Call When Needed UAS and UASD Performance Metrics

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Introduction

The goal of the Type 1 /2 UAS is to provide information to fire operations and others monitoring fire performance. The UAS Data specialist (UASD) is responsible for providing data support in the delivery of products meeting this goal, ultimately deciding the difference between mission failure or success. The goal of this document is to describe quantitative metrics the team and data specialist can use to gauge mission success. Specific objectives of this report include:

1. Describing the main metrics for measuring UASD and Type 1 / 2 UAS success.
2. Detailing guidelines for making informed decisions on what is possible and when.
3. Application description from the Robertson Draw / Crooked Creek fires near Billings Montana, June 2021.

The ideas in this document are generally recognized as the module objectives and are presented here as an opportunity for all to understand and question what we aim to achieve.

UASD Metrics

The UASD has three primary duties:

1. Provide spatial awareness and analysis for decision support to the flight and management crew.
2. Provide GCS basemap support for Real Time (RT) and Near Real Time (NRT) Intelligence Surveillance and Reconnaissance (ISR) missions.
3. Provide image processing and product development for mapping the fire perimeter and behavior.

The quickest product/service provided by the Type 1 / 2 UAS is NRT ISR directly to teams on the ground. Decision support (1) & ISR support (2) are essential for each flight and generally have 'softer' time frames, meaning there is usually more time available than is required to complete the mission. ISR support requires basemap production that will serve as the background for web-enabled video streams directly from the aircraft to incident and division commanders. The ISR mission can be further enhanced through direct streaming of 3-D Full Motion Video (FMV) in ArcPro. Spatial awareness support is provided through LRZ assessment, viewshed analysis, and provision of NIROPS, TFR and other spatial datasets.

Providing imagery-derived products (3) is a more difficult and time-consuming process where products may be requested over all or part of the active fire and perimeter. Depending on the requested data and size of the acquisition area, the race is on to provide a useful product from the moment the aircraft touches the ground to the next morning's operations meeting.

The UASD metrics are based on the time between image acquisition to product delivery into the hands of Operations. Table 1 describes temporal benchmarks for the Type 1 /2 team and the UASD in particular.

Table 1. Benchmarks for Type 1 / 2 UAS products in support of wildfire operations.

Benchmark	Metric	Description	Primary Party
Date Ordered	Hours until first flight.	Time between initial request and first launch.	Entire team
Check in Time	Hours until first flight.	Time between arriving at the incident and first flight.	Entire team.
LRZ Arrival / Setup Time	Hours until first flight.	Hours between arrival at the LRZ and first launch.	Contractor team
Launch	Benchmark	Time of launch.	Entire Team
ISR WiFi Feed	First product available.	Hours since ordered, check in, start of set up.	Contractor team.
Data Collection Start	Data collection start time.	Hours since ordered, check in, start of set up.	Contractor team.
Data Collection Stop	Time of transect completion.	Hours since order, check in, set up, or launch.	Entire team.
AC Landing Time	Benchmark	Time of landing	Entire team
Processing Start	Hours between landing and data process start.	Time data processing begins.	UASD
Process Complete	Hours between AC landing and processing completion.	Time data processing is complete.	UASD
Product Delivery	Hours between landing and delivery.	Measured against all benchmarks.	UASD

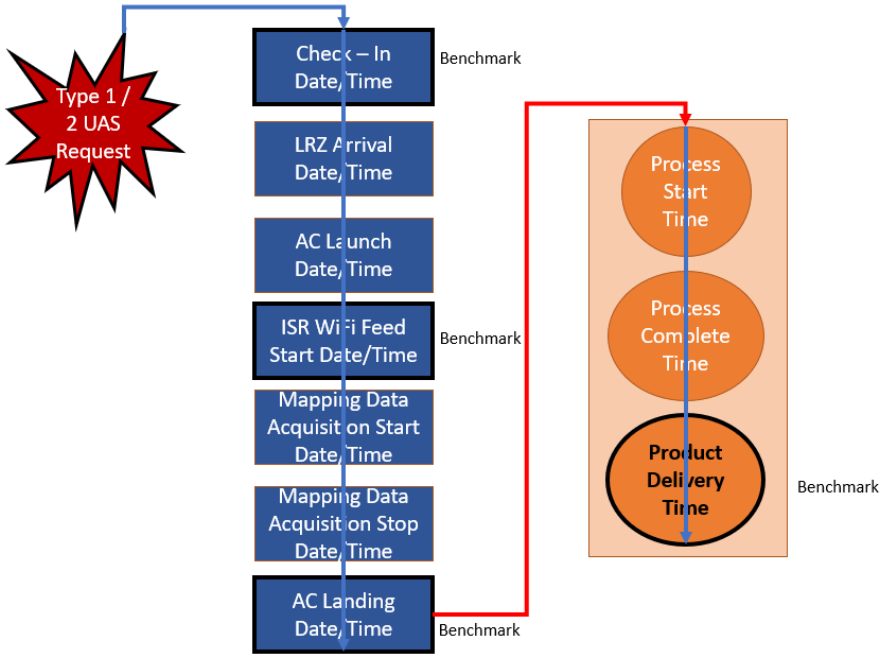

Figure 1. Call When Needed data delivery benchmarks for calculating 'time to delivery' metrics. Team tasks are in blue and Data Specialist specific tasks are in orange.

Under Promise and Over Deliver

To promote the CWN UAS among the fire community, a suggested approach when discussing system capabilities is to "Under Promise and Over Deliver", meaning we want to lay out reasonable expectations and strive to excel beyond those expectations. When the target product is derived imagery mosaics, the difficulty lies in understanding exactly what is possible and how long it will take to get there. This section provides some guidelines for data production and delivery.

Table 2. Suggested Mapping Data Product Delivery Schedule based on the number of Acquisition Hours (AH) flown by the AC.

Data Product	Acquisition Period	Multiplier
EO Ortho	Day	AH * 2
EO Ortho	Night	NA
IR Ortho	Day	AH * 3
IR Ortho	Night	AH * 0.25
IR and EO Ortho	Day	AH * 3
IR and EO Ortho	Night	AH * 0.5

Table 2 describes expected times for mapping product delivery based on hours flown by the aircraft during which imagery is collected over the target area (Acquisition Hours; AH). The guiding rule of thumb suggests the delivery of products based on the EO side of the FLIR duo takes about twice as many hours as it took to collect the data. Infra-Red (IR) products require only about 0.25 AH to produce products at night. Producing IR products during the day can be the most time consuming, requiring image alignment to be completed using both sets of data simultaneously. Note the multiplier rule of thumb assumes a single acquisition area. Multiple areas (with one computer to process with) may double the required time to product delivery.

An Example in Action: Robertson Draw and Crooked Creek

Bridger Aerospace was ordered to the Robertson Draw fire on 18 June, 2021. The supporting interagency crew was comprised of a UAS manager and trainee (Ralston and Hoover) and a single data specialist (Thurau). Fire activities were supported by a Type 2 command including a GISS also qualified as a UASD trainee (Hood). The team assembled in west Billings, Montana Monday, 21 June with LRZ selection and team coordination. Operations began in the fire area on Crooked Creek 22 June. The team was unable to post a basemap to Bridger's software negating our ability to post meaningful ISR. The first full product (visible ortho; Figure 2 and updated perimeter) was provided to operations on 25 June. A detailed description of the first four mission days is provided in Table 2.

Table 2. Detailed mission description with benchmarks for first four days on the Crooked Creek fire.

Date	Time	Benchmark	Metric	Notes
18-Jun	1200	CWN Ordered	Request	
21-Jun	1200	Team Check-in	72	Travel, LRZ search, Team meeting
22-Jun	1100	Arrive LRZ	92	Travel from Billings to Crooked Creek LRZ
22-Jun	1600	Launch	97	Technical issues with aircraft. Return to the ground with no data.
23-Jun	900	Arrive LRZ	Team Benchmark	
23-Jun	1400	Launch	5	Technical issues with aircraft. Resolved and launched.
23-Jun	1545	Data Start	7	
23-Jun	1700	Data Stop	8	Early data stop because of weather.
23-Jun	1800	Land	9	
23-Jun	1800	Process Start		EO Map of about half the fire perimeter area.
23-Jun	2000	Product	11	
23-Jun	2100	Product Delivery	**12, 5.5 days from order to first product.**	Half a product
24-Jun	900	Arrive LRZ	Benchmark	
24-Jun	1200	Launch	3	
24-Jun	1330	Data Start	4.5	
24-Jun	1500	Data Stop	6	
24-Jun	1600	Land	7	
24-Jun	1900	Process Start	10	
24-Jun	2300	Product	14	Full perimeter, Ortho (EO), plus perimeter update
25-Jun	800	Product Delivery	**23, 7 days after order first full product**	First full product

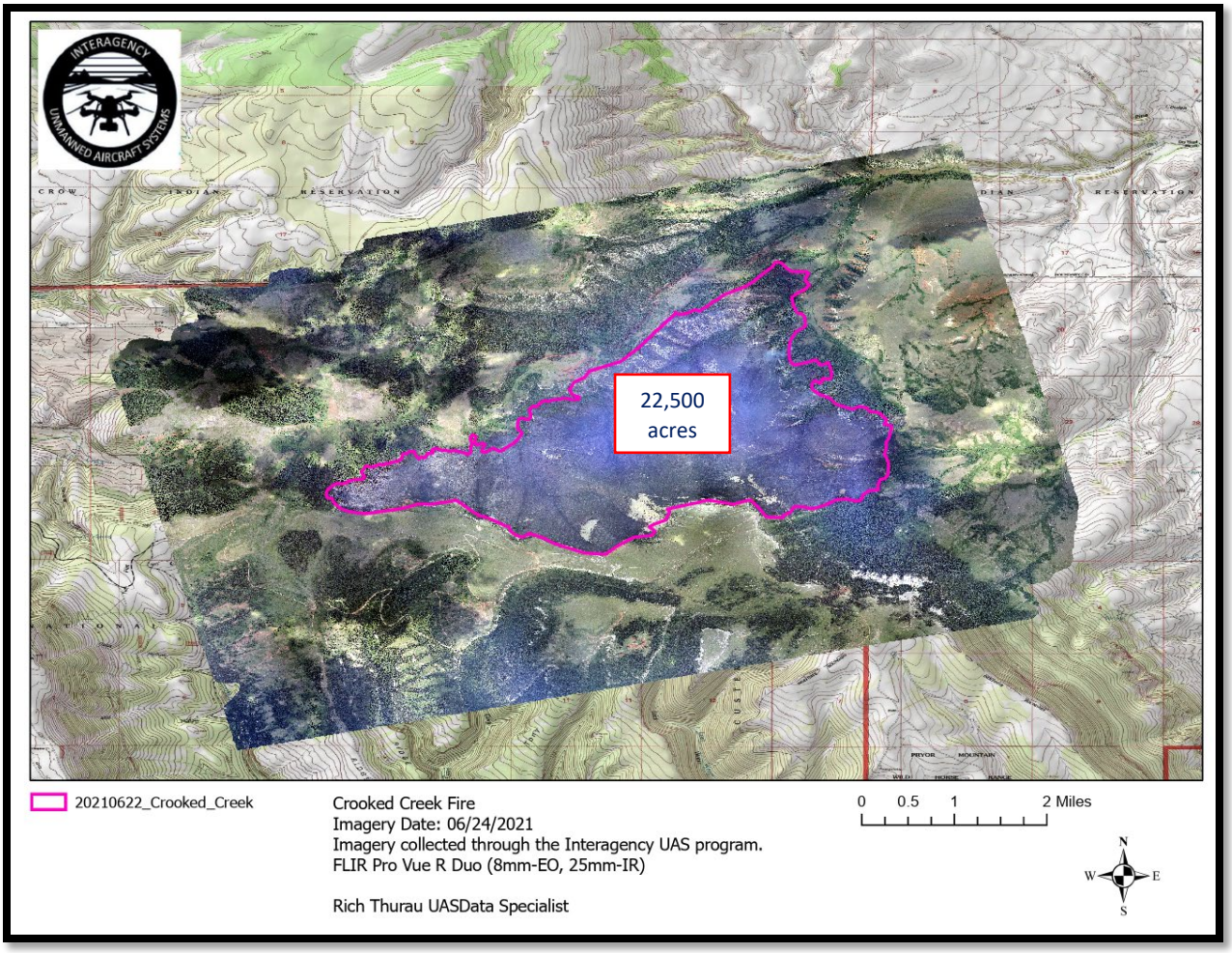

Figure 2. The Crooked Creek visible ortho (and perimeter update) were the first products delivered. The ortho was delivered on 25 June, almost 7 days after the CWN request.

There are a couple time metrics to consider for the product delivered for Crooked Creek. As a team, it took seven days to provide a complete product from the asset order date. The long timeframe involved travel availability and technical difficulties impacting the team's ability to get the aircraft in the air.

The second metric of concern is the perimeter and orthophoto produced by the data specialist. Processing start time was initially delayed because the data required transport. Processing went pretty quickly, producing an ortho in under 4 hours from processing start. While the perimeter was turned into GIS before 2300 hours the same night, the ortho wasn't handed over until after the morning brief. Processing was quick because the product of interest was EO and the flights were daytime.

The Robertson Draw fire was much larger and we were requested to focus on three priority areas for IR mapping. We attempted to hit all three areas in one flight, capturing two contiguous areas covering about 60% of the fire perimeter. Products were developed for close to 60,000 acres in both EO and IR (See Figure 3).

It took more than 24 hours to deliver these products to operations for a few different reasons. Because our target was IR and Bridger's IR camera has a 25mm focal length, data acquisition took the entire flight day. Also, a problem with Bridger's IR camera (superimposed images), both EO and IR images had to be aligned and processed together. Processing time had a delayed start and ran more than 16 hours.

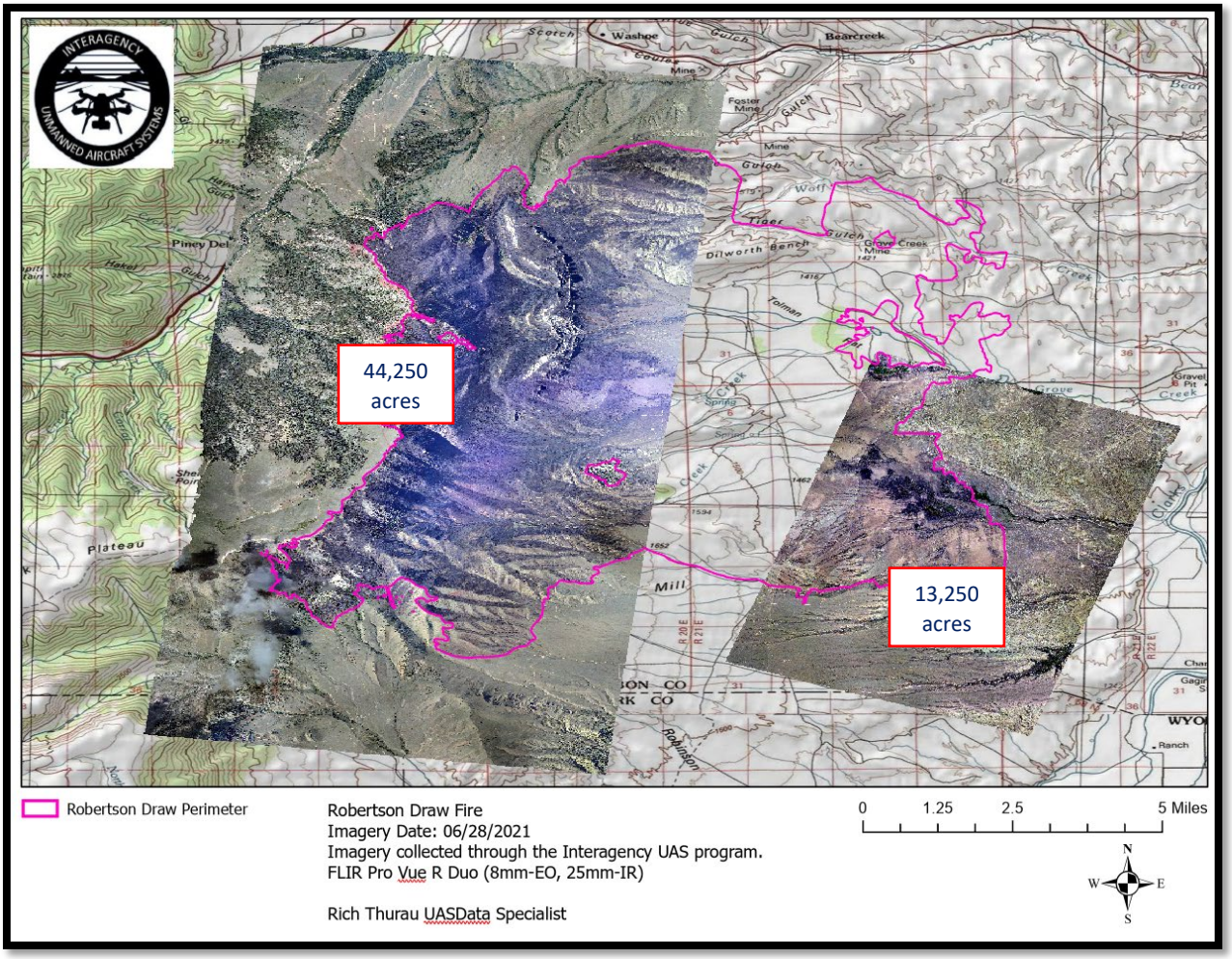

Figure 3. Two ortho product regions were collected on the Robertson Draw fire. IR products were also simultaneously produced for these areas.

Discussion

The emerging capabilities of the Type 1 UAS are continually met with both skepticism and amazement often depending on performance of the entire team. The power lies within real time bird's eye view of the entire situation, greater data resolution both in the pixel and landscape detail, and in temporal delivery of products in the absence of other timely information about the fire behavior. The purpose of introducing metrics is to provide a unified understanding of the team's goals and objectives when responding to a Type 1 UAS request.

Main Metrics

The number one objective of the Type 1 UAS team is to provide better information more quickly than is available otherwise. The quickest 'product' we can provide is real-time ISR through web-enabled sharing or video reports back to operations. Mapping products are more familiar to incident personnel and systems are in place to incorporate updated data provided by the Type 1 UAS. Regardless of what the product is, the metric of greatest concern is the time between when the system was ordered and when the products are delivered, and subsequently, providing a product of the previous day's fire situation prior to the next day's morning briefing. This statement addresses two basic benchmarks; (1) The team must focus on the time between when the Type 1 UAS was requested by the fire and the delivery of the first product, and (2) the UAS Data Specialist must be concerned with the quick and efficient processing and delivery of products prior to the morning briefing the following day.

Deciding What is Reasonable and Possible

While we have some partially understood timelines about what we can deliver and when, many situationally-dependent factors can impact those projections. The "Processing Fire Imagery.pptx" lays out the process of using Metashape to create products from the FLIR Duo Pro by including both sets of imagery for alignment. While this method does seem to provide the best overall alignment, aligning that many images can be time prohibitive. This is where the UAS team must consider what product is being requested and why. Capturing IR in the day time is effective for finding fire but may require the processing EO images as well to get an alignment and ultimately a good product. However, creating EO products during the day, or IR products at night shouldn't require both data sets to process. This makes the process much faster, especially for IR images which can process very quickly by themselves.

Metrics of Robertson Draw / Crooked Creek

Overall, metrics at Robertson Draw and Crooked Creek were not great. Issues with Bridger being able to post our GCS basemaps prevented any meaningful ISR to be presented. The first day was a wash because of aircraft technical issues. The second day resulted in a partial map before being shut down by the weather. That meant it was 5.5 days from date ordered to the delivery of the first Type 1 UAS product and 12 hours from acquisition. While the data were turned around quickly for the first Crooked Creek ortho, by that time the fire was smoldering and delivered data of limited utility.

Work on Robertson Draw did offer some promise, but weather prevented the aircraft for flying the first two available days and then the aircraft became inoperable after a single day's flights. Additional challenges stemming from a malfunctioning IR camera forced processing times beyond 16 hours, missing the next day's operations briefing deadline.

Other Metrics

As awareness of Type 1 UAS capabilities continues to expand, so will the individuals requesting data and video. The Public Information Officer and fire behavior analysts are examples of potential 'customers' where a data delivery should count as a favorable 'metric'.

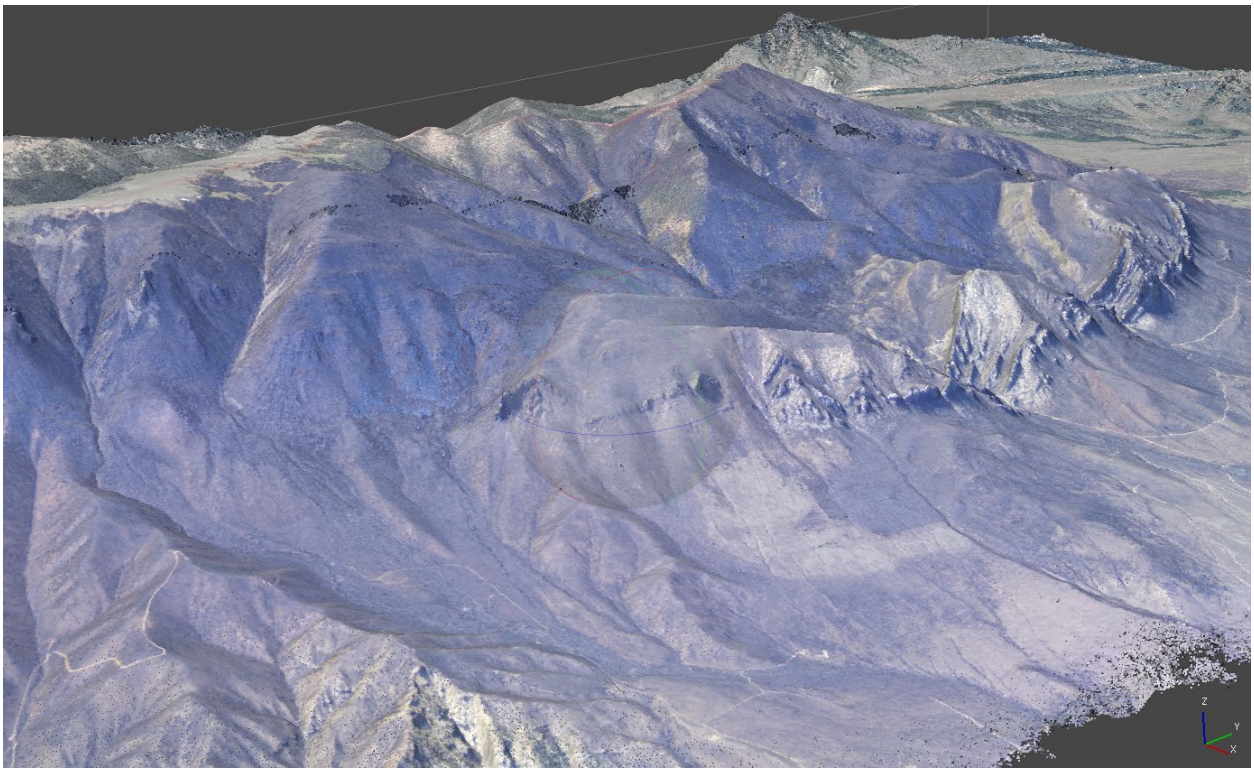

Figure 4. Three-D products were described as useful by the Public Information Officer needing to explain the difficulty terrain presented to firefighters on the Robertson Draw fire. Any product used to provide information to anyone regarding the fire should be considered a positive metric for the UAS team.

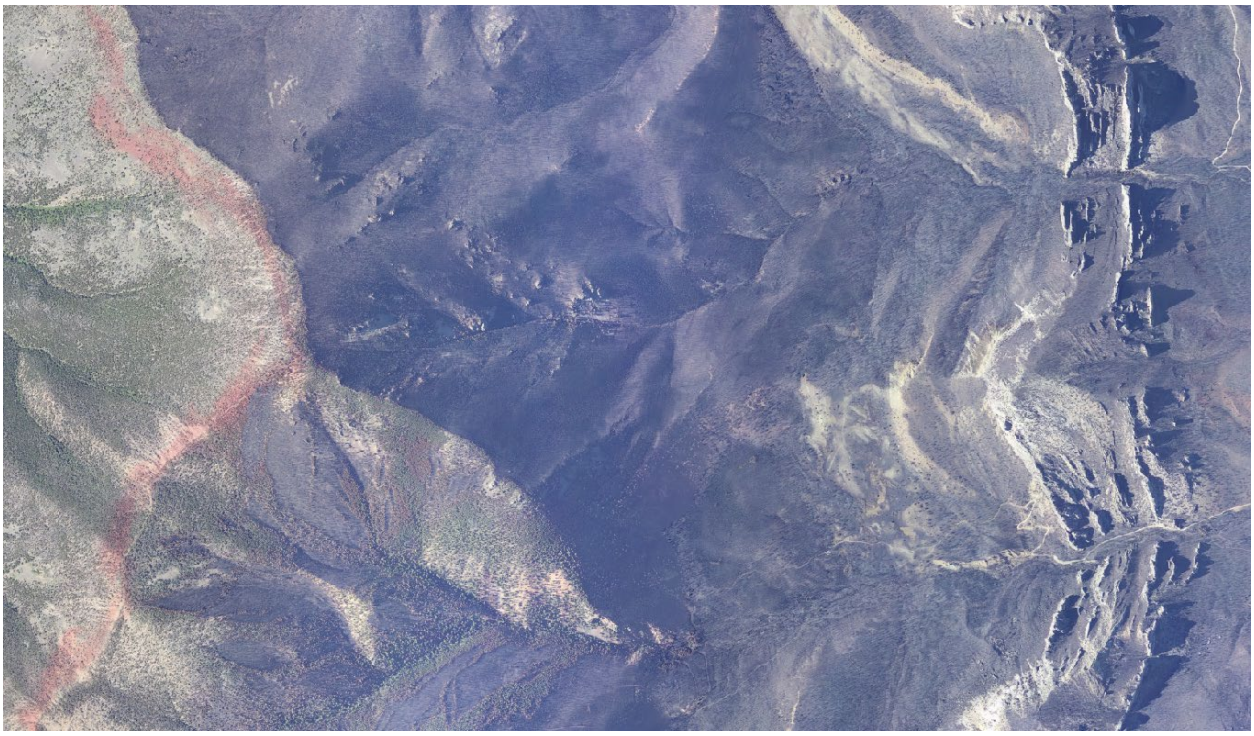

Figure 5. Division commanders found the imagery detail very helpful to seeing the effectiveness of retardant drops.