COLORADO

Center of Excellence for Advanced Technology Aerial Firefighting

Department of Public Safety

Pan-Tilt-Zoom Camera and Data Link Deployment Report: 2020 Colorado Wildland Fires

CoE-21-001.1

Introduction

In 2020, the Center of Excellence for Advanced Technology Aerial Firefighting (CoE) provided incident support to a pair of Colorado wildland fires using a cache of data link radios and pan-tilt-zoom (PTZ) cameras. The purpose of this support on the Grizzly Creek and Cameron Peak Fires was to (1) allow fire managers to remotely monitor areas of fire activity, (2) allow evacuated civilians and the general public to view fire behavior around threatened communities, and (3) extend internet connectivity to firefighters operating in remote areas.

The CoE began purchasing data link equipment in 2019, relying on off-the-shelf technologies commonly used by wireless internet service providers (WISPs) to provide internet access to rural homes and businesses. The CoE adapted this technology (which is intended for permanent deployments) for use on temporary deployments in which speed of setup and teardown is of the essence and infrastructure, such as towers and electrical power, may be unavailable. In the summer of 2019, the CoE conducted a 70-day deployment of this equipment to conduct video surveillance of a debris flow in Southern Colorado.

In preparation for deployments in 2020, the CoE upgraded this cache by purchasing PTZ cameras that can be rotated and zoomed remotely, allowing operators greater flexibility than the CoE's previous system that relied on fixed cameras. The CoE also purchased additional batteries and solar power equipment, allowing three locations to operate using solar energy, in addition to locations that operate with A/C electrical power.

In 2020, the equipment was deployed on the Grizzly Creek Fire from August 16 to September 21, with four radio sites used and two cameras deployed. On the Grizzly Creek Fire, approximately 750 gigabytes of video were streamed over the network. The Cameron Peak Fire deployment began on September 24 and concluded on November 4, with five sites deployed at various times. The public viewed the Cameron Peak Fire streams 219,981 times through YouTube Live. In total, the equipment was deployed for 75 days on these two fires.

Figure 1— Nighttime near infrared view from camera on Grizzly Creek Fire

Technology Used

Equipment was purchased to support the project in 2019 and 2020. All equipment was available commercially and the only custom integration the CoE performed was the wiring of the solar panels and batteries with in-line fuses and connectors.

Table 1— Data Link and Camera Equipment Deployed by the CoE in 2020

Equipment Name	*Purpose of Equipment*
Data Link Equipment	
Ubiquiti PowerBeam® AC Gen 2	Radio used for short- to long-range point-to-point links
Ubiquiti Rocket® Prism AC with airMax® 120° sector antenna and RocketDish™	Radio that integrates with a variety of antennae; used in 2020 for long-range point-to-point links and point to multi-point links
Ubiquiti NanoBeam® AC	Small form-factor radio used for short-range point-to-point links
Ubiquiti UniFi® AC mesh access point	WiFi access point used to provide internet to firefighters
Ubiquiti UNMS System	Remote monitoring system for Ubiquiti products
Sierra Wireless RV50 Modem	Low-power cellular modem for connecting radios and cameras to Verizon or AT&T cellular internet
Power Equipment	
Ubiquiti sunMax™ SolarPoint	Solar controller for charging batteries and ethernet switch with power over ethernet for powering cameras and radios
2x 55 Amp Hour Sealed Lead Acid Battery wired in series	Energy storage for solar-powered nodes, provides 24 volt output
2x 180 watt Solar Panels wired in series	Energy collection for solar-powered nodes
Camera Equipment	
Axis M5525-E PTZ camera	Camera with 10x optical zoom
Axis P5655-E PTZ camera	Camera with 32x optical zoom
TyCon TP-POE-2456D	Power over ethernet converter; converts power from the format created by the SolarPoint to a format usable by the Axis cameras
Intel NUC with Milestone video management system software	Computer with video server software; allows video to be recorded and for users to login to a website or mobile app to steer cameras.
CamStreamer	Software running on the Axis Camera to stream the feed directly to YouTube Live or other destinations
Google Chrome Remote Desktop	Remote access software for accessing the local network housing the cameras and radios; allows for camera control and administration

Grizzly Creek Fire

CoE staff deployed on the Grizzly Creek Fire in August 2020 to conduct a resource tracking pilot project deployment using the Team Awareness Kit (TAK) mobile app. As part of this pilot project, CoE staff anticipated a need to extend internet connections to remote fire camps for the purpose of allowing firefighters to access updated fire maps using TAK. Staff packaged the data link cache into a truck and readied it for immediate use should the opportunity arise. Ultimately, all firefighters participating in the resource tracking pilot project had access to mostly reliable cellular internet, allowing them to use the TAK app. However, CoE staff notified the incident management team (IMT) on the fire about the data link and camera equipment cache and offered to deploy it in a video surveillance role if needed.

Figure 2— PowerBeam installed at home of CoE staff member in Glenwood Springs

The team requested that a camera with control access be set up to monitor fire activity in the No Name Creek drainage northeast of the city of Glenwood Springs, Colorado. In this area, forward progression of the fire had been stopped in the bottom of the drainage, but the fire still posed a threat should it cross the drainage. No Name Creek drains into the Colorado River in Glenwood Canyon and Lookout Mountain on the opposite side of Glenwood Canyon offers an excellent view up the No Name drainage.

A CoE staff member lives in Glenwood Springs and offered to host the internet connection and video server for the link using a PowerBeam. Lookout Mountain has a direct line-of-sight to much of Glenwood Springs, but unfortunately this staff member's house is hidden from the mountaintop by a spur ridge. As a result, CoE staff calculated that a repeater site would be needed to bounce the signal to Lookout Mountain. Fortunately, the Glenwood Caverns Adventure Park on top of Iron Mountain has line-of-sight to both the house in Glenwood Springs and the top of Lookout Mountain. Park staff agreed to allow the CoE to place a repeater radio on a ride at the park, so CoE staff installed a Rocket® Prism AC with airMax® 120° sector antenna and tied it into the park's electrical power. This

Figure 3— Repeater radio at Glenwood Adventure Park

radio communicated with both the house in town and the node at the top of Lookout Mountain.

On Lookout Mountain staff set up a tripod to host a PowerBeam and an Axis P5655-E camera. The system was powered by solar power. Midway through the deployment, a thunderstorm caused the solar panel and its attached aluminum tripod frame to blow away from the tripod. Fortunately, no damage occurred and CoE staff plugged the panels back in and weighed them down with rocks.

Figure 4— Equipment installed at Lookout Mountain

In Glenwood Springs, a commercial internet connection was procured for use by the network at the CoE staff member's house. CoE staff stood up the Milestone server on this internet connection and connected it to the camera. Two Milestone logins were created, one with PTZ access to the camera and one with only the ability to view the feed. These logins, and details on how to access the feeds through the server's web interface or through the Milestone mobile app, were provided to the IMT.

Once the video feed at Lookout Mountain was operational, the CoE received positive feedback on it from the team, as well as a request to set up a second feed at Windy Point to provide a closer look at the No Name Creek drainage. Staff used the Ubiquiti airLink tool, which allows for the planning of radio links to ensure that they will function as intended, and determined that a link from Windy Point to Lookout Mountain should be just barely possible. When onsite at Windy Point, staff could see the radio towers at Lookout Mountain from one rock outcrop when looking between the treetops. This location was selected and a solar powered camera, PowerBeam, and a WiFi access point were transported to the site by Utility Terrain Vehicle (UTV) and set up. A Rocket Prism AC radio with RocketDish was set up at the Lookout Mountain portion of the link to provide the most robust signal possible.

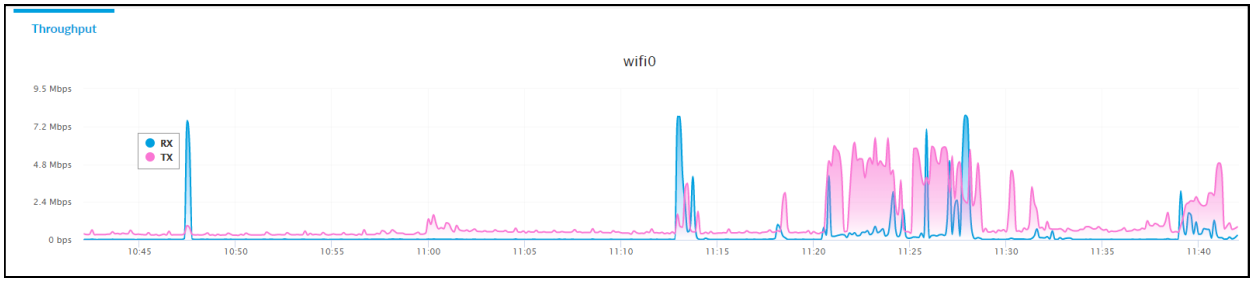

Figure 5— Internet traffic passed by Ubiquiti radios over an hour (note spikes in usage as firefighters used WiFi)

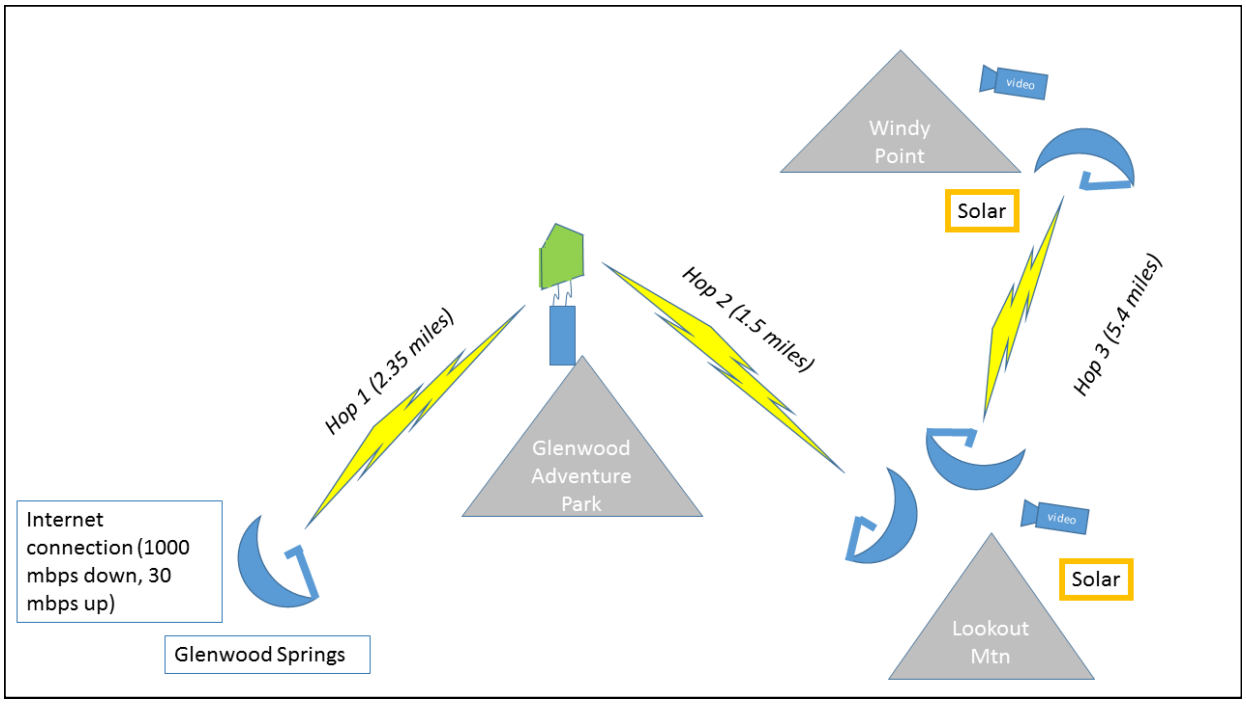

Figure 6— Schematic of equipment and radio links used during the Grizzly Creek Fire

The link to Windy Point from Lookout Mountain was successfully established and an Axis M5525-E camera was set up to monitor the fire. Since Windy Point has marginal cell service, yet was staffed by a fireline lookout and was a meeting point for supervisors, CoE staff also stood up a WiFi hotspot at this site. The hotspot had no password and utilized the same radio links as the camera for accessing the internet connection in Glenwood Springs. The Ubiquiti radio links were optimized for range rather than performance, so the connection speed at Windy Point was limited to roughly 15 megabits per second down and 4 megabits per second up, but was sufficient for video chats, phone calls, and web browsing.

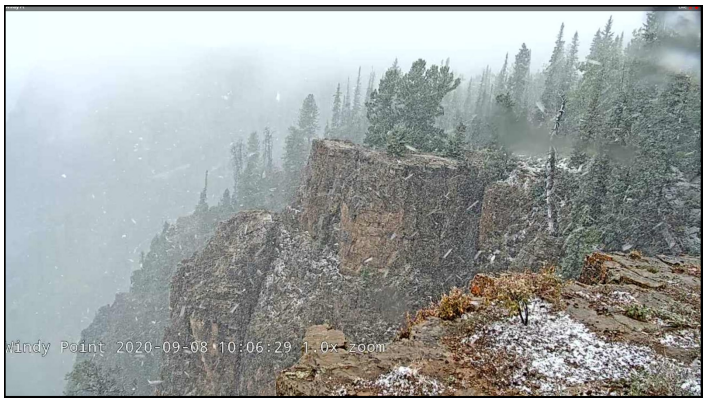

Figure 7— Windy Point camera feed operational during an early September snowstorm

In total, the system on the Grizzly Creek Fire was in operation for 34 days. During this time, the two video cameras were in constant operation, feeding an estimated 750 gigabytes of data to the Milestone server. Video control access was provided to IMT members ranging from the Division Supervisor covering the No Name Creek drainage, to the Branch Director and Planning Operations. The CoE also set up a monitor displaying the live video feeds at the Incident Command Post operations yurt. Once fire activity had diminished in the No Name Creek drainage, the IMT allowed the equipment to be removed and CoE staff spent a day tearing down the radios at Windy Point, Lookout Mountain, and Iron Mountain.

Cameron Peak Fire

Days after the Grizzly Creek Fire deployment ended, the Cameron Peak Fire in Northern Colorado experienced rapid growth, leading to the evacuation of Red Feather Lakes and surrounding communities. The CoE was contacted by a Colorado Division of Fire Prevention and Control (DFPC) Battalion Chief (who was acting as an Agency Administrator on the IMT for the fire) with a request to set up a video camera near Red Feather Lakes. In addition to providing video to the IMT, this camera was intended to serve a video feed to the general public, allowing evacuated citizens and others to view fire behavior. The intent of this deployment was to (1) help inform the public about the fire, and (2) supplement the outreach efforts of the IMT's public information office.

A forecasted wind event that would push the fire further to the east necessitated a tight time-frame to set up the camera. The Battalion Chief identified an area to set up the camera where it could be expected to remain intact should the fire burn through the area and where cellular internet was present. The CoE responded to the fire with a single camera and solar power system and received assistance from the DFPC Montrose Helitack crew to set up the system. To expedite the deployment, rather than establishing a link to a traditional internet connection using the Ubiquiti radios, the CoE deployed a cellular modem at the camera itself to directly serve the video stream onto the internet.

Figure 8— Camera and cellular data link in operation at Red Feather Lakes

The camera was set up on September 24 and a YouTube live stream was initiated from the camera. The CoE used an app called CamStreamer that ran on the camera itself to interface with YouTube and pass the stream. Unlike during the Grizzly Creek Fire deployment, the CoE had no capability to remote into the camera to control it during this deployment, so a CoE staff member set up the camera to conduct an automated tour in which it panned and zoomed across its field of view to cover the present location of the fire and areas of expected fire growth.

The system used Verizon cellular internet and streamed video to YouTube at 720-pixel (p) resolution. On the first night of the deployment, power was cut to Red Feather Lakes and, as a result, other video sources—such as a county-operated webcam that served still images from a nearby site—failed. However, the system continued running off solar power and provided the only public video stream of the fire during that time. After a week in operation, the system

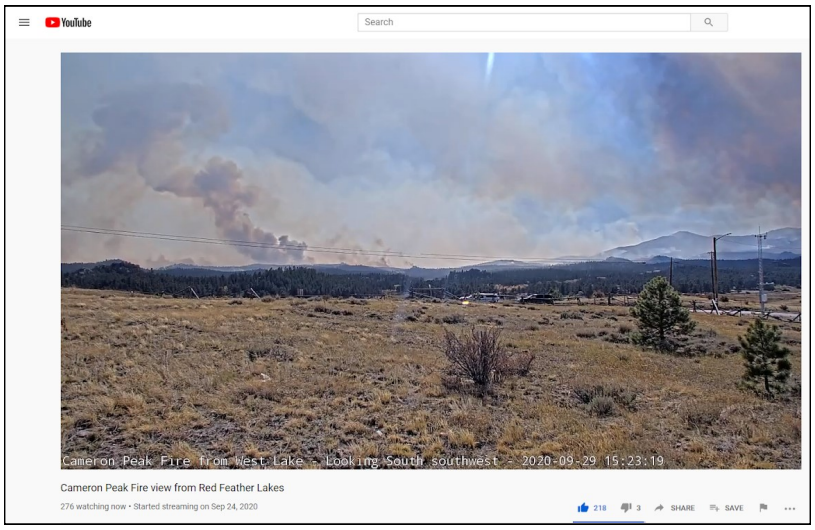

Figure 9— Snapshot from YouTube Live stream of the Cameron Peak Fire viewed from Red Feather Lakes

experienced a short period of downtime, and while the stream automatically recovered, the CoE was concerned about continuing to rely on cellular internet since it had become apparent that the Cameron Peak Fire would be a long-duration event and would require weeks of additional monitoring.

As a result, the CoE returned to the fire on October 2 and, with assistance from Montrose Helitack, repositioned the camera approximately 1 mile to the west at a location where it could link to the Red Feather Lakes Volunteer Fire Department using NanoBeam radios. This allowed the CoE to use a DSL line at the fire station as the internet connection for the stream. Stream resolution was increased to 1080p and a second stream was initiated at the Deadman Fire Lookout Tower, approximately 8 miles west of Red Feather Lakes. The CoE stood up a solar powered camera on the observation deck of this tower and linked it to the fire station using PowerBeam radios. This second stream was served to YouTube at a resolution of 720p. The CoE also installed a Windows computer running Google Chrome Remote Desktop at the fire station; this allowed CoE staff to remotely access the computer and login to the configuration pages for the cameras. In addition, the system allowed staff to update the video tours to account for changes in fire growth and to remotely administer the radio and solar equipment.

Figure 10— Storm damaged solar panels at the Deadman Lookout site

This system operated for approximately a week, until a winter storm hit the fire area and iced over the solar panels. The site at Red Feather Lakes came back up after the storm cleared, but aside from a brief moment of uptime, the site at Deadman Lookout did not function after the storm. When the CoE took down the equipment in November, staff found that the solar panels—which had been zip-tied to the lookout tower

Figure 11— Helicopter water drop filmed from camera on Horsetooth Mountain

decking—had been ripped loose and flipped over so they were facing the ground. This removed the source of power for the node and took down the Deadman site.

By mid-October, fire activity near Red Feather Lakes had abated and evacuation orders in this area were lifted. However, the Cameron Peak Fire continued to burn to the east and threatened communities west of Fort Collins, leading to new evacuation orders. On October 16, CoE staff again visited the fire and set up a camera on Horsetooth Mountain to monitor fire behavior in the area of Redstone Canyon and Buckhorn Mountain. Staff received assistance from DFPC Cañon City Helitack to set up the camera and coordinated with Larimer County radio and IT staff to utilize a county radio tower and infrastructure. The camera was connected directly to county internet at Horsetooth Mountain and received power from backup generators that were providing power to the site. County IT staff assisted the CoE in remotely accessing the camera, allowing a tour of the fire to be programmed and updated.

Figure 12— Larimer County radio technician installing camera at Horsetooth Mountain

On October 22, the camera at Red Feather Lakes captured distant footage of the East Troublesome Fire as it experienced extreme fire behavior and made a run through Grand Lake into Rocky Mountain National Park. Shortly after this, the Red Feather Lakes camera went offline. This was likely due to the positioning of solar panels at this site, which—as the sun became lower in the sky each day—were increasingly blocked by boulders from receiving light sufficient to recharge the batteries.

Figure 13— East Troublesome Fire smoke column captured from Red Feather Lakes

Additional snowfall in late October finally facilitated containment of the Cameron Peak Fire, so on November 3-4 CoE staff worked with Cañon City Helitack personnel and Larimer County radio staff to disassemble all remaining equipment

on the fire. All equipment was successfully recovered and the only damage during the deployment was to the aluminum frames on solar panels at the Deadman site, which had been twisted when the panels were ripped loose during the winter storm. In total, three cameras were deployed on the Cameron Peak Fire for 40 days. Throughout this time period, the public viewed the Cameron Peak Fire streams 219,981 times via YouTube Live.

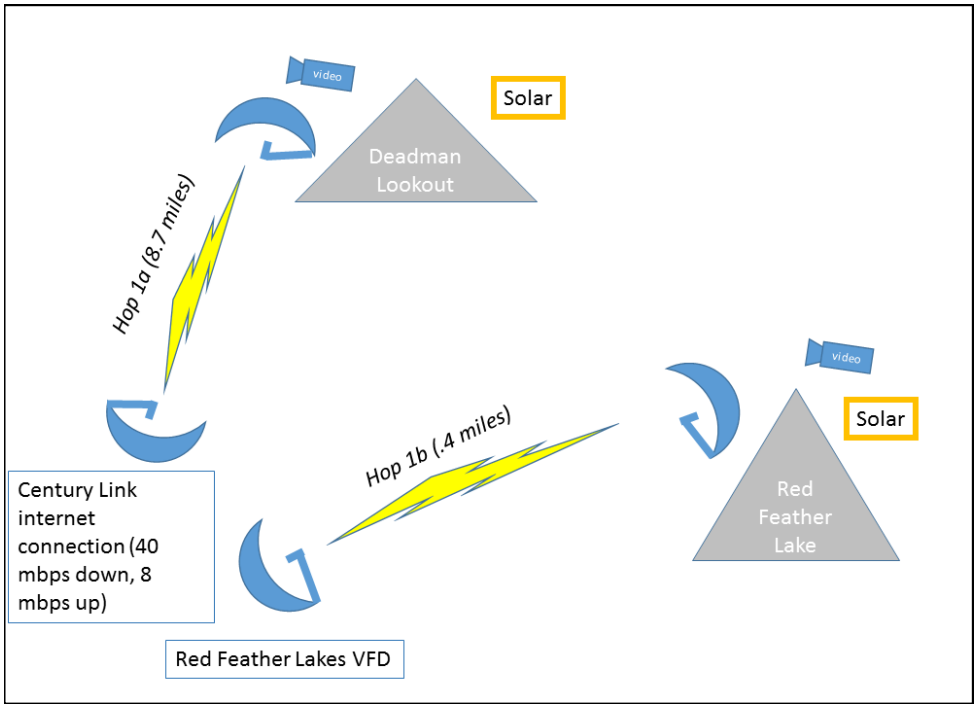

Figure 14— Schematic of equipment and Ubiquiti radio links used during the Cameron Peak Fire (cameras operating off cellular or County internet not shown)

Next Steps

Over the winter of 2020–2021, CoE staff will rehabilitate equipment used during the fire season and will prepare for future deployments of this technology to assist in public safety responses in Colorado. Staff will explore enhancements for camera control, which will allow incident managers to reliably control cameras and also record video for later analysis. Additionally, further exploration of streaming to public sites such as YouTube Live will occur, with emphasis on optimizing stream quality and adding overlays to help viewers understand where the cameras are looking in real time. The CoE expects to formalize an ordering procedure for this equipment and conduct additional outreach to help DFPC managers and other first responders access this cache to extend internet connections or stream video during future disaster responses.