

# *USDA Forest Service*

## *Fire Imaging Technologies for Wildland Fire Operations*

**USERS GUIDE**

**FEBRUARY 2020**

## I. Introduction

For 50 years the wildland fire community has used thermal imaging to map wildland fires. Agency aircraft equipped with infrared (IR) sensors under the Forest Service's (FS) National Infrared Operations (NIROPS) program have been the mainstay collection platforms for over 40 of those years.

In the last 10 years additional fire imaging technology and capabilities have become available to the wildland fire community, much of it stemming from the U.S. government, both civil and defense, as well as private industry. The following is a brief timeline of IR capabilities used to support wildland fire operations:

- In 1969 the Forest Service began to use IR sensors on manned aircraft, which later became NIROPS
- In the mid-1990's national system collection platforms became available as surge capacity for NIROPS
- In the early 2000's NASA earth observation satellites Aqua and Terra became available with the Moderate Resolution Imaging Spectroradiometer (MODIS) active fire detection
- In 2003 the Forest Service introduced the Firewatch Cobra helicopter program equipped with electro-optical (EO) and infrared (IR) sensors coupled with data transfer technology
- In the mid-2000's there were some first-attempts at using National Guard unmanned aerial vehicle (UAV) on wildfires for information gathering
- In 2012 the Suomi National Polar-orbiting Partnership (NPP) and NOAA-20 satellites became available featuring the Visible Infrared Imaging Radiometer Suite (VIIRS)
- In 2012 the Forest Service introduced the Enterprise Geospatial Portal (EGP) as a dashboard display for fire information gathered from various data sources, including satellite collections
- In 2013 Forest Service introduced the NightWatch program equipped with EO/IR sensors
- In 2014 the Colorado State's Division of Fire Prevention and Control (DFPC) introduced their Multi-Mission Aircraft (MMA) program equipped with EO/IR sensors along with data transmission capabilities
- In 2015 an MOU between the Forest Service and Department of Defense allowed use of Air National Guard Distributed Real Time IR (DRTI) aircraft with data streaming capabilities
- In 2016 the Forest Service contracted with private sector vendors to provide aircraft equipped with EO/IR sensors
- In 2018 the Bureau of Land Management (BLM) hosted the first contracts for large Unmanned Aircraft Systems (UAS) equipped with EO/IR and downlink capabilities
- In 2019 the Forest Service contracted additional aircraft equipped with IR sensors to provide surge capacity for NIROPS
- In 2020 the Forest Service continued expanding use of contract aircraft to provide IR imaging

During this time the wildland fire community, with input from the Forest Service remote sensing program, governmental agencies and private industry, has been continuously evaluating how best to use airborne and space-based platforms to gather intelligence and integrate IR data into fire operations to improve situational awareness and support strategic and tactical decisions.

### A. Incident Awareness and Assessment (IAA) Defined:

Incident Awareness and Assessment (IAA) is similar to the Department of Defense's definition of *Intelligence, Surveillance, and Reconnaissance (ISR)*. However, ISR is conducted outside of the United States over foreign territories or within the United States during Homeland Defense events, while IAA is conducted within the United States in support of Defense Support of Civil Authorities (DSCA) operations (e.g. natural disasters). IAA focuses on providing timely and usable information to all levels of command and to local, State, Civil, and

Federal leaders in order to save lives, reduce human suffering, and protect property. IAA capabilities include electro-optical (EO), infra-red (IR), and Full Motion Video (FMV).

The wildland fire community has similar needs for IAA. Information gathered from collection platforms provides critical situational awareness for fireline personnel, Incident Management Teams (IMT), fire managers, and agency administrators to inform tactical and strategic decisions. Systems intended for wildland fire operations are evolving and range from small hand-held devices, sensors on manned and unmanned aircraft, and satellites. IR collection platforms currently in use include:

**IAA Aircraft Systems:**

- FS National Infrared Operations (NIROPS)
- FS FireWatch Helicopters
- FS NightWatch
- Colorado DFPC Multi-Mission Aircraft (CO-MMA)
- Air National Guard Distributed Real Time Infrared (DRTI)
- California National Guard MQ-9 Reaper Unmanned Aerial Vehicles (UAV)
- Private sector manned fixed wing aircraft equipped with camera-ball or nadir-looking EO/IR camera systems under contract to federal, state, or local government agencies
- Unmanned Aircraft Systems (UAS) ranging from commercially available small UAS with limited endurance to large private sector UAS with long endurance and sophisticated EO/IR sensors

**IAA Satellite Systems:**

- NASA earth observation satellite Aqua and Terra featuring MODIS active fire detection
- NOAA and Suomi NPP satellites featuring the VIIRS-I and VIIRS-AF band for heat detection
- NOAA Geostationary Operational Environmental Satellite systems (GOES-16/17) featuring IR and lightning detection capabilities
- FS Ignition Point (IgPoint) program displaying thermal detection data in the Enterprise Geospatial Portal (EGP) for new fire starts
- Commercial satellites that have high resolution thermal detection capabilities

Field demand for overhead imagery data to inform strategic and tactical decision making is on the increase, especially as end-users realize the potential and are able to integrate it into their operational planning cycles. However use of this technology cannot be supported without operational objectives and requirements which would support innovation, developing technology, and broader use of fire imaging and technology systems.

**B. Fire Imaging Technologies**

Aircraft equipped with IR systems can be loosely divided into two broad categories, Electro-Optical/Infrared (EO/IR) camera ball systems and Line Scanner/Step-stare IR camera systems equipped with multi-spectral arrays including thermal bands.

**1. Electro-Optical/Infrared (EO/IR) Camera Ball Systems:**

Systems that incorporate a high resolution EO/IR camera array mounted in a steerable gimbal mounted turret are commonly used for IAA missions. The combination of EO and IR cameras allows the operator to switch back and forth between visual and IR modes to identify and distinguish targets on the ground, and includes zoom capability. EO/IR camera balls are typically mounted beneath the aircraft and can be aimed by the operator in any downward direction regardless of direction of flight.

Capabilities of EO/IR camera systems vary by the manufacturer and model used. Mid-wave IR (MWIR) and/or Long-wave IR (LWIR) are the most commonly used bands for wildland fire operations to capture high-resolution thermal imagery. Some camera systems may be cooled and can filter out extraneous heat signatures, improving the imaging and detection capabilities. When EO/IR cameras are paired with mapping and navigation software these systems are capable of providing highly accurate map products showing location of active heat perimeters, spot fires, new starts, and generate KMZ, KML and/or GIS shapefiles.

EO/IR camera ball systems can be flown at varying altitudes ranging from low level to 20,000 feet above ground. The acquisition altitude is typically governed by the need to avoid conflict with tactical aircraft operating in the incident's Fire Traffic Area (FTA) as well as gain a wider perspective.

Due to the higher resolution, EO/IR camera ball systems are very effective tools for providing over-watch for specific areas of interest on a wildland fire, detecting spot fires or new fires, providing support for a ground operation (i.e. burn out or line construction), monitoring impingement of trigger points, and identifying location and amount of residual heat during the mop-up phase. Most cooled EO/IR camera systems have the sensitivity to detect body heat, and can be used to spot individuals or animals on the ground. Aircraft with EO/IR camera ball systems can be used to map fires, however due to the narrower field of view it generally takes longer to map a fire than other systems such as Line Scanner or Step-Stare camera systems (see below).

## **2. Line Scanner / Step-Stare IR Camera Systems:**

Line scanners or downward looking camera systems that employ a step-stare technique are optimized to rapidly acquire imagery over a large area. Unlike a camera ball system that uses 'cursor-on-target' techniques, line scanners and step-stare systems capture imagery in a swath to either side of the aircraft resulting in a wide field of view. Each successive swath along the flightpath is compiled into an image mosaic showing areas of heat detection, which are then analyzed and processed into map products showing perimeter, areas of heat intensity, and location isolated heat sources.

Capabilities of these systems vary by the manufacturer and model used. Some systems consist of a multi-spectral array of EO, SWIR, MWIR, LWIR, and NIR bands to generate an image mosaic. Other systems just use LWIR and NIR. When combined with navigation and mapping software, highly accurate map products can be constructed for further use by fire managers.

The line scanners used by Forest Service NIROPS aircraft use rotating mirrors to reflect thermal IR to the MWIR-LWIR scan head in a wide swath on either side of the flight path. The successive lines are compiled into a high-resolution imagery showing heat detection from which highly accurate map products are produced.

Aircraft equipped with these sensors typically fly a series of passes over the fire, similar to mowing a lawn. The field of view of each pass is dependent on the altitude, which in turn is determined by the sensitivity of the sensors and the capabilities of the host aircraft. For optimum coverage, aircraft equipped with step-stare or line scanners will typically conduct missions from 10,000 to 18,000 feet above ground, well above the Temporary Flight Restriction (TFR).

The advantage to these systems is the high scan volume (acres per hour), capable of scanning up to 400,000 acres per hour, depending on the altitude and speed of the host aircraft. Even on the low end, these scan volumes are significantly higher than an aircraft equipped with EO/IR camera ball. As a

result, these systems are better suited for mapping large fires in a short amount of time. Depending on the speed and range of the host aircraft they can map numerous large fires spread out over a geographic or multiple geographic areas in a single operational period.

## II. Operational Needs

IR collection platforms available for wildland fire operations are increasing in number and capabilities. Real-world operational experiences over the last few years have shown that not all platforms possess the same capabilities, products or services. Actual practice has shown that certain combinations of platform and sensor are better suited for one mission type while other combinations may be better suited for another, but there also exists some overlap in capabilities.

The purpose of this guide is to identify the primary types of IR capabilities that are needed to support wildland fire operations, by identifying key differences in technologies, and to provide assistance to Fire Managers in selecting the best tool for the job based on end-user requirements.

### A. Discussion Points

Demand for IR intelligence to support strategic and tactical operations is growing, as are the different types of IR systems that are becoming available to the wildland fire community. At current levels the number of IR collection platforms is still relatively finite. During higher preparedness levels (PL) requests for overhead imagery may exceed collection capacity resulting in the need to be prioritized at the GACC and National levels.

Determining the end-user's information requirements should be the first step for fire managers. As the number of options for IR platforms increase, it is important to recognize that some platforms are better suited for a particular mission over others. As such, identifying what the end-user needs, how they intend to use the information, and how often it is needed will ultimately assist with selecting the best tool(s) for the job.

Polling of incident management personnel in late 2017 revealed a preference for GIS-ready map products as opposed to raw imagery, pictures, or full motion video (FMV). While pictures or FMV are useful for tactical purposes, the majority of responses indicated that map products such as KMZ, KML, and GIS shapefiles were in much higher demand and had much more long term value. Video streaming in the IR spectrum has been successful in locating spot fires, monitoring burn out operations, providing situational awareness of fire activity when obscured by the smoke column or inversions, and has also been used to gauge fire behavior and calibrate fire spread models. However, monitoring live video streaming by ground personnel can be laborious and require additional personnel and/or proprietary data link equipment especially in areas of limited or no wifi or cellular connectivity.

### B. Infrared Missions to support Wildland Fire Operations

The Forest Service Fire and Aviation Management (FAM) has identified four types of missions that IR collection platforms play a key role in providing support for wildland fire operations and decision making. The four missions are described in Figure 1 below.

**Figure 1.** Fire Imaging Missions to Support Wildland Fire Operations

Mission Description	Current Capabilities	Best Use
<p><b>Detection:</b> Aircraft (AC) or satellite system equipped with thermal sensors that can detect new fires.</p> <ul style="list-style-type: none"> <li>• Improve response times and provide for public safety</li> <li>• Discriminate false positives</li> <li>• Assist with risk assessment and Go / No-Go decisions</li> </ul>	<ul style="list-style-type: none"> <li>• DRTI, CO-MMA, NightWatch, and contract A/C</li> <li>• Scan large area post lightning event i.e. national forest or GACC</li> <li>• Derive GPS location data and maps of new fires</li> <li>• EGP’s IgPoint is being refined for 24/7 detection</li> </ul>	<ul style="list-style-type: none"> <li>• AC with EO/IR camera ball may be best use</li> <li>• Order when lightning event is forecasted or has occurred</li> <li>• AC w/ EO can differentiate fire from false positive</li> </ul>
<p><b>Large Fire Perimeter Mapping:</b> AC equipped with thermal sensors are used to derive incident map data (perimeter, heat stratification, acres) to update incident maps, SA, inform strategic and tactical decisions, etc.</p> <ul style="list-style-type: none"> <li>• Map 50-70 large fires per 24 hrs</li> <li>• National coverage</li> </ul>	<ul style="list-style-type: none"> <li>• NIROPS primary role</li> <li>• Agency AC</li> <li>• Additional capacity to support NIROPS with contractors will be in place for 2020</li> </ul>	<ul style="list-style-type: none"> <li>• Large Fires: NIROPS line scanner and step-stare IR camera systems are best use for large fires at night</li> <li>• Small Fires: AC with EO/IR camera balls are capable of mapping fires &lt;1,000 acres in timber or &lt;10,000 acres in light fuels</li> <li>• Desert Fires: AC with EO/IR sensors during daytime hours is best use</li> </ul>
<p><b>Tactical Incident Awareness and Assessment (IAA):</b> Thermal imagery from AC is used throughout the operational period to acquire additional intelligence on fast moving dynamic fires, and/or in close proximity to values.</p> <ul style="list-style-type: none"> <li>• Update SA, monitor spread, and support tactical operations</li> <li>• Day or Night updates</li> <li>• Persistent or Periodic coverage</li> <li>• Provide real-time alerts</li> <li>• Updated map products</li> <li>• Map fires in support of, or in lieu of, NIROPS</li> </ul>	<p>Persistent IAA: 12-18 hrs on-demand coverage for single fire</p> <ul style="list-style-type: none"> <li>• Large UAS or FireWatch helicopter role</li> <li>• Dedicated coverage of one fire</li> </ul> <p>Periodic IAA: 1-2 hrs of coverage for multiple fires</p> <ul style="list-style-type: none"> <li>• Manned aircraft role (AA-51, CO-MMA, DRTI, contract AC, etc.)</li> <li>• Can be assigned to cover multiple fires in one operational period</li> </ul>	<ul style="list-style-type: none"> <li>• AC equipped with EO/IR camera ball may be best use</li> <li>• Large UAS may be best use to provide persistent day and night coverage of a single fire</li> <li>• Manned AC is best use to provide periodic coverage of multiple fires</li> <li>• Number of fires manned AC can cover is limited by range and speed of the AC</li> </ul>
<p><b>Strategic Intelligence (Dashboard):</b> Maintain a Common Operating Picture to provide situational awareness of fires nation-wide.</p> <ul style="list-style-type: none"> <li>• Satellite IR data, fire perimeters, resources, etc.</li> <li>• Inform strategic decisions (non-tactical)</li> <li>• Prioritize response and resources</li> </ul>	<p>EGP dashboard display:</p> <ul style="list-style-type: none"> <li>• MODIS and VIIRS detections</li> <li>• IgPoint detections</li> <li>• HDDS commercial satellite imagery (when available)</li> <li>• Import fire perimeter maps</li> <li>• Regional and National level decision support</li> </ul>	<ul style="list-style-type: none"> <li>• Satellite detection may be best use for nation-wide coverage</li> <li>• Combine with additional data from other sources (i.e GEOMAC)</li> </ul>

### III. Comparison of Capabilities

Figure 2. Comparison of capabilities of different IR collection platforms

<b>Platform</b>	<b>Type of Sensor</b>	<b>IR Capability</b>	<b>Video Steaming</b>	<b>Day or Night</b>	<b>Map Products</b>	<b>Cost</b>	<b>Best Use</b>
<b>FS NIROPS</b>	Line Scanner	Dual Band IR (MWIR-LWIR)	No	Night	GIS Ready Shapefiles, KMZ, and PDF Map	\$1150/hr King Air	Mapping multiple large fires across multiple Geo Areas
<b>FS NIROPS Contracted Capacity<sup>1</sup></b>	Step-stare EO/IR systems	IR bands vary by vendor	No	Day or Night	GIS Ready Shapefiles, KMZ, and PDF Map	Varies by vendor	Mapping multiple large fires across multiple Geo Area
<b>DRTI</b>	EO/IR Camera Ball	IR, EO	Yes, via JTAC	Day or Night	Lat/Long of heat detection points	None	Detection and IAA
<b>CO-MMA</b>	EO/IR Camera Ball	IR, EO	Yes, via CO-WIMS website	Day or Night	GIS Ready Shapefile, KML and PDF Map	\$1800/hr	Detection and IAA Mapping fires <10K acres
<b>FS Night Watch AA51</b>	EO/IR Camera Ball	HD IR and EO, Laser.	Yes, via MPU5 radio link	Night	GIS Ready Shapefiles, KMZ, and PDF Map	\$2249/hr	Detection, IAA, and mapping small fires or portions of large fires
<b>FS Fire Watch Cobra</b>	EO/IR Camera Ball	HD IR and EO, Laser.	Yes, via MPU5 radio link	Day	GIS Ready Shapefiles, KMZ, and PDF Map	\$2800 per hr. includes ATGS, data van	IAA and mapping small fires or portions of large fires
<b>Vendor provided IAA<sup>2</sup></b>	EO/IR Camera Ball	IR, EO	Varies by vendor	Day or Night	Varies by vendor	Varies by vendor	Detection, IAA, and mapping fires small fires or portions of large fires

<sup>1</sup> NIROPS will be augmented with contractors providing additional capacity.

<sup>2</sup> Vendors on contract to provide IAA capabilities. FS has contract for manned aircraft, BLM has contract for large UAS

**IV. Consideration for Use**

Fire Situation	End-User Requirements	Best Use Considerations
<p><b>Large Wildfire (active)</b></p> <ul style="list-style-type: none"> <li>• Containment objectives not met</li> <li>• Fire is actively spreading and increasing in size</li> <li>• Primary control objectives are to contain/confine fire and/or protect VARs</li> </ul>	<p>Map products needed:</p> <ul style="list-style-type: none"> <li>• PDF geo-rectified map of heat perimeter</li> <li>• Areas of intense, scattered, isolated heat</li> <li>• GIS Shapefiles and KMZ/KML</li> <li>• IR Log</li> </ul>	<p>Order NIROPS via online request form</p> <ul style="list-style-type: none"> <li>• Request will be assign to one of the NIROPS aircraft, including contractors</li> <li>• NIROPS AC have scan volume of 100,000 to 400,000 acres/hour</li> </ul>
<p><b>Large Wildfire (very active w/ VARs)</b></p> <ul style="list-style-type: none"> <li>• Containment objectives not met</li> <li>• Fire is very active and is spreading towards VARs</li> <li>• Fire has exceeded or anticipated to exceed trigger points / MAPs</li> <li>• Additional daytime SA is needed to monitor MAP impingement, i.e. evacuation trigger points</li> </ul>	<p>Service/Map products needed:</p> <ul style="list-style-type: none"> <li>• Same map products as above</li> <li>• Additional updates during the day (periodic or persistent) are needed</li> <li>• Ability to quickly transfer information or data to incident</li> </ul>	<p>Consider ordering:</p> <ul style="list-style-type: none"> <li>• NIROPS for once-per-night update –and-</li> <li>• IAA platform equipped with EO/IR sensors for daytime update(s)</li> <li>• If persistent IAA is needed, consider ordering large UAS or dedicated IAA platform w/ data link and radio communication</li> </ul>
<p><b>Large Wildfire (not active)</b></p> <ul style="list-style-type: none"> <li>• Containment objectives have been met or nearing completion</li> <li>• Forward movement of fire has been halted</li> <li>• Minimal increase in size / activity</li> <li>• Character of the fire is primarily smoldering</li> <li>• Primary operation is mop-up and patrol</li> <li>• Minimal change from previous 24 hrs</li> </ul>	<p>Service/Map products needed:</p> <ul style="list-style-type: none"> <li>• Map products showing amount and location of residual heat</li> <li>• Monitor residual heat near to VARs or MAPs</li> <li>• Inform mop-up decisions</li> <li>• Entire fire does not need to be mapped</li> </ul>	<p>Consider ordering:</p> <ul style="list-style-type: none"> <li>• IAA platform equipped with EO/IR camera-ball (NIROPS is not optimized for this mission)</li> <li>• EO/IR camera-ball has better sensitivity for smoldering fires</li> <li>• EO/IR camera-balls have lower scan volume &lt;10,000 acres/hour</li> <li>• For efficiency specify area of interest for scanning (i.e. NE flank, Div W, hillside above subdivision, etc. instead of “fly the entire fire”)</li> </ul>
<p><b>Large Wildfire (light fuels)</b></p> <ul style="list-style-type: none"> <li>• IR sensors can only map the heat it detects</li> <li>• Fires that burn in light fuels often have portions that go out prior to the NIROPS nighttime flight.</li> <li>• Areas of ‘cold black’ may be hard to distinguish, especially in light grass fuels.</li> <li>• Only the leading edge of the fire or areas burning in heavier fuels will show sufficient heat for detection</li> </ul>	<p>Map products needed:</p> <ul style="list-style-type: none"> <li>• PDF geo-rectified map of heat perimeter</li> <li>• Areas of intense, scattered, isolated heat</li> <li>• GIS Shapefiles and KMZ/KML</li> <li>• IR Log</li> </ul>	<p>Consider ordering:</p> <ul style="list-style-type: none"> <li>• IAA platform with EO/IR for late afternoon/early evening flight</li> <li>• EO camera can distinguish ‘cold black’ and generate accurate map of burned perimeter</li> <li>• IR sensor will detect heat from open flames or smoldering embers even during daytime</li> <li>• NIROPS is not optimized to detect ‘cold black’</li> </ul>



Fire Situation	End-User Requirements	Best Use Considerations
<p><b>Isolated Small Wildfire (&lt;1,000 acres in timber, or &lt;10,000 acres in light fuels)</b></p> <ul style="list-style-type: none"> <li>• Containment objectives not met</li> <li>• Fire is actively spreading and increasing in size</li> </ul>	<p>Map products needed:</p> <ul style="list-style-type: none"> <li>• PDF geo-rectified map of heat perimeter</li> <li>• Areas of intense, scattered, isolated heat</li> <li>• GIS Shapefiles and KMZ/KML</li> </ul>	<p>Consider ordering:</p> <ul style="list-style-type: none"> <li>• IAA platform w/ EO/IR camera-ball</li> <li>• If located near other large fires that are being flown by NIROPS, NIROPS may be a good fit</li> </ul>
<p><b>Post Lightning Storm Fire Detection</b></p> <ul style="list-style-type: none"> <li>• Lightning data or forecast indicates widespread lightning activity occurring or expected to occur across a large area</li> <li>• Concern with locating hold-over fires and/or new starts in smoky conditions</li> </ul>	<p>Service/Map Products needed:</p> <ul style="list-style-type: none"> <li>• Day or night scan of area impacted by lightning storms (based on lightning detection)</li> <li>• GIS shapefiles (points) of new starts, including KMZ or KML</li> <li>• Basic size up information, including if fire is staffed or not</li> <li>• Map any perimeter &gt;10 acres</li> </ul>	<p>Consider ordering:</p> <ul style="list-style-type: none"> <li>• IAA platform equipped with EO/IR camera-ball</li> <li>• Size of scan area may dictate type of AC used (speed and range)</li> <li>• Will need to identify central POC for dissemination of IR data (i.e. GACC or EOC) along w/ GISS support to exploit and display GIS data</li> </ul>

## Appendices: IAA Aircraft Systems for Wildland Fire

The following appendices identifies IAA aircraft systems available for wildland fire support. The list is not inclusive of all the options and there are a number of vendors on various contracts or agreements that may be available to provide similar IR mapping or over watch services. The IAA systems described in this guide primarily focus on wildland or cooperating agency aircraft systems.

Appendix A: USFS National Infrared Operations (NIROPS)

Appendix B: USFS FireWatch Program

Appendix C: USFS NightWatch Program

Appendix D: National Guard Distributed Real Time Infrared (DRTI)

Appendix E: California Air Guard

Appendix F: Colorado Multi-Mission Aircraft (CO-MMA)

## Appendix A: National Infrared Operations program (NIROPS)



The National Infrared Operations (NIROPS) is operated by the US Forest Service to provide IR mapping of wildfires across multiple geographic areas. NIROPS provides a once-per-24-hour update of the fire's heat perimeter and distribution of heat within the perimeter. NIROPS consists of agency-owned aircraft equipped with the Phoenix line-scanner system. Staffed with agency pilots, IR Technicians, IR Interpreters (IRIN) and National Coordinators (IRCN) the NIROPS program has a workflow that has supported upwards of 49 fires spread across multiple geographic areas in a single night.

To respond to the increasing demand for NIROPS fire mapping service, the Forest Service is hosting contracts to provide additional capacity to the NIROPS program using vendor-aircraft equipped with commercial IR sensors. The vendors deliver equivalent IR map services and products as agency NIROPS.

Agency-aircraft have a scan volume of 300,000 acres per hour. Vendor-aircraft have a scan volume ranging from 100,000 to 400,000 acres per hour depending on the aircraft and sensor used.

### **Deliverables**

- Geo-rectified PDF map showing heat perimeter with areas of intense, scattered, and isolated heat
- KMZ or KML
- GIS ready shapefiles compatible with the GSTOP format
- IR Interpreter's Log
- All map products will be posted to the incident's IR folder on the NIFC-FTP by 0400 hours MDT

### **Considerations**

- NIROPS is typically flown at night when there is the greatest temperature contrast between the fire and the ground.
- Agency-aircraft equipped with the Phoenix Line Scanner are optimized for nighttime operations
- Vendor-aircraft equipped with EO/IR sensors are capable of providing pre-dusk coverage on a case-by-case basis provided the earlier missions do not impede night time operations on other fires

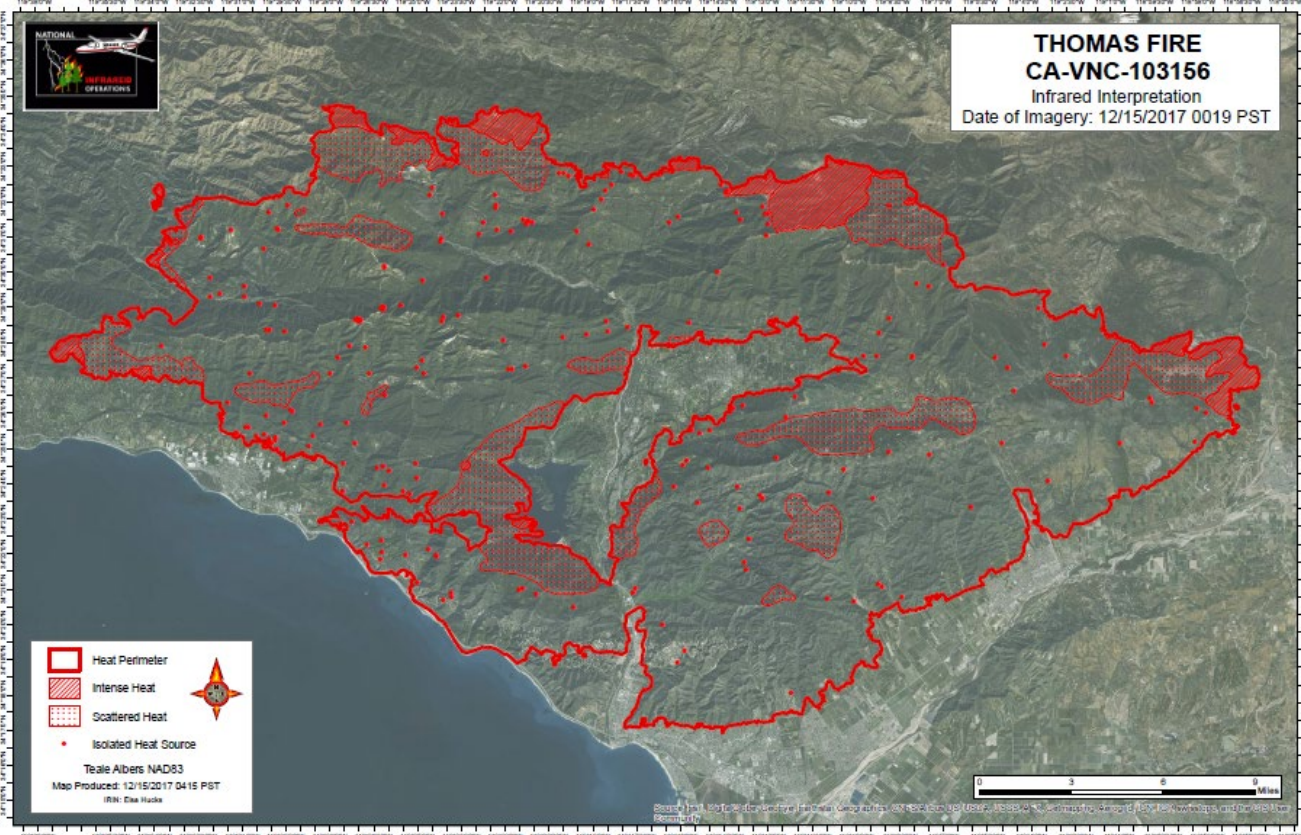
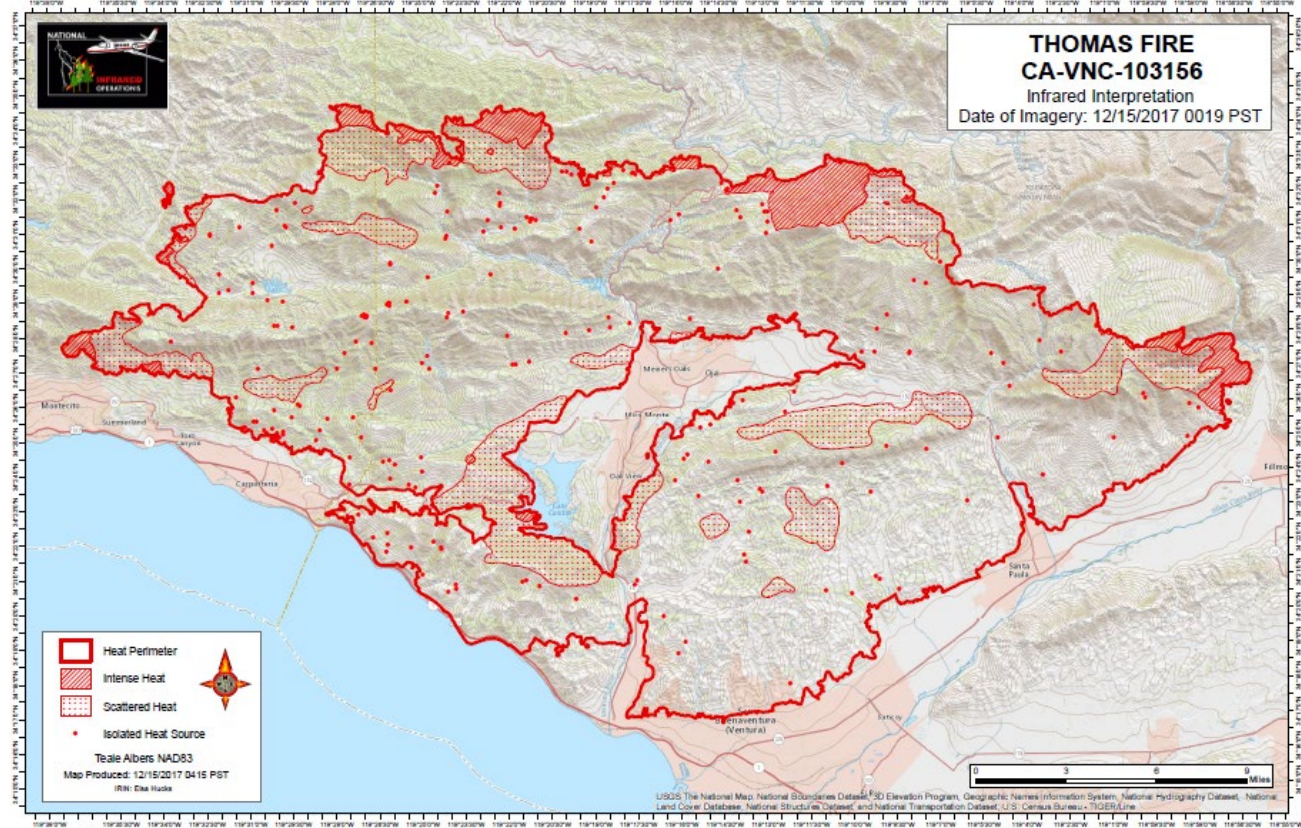
- Daytime flights (early evening before sunset) may be more accurate for fires burning in light fuels to map ‘cold black’ perimeters
- IR sensors can only map the heat they detect. ‘Cold black’ perimeters (e.g. fires that burned in fine fuels) are difficult to detect and may require assistance from incident SITL or GISS to provide existing perimeter, or request the mission be conducted pre-dusk
- Cloud cover and fog (water vapor) inhibits infrared capability and accuracy
- Cost for IR mapping service varies by aircraft used, size of the fire, as well as proximity to other fires
- NROPS aircraft fly above the incidents Temporary Flight Restriction (TFR) at altitudes ranging from 6,000 to 18,000 feet above ground
- If additional IR missions are needed, consider ordering Tactical IAA collection platforms for additional daytime acquisition (see Consideration for Use table in Section IV)

**Ordering**

- Requests for NROPS are to be submitted to the online IR scanner order website (<https://fsapps.nwcg.gov/nroops>) prior to 1530 hours MDT
- Each day the National IR Coordinator will review the number and location of requests and assign the missions to an aircraft to be flown that evening
- During high demand periods, fires may be prioritized based on national and geographic area priorities
- An IR Interpreter (IRIN) will be assigned if the fire is flown by an agency or exclusive use contracted aircraft. Vendors under end product contract will provide interpretation and map products
- A Resource Order with A-number will be generated in ROSS
- Once the fire is assigned to an aircraft, the SITL or GISS will be contacted by the IRIN or vendor’s interpreter to work out any additional details or refine the request

**Cost**

Aircraft	2020 Flight Rate (Hr)	Notes
King Air (N148Z)	\$1,150.00	6 mile swath at 10,000AGL
Citation (N144Z)	N/A	Not available in 2020
Vendor Aircraft	Varies by vendor	Varies by vendor



**Appendix B: USFS FireWatch Program (AA-507, AA-509)**



The USFS Firewatch Cobra has been providing Incident Awareness and Assessment (IAA) support for over 15 years. Equipped with an EO/IR camera ball, the Firewatch Cobra has been able to provide incidents with geospatial support as well as perform tactical aerial supervision / helicopter coordinator (HLCO) roles. The Firewatch Cobra will arrive at an incident with a flight crew consisting of a pilot and Air Tactical Group Supervisor, and is also accompanied by a GIS support van. In the past the Firewatch Cobra has been able to supply real time situational awareness by transmitting raw imagery through microwave transmissions to a laptop. Now as they continue to test new technologies they are moving toward Mesh Networking capabilities that will be able to provide that same real time situational awareness and stream imagery with imbedded Meta-data to the GIS van or line personnel equipped with mesh networking compatible radios.

**Deliverable**

- Provide over watch in support of ground operations, detect spot fires, and provide aerial supervision in low visibility conditions
- Provide perimeter mapping services for smaller fires, or provide map updates for portions of larger fires
- GIS ready shapefiles and KMZ compatible with the GSTOP format
- Products can be loaded to the incident's IR folder on the NIFC-FTP site or incident's Firenet drive
- Products, including FMV, can also be provided via thumb-drive

- If mesh networking capability can be established on the incident, FMV raw imagery can be transmitted to field personnel equipped with compatible radios
- Able to cover multiple fires, if within close proximity. However with short fuel durations this is not ideal

**Near Real Time Awareness**

- Information captured by the platform is recorded and then processed after landing
  - Latency could be up to 3 hrs
  - This will change as Mesh Network capability is stood up
- Inflight tasking can be provided during flights through radio communication
  - Will be monitoring incident frequencies and can provide information updates to ground personnel
- EO camera can take color photos of areas of interest on the fire
  - These can be recorded and processed after landing or transmitted through Mesh Network
- Infrared Camera can take snapshots of areas of interest on the fire and be display the same as EO
- Video can be taken from either the EO camera or the Infrared camera to display continuous view of particular areas (these cameras can also be fused to show a “blended” video or picture of infrared and color.)
  - These can be recorded and processed after landing or transmitted through Mesh Network
  - The video will be narrated by the ATGS on board aircraft

**Considerations**

- Restricted to day-time flights
- Has a standard duration of 2.5 hours over the incident
- Due to fuel and transit time, it’s best when the helicopter is prepositioned close to the incident
- Functions well in the low level and low visibility environment
- Good capability to map small fires, or fires burning in light fuels and can map “cold black”
- FireWatch typically flies inside the Fire Traffic Area
- Mostly used in California but can on occasion be used to support other GACCs

**Ordering**

- To order the cobra for intelligence gathering, order as Fixed Wing infrared with “Firewatch” in the special needs
- Can also be ordered as an ATGS/HLCO platform for initial attack without the GIS support equipment

**Cost**

Aircraft	Flight Rate (Hr)	Notes
AA-507	\$2,800.00	ATGS / HLCO ATGS / HLCO. Delivers program standard products ATGS / HLCO
AA-509	\$2,800.00	





## Appendix C: USFS NightWatch Program (AA-51)



Air Attack 51 is an Air Attack platform based in Southern California on the Angeles National Forest. Even though the primary mission is to provide night aerial supervision, the aircraft is equipped with the same EO/IR capability as the FireWatch Cobra and is able to provide similar over watch and fire mapping support to Fire Managers.

### Deliverable

- Provide over watch in support of ground operations, detect spot fires, and night aerial supervision
- Provide perimeter mapping services for smaller fires, or provide updates for portions of larger fires
- GIS ready shapefiles and KMZ compatible with the GSTOP format
- Products can be loaded to the incident's IR folder on the NIFC-FTP site or incident's Firenet drive
- Products, including FMV, can also be provided via thumb-drive
- Able to cover multiple fires within Southern California when not being used as a night Air Attack platform (primary role)

### Near Real Time Awareness

- Information captured by the platform is generally recorded and then processed after landing
  - Latency could be up to 3 hrs.
- Inflight tasking can be provided during missions through radio communications
  - Will be monitoring incident frequencies and will be providing information to ground personnel
- EO camera can take color photos of areas of interest on the fire during daylight
  - These can be recorded and processed after landing or transmitted
- Infrared camera can take snapshots of areas of interest on the fire and be displayed the same as EO camera day or night
- Video can be taken from either the EO camera or the Infrared camera to display continuous view of particular areas
  - These can be recorded and processed after landing

- The video will be narrated by the ATGS on board aircraft

**Considerations**

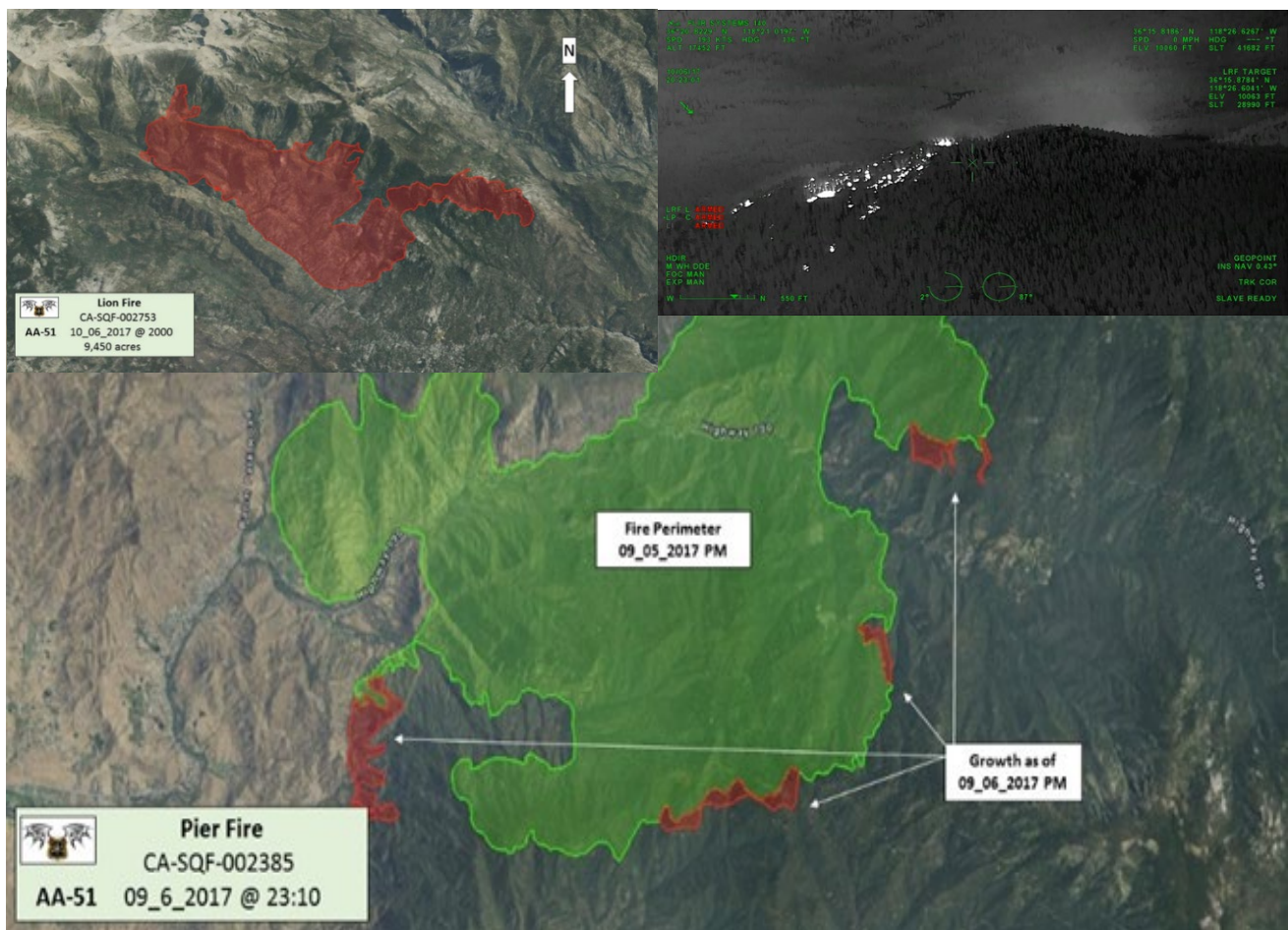
- Has the ability to fly both day and night. In 2020 the aircraft will be dual staffed for daytime and night time operations
- Has a 5 hour flight time endurance
- Is designated for use primarily in the Operations Southern California (OSC) GACC
- IR sensors and cameras function well at night when there is more contrast from fire and ground heat
- Typically operates within or above the Fire Traffic Area

**Ordering**

- Needs approval of the OSC duty chief for use
- Orders get sent to Angeles National Forest
- Order Fixed Wing Air Attack with “Night Air Attack” in special needs specify intel/aerial supervision/both

**Cost**

Aircraft	Flight Rate (Hr)	Notes
AA-51	\$2,363.00	ATGS / HLCO. Delivers program standard products



## Appendix D: Distributed Real Time Infrared (DRTI)



The Distributed Real Time Infrared (DRTI) RC-26 aircraft is an Air National Guard asset that has been available for Incident Awareness and Assessment (IAA) on wildland fires since 2016. Like other Air National Guard assets, these aircraft are ordered under a NIFC Request for Assistance to the Department of Defense. Equipped with an EO/IR camera ball, the DRTI aircraft is best used for detection of new fires across a large area following a lightning storm, or for situation awareness updates on large fires. When assigned to IAA mission on a large fire, the DRTI can be ordered with multiple Joint Terminal Attack Controllers (JTAC) who are equipped with radios to receive live-stream video and data transmissions. JTACs can be co-located at ICP and are also fireline qualified to provide real time situational updates to line personnel.

### **Deliverable**

- DRTI map products are different from NIROPS, FireWatch or any of the IR vendors. DRTI products need to be post-processed by a GISS into standard perimeter polygon
- Provides GIS point vector data (does not produce a perimeter map) showing updated location(s) of the fire, spot fires, or new fire starts
- Capable of detecting body heat of ground personnel or animals in addition to heat from fire
- Aircraft has the speed and range to cover a 1,000 mile area in a single fuel cycle for wide area detection
- Provides FMV updates of the fire that can be viewed in real-time by line personnel via JTAC, or at ICP via ground station

### **Real Time Awareness**

- Information captured by the platform can be loaded or transmitted in flight to JTAC personnel on the ground, either on the fireline or located at ICP
- Inflight tasking can be provided during flight by text or email
- EO/IR cameras can take photos or FMV of areas of interest on the fire
- Have had the ability to show where the sensor is looking on an incident map display next to the IR imagery

### Considerations

- Capable of day or night operations (may need to double crew if both are desired)
- Can support a single incident or GACC with multiple incidents
  - If supporting a single incident a member of the IMT can work with the aircraft personnel for daily needs
  - If supporting multiple incidents from the GACC the following is recommended
    - A Red Carded Firefighter, like an Aerial Observer or ATGS to ride onboard aircraft
    - A SITL type person that can help coordinate the aircraft request
    - A GISS person to post-process and disseminate map products as needed
    - Additional dispatcher support at the GACC, especially if night missions are planned
- Can co-locate JTAC at ICP or on a division to live stream photos or video in near real-time to IMT or ground personnel, and can relay specific requests to provide coverage for specific areas of interest
- Where information is going to be sent and stored needs to be worked out
- DRTI typically operates well above the Temporary Flight Restriction (TFR) at 10,000' to 18,000' above ground

### Ordering

- Contact GACC and communicate need, GACC will coordinate with the NICC
- If DRTI is available, NIFC will submit a Request for Assistance (RFA) to the National Guard Bureau
- A minimum number of days may be required
- A federal liaison may be assigned for coordination between NIFC, GACC's, and incident management team(s)
- Note: 2020 will be the last year the National Guard will be operating the RC-26 aircraft

### Cost

Aircraft	Flight Rate	Notes
Condor 26	No cost to the incident	Requires incident GIS support, not capable of aerial supervision

## Appendix E: California Air Guard



The California Air Guard (CNG) has four options to support Incident Awareness and Assessment (IAA) missions on wildfires within the state of California under an agreement with CALFIRE. CNG has the RC-26, UH-72 Lakota, MQ-9 Reaper, and the RQ-7 Shadow. All have the ability to provide some level of near real time IAA, Damage Assessment, Wildfire perimeter, and Search and Rescue. The CNG RC-26 aircraft, like the ANG DRTI aircraft, are capable of supporting one or more incidents with products and updated IAA intelligence. The UH-72 Lakota helicopter has the ability to be more tactical at low level within the Fire Traffic Area, while the Reaper and Shadow are unmanned aerial vehicles (UAV) that fly well above the Fire Traffic Area. All assets have support staff that assist in the products, and there is a web view that will allow for disconnected used to view video in real-time.

### Deliverable

- Function as a perimeter informing tool
- Able to cover multiple fires with the RC-26 and Reaper depending on proximity. Multiple fires would mainly be updating perimeters; where full incident perimeters could limit the number of incidents supported
- GIS-ready intelligence (does not produce its own map but provides the files for GISS personnel, in the form of a point file)
- Perimeter updates can be viewed in a real-time Domestic Operations Awareness and Assessment Response Tool (DAART) website

### Real Time Awareness

- Information captured by the platform can be loaded or transmitted in flight to JTAC personnel on the ground, either on the fireline or located at ICP
- Inflight tasking can be provided during flight by text or email
- EO/IR cameras can take photos or FMV of areas of interest on the fire
- Have had the ability to show where the sensor is looking on an incident map display next to the IR imagery

**Considerations**

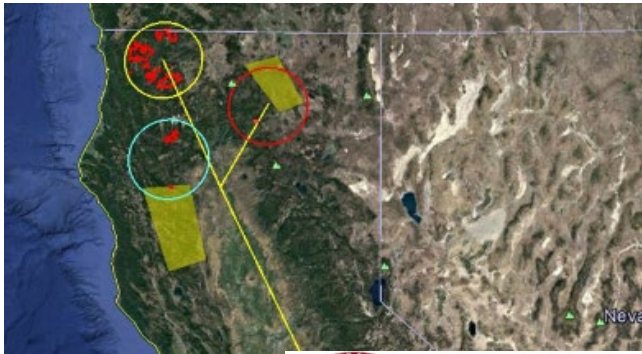
- RC-26 and MQ-9 Reaper are capable of day or night operations (may need to double crew if both are desired)
- Can support a single incident or GACC with multiple incidents
  - If supporting a single incident a member of the IMT can work with the aircraft personnel for daily needs
  - If supporting multiple incidents from the GACC the following is recommended
    - A Red Carded Firefighter, like an Aerial Observer or ATGS to ride onboard aircraft
    - A SITL type person that can help coordinate the aircraft request
    - A GISS person to post-process and disseminate map products as needed
    - Additional dispatcher support at the GACC, especially if night missions are planned
- With near real-time intel ground personnel can request DRTI to provide coverage for specific areas of interest
- Where information is going to be sent and stored needs to be worked out
- RC-26 typically operates well above the Temporary Flight Restriction (TFR) at 10,000' to 18,000' above ground
- MQ-9 Reaper (UAV) has same functionality as the RC-26 but requires more logistical support.
  - Sky conditions need to be clear between launch area and incident
  - Several declarations are needed from the State and a COA will need to be requested and approved from Secretary of Defense (SECDEF)
  - Significant support is required
    - Remote Pilots
    - Analyst for imagery
    - Plane to guide drone from launch to managed airspace
- UH-72 Lakota (helicopter) and RQ-7 Shadow (UAV) have limited time on station
- RC-26 and RQ-9 Reaper typically operate above the Temporary Flight Restriction (TFR)
- UH-72 Lakota and MQ-7 Shadow may need to operate within the Fire Traffic Area (FTA)

**Ordering**

- Order through CALFIRE
- Federal agencies can order through established resource request procedures outlined in the *Reciprocal Fire Protection Cooperative Agreement for State of California Military Department Assets*
- Determine which incidents will use the live feed and request support personnel through guard to support the request

**Cost**

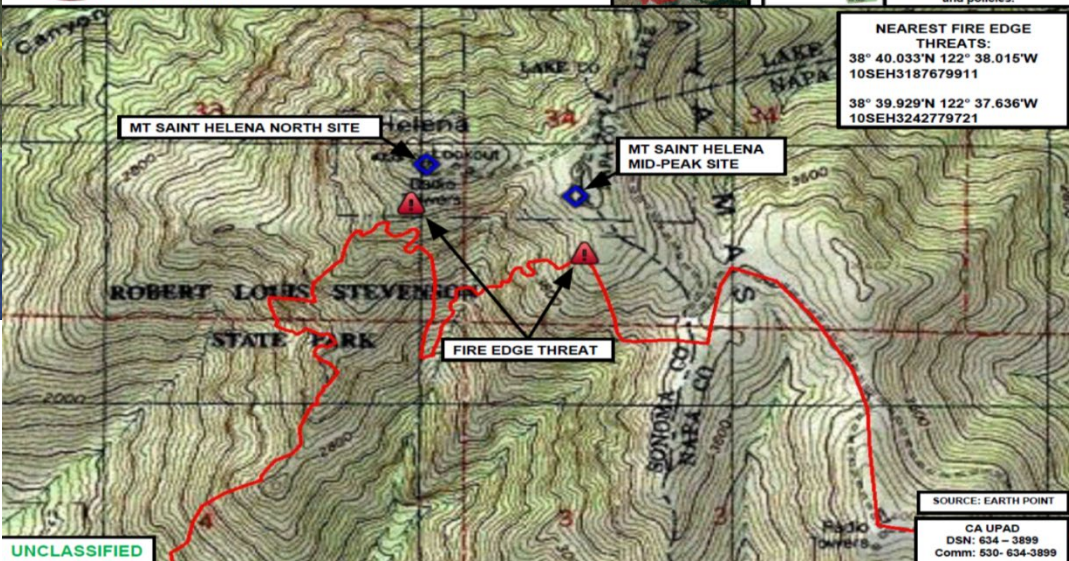
Aircraft	Flight Rate	Notes
	State Agreement	Researching costs



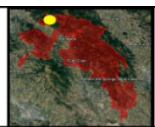
**NATIONAL GUARD**  
**SONOMA COUNTY, CA**  
**POINT OF INTEREST: TUBBS FIRE EDGE THREATS**  
 DDM: 38° 39.632'N 122° 37.675' W  
 MGRS: 10SEH32379172  
 DOI: 16JUN17



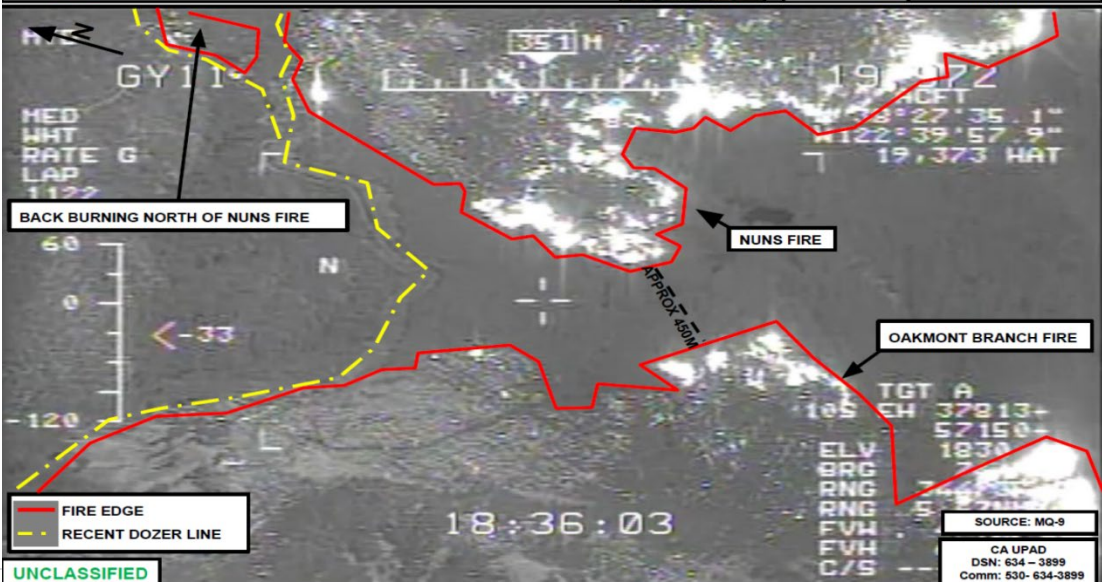
**UNCLASSIFIED**  
 ATTENTION: This document contains U.S. persons information which has been included consistent with all applicable laws, directives, and policies.



**NATIONAL GUARD**  
**SONOMA COUNTY, CA**  
**POINT OF INTEREST: OAKMONT BRANCH AND NUNS FIRES**  
 DDM: 38° 27.711'N 122° 33.995'W  
 MGRS: 10SEH3781357150  
 DOI: 16OCT17 1136PST



**UNCLASSIFIED**  
 ATTENTION: This document contains U.S. persons information which has been included consistent with all applicable laws, directives, and policies.



## **Appendix F: Colorado Multi-Mission Aircraft**

Operated by the Colorado Department of Public Safety Division of Fire Prevention and Control (DFPC) the Colorado Multi-Mission Aircraft (CO-MMA) is a Pilatus PC-12 equipped with a Wescam MX-15 EO/IR camera ball and paired with sophisticated mapping software that is capable of fire detection as well as perimeter mapping.

The CO-MMA was designed to perform three primary Incident Awareness and Assessment (IAA) missions:

- Fire Detection
- Tactical Decision Support on initial attack / emerging fires
- Strategic Planning Support on large fires



Based within Colorado, one of the PC-12s is often available to respond to fires in other geographic areas at the request from the NICC or on a state-to-state request. While not a direct replacement for NIROPS, the CO-MMA is capable of mapping fire perimeters at a lower acres/hour rate, and provides shapefiles or KMLs of the fire perimeter.

### **Deliverable**

- Geo-rectified PDF map of the incident on a base map (topo)
- KML/shapefiles of the fire perimeter as well as concentrations of heat or isolated hotspots
- Ortho-imagery of the fire perimeter
- Identification and mapping of structures and other public safety points
- Video clips to provide situational awareness
- Fire detection (GIS points) and size-up information
- Can map entire perimeter of small fires, or provide perimeter updates of large fires
- Perimeter updates can be viewed near-real time in either the CO-WIMS or EGP websites

### **Near-Real Time Awareness**

- Information captured by the platform can be loaded to web service while in flight by 3G cellular connection
- Inflight tasking can be provided during flight by email or Google Chat
- EO and IR cameras can take video and photos of areas of interest on the fire
- Provide over watch of areas of interest in support of ground operations, and provide voice updates by radio, data if recipient has cellular service for email

### **Considerations**

- Capable of flying day or night missions
- Can support a single incident or GACC with multiple incidents
- Can be tasked with wide area detection flight following lightning storm



- Can provide periodic IAA support to multiple large wildfires, number of fires dependent on how far apart they are
- Can provide Air Attack role if ATGS qualified Mission Sensor Operator (MSO) is on board
- Fully carded for recon, air attack, and IR missions

**Ordering**

- Contact GACC if incident is outside of the Rocky Mountain Area (RMA) GACC
- Order through ROSS ordering system as “Fixed Wing -Infrared”
- Coordinate with the incident if assigned directly, or order recommend person to be supported out of the GACC

**Cost**

Aircraft	Flight Rate (Hr)	Notes
Wildland 2-7	\$1,800.00	Requires incident GIS support, ATGS capable
Wildland 2-8	\$1,800.00	

**Additional Information**

- <https://www.colorado.gov/pacific/dfpc/multi-mission-aircraft-mma>