



COLORADO

Center of Excellence for Advanced Technology Aerial Firefighting

Department of Public Safety



Photo Credit: CoE

2019 Night Aerial Operations Trials

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Purpose

This document reports on Colorado Division of Fire Prevention and Control (DFPC) night helicopter operations training and trials conducted during 2019. The goal is to share what we have learned and discuss what additional research is needed to advance the program.

Background

Night aerial firefighting using helicopters with buckets has never before been attempted in Colorado. DFPC conducted night flying trials in 2019 to (1) evaluate if it can be done safely, (2) train personnel in night bucket operations, and (3) build a basis of operations before performing further evaluations to determine if night operations benefit firefighters and communities.¹

The Center of Excellence for Advanced Technology Aerial Firefighting (CoE) was directed to conduct research on night aerial operations for wildland firefighting by Colorado Senate Bill 14-164, which also created the CoE in 2014. A Night Aerial Firefighting Operations Summit was held on January 27–28, 2016, and aircraft operators, vendors, and experts in the field of night aerial firefighting operations provided the CoE with input and recommendations to help shape and guide Colorado’s night operations program. That year, CoE staff also traveled to Southern California to talk with current practitioners and conduct further research on night helicopter operations programs in the region. The CoE also published an Interim Report in January 2018, documenting its research efforts to date (Night Aerial Firefighting Operations Interim Report, CoE-18-001.8, available on the CoE website at cofiretech.org). The report identified several paths forward, including a location-specific night operations program and further research to identify if any of the existing or new approaches to night aerial firefighting make sense for Colorado.

While the occurrence is not universal, severity of fire behavior often decreases at night on wildfires in all types of terrain. This decrease in severity is attributed to factors such as higher humidity, lower temperatures, less solar heating and, often, lower winds. However, air operations on wildfires all but cease as nightfall approaches. With the exception of Southern California night operations, current practice and policies limit aerial firefighting operations in the US to official daylight hours. Daylight hours are defined as 30 minutes prior to sunrise until 30 minutes after sunset (National Wildfire Coordinating Group, 2018).

Current night helicopter operations in Southern California use a mix of Type 1 and Type 2 helicopters equipped with external tanks ranging from 360–1,000 gallons in capacity, as well as snorkels for daytime hover-fill operations. With few exceptions, hover-fill operations are not performed in California during night operations. Current practice in Southern California allows only ground-filling at known, approved landing sites at night. These programs don’t operate over the entire state, but are limited to defined geographic areas of operation in Southern California.

¹No active firefighting using helicopters at night occurred in Colorado in 2019.

The CoE recently participated in Single Engine Air Tanker (SEAT) night operations trials in Oregon. The objectives were to test ground personnel lighting/marketing, target marking devices, and suppressant delivery and to gain experience and lessons learned. SEAT operations are not currently part of Colorado's Night Operations Trials, but—based on what is being learned in Oregon—it seems warranted to further our research into the potential capabilities of SEAT night operations.

Colorado Demographics Related to Wildland Fire

Colorado's population increased by 1.4% from July 1, 2017, to the same date in 2018. In other words, Colorado grew by 79,662 residents during this time frame. The number of people living in areas at risk from the effects of wildland fire increased by nearly 50 percent from 2012 to 2017, based on current Colorado Wildfire Risk Assessment data compiled by the Colorado State Forest Service (Colorado State Forest Service, 2018). As of 2017, approximately 2.9 million people live in Colorado's wildland-urban interface—the area where human improvements are built close to, or within, natural terrain and flammable vegetation—compared to 2 million people just 5 years earlier. The new figure represents approximately half of the state's total population.

Justification to Conduct Night Flying Trials in Colorado

Based on these changing demographics—and the fact that in 2018 more than 450 homes were destroyed or damaged in wildfires across Colorado—DFPC feels there is a need to have the ability to fly fire suppression missions at night. The decision to conduct the trials documented in this report arose from discussions in late 2018 between the DFPC Aviation Unit, DFPC Wildland Fire Management Section leadership, and aircraft vendors.

In early 2019, DFPC leadership evaluated helicopter night operations proposals. This included the development of a comprehensive plan to test and evaluate night flying procedures through trials.

Night water-dropping operations that were tested during the 2019 trials could eventually give DFPC fire managers another tool to fight problem wildfires and ultimately reduce impacts to communities.

DFPC Night Operations Training Conducted in 2019

The 2019 trials consisted of one Bell 205A-1++ helicopter with night vision imaging system (NVIS) lighting and a single pilot qualified to fly with night-vision goggles (NVGs). The aircraft was flown in single pilot operations. This helicopter was on an exclusive-use contract with DFPC and was based out of Cañon City, Colorado. The helitack crew from Cañon City was actively involved at each training and worked closely with the night pilot to direct the drops or complete other training objectives for each scenario. Based on the trials, a minimum of three helitack personnel are needed—one aircraft manager, one dip site manager, and one assisting on the fireline.

All operations were performed using a belly-hooked Bambi Bucket® that provided rapid refill over both open water and a fixed dip site (“pumpkin”). The decision to “dip” at night rather



Photo 1. DFPC Helicopter 58HJ Arriving at Brush Hollow Reservoir on August 21, 2019 (Photo Credit: CoE)

than ground-filling the helicopter, as is the common practice for existing night-flying firefighting helicopters in the United States, dictated a slow, deliberate start to the trials to ensure safety while evaluating the new concept. All operations were performed under the vendor’s Federal Aviation Administration (FAA) Part 133 Rotorcraft External Load Operator certificate.

The trials were undertaken during the summer of 2019 at Brush Hollow Reservoir, which is located at Brush Hollow State Wildlife Area northwest of Penrose, Colorado. The reservoir is at an elevation of 5,448 feet. Night training and proficiency missions were flown on June 5, June 27, July 31, and August 21, 2019. The pilots who flew the night training missions performed reconnaissance flights during daylight hours to identify aerial hazards and review planned approaches and exits from the drop sites and reservoir.

Weather conditions onsite varied from partly cloudy to clear, with temperatures ranging from 55°F on June 5 to 82°F on July 31. Winds were from the northwest and averaged 6 miles per hour. Moon phases ranged from a new moon on July 31 with only 1% illumination to a waning gibbous moon on August 21 with 71% illumination (Calendar-12.com. 2019). The moon can be an advantage or disadvantage to the use of NVIS depending on its location relative to the user. However, the NVG image quality increases with an increase in the amount of ambient light from stars that is reflected from the terrain.

The trials included a series of flights with the night pilot working with the DFPC helitack crew to determine if night aerial water drops with a bucket—including dipping from an open water source as well as a fixed fill site—are possible, repeatable, and effective at an acceptable level of risk.

The 2019 trials consisted of the following activities, intended to determine and demonstrate the safety and efficacy of aerial firefighting in Colorado at night:

- Performing takeoffs, landings, and hovering
- Practicing transitioning from aided night flight to unaided night flight and back to aided flight
- Hover-filling the bucket from a lit portable dip tank at night and dropping water onto marked targets
- Hover-filling the bucket from an unlit open water source and dropping onto marked targets/mock fireline
- Affirming and expanding developed safety procedures for nighttime fire suppression operations

Consideration of Safety Issues

In addition to the usual risks involved in aerial firefighting, there are additional safety considerations for night flying. Even with NVG-aided vision, pilots may have difficulty seeing certain aerial hazards. Limited depth perception and fields of view could result in loss of situational awareness or spatial disorientation. The pilot had contingencies in place for the possible failure of the NVGs while in flight.

No safety issues arose during the trials, but it is important to recognize the following practices used to help overcome known safety issues:

- Pilots must keep scanning and always be aware of terrain features.
- Pilots must not target fixate.
- Pilots must dip next to the shore with a good reference feature to help with orientation.
- Proficiency and experience in the use of NVGs is an important component in offsetting many of the visual limitations of NVGs.
- Pilots must be aware of the limitations of the NVG image and its effect on their perception.
- The additional effort of viewing and interpreting the NVG image, the scanning requirements, and additional weight of the NVGs may lead to an increase in pilot fatigue.
- Effective Crew Resource Management practices by the ground crews can provide the pilot with additional information about the terrain and obstacles.

- Practitioners must be willing to accept less production at night, particularly if working out of a fixed dip site.
- Don't try to go too fast; slow and effective is better.

Detailed mission briefings and operational risk assessments were conducted prior to each flight to review the potential risks and hazards of each mission. The material and reference sources contained in the DFPC Night Flying Guidelines were used to assist DFPC in supporting these night flying trials.

Night Operations Results to Date

The trial was limited to ensure that complex lessons were learned in a safe environment, controlling for risks. Within that framework, here's what we demonstrated:

- A Bell 205A-1++ helicopter equipped for flight with NVGs can safely and effectively deliver water with a Bambi Model 2024 240-gallon bucket in conditions typically encountered in Colorado. Night helicopter firefighting missions may provide wildland fire suppression benefits, but no attempt was made to quantify these benefits during this study.
- Overall, the drop heights and speeds during the night operations were similar to those of daylight operations.
- The demonstrations showed an efficient and safe system. The night pilot was capable of (1) communicating with and following directions from firefighters on the ground at each drop site during the operation, and (2) using NVGs for detecting the small targets (i.e., wildland fire fusees, PowerFlare flashing light beacons [light pucks], and live fire [burning firewood] in 50-gallon drums).
- The activities undertaken during the trials did not reveal any technical or safety issues that should prevent a helicopter from flying and dipping in the type of terrain we tested it in.
- The night pilot and helitack crew on the ground were able to develop and practice effective communications, as well as useful techniques for identifying personnel and drop locations.
- Ground crews observed acceptable turnaround times and achieved accuracy during the night drops when targeting simulated fires.
- The night-flying helicopter was able to successfully identify personnel on the ground and accurately target simulated fire edges and hot spots.
- All operations to this point used a belly-hooked 240-gallon Bambi Bucket over both open water and a fixed dip site (3,000-gallon pumpkin), resulting in acceptable turnaround times during the simulated fire scenarios. The average fill time observed during the trials over open water was 10 seconds.
- The pilot flew approximately 10 hours at night and production rates averaged 18 drops per hour with a 240-gallon bucket, or approximately 4,320 gallons per hour.

- The training depended on simulating fires and on the use of visual aids for the pilot and ground crew to communicate their intentions of safely delivering water to achieve a specific outcome on future wildland fires. The targets were illuminated by firefighters on the ground with handheld lasers and ground target indicators (flashing beacons). The laser

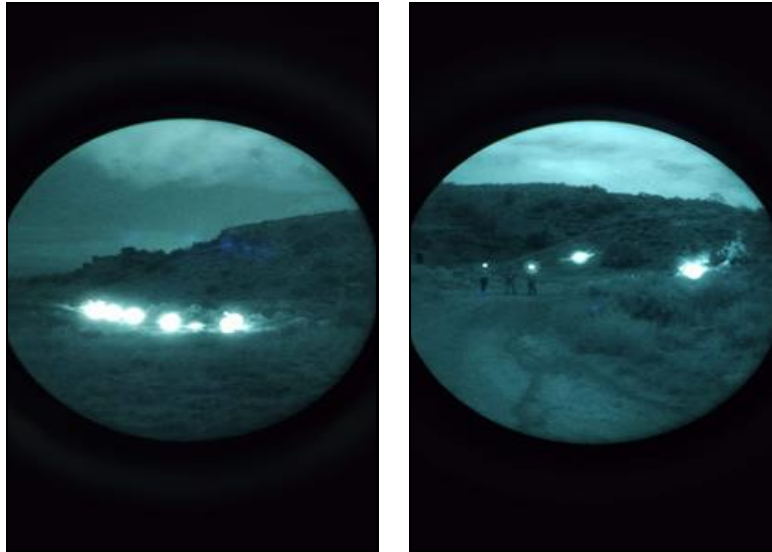


Photo 2. Pictures Taken Using the PowerFlares During Night Helicopter Operations (Photo Credit: CoE)

pointers and target indicators were clearly visible from the aircraft using NVGs.

Water Delivery Rates Compared to Daytime

Our trials were conducted with a belly-hooked bucket. There may be advantages to using a bucket rather than a tanked helicopter, but no direct comparison was conducted during our trials.

Production rates are important for both day and night aerial firefighting. Having a dip site closer to the fire reduces the distance, which results in quicker turnaround times (and in turn increases efficiency in gallons dropped to support the ground firefighters).

The water source on Brush Hollow Reservoir was approximately .3 mile from the targets, resulting in approximately a 3.25-minute turnaround on targets.

The rates calculated from DFPC flight-time records show no differences in the rate of water delivery between NVG night operations and daylight operations. Fill times, loiter times, and transit times were not appreciably different as pilot experience with NVGs increased. The 240-gallon load of the Bambi Bucket could be delivered at the same rate as daytime operations. During the August 21 trials, 19 buckets (for a total 4,598 gallons) were delivered to the drop sites in 1 hour.



Photo 3. Night Helicopter Bucket Drop at Brush Hollow Reservoir in June 2019 (Photo Credit: Cañon City Helitack)

When filling the bucket from the reservoir under NVG conditions, some problems were encountered; these were mostly related to maintaining adequate hover height over the water. Use of the radar altimeter and dipping close to shore to maintain a good reference and spatial awareness helped mitigate this issue.



Photo 4. Night Helicopter Dipping from 3000 Gallon Pumpkin (Photo Credit: Cañon City Helitack)

When dipping out of the 3,000-gallon pumpkin, times were slightly slower due to the smaller inner collar opening (9 feet) to set the bucket in. After the initial trial, the lighting for the pumpkin was adjusted. Also, three of the light beacons were placed approximately 50 feet upwind from the pumpkin as an aid to indicate wind direction for the pilot .

Some other lessons from the pilot's point of view included the following:

- It is slightly harder to do point drops at night because of less reference to the bucket under the helicopter and it is very easy to get it swinging at the last minute with slight pedal inputs.
- After the slight sliver of a moon went down, it got really dark. Positioning the landing light straight down seemed to work really well, but only to show the bucket in the water, otherwise it was useless until at a hover because it didn't illuminate the bucket. The search light was a little too close to the front of the aircraft and caused some reflection issues.
- Front pulse lights on steady work really well for seeing what is in front of the aircraft, but at a hover or high they are a distraction and you can see better without the lights.

Safety and Risk Management

The DFPC Night Flying Guidelines contain the conditions that would support conducting actual night-flying missions. The decision to fly helicopters at night for water drops should only be considered after a thorough risk/benefit analysis. Nighttime helicopter operations may be appropriate in situations in which the following conditions exist:

- Lives are or will be threatened
- Structures are or will be threatened
- Resources of significant economic value are or will be threatened
- Excessively high suppression cost will be prevented

At least one of these four requirements must be met before night flying operations can be supported.

If the above conditions exist and the IC decides to conduct aircraft-based fire suppression operations at night, the assigned Pilot(s) must still approve of the operation.

Per current operations guidelines, DFPC helicopters will not respond to a fire in darkness. It is a requirement for the night pilot to see the fire incident and dip sight during the day to reduce the risk (i.e., by being aware of the potential aerial hazards that could be encountered in flight during suppression operations).

Attention to detail with safety as a primary focus is critical to ensuring safe night operations. This includes performing operational briefings and weather briefings, using nighttime operational checklists and required personal protective equipment, confirming

communications plans, reviewing aerial flight hazards, and identifying alternative landing sites/airports.

DFPC requires FAA-certified NVG pilots. Two pilots took part in the trials—one with a high number of NVG flight hours and the other with limited NVG hours.

Before testing nighttime hover-fill operations, aviation managers had a number of questions about the practice of utilizing a bucket over a tank, such as:

- Will the water spray on the windshield be a factor when using a bucket on a short line?
- Will the pilot be able to control the aircraft and maneuver over the water source while using NVGs?
- Is there the possibility of an inadvertent drop?
- Will the pilot be able to see the bucket while in flight if any issues arise or if entanglement occurs?

None of these issues manifested themselves during the 2019 DFPC night training missions.

Costs for Night Operations Contract

In the 2019 fire season, DFPC contracted for two Type 2 Bell 205A-1++ helicopters on exclusive-use, 150-day contracts. These helicopters were located in Cañon City and Montrose, Colorado, and were staffed by 12-person DFPC helitack crews that are available 7 days/week during the mandatory availability period.

DFPC Aviation estimates that the operating costs for the night helicopter trials will be approximately \$100,000 over a 3-year period from 2019–2021. Flight time for the night trials was about 5.4 hours for a cost of \$10,139.53.

There was not an added per-hour flight cost for the NVIS-equipped helicopter, but night operations required additional personnel, including:

- Additional ground personnel trained and available at night to manage helicopter operations
- Additional flight crew to extend operating hours
- Additional firefighting personnel to direct and manage drop operations at the fireline
- Additional overhead and supervision
- Potential need for night aerial assets acting as aerial supervision
- Potential addition of crew quarters at DFPC helibases

The above-listed personnel are not typically assigned at night on wildland fires and will represent additional costs. During the 2019 trials, DFPC managed this by shifting crew work shifts to later times on days when night testing/training was conducted and by paying for

extended operational hours; however, full quantification of additional personnel costs was not examined by the CoE.

Potential Paths Forward

Based on the night-flying trials performed during the 2019 season, the CoE recommends that DFPC consider the following as part of future night operations training and evaluations:

- Contract for another pilot qualified to fly with NVGs. Limits on flight time and availability of an NVG-qualified pilot restricted the testing in the 2019 season.
- Expand the topography and fuel types of the night tests. The terrain around Brush Hollow is gently rolling and is primarily grass, brush, and scattered junipers. It would be useful to look at some areas with more brush and standing timber to see how that terrain affects drop heights and production. The increased risks that are inherent in an expanding terrain envelope are warranted since they will result in better preparedness for a rescue in the event of a mishap with the night operations helicopter.
- Expand night training to include other helitack crews and integrate the helicopter with ground crews, local jurisdictions, and incident management teams.
- Develop a structured nighttime technical rescue training with Colorado Army National Guard input and recommendations, or another helicopter that is NVG-capable.
- Consult with agencies that are currently involved in night hover-filling operations, such as the Orange County Fire Authority in California or Emergency Management Victoria in Australia, for specific policy and procedural documents that may assist with applying new technology, enhancing effectiveness, and improving risk management practices (DFPC Night Flying Guidelines, 2019).
- If the DFPC night operations program expands to more than one aircraft, we recommend that the DFPC Multi-Mission Aircraft and crews train with the night helicopter in future exercises to provide aerial supervision. Alternatively, DFPC may want to obtain night capable Aerial Supervision platforms.
- We recommend that the 2020 training cycle include the use of the Android Team Awareness Kit (ATAK; a geospatial infrastructure and situational awareness application) by the pilot and ground crews to improve communication and situational awareness, particularly as terrain and task complexity increase. ATAK's map-based interface could provide pilots with up-to-the-second awareness of the locations of both the water drop targets and of firefighters on the ground. The CoE is currently exploring the use of ATAK for use on wildland fires.
- While rotary-wing aircraft are used at night to fight wildland fires, there is a need for more research into how effective they are in halting or delaying fire spread.
- More research may also be needed on the feasibility of using fixed-wing air tankers, including SEATs, after dark to combat fires. Advances in technology that could make fixed-

wing aircraft more acceptable for night missions—such as synthetic vision and terrain awareness—need to be examined as well. This would be treated as a separate evaluation.

Conclusions

Recent large wildfires in Colorado and an increasing population in fire-prone areas resulted in DFPC considering the addition of a night aerial firefighting resource. Conducting the night operations training and trials in 2019 was a major step toward a night aerial firefighting capability in Colorado, even though the resource was not tested on any actual fires.

The training/currency events have shown that this is a viable concept and could provide DFPC with the ability to perform night hover-filling water delivery operations from a Type 2 helicopter in support of fire-suppression operations.

Based upon the experience gained during 2019, DFPC will be poised to utilize this mission profile on actual fire operations throughout the entire state of Colorado in 2020.

Continuing to work with the DFPC Aviation Unit Chief and the Cañon City Helitack Crew, as well as with Kachina Aviation, will afford the CoE with the opportunity to perform further research and increase DFPC's collective knowledge about the effectiveness of night aerial firefighting.

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