easy was it to deploy the Fotokite system (1 is easy, 5 is very difficult)?", used a five-point Likert scale response method. The average response rating was 2.50. Breakdowns of the answers are displayed in Figure 4.1.

Figure 4.1: Rating of 2.50 for the question "How easy was it to deploy the Fotokite system (1 is easy, 5 is very difficult)?"

Question 4, "How easy was it to land and stow the Fotokite system (1 is easy, 5 is very difficult)?", also used a five-point Likert scale response method. The average response rating was 2.00. Breakdowns of the answers are displayed in Figure 4.2.

Figure 4.2: Rating of 2.00 for the question "How easy was it to land and stow the Fotokite system (1 is easy, 5 is very difficult)?"

Question 5, "How easy was Fotokite maintenance (1 is easy, 5 is very difficult)?", also used a five-point Likert scale response method. The average response rating was 2.63. Breakdowns of the answers are displayed in Figure 4.3.

Figure 4.3: Rating of 2.63 for the question "How easy was Fotokite maintenance (1 is easy, 5 is very difficult)?"

Question 6, "How easy was it to transport the Fotokite system (1 is easy, 5 is very difficult)?", also used a five-point Likert scale response method. The average response rating was 2.63. Breakdowns of the answers are displayed in Figure 4.4.

Figure 4.4: Rating of 2.63 for the question "How easy was it to transport the Fotokite system (1 is easy, 5 is very difficult)?

Question 7, "How easy was it to aim the Fotokite system to obtain the best view or vantage point (1 is easy, 5 is very difficult)?", also used a five-point Likert scale response method. The average response rating was 2.50. Breakdowns of the answers are displayed in Figure 4.5.

Figure 4.5: Rating of 2.38 for the question "How easy was it to aim the Fotokite system to obtain the best view or vantage point (1 is easy, 5 is very difficult)?"

To Question 8, "Is the ability to capture and distribute video important to you? If so, why?", we received the following answers (unedited):

- *Yes. We use the video for traffic surveillance, livestreaming, and other types of documentation.*
- *Video capture is very important since the drone can remain in flight and take hours of constant video, we have a number of different uses for a device that can capture hours of video at a time.*
- *Yes. Our intent is to use this as a portable CCTV for the TMC.*
- *Yes, to share for situational awareness and PIO*

- *Yes. Situational awareness is seldom restricted to personnel on-sight. Typically, upper management or support personnel who are no on-sight are in need of visual information.*
- *Yes. We utilize this feature in our TMC in order to gain situational awareness in areas with limited technology and camera coverage.*
- *Important for close collaboration with TMC.*
- *Yes. We used the Kite in areas not covered my cameras, to stream footage to the TMC.*

To Question 9, "For what situations or tasks would you see the Fotokite system most useful?", we received the following answers (unedited):

- *Traffic Surveillance and livestreaming events.*
- *We plan to primarily use the drone for traffic surveillance and possibly speed zone surveys. Another use will be as a portable CCTV camera for our Transportation Management Center (TMC) during a major traffic or news worthy event.*
- *TMC, incident management, microwave path surveys.*
- *Situational awareness at incidents or longer term operations, monitoring operations.*
- *Incident management. Extended closures. Progress monitoring (time-lapse imaging).*
- *Large incidents in areas lacking current camera coverage.*
- *Large-scale incidents. Incidents where no traffic camera is available*
- *Live streaming in areas not covered my traffic cameras*

To Question 10, "Are there features you would like to see added to the Fotokite system? Please describe.", we received the following answers (unedited):

- *System to automatically unwind tether before landing.*
- *Visible date and time coding on the recorded video. During livestream, the data is visible but not on the recorded video.*
- *More robust data connection, perhaps thru satellite connectivity.*
- *Stream resolution control.*

To Question 11, "Please provide any other information, documents, or feedback that you believe may be valuable for this research on Fotokite system evaluation for DOTs.", we received the following answers (unedited):

- *The Traffic Division plans on expanding the use of the Fotokite throughout the State connected to Starlink satellite internet to allow for livestreaming in areas with no cellular service.*
- *We plan on further experimenting and expanding the Fotokite's uses and will continue to demonstrate how it can benefit Caltrans throughout the State. District 10-Stockton is currently in the process of purchasing a Fotokite to enhance their Operation Divisions.*
- *Support improvement from Fotokite.*
- *Rural areas have challenges with cellular data connection and I found the Fotokite's connection to have issues, especially during updates. Would like to see a more robust high speed data connection solution.*
- *Lack of support from Fotokite has made this testing process challenging. Frequent maintenance issues that require the device to be sent back to Fotokite have made our testing phase difficult. This along with zero communication from Fotokite on repair timelines, has led to us not utilizing the product as much as we would be otherwise. As an example, one of the WSDOT allocated kites has been in service with the Fotokite team since 03/25/25. WSDOT has received no follow up from the engineering team regarding an estimated time of repair or return to service timeline.*

Chapter 5:
Conclusions and Future Research

Conclusions for Fotokite in WSDOT Southwest Region Operation

For WSDOT operations, Fotokite was able to relay footage to the southwest region TMC during both scheduled and unscheduled events when needed. Since the southwest region of WSDOT is well equipped with cameras, Fotokite deployment was mainly necessary when a bird's-eye view of the scene was required and when cameras are not available in the incident area. Since WSDOT has not yet incorporated a LEO satellite network system into their incident response trucks, largely due to these trucks operating mainly near cities with dense populations, the Fotokite live streaming feature using the LEO satellite network has not been tested in this region.

Additionally, Fotokite is not compatible with WSDOT rapid incident response scenarios for three reasons:

1. *The setup and connection time takes a minimum of 15 to 20 minutes before the system is ready for livestreaming, and most incidents are often resolved in less than an hour.*
2. *The Fotokite portable unit is too bulky to be stored and moved easily in incident response trucks*
3. *Each incident response truck has only one personnel who may be occupied with managing the incident and therefore unable to set up the Fotokite.*

Fotokite was initially purchased to assist with monitoring heavy winters and mudslides. However, since no major incidents requiring Fotokite deployment have occurred, it has been underutilized, with a usage rate of less than 1% as of this report's conclusion. For WSDOT, Fotokite proves valuable mainly in incidents lasting longer than one hour and for long-term traffic operation studies.

Conclusions for Fotokite in Caltrans Operation

For Caltrans operations, Fotokite was able to relay footage to multiple TMCs during both scheduled and unscheduled events when needed. Fotokite deployment is mainly necessary for traffic surveillance, speed zone surveys, use as a portable CCTV camera during major incidents or newsworthy events, microwave path surveys, situational awareness, long-term operation monitoring, extended closures, and time-lapse imaging. Since Caltrans incorporates a LEO

satellite network system into Fotokite operations, the system was able to provide valuable insights in areas with little or no camera infrastructure or minimal to no LTE network. For example, Fotokite was successfully paired with a Starlink high-performance flat dish to deliver live streaming footage in an area with limited signal to at least 35 Caltrans personnel located at Caltrans Headquarters in Sacramento and Caltrans District 6 TMC Office.

In Caltrans operations, the consistency of livestreaming footage is more important than high resolution. Since Caltrans prefers to use its own network to communicate with TMCs, having user-controlled resolution options would help produce smoother footage from Fotokite as Caltrans could feed Fotokite streaming into the WOWZA server and thus increase footage distribution. As of June 2025, Fotokite does not offer user-controlled resolution settings for footage. Although Fotokite implemented automatic degradation of footage resolution when network quality decreases, this feature should be further developed to allow user control if possible.

Additionally, Caltrans has the following concerns:

1. *The RID issue has been mitigated but a permanent solution has not yet been found. The Fotokite team is working to further mitigate RID issues while remaining compliant with FAA regulations.*
2. *Users depend heavily on customer support since they cannot easily troubleshoot Fotokite independently. The Fotokite manual includes some basic troubleshooting steps. However, most issues that occurred during the evaluation period were resolved only with vendor intervention.*

For Caltrans, Fotokite proves valuable for relaying footage to multiple TMCs, situational awareness, and research studies.

Future Work

Since the Fotokite was first introduced in 2019, its 10-year performance remains unknown. In addition, the vendor has stated that the Fotokite product lifespan is five (5) years and that it will not be warranted beyond that point. Another evaluation should be conducted to determine Fotokite's long-term performance and whether its lifespan can be extended so that DOTs can achieve a good return on investment.

References

[1] Fotokite, "Fotokite User Manual Version 2.17."

Appendix A:
WSDOT Flight Log

2023 WSDOT Flight Logs

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
11/04	10:00	WSDOT IRT	SORENSEN	SB I-5 MP 31	1 HR	HEAVY RAIN	NO ISSUES TO REPORT
11/08	15:00	WSDOT IRT	SORENSEN	NB I-5 MP 70	1 HR	CLEAR SKY	CONDENSATION ON LENSE
11/11	10:00	WSDOT/IRT	SORENSEN	EB SR 500 MP 4	15 MIN	OVERCAST	NO ISSUE TO REPORT
11/18	11:00	WSDOT/IRT	SORENSEN	NB I-5 MP 30	30 MIN	PRTLY CLOUDY	NO ISSUE TO REPORT

Figure A.1: WSDOT southwest region flight logs in November 2023

2023-2024 WSDOT Flight Logs

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
12/15	0100AM	WSDOT IRT	SORENSEN	EB 500 MP 16	2.5 HRS	BREEZY	NO ISSUES TO REPORT
12/16	11:00	WSDOT IRT	SORENSEN	NB I-5 MP 45	5 MINS	CLEAR	MOTOR FAILURE, SAFETY LANDING
02/07	1300	WSDOT IRT	SORENSEN	D5 PL	30 min	cloudy	1 motor slow to start, no other issues
02/08	1400	WSDOT/IRT	SORENSEN	WSDOT PL	15	CLOUDY	camera controls disappreared on tablet
02/10	1600	WSDOT/IRT	SORENSEN	nb sr411 mp 5	3 hours	CLEAR SKY	tablet crashed, recall button pressed
02/27	2:00	WSDOT IRT	SUITTER	RUSH RD	10MIN	CLOUDY	NO INTERNET FOR 15MIN
03/06	12:00pm	WSDOT IRT	SUITTER	D5 PL	5MIN	CLEAR	NO INTERNET 15 MIN DELAY
03/27	12:00pm	WSDOT IRT	SUITTER	RUSH RD	15 MIN	CLEAR	NO INTERNET 15 MIN DELAY
04/17	9:45am	WSDOT IRT	SUITTER	KELSO YARD	5MIN	CLEAR	NO ISSUES TO REPORT
04/17	9:45AM	WSDOT IRT	SORENSEN	KELSO YARD	5 MIN	CLEAR	CAMERA LAGGING IN TIME
04/10	1100AM	WSDOT IRT	SORENSEN	SR 503 MP 10	3 HR	CLEAR	NO ISSUES TO REPORT

Figure A.2: WSDOT southwest region flight logs in December 2023, February 2024, March 2024, and April 2024

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
05/16	2200	WSDOT IRT	SORENSEN	NB I-5 MP 25	2.5 HRS	CLEAR	NO ISSUES TO REPORT
05/19	2200	WSDOT IRT	SORENSEN	SB I-5 MP 65	3 HR	OVERCAST	NO ISSUES TO REPORT
05/22	1400	WSDOT/IRT	SUITTER	DOT P/L	30 MIN	LIGHT RAIN	NO ISSUES TO REPORT
05/23	1500	WSDOT/IRT	SORENSEN	SB 503 MP 50	30 MIN	OVERCAST	TABLET SCREEN GLITCHY

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
07/31	1500	WSDOT IRT	SORENSEN	NB I-5 MP 21	2.5 HRS	CLEAR	NO ISSUES TO REPORT
07/31	1510	WSDOT IRT	SORENSEN	NB I-5 MP 24	10 mins	clear	NO ISSUES TO REPORT
07/31	1515	WSDOT/IRT	Sorensen	NB 5 mp 27	10 MIN	clear	NO ISSUES TO REPORT
07/31	1531	WSDOT/IRT	SORENSEN	NB i-5 mp 30	10 MIN	clear	no issues
08/22	0800	Traffic ops/study	T/Branch	Pioneer st/SB 5	4-5 hrs	Clear	no issues
07/31	1400	WSDOT, IRT	sorensen	NB-i-5 mp 2	15 mins	clear	no issues

Figure A.3: WSDOT southwest region flight logs in May, July, and August 2024

2025 WSDOT Flight Logs

01/23	0030	IRT	SORENSEN	SB 5 MP 42	2.5 HRS	DOWNPOUR	NO ISSUES
02/04	0900	WSDOT IRT	SORENSEN	WB 14 MP 4	1 HR	RAIN/ SNOW	NO ISSUES
02/05	1200	WSDOT IRT	SORENSEN	EB 14 MP 25	30 MIN	BREEZY	STRUGGLED IN LIGHT WIND
02/13/25	2200	WSDOT IRT	SORENSEN	NB I-5 MP 79	2 HR	CLEAR	ELECTROMAGNETIC INTERFERENCE
06/08/25	0900	wsdot irt	sorensen	sr 433 mp 0.1	30 mins	clear / sun	RID issue, self fixed
06/12	1030	WSDOT IRT	SORENSEN	DOT SW HQ	15 MIN	CLEAR/SUN	RID/POWER ISSUE, RESET, NO ISSUE

Figure A.4: WSDOT southwest region flight logs in January, February, and June 2025

Appendix B:
Caltrans Flight Log

2023 Caltrans Flight Logs

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
08/24/23	12:30	Microwave Path Analysis	Jeremiah Pearce	Shasta Lake City CA 40 39' 45.25" N 122 23' 14.83"W	15-minutes	Sunny, 85 degrees – light winds	Ascended to 150' and descended to 80' to take photos.
08/28/23	07:00	Demonstration for D2 Maintenance Division Chief	Jeremiah Pearce	District 2 DO 40 35' 22.28" N 122 23' 50.99" W	10-minutes	Sunny, 65 degrees – light breeze	Ascended to 150'. Demonstrated ease of use, control and ergonomics.

Figure B.1: Caltrans District 2 flight logs for August 2023

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
8/28/23	Various	Research to pull RTSP.	Andres Chavez	Cameron Park	Various	Fair	
8/29/23	Various	Research to pull RTSP.	Andres Chavez	Cameron Park	Various	Fair	
8/30/23	Various	Research to pull RTSP.	Andres Chavez	Cameron Park	Various	Fair	- Discovered onboard Cradlepoint modem and external digi modem are using the same default subnet of 192.168.2.*.
8/31/23	Various	Research to pull RTSP.	Andres Chavez	Cameron Park	Various	Fair	- Changed Digi modem's subnet to 192.168.200.*.
9/12/23	Various	Pulled RTSP from 3 sources via Verizon cellular modem.	Andres Chavez	Cameron Park	Various	Fair	- Successfully connected to Verizon cellular modem and pulled streams from ports 5010 and 5012. Simultaneously pulled streams by Sean Campbell, Andres Chavez and Jared Sun.
9/12/23	1400-1630	Dry run for D3 demo. Purpose was to test pulling video feed into D3 Wowza while at the TMC parking lot.	Andres Chavez & Sean Campbell	Rancho Cordova TMC	2:30 hours	Fair	- Successfully connected to Verizon cellular modem and pulled streams from ports 5010 and 5012 from D3 Wowza server. Keith Koppen from D2 successfully viewed streams from internal page at: https://sv03tmcwebproxy/portable-video-wall - Had intermittent success using Starlink for the uplink. RGB stream would disconnect after a few seconds, IR stream was very solid.
9/14/23	0830	2nd dry run for D3 Demo; Purpose was to	Andres Chavez	Cameron Park	30 min	Fair	Cradle point connected to ATT network, which is notoriously poor in

Figure B.2: Caltrans District 3 flight logs for August and September 2023 (1)

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
		test live.fotokite.com feed.					this town. Connecting via live.fotokite.com took tens of seconds the first time. The second time, it took less 5. However, video quality is poor. Much better when testing with external Digi/Verizon link.
9/15/23	1000-1230	D3 Demo.	Andres Chavez, Sean Campbell, Barry Pavan	Rancho Cordova TMC	2:30 hours	Fair	Showed feed 3 ways: 1) Via Verizon modem through Wowza to internal Portable-Video-Wall. 2) Via live.fotokite.com. 3) Via sharing screen on tablet using WebEx meeting.

Figure B.2: Caltrans District 3 flight logs for August and September 2023 (2)

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
9/27/23	2000	Dry run before demo.	Andres Chavez	Cameron Park	30 min	Fair	Updated firmware on base station and kite. Charged battery.
9/28/23	0930	AHMCT demo	Andres Chavez, Sean Campbell	Davis CA	2:00 hours	Winds 9-11MPH	Max height set to 50ft. Did not have any wind warnings. Tablet went to sleep mode and would not connect properly after waking up. Had to reboot both the drone and the tablet to reconnect. Asked Anh to attempt to reproduce. However…. (read tomorrow's report)
9/29/23	1000	Hand off to, and train Ho Eric and Minh Tran	Sean Campbell, Ho Eric, Minh Tran	Davis CA	2:00 hours	Fair, no wind	Restarted base station and noticed tablet's wireless network switched to AHMCT's network. When base station back up, tabled did not connect to base station. It stayed connected to AHMCT's wifi. (This may be root cause of yesterday's problem.) Saved SSID for AHMCT was "forgotten" and normal operation was restored.

Figure B.3: Caltrans District 3 flight logs for September 2023

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
10/31/23	11:30	Microwave Path Analysis	Jeremiah Pearce	I-5/SR273 Interchange Redding CA 40 37' 43.56" N 122 22' 9.13"W	15-minutes	Sunny, 72 degrees – light winds	Ascended to 50', ascended to 75', descended to 50', and descended to ground level to confirm visual line-of-sight to Tuscan Buttes. Could not confirm line-of-site, sun was in a bad position and reflecting light off of the haze.
10/31/23	14:30	Microwave Path Analysis	Keith Koeppen	I-5/SR273 Interchange Redding Ca 40 37' 43.56" N 122 22' 9.13"W	15-minutes	Sunny, 78 degrees – light breeze	Ascended to 50'. Confirmed line-of-site and took photos. Ascended to 150'. Descended to ground level.

Figure B.4: Caltrans District 2 flight logs for October 2023

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
11/07/23	13:45	Microwave Path Analysis	Ozair Purmul	Red Bluff Maintenance Station Red Bluff CA 40 32' 27.82" N 122 14' 51.39"W	25-minutes	Sunny/PC, 66 degrees – 20 mph gust winds	Ascended to 50', ascended to 60', ascended to 75', and descended to ground level to confirm visual line-of-sight to Tuscan Buttes and take photos. Moved to another location 20' South. Ascended to 60' confirm visual line-of-sight to Tuscan Buttes and take photos. Descended to ground level.
11/20/23	15:29	Photos for presentation	Jeremiah Pearce	District 2 DO 40 35' 22.28" N 122 23' 50.99" W	10-minutes	Sunny/PC, 66 degrees – light winds	Ascended to 50' and descended to ground 3' level to take photos of the Fotokite in action.
11/23/23	20:40	Night flight/low light condition test and prep for Innovation Leadership Council Meeting the following Tuesday	Jeremiah Pearce	Shasta, CA 40° 37' 23.53" N 122° 29' 42.81" W	3-minutes	Clear skies, 55 degrees – calm 8-mph winds	Ascended to 100'. Fotokite displayed an alarm on the controller indicating a high-wind event and the aircraft was descending. Aircraft crashed during descent. See accident report dated 12/06/23.
11/28/23	12:45	Live demonstration for the Innovation Leadership Council Meeting at District 2	Keith Koeppen	I5/SR44 Interchange Redding 40° 35' 11.25" N 122° 21' 43.58" W	1.25-hours	Clear skies, calm winds	C. Turner and crew were on site with Part 107. Provided video feed to audience. Operating the Hornet after exchange with Andre due to crash noted above.

Figure B.5: Caltrans District 2 flight logs for November 2023

2023							
12/13/2023	0910-1100	Test	Ramiro/Sergio	District Office	1.83	Cool with mild wind	Pilot's Comment: First test of Foto Kite was conducted in the parking lot of DO of D6. We used 120v plug to run the mission. Our height was initially limited due to not having good GPS signals. We lost camera feed 6 times, it went blank on the screen. It safety laneded once due to wind warning, although wind was less than 5 mph. At the end we also ran into tablet saying it didnt have control to land, so we had to press physical button on the base. During our flight the windows updated.
12/21/2023	0940-1120	Test	Ramiro/Sergio	District Office	1.67	Cool with mild wind	Tablet giving error message for Edge browser.
12/28/2023	0900-1200	Test	Aakash/Paul	District Office	3	Partly sunny.	Preflight inspection: Got an application error on the tablet after booting. Did not affect application to run Fotokite. Pilot's Comment: We tested the Foto Kite with Samer. Made a video documenting set up and operation of the drone. We on battery back up. We were able to fly to 150 ft with no problem and drone was responding well. With Samer with came to conclusion that unit was ready to be

Figure B.6: Caltrans District 6 flight logs for December 2023

Caltrans District 2
Fotokite Tethered UAV Accident Report
Date and Time: *Thursday, November 23, 2023 at approximately 20:40*
Location: *40° 37' 23.53" N, 122° 29' 42.81" W*
Weather Conditions: *55° clear skies, calm 8mph winds Gusting to 16 mph from the North (see attached MesoWest Report for PG&E Station on my property).*
Objective: *Test the Fotokite in low/no light conditions and test the streaming video and livestream link setup process for the Innovation Leadership Council meeting the following Tuesday.*
Event Log:
1.) Approximately 20:30: Pilot and a visual observer set up the Fotokite at the launch site and ensured base was at least 15' away from structure (house).
a. Performed pre-flite checks and system startup.
2.) Approximately 20:35: After system bootup, pressed the start button and Fotokite ascended to the 3' level.
a. Intention to ascend to 100' Above Ground Level (AGL) and monitor CCTV image in low/no light conditions at 10' increments below 100'. Used the slide control to ascend the aircraft to 100' AGL.
b. As aircraft ascended it reached a point that an alarm was triggered on the controls that indicated a high-wind event and the aircraft was descending. It appeared to the pilot as though the aircraft had not quite reached 100' AGL but was very close (80 – 100' AGL). Upon visual observation it appeared that the winds were higher at the elevation of the aircraft and that the aircraft was making adjustments to stay within its flight path. This was evident both visually and audibly.
c. As the aircraft descended it reached a point (pilot estimates somewhere between 60 – 70' AGL) where it began to fly erratically. The aircraft did not appear to be following a defined descension path, making large arcing movements back and forth between the East and West, before eventually following a path to the West over my house. Due to the erratic nature of the flight path, pilot could not determine if the base unit was actively retracting the aircraft.
d. As the aircraft flew further over the house, the tether became stuck along the shingles folded over the rake of the roof, preventing the base from retracting the aircraft. This caused the aircraft to fly further to the West and over the home, ultimately coming in contact with the ridge line

of the roof and bouncing twice before crashing next to the chimney pipe (see photos of crash site).

3.) Approximately 20:40: Pilot immediately went into recovery mode.

a. Using ladder, pilot climbed on roof to crash site.

b. Visual inspection of aircraft

i. Two sets of rotors had dislodged from the aircraft.

ii. Of the two sets of rotors that had dislodged from the aircraft, one set had a connector tab sheered and was no longer usable.

iii. All but one set of rotors had been scratched up from the impact but remained intact.

iv. Frame of the aircraft remained intact with some minor scuff marks but appeared to be in usable condition.

c. At the crash site the tether had wrapped itself around the chimney pipe guy bracket when the aircraft had crashed. Pilot freed the tether and walked the aircraft over to the edge of the roof, freeing the tether from the tension induced by the shingles folded over the rake of the roof. After freeing the tether, the base retracted the tether mechanically until the aircraft was restored to its home position.

d. Pilot took a photo of the launch site setup immediately after crash cleanup. Photos were not taken of the crash site immediately after the crash due to low light levels, difficult access, and limited manpower.

4.) Friday, November 24, 2023 09:27: Pilot reported crash to the Project Manager.

Item B.7: Caltrans District 2 Fotokite crash report for 2023

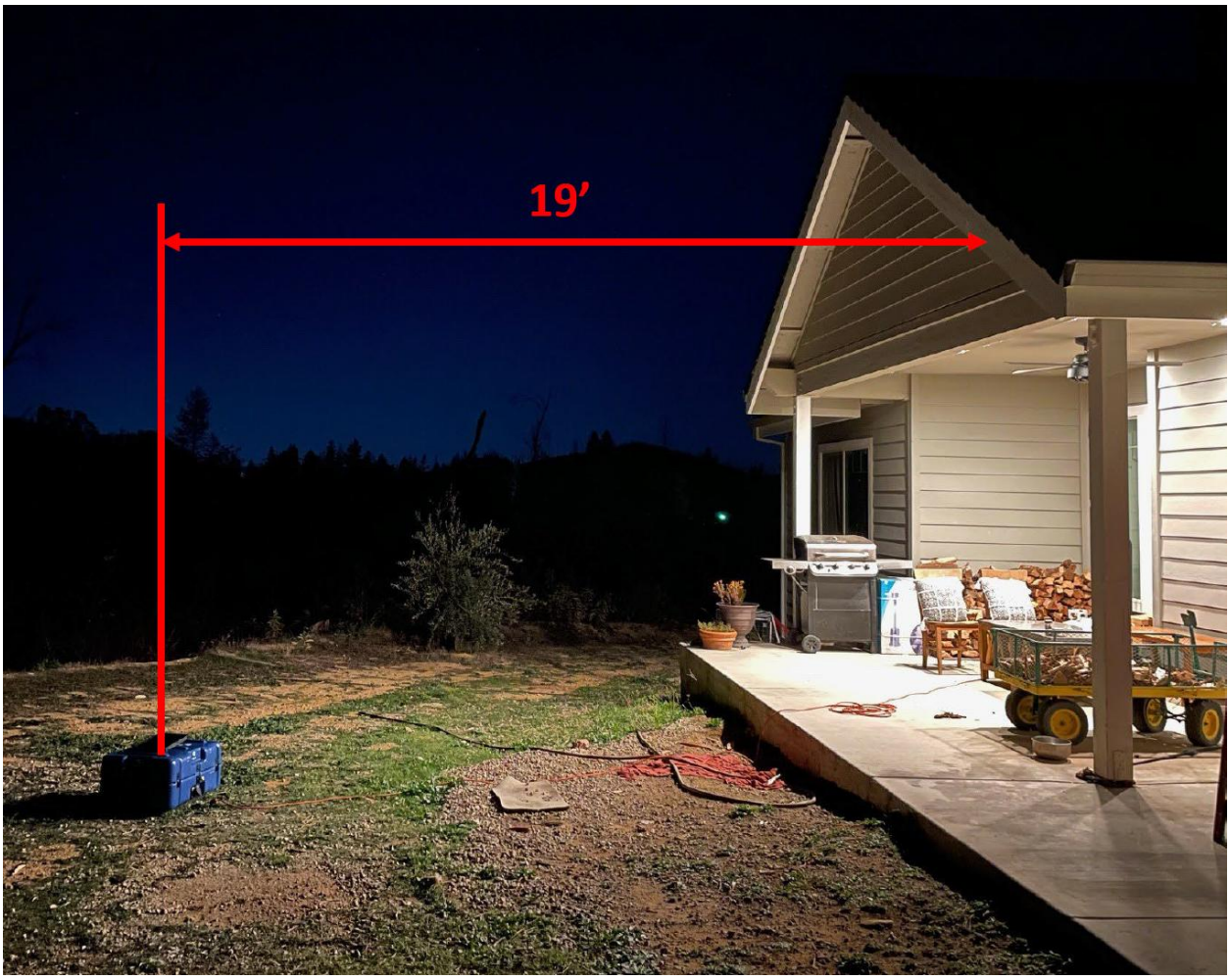

Figure B.7: Caltrans District 2 Fotokite crash report documentation demonstrating the height of the building hit

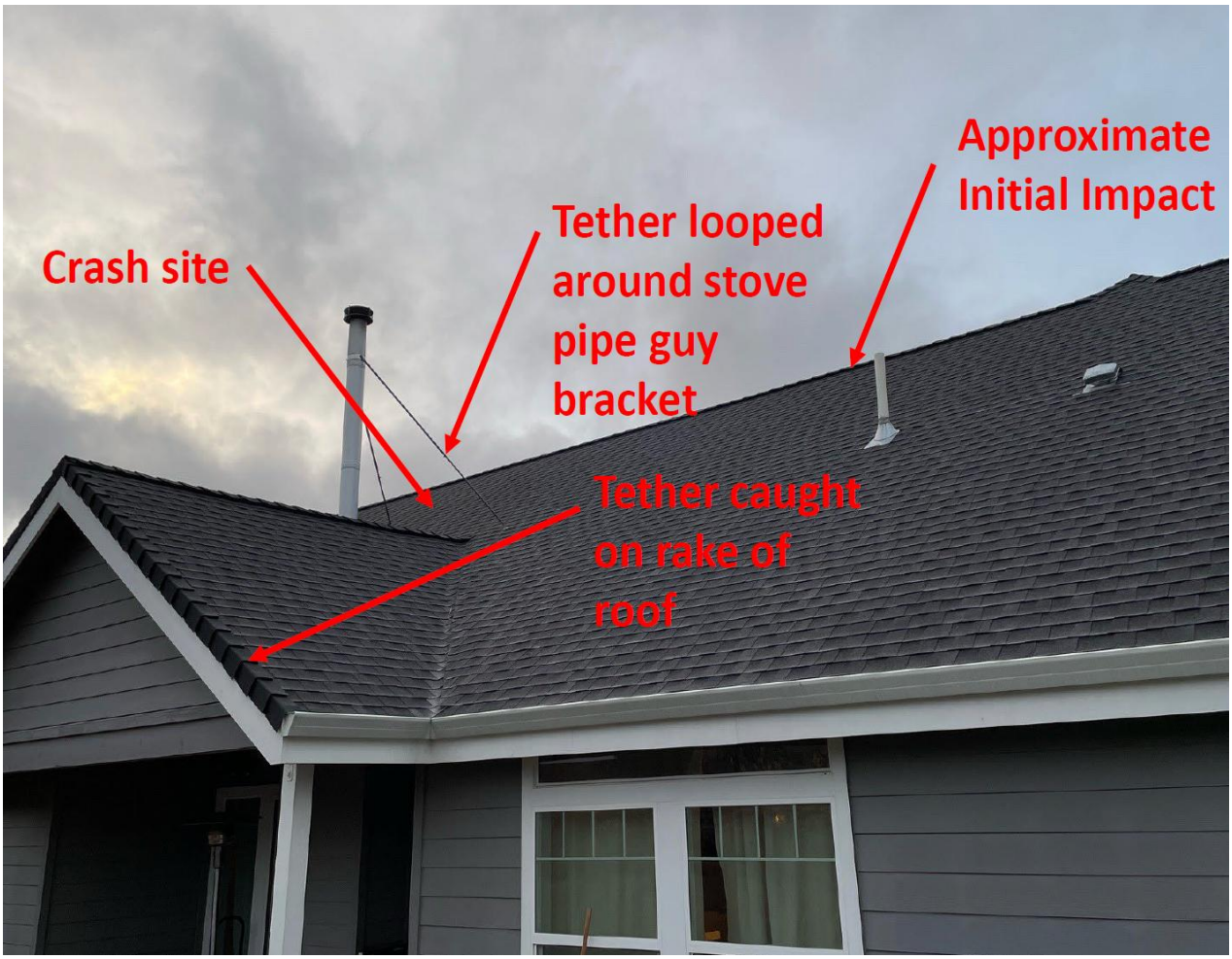

Figure B.7: Caltrans District 2 Fotokite crash report documentation demonstrating the crash site and items on the roof the UAS hit.

STATION: PG617
STATION NAME: Whiskeytown-Shasta
LATITUDE: 40.62254
LONGITUDE: -122.49539
ELEVATION [ft]: 977.0
STATE: CA

Station_ID	Date_Time	air_temp_s	relative_hu	wind_spee	wind_direc	wind_gust_	volt_set_1	wind_chill_	wind_cardi	heat_index	dew_point_temperature_set_1d
		Fahrenheit	%	Miles/hour	Degrees	Miles/hour	volts	Fahrenheit	code	Fahrenheit	Fahrenheit
PG617	11/22/202	52.41	67.73	0.3	327.8	2.42	12.65		NNW		41.95
PG617	11/22/202	51.92	68.85	0.24	278.2	1.53	12.64		W		41.91
PG617	11/22/202	51.53	70.64	0.31	310.5	1.9	12.64		NW		42.21
PG617	11/22/202	50.56	74.36	0.37	200.8	1.75	12.64		SSW		42.62
PG617	11/22/202	50.51	73.76	1.5	353	3.29	12.63		N		42.36
PG617	11/22/202	52.14	65.79	1.59	336.7	3.43	12.63		NNW		40.94
PG617	11/22/202	52.53	64.75	0.93	295.8	2.42	12.62		WNW		40.89
PG617	11/22/202	51.17	68.07	0.69	311.3	2.27	12.62		NW		40.9
PG617	11/22/202	51.3	67.49	0.85	333.6	3.65	12.62		NNW		40.8
PG617	11/22/202	50.42	69.16	1.81	302.6	4.02	12.61		WNW		40.59
PG617	11/22/202	51.2	66.17	2.28	330	3.88	12.61		NNW		40.19
PG617	11/22/202	52.23	64.39	1.44	269.7	3.21	12.6		W		40.46
PG617	11/22/202	51.06	67.73	1.24	11.88	3.65	12.6		NNE		40.66
PG617	11/22/202	51.49	65.45	1.08	0.86	3.88	12.59		N		40.18
PG617	11/22/202	52.94	62.26	1.58	57.98	5.11	12.59		ENE		40.26
PG617	11/22/202	52.29	64.12	1.72	325.3	4.45	12.58		NW		40.41
PG617	11/22/202	53.83	59.16	1.3	301.8	5.04	12.58		WNW		39.78
PG617	11/22/202	52.74	62.88	0.56	20.35	3.51	12.58		NNE		40.33
PG617	11/23/202	52.67	62.1	1.52	359.7	5.11	12.57		N		39.94
PG617	11/23/202	54.72	57.13	1.13	107.7	4.45	12.57		ESE		39.71
PG617	11/23/202	56.49	52.86	1.69	125.2	4.45	12.57		SE		39.36
PG617	11/23/202	58.55	49.43	2.8	281	7.74	12.56		W		39.54
PG617	11/23/202	61.69	44.36	4.45	320.6	11.18	12.56		NW		39.63
PG617	11/23/202	59.64	47.67	5.33	32.54	9.86	12.55		NNE		39.61
PG617	11/23/202	58.55	50.3	0.98	99.2	4.17	12.55		E		39.99
PG617	11/23/202	57.7	51.95	1.05	191	3.88	12.55		S		40.04
PG617	11/23/202	57.66	52.63	1.07	294.8	3.36	12.55		WNW		40.34
PG617	11/23/202	58.78	50.97	2.24	7.45	6.21	12.55		N		40.55
PG617	11/23/202	58.95	50.87	1.78	358.7	3.51	12.54		N		40.65
PG617	11/23/202	59.33	50.12	2.9	318.2	8.91	12.54		NW		40.62
PG617	11/23/202	59.84	48.92	3.27	350.4	10.96	12.54		N		40.46
PG617	11/23/202	60.47	47.93	3.76	323.6	9.21	12.54		NW		40.51
PG617	11/23/202	59.75	49.63	3.15	40.23	5.41	12.53		NE		40.75
PG617	11/23/202	57.1	55.65	0.97	315.1	3.8	12.53		NW		41.26
PG617	11/23/202	57.68	54.53	2.39	338	6.43	12.53		NNW		41.28
PG617	11/23/202	59.49	50.99	3.32	277.6	6.5	12.53		W		41.21
PG617	11/23/202	58.62	53.15	3.5	319	9.06	12.53		NW		41.49
PG617	11/23/202	58.17	54.48	1.86	1.87	5.26	12.52		N		41.71
PG617	11/23/202	58.09	54.82	2.49	304.2	5.34	12.52		NW		41.8
PG617	11/23/202	57.59	55.97	3.13	348.9	8.4	12.52		N		41.87
PG617	11/23/202	58.18	54.56	2.34	307.7	5.26	12.52		NW		41.76
PG617	11/23/202	57.64	55.56	2.44	314.8	5.04	12.52		NW		41.73
PG617	11/23/202	57.24	56.25	1.29	359.6	4.02	12.51		N		41.67
PG617	11/23/202	53.8	63.46	1.3	238.8	4.38	12.51		WSW		41.58
PG617	11/23/202	55.28	59.87	1.9	298.4	7.89	12.51		WNW		41.46
PG617	11/23/202	56.1	57.23	2.51	231.3	7.67	12.51		SW		41.05
PG617	11/23/202	53.92	61.47	0.9	161.1	3.29	12.51		SSE		40.86
PG617	11/23/202	53.51	61.81	1.32	293.3	3.21	12.51		WNW		40.61
PG617	11/23/202	53.79	60.58	2.1	348.8	5.26	12.5		N		40.36
PG617	11/23/202	52.37	63.68	1.24	293.6	3.36	12.5		WNW		40.31
PG617	11/23/202	50.99	66.59	1.43	344.5	3.73	12.5		NNW		40.15
PG617	11/23/202	51.94	62.99	2.53	331.5	5.34	12.5		NNW		39.62
PG617	11/23/202	52.03	62.14	1.75	357.3	3.73	12.5		N		39.35
PG617	11/23/202	49.79	67.11	0.53	336.7	1.9	12.49		NNW		39.21
PG617	11/23/202	49.15	68.94	0.56	245.3	2.64	12.49		WSW		39.29
PG617	11/23/202	49.06	68.62	0.93	269.4	2.19	12.49		W		39.08
PG617	11/23/202	49.76	66.48	1.43	260.3	3.43	12.49		W		38.93
PG617	11/23/202	48.06	71.42	1.04	261.9	2.64	12.49		W		39.16

Figure B.7: Caltrans District 2 Fotokite crash report documentation concerning latitude, longitude, wind speeds, and temperatures (1)

PG617	11/23/202:	48.53	70.13	1.69	267.8	3.73	12.48	W	39.14
PG617	11/23/202:	48	70.97	0.83	350.5	2.34	12.48	N	38.94
PG617	11/23/202:	47.73	71.33	0.78	302.5	2.92	12.48	WNW	38.81
PG617	11/23/202:	48.61	69.53	1.35	310.2	3.8	12.48	NW	38.99
PG617	11/23/202:	48.15	71.27	0.51	344.6	3.8	12.47	NNW	39.19
PG617	11/23/202:	47.25	73.82	0.67	336.1	2.12	12.47	NNW	39.23
PG617	11/23/202:	47.94	73.49	0.68	342.9	2.64	12.47	NNW	39.78
PG617	11/23/202:	49.15	72.06	1.04	303.7	2.49	12.47	WNW	40.44
PG617	11/23/202:	50.66	69.17	0.78	323.5	2.19	12.47	NW	40.83
PG617	11/23/202:	53.14	65.39	1.16	314.3	3.07	12.48	NW	41.73
PG617	11/23/202:	54.61	60.17	2.19	4.16	6.43	12.47	N	40.95
PG617	11/23/202:	56.48	54.83	5.93	29.41	14.03	12.48	NNE	40.3
PG617	11/23/202:	57.29	51.9	7.69	40.43	13.52	12.5	NE	39.63
PG617	11/23/202:	57.33	51.92	8.24	36.93	14.47	12.51	NE	39.68
PG617	11/23/202:	57.46	51.29	8.64	38.35	15.05	12.51	NE	39.48
PG617	11/23/202:	57.61	50.13	9.03	40	14.83	12.51	NE	39.03
PG617	11/23/202:	57.82	49.15	8.41	39.22	14.1	12.52	NE	38.72
PG617	11/23/202:	58.07	47.94	7.95	43.14	13.3	12.52	NE	38.31
PG617	11/23/202:	58.49	46.79	5.94	56.04	10.81	12.52	NE	38.07
PG617	11/23/202:	58.83	45.39	6.56	72.5	10.89	12.52	ENE	37.61
PG617	11/23/202:	59.14	43.67	6.81	59.46	12.49	12.53	ENE	36.9
PG617	11/23/202:	59.44	42.5	6.38	54.25	13.59	12.53	NE	36.49
PG617	11/23/202:	59.59	41.58	7.08	43.88	13.01	12.53	NE	36.07
PG617	11/23/202:	59.85	40.97	6.32	47.55	11.69	12.54	NE	35.93
PG617	11/23/202:	60.01	40.04	7.25	39.57	14.61	12.56	NE	35.49
PG617	11/23/202:	60.03	38.76	7.43	39.65	12.7	12.81	NE	34.69
PG617	11/23/202:	60.15	38.07	8.44	34.07	15.93	13.16	NE	34.34
PG617	11/23/202:	60.26	37.47	8.56	46.93	15.56	13.41	NE	34.04
PG617	11/23/202:	60.82	37.05	8.91	61.61	15.49	13.6	ENE	34.26
PG617	11/23/202:	61.28	36.58	7.16	50.58	14.39	13.7	NE	34.35
PG617	11/23/202:	61.8	35.72	6.27	45.25	12.86	13.69	NE	34.22
PG617	11/23/202:	62.01	35.1	6.5	58.06	12.28	13.67	ENE	33.97
PG617	11/23/202:	62.27	34.14	7.62	68.56	14.17	13.68	ENE	33.5
PG617	11/23/202:	62.55	33.44	7.84	74.61	15.2	13.66	ENE	33.23
PG617	11/23/202:	62.67	32.49	6.4	69.53	14.1	13.66	ENE	32.62
PG617	11/23/202:	62.87	31.4	6.85	66.79	13.3	13.67	ENE	31.95
PG617	11/23/202:	63.47	31.51	4.78	47.48	10.59	13.67	NE	32.56
PG617	11/23/202:	63.61	30.01	5.71	40.93	10.67	13.65	NE	31.48
PG617	11/23/202:	63.83	30.09	3.75	36.64	8.48	13.65	NE	31.73
PG617	11/23/202:	64.18	27.46	7.31	18.83	14.17	13.65	NNE	29.78
PG617	11/23/202:	64.33	26.86	5.73	29.84	14.1	13.65	NNE	29.37
PG617	11/23/202:	64.08	25.39	9.13	9.57	19.07	13.66	N	27.79
PG617	11/23/202:	64.21	24.28	8.48	23.29	17.39	13.66	NNE	26.82
PG617	11/23/202:	64.4	24.59	7.25	12.59	18.34	13.67	NNE	27.28
PG617	11/23/202:	64.25	23.75	9.95	14.01	18.12	13.67	NNE	26.32
PG617	11/23/202:	64.3	24.43	7.25	20.33	16.44	13.67	NNE	27.04
PG617	11/23/202:	64.38	23.99	7.99	11.55	18.78	13.67	NNE	26.67
PG617	11/23/202:	64.46	23.51	7.3	18.41	13.74	13.67	NNE	26.25
PG617	11/23/202:	64.45	23.98	6.88	20.55	12.42	13.67	NNE	26.72
PG617	11/23/202:	64.36	22.93	6.53	31.25	14.83	13.67	NNE	25.57
PG617	11/23/202:	64.28	22.96	5.99	12.12	14.61	13.67	NNE	25.53
PG617	11/23/202:	64.1	23.49	5.09	19.51	14.03	13.67	NNE	25.92
PG617	11/23/202:	63.9	23.84	5.29	22.72	11.69	13.67	NNE	26.11
PG617	11/23/202:	63.76	23.97	6.66	17.08	14.53	13.67	NNE	26.12
PG617	11/23/202:	63.49	25	6.61	20.52	15.56	13.66	NNE	26.91
PG617	11/23/202:	63.34	24.5	9.25	20.39	15.78	13.36	NNE	26.29
PG617	11/23/202:	63.02	25.1	7.73	6.99	14.91	13.33	N	26.6
PG617	11/23/202:	62.43	25.8	7.1	10.38	12.7	12.88	N	26.76
PG617	11/23/202:	62.23	26.14	7.1	12.93	12.86	12.82	NNE	26.9
PG617	11/23/202:	61.72	27.08	5.63	15.24	10.74	12.8	NNE	27.32
PG617	11/23/202:	61.16	27.82	5.34	3.48	12.06	12.78	N	27.49
PG617	11/23/202:	60.64	28.64	5.43	0.71	12.28	12.77	N	27.74
PG617	11/23/202:	60.73	28.38	5.95	3.45	12.7	12.76	N	27.6
PG617	11/23/202:	60.26	29.21	5.23	358.2	11.91	12.75	N	27.89
PG617	11/23/202:	60.15	29.13	6.39	359	12.2	12.75	N	27.73
PG617	11/23/202:	60.05	29.2	5.31	3.41	11.18	12.74	N	27.7

Figure B.7: Caltrans District 2 Fotokite crash report documentation concerning latitude, longitude, wind speeds, and temperatures (2)

PG617	11/23/202:	59.93	29.26	5.57	6.75	11.69	12.74	N	27.64
PG617	11/23/202:	59.84	29.37	5.71	3.12	13.01	12.73	N	27.66
PG617	11/23/202:	59.46	29.89	4.56	4.11	10.96	12.73	N	27.75
PG617	11/23/202:	58.57	31.44	3.02	3.73	7.89	12.73	N	28.2
PG617	11/23/202:	58.03	32.2	4.03	20.82	7.67	12.72	NNE	28.31
PG617	11/23/202:	58.35	32.12	5.27	19.89	12.86	12.72	NNE	28.53
PG617	11/23/202:	58.3	32.15	5.36	20.02	14.1	12.71	NNE	28.51
PG617	11/23/202:	58.06	32.65	6.14	17.75	13.15	12.71	NNE	28.68
PG617	11/23/202:	58.11	32.81	5.8	22.48	12.64	12.71	NNE	28.84
PG617	11/23/202:	57.62	33.54	5.67	24.06	10.45	12.71	NNE	28.94
PG617	11/23/202:	56.91	34.82	4.58	29.98	7.59	12.7	NNE	29.23
PG617	11/23/202:	56.33	35.97	4.33	35.21	8.18	12.7	NE	29.51
PG617	11/23/202:	56.66	35.33	5.94	42.46	9.79	12.7	NE	29.37
PG617	11/23/202:	56.61	35.92	5.49	16.97	10.67	12.69	NNE	29.73
PG617	11/23/202:	55.8	37.22	4.8	14.1	12.78	12.69	NNE	29.88
PG617	11/23/202:	56.23	36.92	5.13	20.1	11.54	12.69	NNE	30.07
PG617	11/23/202:	56.11	37.56	3.9	49.16	8.11	12.68	NE	30.38
PG617	11/23/202:	55.41	39.29	6.76	39.49	15.12	12.68	NE	30.87
PG617	11/23/202:	55.58	38.27	8.39	31.57	16.3	12.68	NNE	30.37
PG617	11/23/202:	55.14	38.41	6.77	25.03	17.39	12.68	NNE	30.07
PG617	11/23/202:	54.94	38.36	5.44	26.4	11.62	12.67	NNE	29.85

Figure B.7: Caltrans District 2 Fotokite crash report documentation concerning latitude, longitude, wind speeds, and temperatures (3)

UAS Maintenance and Inspection Log for GUNROCK

Maintenance and Inspection Log for Drone: GUNROCK

Type	Performed by	Date	Post/Pre	Description	Remarks	Aditional Repair	Needs Replacement Parts
Inspection	Aakash Koirala	12/28/2023	Pre	Pre Flight Inspection: We got an application error on the tablet after booting. It did not affect the application to run the foto kite.	Battery back up was at 69% and partly sunny.	Not Needed	Not Needed
Inspection	Aakash Koirala	12/21/2023	Pre	Inspection Before Flight	Battery at 99% on the Backup. The tablet was giving us error message for Edge browser.	Not Needed	Not Needed

Flight Log for UAS: GUNROCK

Mission Information:

Date	Start Time	End Time	Total Hours
2023-12-28	09:00	12:00	3 hrs

Location	County	Route	Post Mile	Pilot	Observer	Mission Purpose
OLIVE AVE	FRE	99	23.3	Aakash Koirala	Paul M Yamashita	Training

Drone Information:

Drone	Make and Model	Serial Number
GUNROCK	FOTOKITE Sigma	FA3MCRHKAK

Weather Conditions: 63F Partly Sunny with wind of 5mph. Humidity: 70%. Barometer: 30.21" Hg

Comments: Testing Foto Kite and demo

Pilot's Comment: We tested the Foto Kite with Samer. Made a video documenting set up and operation of the drone. We on battery back up. We were able to fly to 150 ft with no problem and drone was responding well. With Samer with came to conclusion that unit was ready to be feild tested.

Figure B.8: Caltrans District 6 flight logs for December 2023 (1)

Mission Information:

Date	Start Time	End Time	Total Hours
2023-12-21	09:40	11:20	1.66666666667 hrs

Location	County	Route	Post Mile	Pilot	Observer	Mission Purpose
OLIVE AVE	FRE	99	23.3	Ramiro Cuevas	Sergio Venegas	Training

Drone Information:

Drone	Make and Model	Serial Number
GUNROCK	FOTOKITE Sigma	FA3MCRHKAK

Weather Conditions: 52F Partly Sunny with winds of 5.4mph. Humidity: 92%. Barometer: 29.6" Hg

Comments: FOTO KITE TEST

Pilot's Comment: Used battery to power the drone. We were only able to fly around 82 ft despite setting the height to 150 ft.

Mission Information:

Date	Start Time	End Time	Total Hours
2023-12-13	09:10	11:00	1.83333333333 hrs

Location	County	Route	Post Mile	Pilot	Observer	Mission Purpose
OLIVE AVE	FRE	99	23.3	Sergio Venegas	Ramiro Cuevas	Training,Te

Drone Information:

Drone	Make and Model	Serial Number
GUNROCK	FOTOKITE Sigma	FA3MCRHKAK

Weather Conditions: 59F Sunny with humidity 35% wind of 5 to 10 mph

Comments: Testing Foto Kite

Pilot's Comment: First test of Foto Kite was conducted in the parking lot of DO of D6. We used 120v plug to run the mission. Our height was initially limited due to not having good GPS signals. We lost camera feed 6 times, it went blank on the screen. It safety laneded once due to wind warning, although wind was less than 5 mph. At the end we also ran into tablet saying it didnt have control to land, so we had to press physical button on the base. During our flight the windows updated.

Mission Information:

Date	Start Time	End Time	Total Hours
2023-12-11	08:30	02:30	18 hrs

Figure B.8: Caltrans District 6 flight logs for December 2023 (2)

Location	County	Route	Post Mile	Pilot	Observer	Mission Purpose
D3 to UC Davis	FRE			Andres Chavez	Sergio Venegas	Other,Initial FOTO KITE Demo

Drone Information:

Drone	Make and Model	Serial Number
GUNROCK	FOTOKITE Sigma	FA3MCRHKAK

Weather Conditions: 67 F Partly Sunny, wind of SW 6MPH with Gust of 10 mph

Comments: D3 to UC Davis

Pilot's Comment: On December 11, 2023, drove from Fresno to D03 TMC to pick up a tethered drone (kite drone). Arrived at the D03 TMC approximately 0830 and led into the back parking area to be given a demonstration of the kite drone. Was given a tutorial on the equipment; tablet, external battery, and kite. Encountered an issue with the kite emergency on board battery not charging correctly. Andres attempted several times to correct the issue along with the grad student from UC Davis, but to no avail. After a brief discussion among us, it was decided to meet them on the UC Davis Campus to swap the kite out with a working kite they had that was attached to a base unit that was not working.Met them at the UC Davis site at approximately 2 pm, where they had already exchanged the defective kite with the working one. We went through the tutorial again and had a successful launch. We were able to launch the kite, watched it attain a height of 5 feet AGL and did a diagnosis of systems and the camera. The kite was then sent to approximately 100 feet AGL where we were able to rotate the kite in both a clockwise and counter-clockwise direction; played with the zoom feature, and thermographic display. Both the zoom and thermos performed well and was easy to control. The emergency recall was tested and we observed the kite coming down in short order as if the unit lost power or was recalled by the operator.

Figure B.8: Caltrans District 6 flight logs for December 2023 (3)

2024 Caltrans Flight Logs

Mission Information:

Date	Start Time	End Time	Total Hours
2024-01-06	13:00	16:00	3 hrs

Location	County	Route	Post Mile	Pilot	Observer	Mission Purpose
MILLUX RD	KER	5	30.74	Sergio Venegas	Aakash Koirala	Other,Incident Response

Drone Information:

Drone	Make and Model	Serial Number
GUNROCK	FOTOKITE Sigma	

Weather Conditions: High: 57° Low:36°

Comments: Test Live stream the Incident using different method we currently have.

Pilot's Comment: The Fotokite was taken out to an incident on CA5. The battery was at 25% so We ran the drone using Trucks inverter. The inverter was rated for 350 watts. We were able to operate the drone from the Trucks bed for majority of the time. Initially, Due to cross wind from moving traffic, the drone started oscillating side to side, we were at height 80ft. We landed the drone and moved a bit away from the traffic to miss the wind. We increased the height incrementally(10ft). We stated at 30 ft incrementally to 90ft. After moving, the drone performed stable. We were able to livestream using the fotokite built in app to district office/TMC and to remote workers from the location. After halfway in, (2hrs in) the drone kept on landing with the warning battery running low, even though it was plugged in. We suspected it was due to the inverter was limited to 350 watts. We switched the outlet to different truck that had power rating of 2.5 kw, after that there was no Problem with the flight. We concluded the availability to stream nonstop was very fundamental and proved to be very useful. Only concern we had was whenever the big trucks passed us with speed, the drone felt the wind.

Figure B.9: Caltrans District 6 flight logs for January 2024

2024							
1/6/2024	1300-1600	Fog Crash	Sergio / Aakash	KER 5 @ Millux	3	Cold, foggy, overcast	Pilot's Comment: The Fotokite was taken out to an incident on CA5. The battery was at 25% so We ran the drone using Trucks inverter. The inverter was rated for 350 watts. We were able to operate the drone from the Trucks bed for majority of the time. Initially, Due to cross wind from moving traffic, the drone started oscillating side to side, we were at height 80ft. We landed the drone and moved a bit away from the traffic to miss the wind. We increased the height incrementally(10ft). We stated at 30 ft incrementally to 90ft. After moving, the drone performed stable. We were able to livestream using the fotokite built in app to district office/TMC and to remote workers from the location. After halfway in, (2hrs in) the drone kept on landing with the warning battery running low, even though it was plugged in. We suspected it was due to the inverter was limited to 350 watts. We switched the outlet to different truck that had power rating of 2.5 kw, after that there was no Problem with the flight. We concluded the availability to stream nonstop was very fundamental and proved to be very useful. Only concern we had was whenever the big trucks passed us with speed, the drone
5/9/2024	0930-1100	Demo	Sergio/Paul	TMC Academy	0.5	Indoors	No issues
5/9/2024	1530-1700	Demo	Sergio/Paul	TMC Academy	0.5	Indoors	No issues
6/12/2024	1100-1300	Kid's Day	Unknown	District Office	2	Clear, warm	No issues
7/17/2024	1000-1200	Mobile EOC Cooling Test	Paul	CHP Parking lot	2	Clear, hot	No issues
8/22/2024	1700-1830	Back to School Night	Paul		1	Clear, warm	No issues
9/18/2024	0730-0930	Traffic Surveillience	Paul	MAD 41 @ Ave 12	1.75	Clear, cool	No issues
10/3/2024	0930-1100	Demo	Paul	TMC Academy	0.5	Indoors	No issues
10/3/2024	1530-1700	Demo	Paul	TMC Academy	0.5	Indoors	No issues
10/22/2024	1300-1500	Test & prep for Shakeout drill	Paul	CHP Parking lot	2	Clear, warm	Per Ahn, internal temp was hot for current ambient temp
		Hornet replaced Gunrock					
10/23/2024	0900-1100	ShakeOut 2024 - Emerg Drill	Paul	KIN 5/41	2.25	Clear, warm	Repeated RID error messages

Figure B.10: Caltrans District 6 flight logs for January, May, June, July, August, September, and October 2024

2025 Caltrans Flight Logs

Date	Time	Job type/description	Operator	Location	Duration	Weather	Notes
02/13/25	08:00	Chain control point operations	Jeremiah Pearce	Pollard Flat Interchange Shasta County CA 40 59' 54.32" N 122 24' 54.01"W	2-hours	Light snow, 34 degrees – light winds	Fotokite system pushed an update mid-flight affecting the stream. Unable to livestream due to the update. After consultation with tech support, brought the unit back to the shop for further updates and troubleshooting. Confirmed operation later in the afternoon.

Figure B.11: Caltrans District 2 flight logs for February 2025

2025							
2/13/2025	1030-1130	Demo & record Fotokite Rooftop Model	Paul	D10 Maint yard	0	Cloudy, rainy, cold	Tablet would not start up
2/19/2025	1000-1015	Test tablet	Paul	District Office	0	Indoors	Tablet would not open Fotokite application correctly when tablet was powered off and then on while unplugged. If tablet was plugged in, eventhough battery was 100%, and then turned on, tablet opened Fotokite application. Powered up Hornet to verify if tablet would connect and operate unit. Verified it connected to Hornet and launched kite, kite obeyed, hovered and then landed upon
2/20/2025	1130-1300	Demo Fotokite at D10	Paul/Yoseph	D10 Maint yard	1.5	Clear, cool, mild wind	Tablet was already powered up and connected to Hornet. Several people took turns operating kite, demo livestream feature. Did not remember seeing remote operation feature, Will follow up and check next week. Operated fine.
2/27/2025	1300-1400	Update/fix tablet issue	Paul	DO	0.5	Indoors	Could not duplicate tablet issue. Esther assisted with updating tablet to include remote access during livestream. Andre suggests I power tablet up and down a number of time to see if issue is duplicated. New tablet is being shipped to replace current unit.
3/7/2025	0800-1600	FITI-STEP Forum	Paul/Benjamin	Fresno Conv Ctr	1	Indoors	Fotokite program shut down shortly after booting up. Started up replacement tablet, but required password - will need to contact support.
3/19/2025	0700-0900	Traffic Survellience	Paul/Brandon	MAD 41 @ Ave 12	2	Cool, clear	Tablet display kept freezing up while recording video. Verifed video feed after recording, no glitches or issues. Issues were with oringal tablet. Will swap out after mission.
3/26/2025	930	NA	Paul	NA	0.25	NA	Swapped out tablets. Logged into Hornet with new tablet. Packaged old tablet and set up be shipped out on 3/26.
4/2/2025	1100-1200	Demonstration	Paul	Woodward Park, Fresno	0.5	Clear, warm	Demonstrated livestream and remote control to participants - no issues
4/10/2025	1100-1130	Demonstration	Paul	TMC	0.5	Indoors	Demonstrated livestream - no issues
5/1/2025	1100-1130	Demonstration	Paul	TMC Academy	0.5	Indoors	Demonstrated livestream - no issues
5/1/2025	1630-1700	Demonstration	Paul	TMC Academy	0.5	Indoors	Demonstrated livestream - no issues
5/6/2025	0930-1000	Demonstration	Paul	Mtce SR Safety Stand down - Bakersfield	0.5	Clear, warm	Demonstrated livestream and remote control to participants - no issues

Figure B.12: Caltrans District 6 flight logs for February, March, April, and May 2025