Fire and Aviation Management

Project Report

Liaison and Special Projects

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Forest Service—Engineering

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Infrared Field Users' Guide and Vendor Listings

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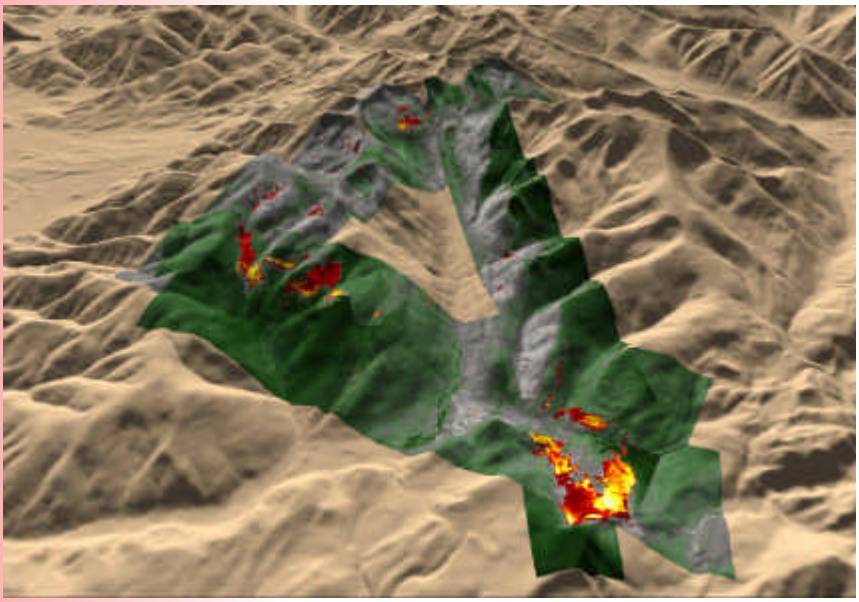

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Abstract

Infrared (IR) sensors have been aiding wildland firefighters for nearly 40 years. Originally only used for initial detection, IR sensors are now used to detect, monitor, and direct fire suppression and mop-up operations. Recent technological developments have resulted in proliferation of IR scanners at fire camps across North America. They range from small handheld units to airborne units that can cover millions of acres per hour with real-time output. Classifying IR scanners into type categories will enable incident commanders and situation unit leaders to select the proper equipment for each situation, thus avoiding waste of time and money on imagery that will not be useful. Modeled on the typing scheme used to classify helicopters, this typing scheme is easy to use and simple to understand for firefighting leaders.

Introduction

In the spring of 2001, the National Incident Commanders asked the National Infrared Operations (NIROPS) program to develop a list of infrared systems that the overhead teams could order when national infrared aircraft are unavailable. A list of IR equipment appropriate for different stages of an incident and general technical information on the fundamentals of IR were also requested. The list provides valuable information, for use during critical phases of the incident, to the fire overhead teams, Geographic Area Coordination Centers (GACC), and state and local fire organizations.

NIROPS appointed a team of specialists that included the National Interagency Fire Center (NIFC) IR technicians, IR interpreters, and Remote Sensing Applications Center (RSAC) personnel. The Department of Forestry Management at the University of Montana assisted with the final write-up. The team sought to reach national and international IR contractors, whether known or unknown by the team, by posting a Request for Information (RFI) in FEDBIZ for one month. In addition, RSAC contacted those contractors who were known to have relevant capabilities, but who did not respond to the RFI.

This report represents a unique endeavor to fulfill the intelligence needs of fire managers. Infrared sensing capabilities are categorized into one of five system types. This scheme is similar to the Overhead Fire Teams' classification scheme. A matrix of the different IR types and their characteristics is presented so fire managers can compare systems to determine which equipment type would best meet their needs.

The report includes a brief description and definition of components used to sort the IR systems into five categories. Information is presented for each company that responded to the RFI or was directly contacted to participate. For each company, information about sensor type, production rate, cost, product type, and level of accuracy is presented. This list will be updated with new information annually or sooner if needed.

The NIROPS team welcomes comments and questions; please contact Tom Zajkowski, RSAC Remote Sensing/GIS Specialist at (801) 975-3758 or e-mail at tzajkowski@fs.fed.us.

Infrared Basics

The four basic elements to consider in thermal IR sensing and interpretation are 1) the source (the fire); 2) attenuation by constituents interfering with the transmission of energy (ground and tree cover, smoke, and the atmosphere); 3) the sensor or detector (whether hand-held, airborne, or space-borne), and 4) the remote sensing analyst and/or image interpreter. The first three are discussed in this section. The Infrared Limitations section contains important information for both the IR analyst and the end-user of the products.

Source

The energy from fires, called heat, is emitted as electromagnetic energy within specific wavelength bands. Most of the energy emitted by heat from wildland fires is in the thermal IR portion of the spectrum. Figure 1 shows the wavelength bands of thermal energy detectable by various receptors (such as the human eye, photographic film, and multi-spectral and thermal sensors). While the human eye detects energy in the short wavelength range of 0.3 - 0.7 microns (µm), energy from fires is emitted at wavelengths an order of magnitude longer (nominally, 2 - 14 µm). For example, consider the wavelengths of energy from a typical earth-surface background versus those from fires with four, fire-relevant combustion temperatures (table 1).

Therefore, most heat or fire-mapping applications utilize long-wavelength, thermal remote sensors. The higher the temperature of the heat source, the more energy is emitted and the shorter the wavelengths that can be used to detect and map that source.

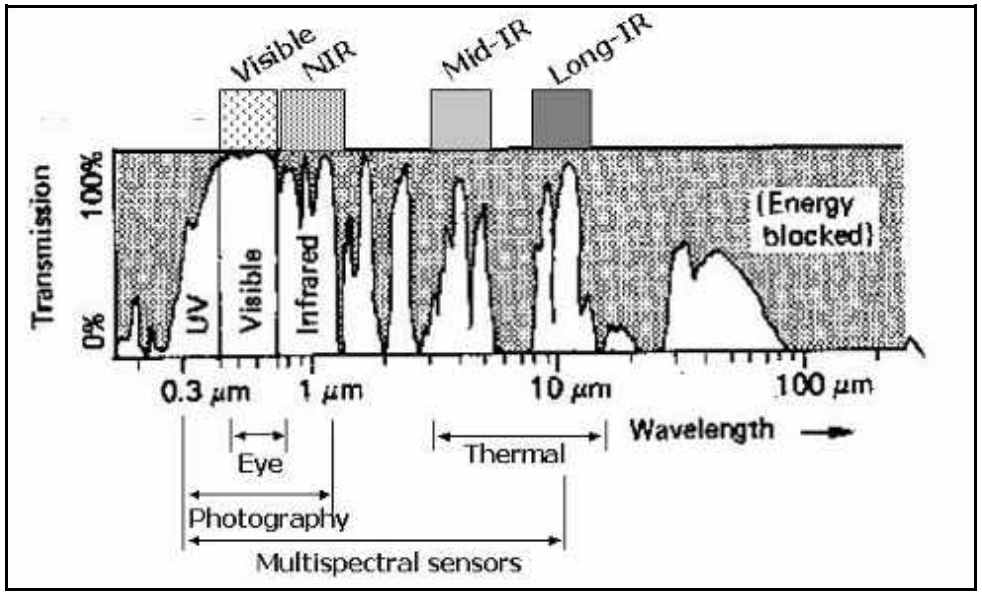

Figure 1—Wavelengths and transmission through the atmosphere (a high percentage of transmission is called a "window") of various wavelength ranges of energy, including visible, near-infrared (NIR), mid-wave infrared (Mid-IR), and long-wave infrared (Long-IR).

Table 1—Wavelengths and Temperature Relationships

Source	Temperature (C)	Nominal Wavelength (µm)
Background	25	10
Fuel ignition	275	5
Glowing	550	4
Cool fire	725	3
Hot fire	1200	2

Attenuation

Certain wavelengths of energy are attenuated by water vapor, solid particle aerosols, and compounds occurring naturally in ambient air. Other wavelengths are relatively free from the effects of scattering and absorption; these are called atmospheric "windows." Figure 1 shows these windows as the percentage of energy transmitted through the atmosphere to a sensor. The dark-hatched areas in Figure 1 indicate "blocked" wavelength regions. Generally, attenuation has two effects of concern. First, short wavelength energy is more affected than longer wavelength energy; this allows us to "see through" smoke at long thermal wavelengths. Second, when attempting to determine temperatures of heat sources, remotely-derived estimates will tend to be lower than the actual (kinetic) temperatures.

The Sensor or Detector

An ideal sensor design considers the wavelength(s) of the sources it is designed to measure, the atmospheric windows for those respective wavelength(s), and the most suitable materials with which to build the actual detector. These three factors produce typical thermal infrared detector systems designed to bracket specific bands, or ranges, of wavelengths. The two most common wavelength bands for remote sensing of fires are 3 to 5 µm and 8 to 12 or 14 µm. Note in Figure 1 that these wavelength bands are consistent with both the wavelengths of typical fire sources and good atmospheric windows. Detectors or sensors that operate at shorter wavelengths "see" color and not heat; this, coupled with atmospheric attenuation, limits the utility of shorter wavelength, or optical, systems to map heat.

Infrared Limitations

Infrared energy and the sensors used to detect and map heat sources have limitations of which the analyst and the user must be aware. These may generally be broken down into four categories: atmospheric effects/attenuation, solar radiation effects, source temperature, and saturation.

Attenuation

The atmosphere influences which wavelengths are chosen to detect heat, and affects the ability to detect heat and determine the actual temperature of the heat source (which may be useful in assessing severity and intensity).

- IR energy can be emitted or reflected. For most fire/heat-mapping applications, we are interested in long wavelength IR energy.
- Water and water vapor absorb IR energy; therefore IR sensors cannot see through dense water vapor (e.g., clouds or fog).
- The atmosphere is a good transmitter of IR energy only in certain wavelength regions, called windows. IR remote sensing is usually restricted to the windows of 3 - 5 µm and 8 - 14 µm in wavelength.

Solar Radiation

- Reflected sunlight may also mix with the emitted IR energy; thus, highly reflective surfaces (rock outcrops, water, snow, bare ground, metal roofs) may appear hot in an IR image. This can create false positives (i.e., the sensor detects fire where there isn't one). This problem can be mitigated by utilizing more than one IR band or looking at the object from multiple angles to see if it is truly on fire.

- Often long-wavelength IR (8 - 14 µm) data is collected to portray background areas around the heat source. Because smoke does not prevent this long wavelength energy from passing through, we can see the background at these wavelengths. Conventional remote sensing (photos, visible bands of Landsat) cannot see through the smoke because it scatters and absorbs short wavelength energy. (Note that heavy, moist smoke also attenuates IR data.)

Heat Source Temperature

- The amount of energy emitted by a fire or heat source depends on the temperature of the object; the higher the temperature, the more energy is emitted. The temperature of an object also affects the wavelength it emits. "Hot" fires can be detected in the 3 - 5 µm range, while "cool" fires can only be seen in the longer portion of the IR spectrum (8 - 14 microns).

- Fires are not perfect emitters of IR energy. Therefore, when IR sensors map the temperatures of heat sources, the apparent temperature of the object will normally be lower than its kinetic temperature. In other words, a measurement of a fire using a thermometer would be 7 to 10 percent higher than the remotely-sensed temperature.

- Emitted energy can also be absorbed by a heavy canopy or over-story. The ability to detect heat beneath a canopy may be reduced by heavy smoke, vegetation, or water vapor. This effect will generally make an object appear cooler than it really is. Also the higher the sensor is above the ground, the more likely this reduced temperature effect is to occur.

- Remote sensing of thermal energy can only detect heat ***on the surface*** of the targets because that is where the energy is emitted. Therefore, heat beneath surface material (e.g., duff, litter, or organic matter) cannot be detected unless it raises the surface temperature enough to cause an increase in long-wavelength IR energy. Note that many surface materials, such as duff, are good insulators.

Saturation

- Very hot objects or heat sources may saturate a sensor, creating low contrast in an image. Therefore, images are best collected when the thermal contrast is highest, which is in the morning or evening. Maximum surface cooling will typically occur near or just after dawn.

- Hot gasses may cause "blooming" in an IR image due to their high temperature. This can happen when a fire flares up and emits a convective fire column that includes gasses hot enough to saturate the sensor, thereby rendering portions of the image unusable.

Figure 2—An example of a fire flare-up that can cause saturation or blooming in an infrared sensor.

Infrared Typing System

In the past, IR systems have been used on fires without prior knowledge of the system's ability to meet the objectives of the fire managers. This has resulted in use of products that may not meet the needs of the fire team.

During the past decade, a number of advancements in thermal IR remote sensing have occurred, and a growing number of these systems are available in aircraft for use in fire management. The IR typing system is a guideline designed to help incident command teams determine the best system for their situation. The typing system informs fire managers about the capabilities and limitations of the available IR systems. They can then use this information to choose a system that will be cost-effective for their situation. Choosing the right IR system ensures that this valuable fire intelligence is obtained in a safe, timely, and cost-efficient manner.

Infrared systems are a combination of the detector, data recorder and processor, Global Positioning System/Inertial Navigation System (GPS/INS), platform, and operator. These components determine which mission profiles the system can accomplish effectively. Infrared systems can be classified in various ways; we have classified them in a manner relevant to the wildland firefighter. The following four components are used to sort the various IR systems into five categories (see Table 2).

Table 2—Infrared System Types

Components	Multiple Incident/Large Fires		Single Incident		
	Type 1	Type 2	Type 3a	Type 3b	Type 3c
Mount	Nadir	Nadir	Gimbaled	Gimbaled	Hand
Geocorrected Products	Yes	Yes	Yes	Optional	Optional
Thermal Band(s)	2+	1	1	1	1
Production Rate (acres per hour)	100,000	10,000	1,000	500	100

Mount

Infrared systems can be mounted in several different ways: nadir, gimbaled, or hand. Hand-held units are designed to be operated as one would use a camcorder. With gimbaled mounts, widely known as forward-looking IR (FLIR) balls, the IR sensor is mounted on a stabilized turret that can be pointed in nearly any direction not blocked by the aircraft. With nadir mounts, the sensor is pointed directly below the aircraft.

Geo-corrected Products

The deliverable product(s) are corrected for applicable sensor distortions and set to a specified map projection with associated map coordinates. Typically, an IR interpreter or image analyst manipulates the data to a point where it can be integrated into an incident's GIS. It is important to check with the infrared provider to determine if an infrared interpreter or extra GIS specialist will be needed.

Thermal Bands

IR sensors can detect a number of thermal bands, or ranges, within the electromagnetic spectrum between 3 - 5 µm and 8 - 14 µm. Systems that detect more than one thermal band are better suited to reject false positives that occur when flying over hot rocks, a metal roof, etc. (See Infrared Basics section for more details.)

Figure 3—Hand-held infrared imager *(left);* gimbaled-mounted turret FLIR system *(middle),* and nadir-mounted line scanner *(right).*

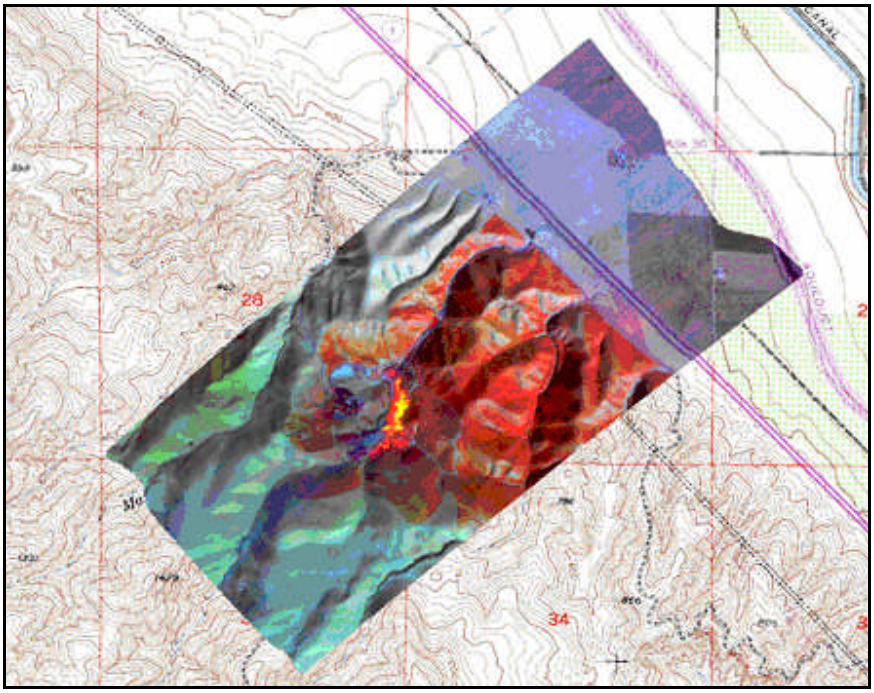

Figure 4—Output from the NASA Airborne Infrared Disaster Assessment System (AIRDAS), a type 1 line scanner, draped over a Digital Raster Graph (DRG). The bright orange and yellow area is an active, controlled burn.

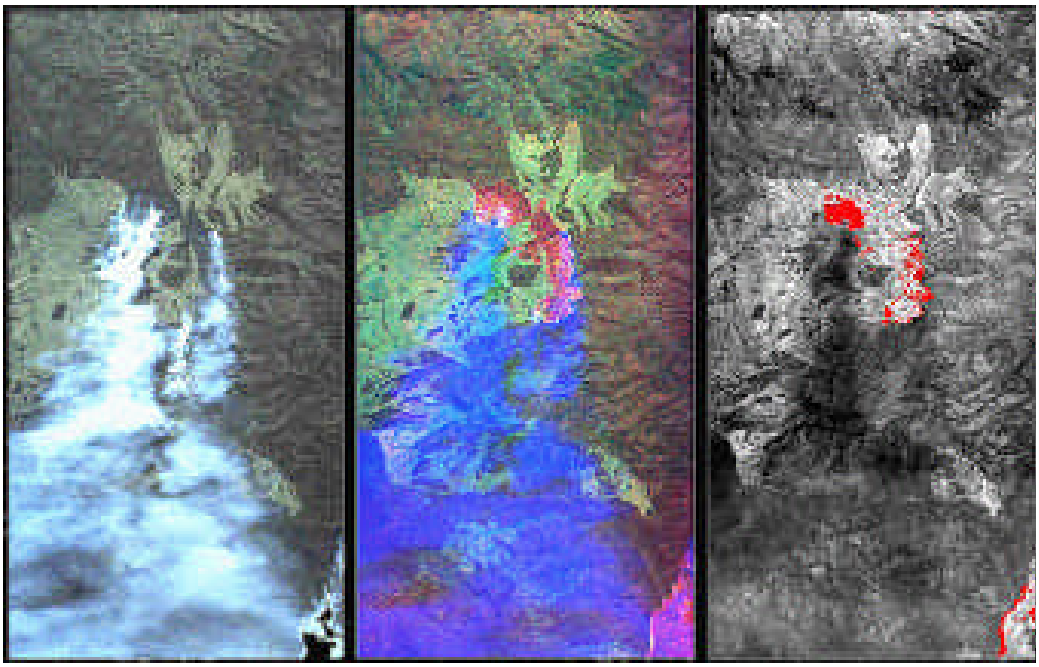

Figure 5—The same fire seen with visible bands *(left),* near- and mid-infrared bands *(center),* and thermal bands *(right).* Notice how the smoke obscures the fire in the visible bands; the fire scare shows well in the near- and mid-infrared, and the active fire is highlighted with the thermal bands. (Image courtesy of Airborne Target Systems, Australia)

Production Rate

The production rate is the area the sensor can cover in one hour stated in acres per hour. Note that the stated value for a particular sensor is the best case and will decrease significantly due to turns, flight-line overlap, mission type, etc. Production rates are determined by the instrument's field of view (FOV) in conjunction with the aircraft's speed and altitude. The values listed for production rates do not include the amount of time it takes to deliver and process the imagery.

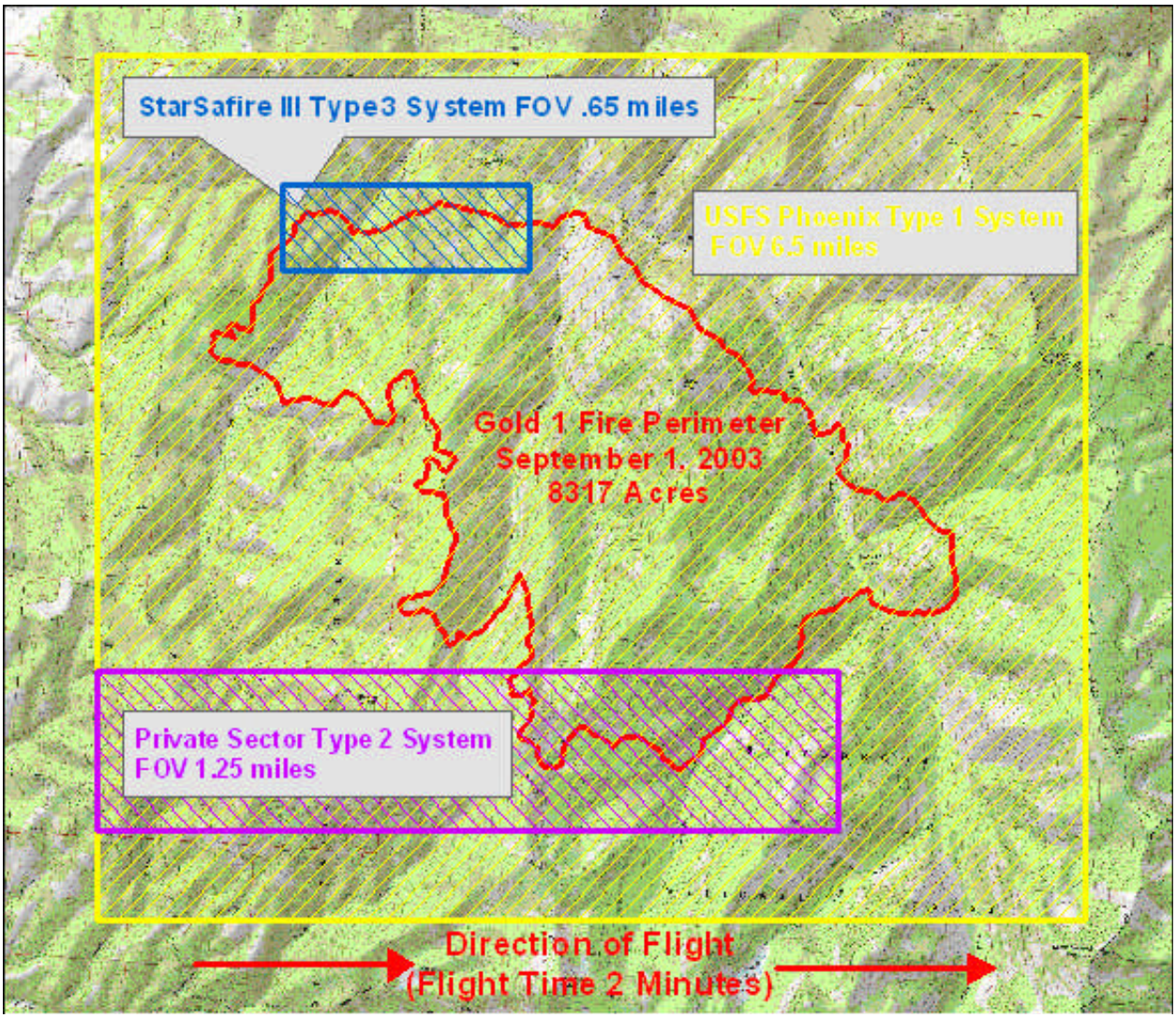

Figure 6—This figure illustrates the production rate of three infrared sensors. The Phoenix type 1 line scanner, mounted on a twin turboprop or jet, is capable of covering the fire in two minutes with a one-mile buffer on each side of the fire, enabling the interpreter to identify spot fires that have jumped containment lines. The private-sector type 2 system mounted on a piston twin-engine aircraft would require seven passes and six turns, which would take nearly 40 minutes, to cover the same amount of ground. The time could be reduced to 32 minutes if the same sensor were mounted on a twin turboprop. A helicopter-mounted type 3 system would take 90 minutes to accomplish the same task (normally type 3 systems are flown much lower so that they can pick up very small heat sources and view critical areas from multiple angles).

Figure 7—The NIFC Citation Bravo and the Phoenix line scanner type 1 platform and sensor.

Type 1

These systems are best used to detect very small heat sources distributed over vast areas and to map large fires. Type 1 systems are capable of imaging a large incident quickly so that fire managers get a snapshot of the situation. Strategic information may be gathered for planning and general assessment of conditions over large areas. They are also useful for a final look before an incident is turned over to the local agency. These systems, mounted on twin-engine or jet aircraft, can cover large areas quickly.

Type 2

These systems are best for gathering data for tactical and near-real-time decision making and should be coupled with products that do not require an on-the-scene IR interpreter. These systems can often be used for multiple purposes, including infrastructure and forest condition mapping and burned area assessment. Unless specifically stated by the vendor, a qualified analyst is required to create the desired data products. Possible platforms are fixed-wing aircraft or helicopters.

Figure 8— An example of a private sector, type 2 aircraft and its sensor.

Figure 9—A FLIR system mounted on a fixed-wing aircraft.
Source Lassen National Forest.

Type 3

These systems are valuable for close-in IR viewing, coupled with visual observation and judgment by on-the-scene fire managers. Type 3 systems are very useful for fire-line mapping and mop-up operations. Because these systems are gimbaled mounted, they can typically view an object from multiple angles, thus detecting heat that may elude nadir-mounted systems. Type 3 systems are generally mounted on helicopters that travel with their own processing centers but a few are mounted on fixed winged aircraft.

Table 3 classifies IR venders by these three types. These vendors have voluntarily submitted their information through RFI-51-03-018. This information has been checked for technical feasibility by NIROPS and RSAC staff. This list of vendors does not constitute an official evaluation, conclusion, recommendation, endorsement, or approval by the Forest Service of any product or service to the exclusion of others that may be suitable.

Table 3—Infrared Vendors Listed by Type

Type	Company Name	Thermal Bands	Mount	Hourly Acquisition Rate (Acres per hour)	Fire Experience	Platform(s)	Georectified Products	Page
I	**USDA-FS National Infrared Operations**	2	Nadir	750,000	Yes	BE200, Cessna Citation Bravo	Yes	12
	USDA-FS PSRS, Riverside Fire Lab	3	Nadir	155,000	Yes	PA31-310	Yes	12
	Sky Research Inc	2	Nadir	500,000	Tests	Cessna 208 Caravan	Yes	12
	EarthData International of Maryland, LLC	2	Nadir	300,000	No	Various	Yes	13
2	**Airborne Data Systems**	1	Nadir	96,000	Yes	Piper Navajo, Seneca	Yes	14
	Blue Skies Consulting, LLC	2	Nadir	30,000	No	Cessna T210N, Antonov AN-2P	Yes	14
	Range and Bearing Corporation	1	Nadir	30,000	Yes	Piper Navajo Chieftain	Yes	14
	SennaBlue LLC	1	Nadir	15,000	Yes	PA31-310 Navajo	Yes	15
	VeriMARC PLUS Inc	1	Nadir	22,000	Tests	Cessna 337	Yes	15
3a	**Angiel EnviroSafe, Inc**	1	Nadir	5,600	No	Piper Aztec	Yes	16
	Fireball Information Technologies, LLC	1	Gimbaled	9,400	Yes	Bell 206 Jet Ranger	Yes	16
	Mid-Valley Helicopters	1	Gimbaled	9,600	Yes	Bell 206B3 Jet Ranger	Yes	16
	San Joaquin Helicopters	1	Gimbaled	12,000	Yes	Bell 206B3 Jet Ranger	Yes	17
	Ventura County Sheriff Aviation Unit/SAR	1	Gimbaled	26,000	Yes	MD 530F or UH-1H	Yes	17
	Vision Air Research	1	Gimbaled	20,826	Tests	Cessna 206, PA-31-310 Navajo	Yes	17
3b	**Helicopter Applicators Incorporated**	1	Gimbaled	500	Yes	Bell 206 Jet Ranger	Yes	18
	Oilton Remote Detection Technologies (ORD-TECH)	1	Gimbaled	640	No	Bell 206 Jet Ranger	Yes	18
3c	**Advanced Building / M.I.R.S**	1	Hand	2,000	Yes	Various	Yes	19
	John Newman (I R Mapping)	1	Hand	900	Yes	Various	Yes	19

Type 1 Systems Contact Information

Company Name	**USDA-FS National Infrared Operations**
Mailing Address	3833 S. Development Ave., Boise, ID 83705
Primary Contact	Darrel VanBuren
Telephone	208.387.5647
Fax	208.387.5560
Email Address	jvanburen@fs.fed.us
Website	http://nirops@fs.fed.us
Emergency Contact	208.859.4475
General Sensor Description	Phoenix Dual Channel Line Scanner

COST: Aircraft: $485-685 per hour. An IR interpreter needs to be assigned at a cost of roughly $500 per day.

REMARKS: The National Infrared Operations group has been flying IR mapping and detection missions since 1966. The group operates several dual-channel line scanners that have been upgraded throughout the years. Its latest version, Phoenix, is capable of producing georeferenced digital products in either .gif or .tiff format. Trained interpreters are able to help create GIS products for an incident. Two types of down-linking equipment will also be available for use this year.

Company Name	**USDA-FS PSRS, Riverside Fire Lab**
Mailing Address	4955 Canyon Crest Dr., Riverside, CA 92507
Primary Contact	Robert Lockwood
Telephone	909.680.1535
Fax	909.680.1501
Email Address	rlockwood@fs.fed.us
Website	www.fireimaging.com
Emergency Contact	27/7 909.315.0181
General Sensor Description	Space Instrument FireMapper

COST: Aircraft: $500 per hour. An image processor also needs to be assigned at a cost of roughly $500 per day.

REMARKS: FireMapper is a research and development project funded by the National Fire Plan and managed by the USDA Forest Service, Region 5. It is dispatched by the south zone coordination center. FireMapper imagery depicts color-coded surface temperatures, which are readily interpretable as fire intensity or activity, on a geo-registered, shaded, relief map. Major fire lines are also shown in 3D on a topographic relief view.

Company Name	**Sky Research Inc**
Mailing Address	445 Dead Indian Memorial Rd., Ashland, OR 97520
Primary Contact	Sue Gray
Telephone	541.482.7603 ext. 105
Fax	541.488.4606
Email Address	sue.gray@skyri.com
Website	www.skyri.com
Emergency Contact	Sky or Anne Sky 541.448.1333
General Sensor Description	AIRDAS

COST: Ferry: $1,680 per hour. Operations: $2,200 per hour (minimum 3 hours per day). A qualified IR interpreter is also needed at a cost of roughly $500 per day.

REMARKS: Sky Research provides operation management, consulting services, and aircraft modifications for organizations involved in emerging remote sensing technologies. Sky Research operates the Airborne Infrared Disaster Assessment System (AIRDAS), a four-channel line scanner designed and built by NASA-Ames Research Center, Moffett Field, CA. This scanner is designed to map and monitor wildland fires and other natural and man-induced disasters. The AIRDAS output is similar to the images produced by the NIROPS Phoenix and can be readily interpreted by interagency IR interpreters.

Company Name	**EarthData International of Maryland, LLC**
Mailing Address	45 West Watkins Mill Rd., Gaithersburg, MD 20878
Primary Contact	Robert C. Barnard
Telephone	301.948.8550
Fax	301.963.2064
Email Address	cbarnard@earthdata.com
Website	www.earthdata.com
Emergency Contact	24/7 301.529.6312
General Sensor Description	ABS Airborne Bispectral Scanner / AMS " Multispectral"

COST: Mobilization: $9,705. Rate: $5,955 per day. Flight: $805 per hour.

REMARKS: The line scanner that the EarthData and SenSyTech team operates is almost identical to the Daedalus ABS 3500 system that has been operated by NIROPS since the early 1990s. Therefore, the data products will be identical to those produced by the Daedalus system. An infrared interpreter will need to be ordered.

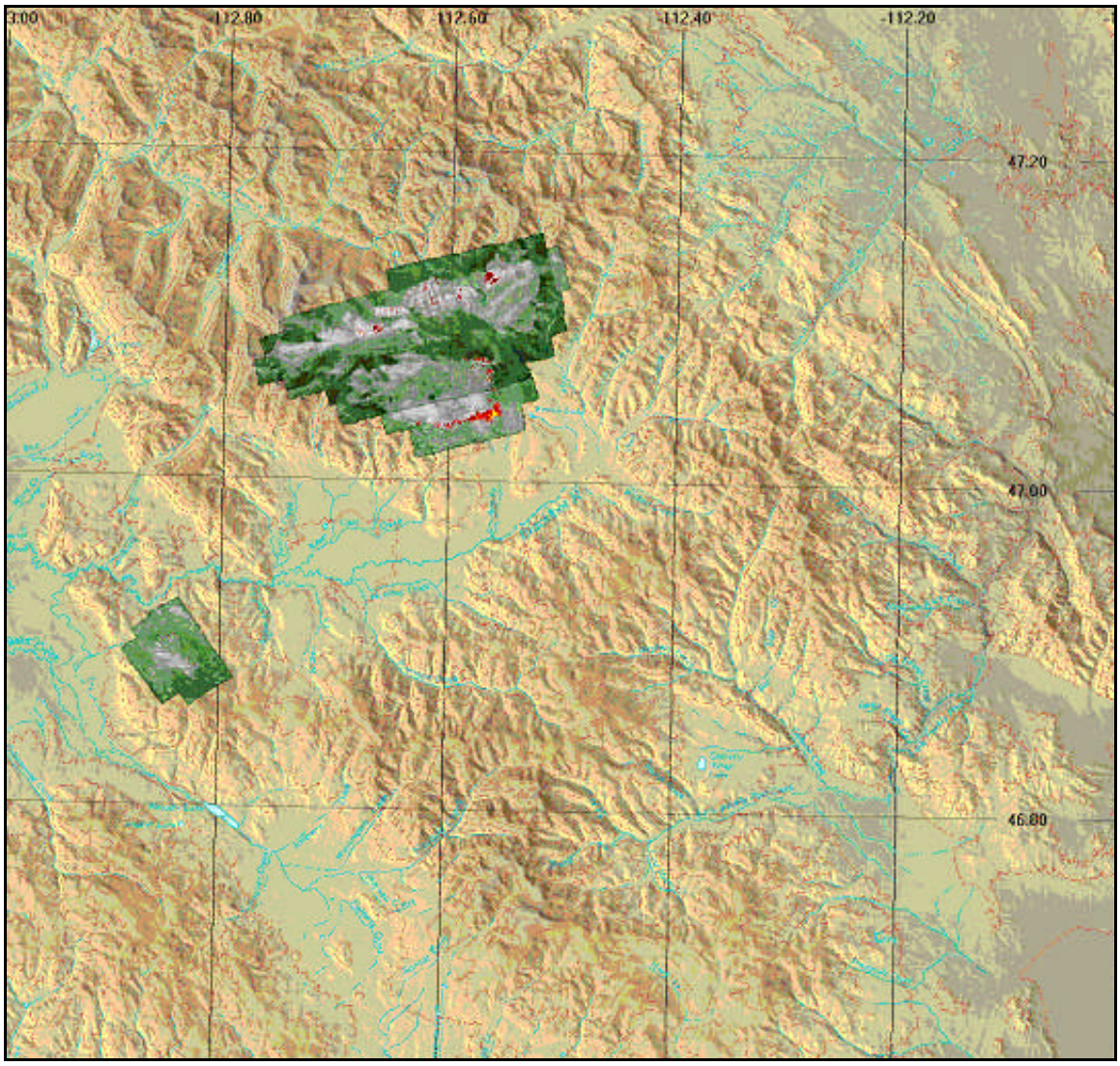

Figure 10—This image shows the use of a type 1 system to detect and map heat sources over a large area. Imagery is from the USFS FireMapper over the North Lincoln Complex in September, 2003. Image courtesy Pacific Southwest Research Station.

Type 2 Systems Contact Information

Company Name	**Airborne Data Systems**
Mailing Address	25338 290th St., Wabasso MN 56293
Primary Contact	David Fuhr
Telephone	507.984.5419
Fax	507.984.3150
Email Address	dfuhr@airbornedatasystems.com
Website	www.airbornedatasystems.com
Emergency Contact	David Fuhr, 507.984.5419
General Sensor Description	Airborne Data Systems Spectra-View

COST: Ferry: $375 - $495 per hour. Operations: $675 - $775 per hour. Additional equipment and processing personnel: $2,000 per day.

REMARKS: Airborne Data Systems' sensor creates five-band, multi-spectral, digital, ortho-rectified mosaics. Visible bands can be used to map infrastructure, and the NIR band is useful for mapping forest condition, fuel load, or moisture content. The thermal band creates a map of fire line hot spots. This data can be viewed as color, color IR with thermal overlays, or individual bands. Data can be used digitally when imported into GIS software, or printed using a printer or plotter.

Company Name	**Blue Skies Consulting, LLC**
Mailing Address	P.O. Box 19012, Albuquerque, NM 87119
Primary Contact	Tami Wiggins
Telephone	505.842.8555
Fax	505.842.8555
Email Address	tami@blueskies.aero
Website	www.blueskies.aero
Emergency Contact	(D) 505.842.8555, (E) 505.301.4040, (N) 505.857.9968
General Sensor Description	Multiple (LIDAR, CIR Camera, Hyperspectral Sensor)

COST: The cost for the system is $800 per day, plus per diem for the crew, plus $550 per hour flight time. Total roughly $4,000 - $5,000 per day.

REMARKS: This operation is a collaboration of three firms: Blue Skies Consulting, EnerQuest, and Kestrel Corporation. The collaboration operates an IR system in the 3 - 5 and 8 - 12 micron range. The equipment is mounted in a fixed-wing aircraft and can produce highly accurate, ortho-referenced, GIS-ready polygon and point files that represent the fire perimeter and/or hot spots. Data can be down-linked to technicians, air-dropped, or hand-delivered. Hardcopy maps and color and IR imagery can also be provided if requested.

Company Name	**Range and Bearing Corporation**
Mailing Address	3747 Privateers Rd., Pender Island, B.C. V0N 2M2 CANADA
Primary Contact	Doug Cambell
Telephone	250.629.3447
Fax	250.629.3557
Email Address	doug@range-bearing.com
Website	http://207.102.122.235/awisweb/index.htm
Emergency Contact	24/7 604.816.6655
General Sensor Description	AWIS

COST: Standby: $3,695 per day. Flight: $468 per hour. Processing: $2,540 per hour.

REMARKS: The Range and Bearing Corporation has performed fire management work in Alberta since 1999. Products are delivered via a secure website or through FTP (file transfer protocol). Products are in ESRI GIS format and include perimeter and hot spot images, tractor lines, and GPS-formatted file locations. Also included is a proprietary hot spot rating tool that ranks hot spots on their escape potential. Escape potential is calculated using a spatial model that considers fire behavior indices, proximity to perimeter, proximity to volatile fuels, values at risk, etc. A three dimensional visual fly-through is also available.

Company Name	**SennaBlue LLC**
Mailing Address	2211 NE 21st, Portland, OR 97212
Primary Contact	Scott Allen
Telephone	1.866.338.0476
Fax	250.760.0002
Email Address	sallen@sennablue.com
Website	www.sennablue.com
Emergency Contact	27/4 1.866.338.0476
General Sensor Description	Long-wave, fully digital, thermal frame imager

COST: Standby: $3,700 per day. Acquisition: $4,380. Flight: $340 per hour.

REMARKS: SennaBlue uses a fixed-wing aircraft to fly over a fire with a single-band (8 - 9 micron) sensor in a nadir position. Aircraft are subcontracted, USFS-carded Piper Navajo and are equipped with a pilot and mechanic within the stated costs. Their primary product is a thermal image mosaic with hot spots highlighted. Fire perimeter and hot-spot location data is also available for incorporation into GIS. Hot-spot coordinates (Universal Traverse Mercator[UTM]/Latitude Longitude) are provided for input into GPS. All products can be delivered to the incident command post electronically through e-mail, FTP, or a secure website. Hardcopies can also be delivered.

Company Name	**VeriMARC PLUS Inc**
Mailing Address	4100 Airport Rd., Raymond, MS 39154
Primary Contact	David Stonehouse
Telephone	601.857.8197
Fax	601.857.8177
Email Address	david s@verimap.com
Website	www.verimap.com
Emergency Contact	24/7 403.606.0412
General Sensor Description	Misitubishi IR-M700, Kodak CIR, Profile LIDAR

COST: Ferry: $650 per hour. Standby: $4,520 per day. Acquisition: $2,395.

REMARKS: VeriMARC utilizes a multisensor system that consists of a thermal imager, a digital camera, and a LIDAR (light intensity detection and ranging). Horizontal accuracy is +/- 1 meter because the imagery is rectified to a digital evaluation terrain model developed from the LIDAR returns. The imagery sets are fully ortho-rectified and tiled. Imagery can be processed on board the aircraft or onsite by the vendor. The false-color, post-burn analysis is a larger file size and takes an additional day for processing.

Type 3a Systems Contact Information

Company Name	**Angiel EnviroSafe, Inc**
Mailing Address	43 Angiel Ln., Saugerties, NY 12407
Primary Contact	Pierre Angiel
Telephone	786.897.5562
Fax	N/A
Email Address	Pierreangiel@aol.com
Website	www.angielenvirosafe.com
Emergency Contact	786.897.5562
General Sensor Description	Daedalus ABS Bispectral scanner

COST: $4,000 per 5-hour day plus expenses.

REMARKS: Angiel EnviroSafe uses the Daedalus Airborne Bispectral (ABS) imager mounted in the camera hole of a Piper Aztec twin-engine airplane. This unit is similar to the Daedalus units (now used as backup for the Phoenix systems) used by the NIROPS except that the ABS unit presently uses only one thermal band (8 - 12 micron).

Company Name	**Fireball Information Technologies, LLC**
Mailing Address	1240 Fairfield Ave., Reno, NV 89509
Primary Contact	Tim Ball
Telephone	755.848.4462
Fax	775.328.0694
Email Address	info@fireballit.com
Website	www.fireballit.com
Emergency Contact	24/7 775.848.4462
General Sensor Description	Wescam 12-DS90

COST: Flight: $491 per hour. System: $7,172 per day.

REMARKS: Fireball's IR and visible imagery is geo-referenced and ortho-rectified. IR overlays detailing hot spots and GPS coordinates for use by mop-up crews are also available. Video recordings (both IR and TV) of the flights are available. Digital data can be delivered through Fireball's FTP site or one of the dedicated fire FTP sites. When line-of-site communication is in place, data on location and intensity of heat sources can be viewed on the ground in real time.

Company Name	**Mid-Valley Helicopters**
Mailing Address	P.O. Box 993, Jefferson, OR 97352
Primary Contact	Jill Johnson
Telephone	541.327.1169
Fax	541.327.2910
Email Address	jill@ramsystemsllc.com
Website	www.ramsystemsllc.com
Emergency Contact	Jill Johnson, 541.327.1169, 541.327.2910
General Sensor Description	Agema 1000 Radiometric Infrared

COST: Aircraft availability: $1,960 per day. Flight: $500 per hour. Camera: $2,500 per day. Trailer: $2,500 per day.

REMARKS: Mid-Valley Helicopters operates a Radiometric Airborne Mapping (RAM) system. This system has been developed by RAM Systems Incorporated and sold to several IR mapping vendors throughout the United States. The RAM system is set for a specific heat index on the ground, giving it the capability of discriminating between burning wood, hot rock, cars, etc. RAM systems come with a GIS support trailer that can create map products from the IR data. Also, a data down-link system will be available this year.

Company Name	**San Joaquin Helicopters**
Mailing Address	1407 S. Lexington St., Delano, CA 93215
Primary Contact	Jay Koch
Telephone	916.966.8181
Fax	916.354.0547
Email Address	jkoch76@hotmail.com
Website	www.hhcopters.com
Emergency Contact	916.715.3570
General Sensor Description	FLIR Systems Model 2000AB

COST: Flight: $497 per hour. Standby: $1,650. Trailer: $5,350 per day.

REMARKS: San Joaquin operates a FLIR system. The equipment is capable of producing geo-referenced, panchromatic IR photos, GIS-ready polygon and point files representing fire perimeters, and hot spots and hardcopy GIS-generated map products. The GIS-created maps have thumbnail versions of the geo-referenced panchromatic IR imagery located on a USGS 1:24,000 topographical base map. Digital information, including the video frame “grab” imagery, is copied to CD and hardcopy maps and photos, or can be provided over a LAN (local area network) as e-mail.

Company Name	**Ventura County Sheriff Aviation Unit/SAR**
Mailing Address	375 Durley Ave. #A, Camarillo, CA 93010
Primary Contact	Captain Arve Wells
Telephone	805.338.4212
Fax	805.338.4380
Email Address	Arve.Wells@mail.co.ventura.ca.us
Website	fire.countyofventura.org/Services/Mapping/mapping.html
Emergency Contact	24/7 805.654.5161
General Sensor Description	FLIR Mark II IR & color video system

COST: Approximately $400 per day, plus per diem for crew, plus $1.47 per mile (fuel tender), plus $734 x Hobbs flight time.

REMARKS: Ventura County operates a FLIR system that views energy in the 8 - 12 micron range. The equipment is capable of producing IR and color videos, and GPS-generated, GIS-ready polygon and point files representing fire perimeter and hot spots. The GPS-created data is differentially corrected; the system records the location of the helicopter as it flies over the fire. Digital information, including video, can be down-linked to technicians, air-dropped, or hand-delivered. Color and infrared imagery can also be provided if requested.

Company Name	**Vision Air Research**
Mailing Address	904 E. Washtington St., Boise, ID 83712
Primary Contact	Susan Bernatas
Telephone	208.841.9566
Fax	208.345.0595
Email Address	wildlife@visionairresearch.com
Website	www.visionairresearch.com
Emergency Contact	24/7 208.841.9566
General Sensor Description	PolyTech Kelvin 350 II

COST: Ferry: $250 - 400 per hour. Acquisition: $275 - 575 per hour. Sensor support: $1,850 - 2,500 per day.

REMARKS: This system includes a SONY video camera and a Thermovision (an infrared radiometer). Output includes both color and infrared video in analog or digital videotape. The video includes an overlay of the GPS data. The Vision Air collects frame-by-frame data at up to one frame per second in an on-board computer. This computer has the capability to geo-rectify the data frame by frame. The geo-referenced mosaics can be incorporated into a GIS data product.

Type 3b Systems Contact Information

Company Name	**Helicopter Applicators Incorporated**
Mailing Address	1670 York Rd., Gettysburg, PA 17325
Primary Contact	Jason Cole
Telephone	717.337.1370
Fax	717.337.1527
Email Address	jcole@helicoperapplicators.com
Website	www.helicopterapplicators.com
Emergency Contact	Glen Martin, 8AM - 5PM EST 717.337.1370
General Sensor Description	FLIR Thermovision 1000 Radiometric Infrared Camera System

COST: Flight: $497 per hour. Aircraft Availability: $2,100. Trailer: $5,000 per day.

REMARKS: Helicopter Applicators operates a RAM system similar to the one used by Mid-Valley Helicopters.

Company Name	**Oilton Remote Detection Technologies (ORD-TECH)**
Mailing Address	1821 University Ave. W, Suite N-461, St. Paul, MN 55104
Primary Contact	Zeno Leier
Telephone	651.646.5747
Fax	651.646.5303
Email Address	Oilton@aol.com
Website	N/A
Emergency Contact	8AM - 5PM CST, 651.646.5747; then 763.550.1956
General Sensor Description	Airborne Infrared Detection System (AIRDS)

COST: $17,000 per day.

REMARKS: AIRDS is a gimbaled, thermal infrared sensor filtered to the 8 - 14 micron wavelength. ORD-TECH has developed and successfully demonstrated AIRDS technology for both surface and buried unexploded ordnance, as well as petroleum product contamination. Oilton uses EL Aero of Elko, NV, for its fire contract ships. This system utilizes on-board Differential Global Positioning System (DGPS) and a laser ranging system for calculating the positions of hot spots. The AIRDS system is also equipped with digital line-of-site communication for real-time image downloading.

Figure 11—FLIR system display of a fire (black areas).

Type 3c Systems Contact Information

Company Name	**Advanced Building/M.I.R.S**
Mailing Address	2810 Highway 32, Chico, CA 95973
Primary Contact	Dave Chaplin
Telephone	530.895.1836
Fax	530.895.1741
Email Address	chaparelli24@aol.com
Website	www.Moble-IR.com
Emergency Contact	Dave Chaplin, 530.321.6445
General Sensor Description	Raytheon IR 400DX Pro

COST: $2,500 per day, plus the cost of call-when-needed aircraft.

REMARKS: This system can operate on any aircraft with a 3-pin or 2-pin power connector; however, helicopters are the preferred platform. The system provides a view of the fire's perimeter overlaid over a USGS 1:24,000 topographical map for hot spots within 300 feet of the fire perimeter. Also included are infrared photos, a correlating natural color photo with GPS/ time/date information on the photo, and a 7 - 10 second IR video for each hot spot.

Company Name	**John Newman (IR Mapping)**
Mailing Address	P.O. Box 391, Kernville, CA 93238
Primary Contact	John Newman
Telephone	760.376.2861
Fax	760.376.2861
Email Address	johnlinda@lightspeed.net
Website	N/A
Emergency Contact	24/7 760.549.3292
General Sensor Description	Raytheon Digital PalmIR 250

COST: $1,750 per day, plus the cost of call-when-needed aircraft.

REMARKS: IR Mapping uses a Raytheon Digital PalmIR 250 camera. IR Mapping maps a fire's perimeter location and hot spots using GPS. After landing, perimeter and hot spot information are printed on USGS maps and delivered to the incident management team. IR Mapping relies on the incident management team to provide the aircraft. The equipment can be mounted in a helicopter already assigned to the incident.