County of Los Angeles
CHIEF EXECUTIVE OFFICE
Kenneth Hahn Hall of Administration
500 West Temple Street, Room 713, Los Angeles, California 90012
(213) 974-1101
http://ceo.lacounty.gov

WILLIAM T FUJIOKA
Chief Executive Officer

1/12/10 #8
Final Report

May 7, 2010

To: Supervisor Gloria Molina, Chair
Supervisor Mark Ridley-Thomas
Supervisor Zev Yaroslavsky
Supervisor Don Knabe
Supervisor Michael D. Antonovich

From: William T Fujioka
Chief Executive Officer

FIRE EARLY RESPONSE AND DETECTION SYSTEM – (ITEM NO. 8, AGENDA OF JANUARY 12, 2010) – REPORT

As directed by your Board, The Quality and Productivity Commission (Commission) is pleased to report that it has completed its study of automated early detection and rapid all weather 24-hour response systems to suppress forest and brush fires.

The Commission found there are options available for early detection of fires and opportunities for pilot tests in Los Angeles County including surveillance satellite and ground-based sensor technology systems. To improve firefighting capability, updated helicopter avionics technology and an automated vehicle locator system are available options for rapid fire suppression. Lastly, a common set of rules of engagement for suppressing fires in the extended wildland urban interface is highly needed.

Based on research, interviews, presentations, and analysis of information, the Commission recommends the Board consider the following four recommendations in an effort to improve early detection, rapid all weather 24-hour response, and suppression of wildland fires:

Recommendation 1: Partner with federal agencies in a pilot program to evaluate the ability of the Advanced Hazard Support System employing satellites for early detection and location of wildland fires.

Recommendation 2: Task the Los Angeles County Fire Department to carry out a field test of ground-based visual surveillance cameras and infrared detection sensors to identify suitable technology that meets our geographic and operational needs.

Recommendation 3: Charge the Los Angeles County Fire Department to evaluate improved avionics and Automated Vehicle Locator system for improved rapid suppression of fires.

Recommendation 4: Create a task force consisting of all fire agencies in Los Angeles County to agree on one common set of rules of engagement for suppressing fires in the extended wildland urban interface.

While the existing personnel, procedures, and equipment available to the Los Angeles County Fire Department provide a solid base for suppression of wildland fires, the Commission believes these recommendations will assist the County in optimizing its efforts to provide improved detection, response, and rapid suppression of wildland fires.

If you have any questions or require additional information, please have your staff contact Deputy Chief Executive Officer, Ellen Sandt at (213) 974-1186 or esandt@ceo.lacounty.gov or they may also contact Ruth Wong at (213) 974-1361 or rwong@ceo.lacounty.gov.

WTF:ES
RW:cg

Attachment

c: Chief Information Office
Executive Office, Board of Supervisors
Fire
Internal Services

Wildland Fires

Automated Early Detection
and
Rapid All-Weather 24-Hour Response

A Report by
County of Los Angeles
Chief Executive Office
Quality and Productivity Commission

May 2010

THE LOS ANGELES COUNTY
CHIEF EXECUTIVE OFFICE
QUALITY AND PRODUCTIVITY COMMISSION

***Board Study Working Group*:**

Commissioner Algird Leiga Ph.D., Chair
Commissioner Viggo Butler
Commissioner Ron S. Galperin, Esq.
Commissioner William A. Sullivan, Esq.
Commissioner William C. Waddell, DBA
Assistant Fire Chief Jim Crawford, Fire Department
Mark Greninger, Chief Information Office
Emily Sipchen, Coro Fellow
Ruth A. Wong, Executive Director

Special Thanks to:

Dennis Akers, *Wildland Detection Systems*
Robert Baer, Arizona State University – School of Public Affairs, Alliance for Innovation Intern
Todd Edwards, Montecito Fire District
Chief P. Michael Freeman, Los Angeles County Fire Department
Jerry Goss, *Flame Sniffer,* Wildfire Early Warning System
Ralph Gonzalez, U.S. Forest Service
Kevin Guerrero, CAL FIRE Headquarters, Sacramento
Jerry Henry, *SANDEL Terrain Awareness Warning Systems*
Everett Hinkley, U.S. Forest Service
Graham Kent, *Fire Guard*, University of Nevada, Reno
Jonathan Luck, *Ambient Control Systems*
Bruce Molnia, National Geospatial Intelligence Agency
Dee Pack, Aerospace Corporation
Brian Schwin, U.S. Forest Service
Frank Vernon, *Fire Guard*, University of California, San Diego
Ben Wong, *Southern California Edison*
Nancy Yang, Internal Services Department

Quality and Productivity Commission

Algird Leiga, Ph.D., Chair
Jacki Bacharach
Viggo Butler
Ron Galperin, Esq.
Evelyn Gutierrez
Nancy Harris
Jaclyn Tilley Hill
Patricia D. Johnson
Jeanne Kennedy
Huasha Liu
Gerald Nadler, Ph.D.
Robert Sax, M.D.
William Sullivan, Esq.
Bud Treece
Irshad Ul-Haque
Joseph P. Wetzler
William Waddell, DBA

Executive Staff

Ruth A. Wong, Executive Director
Mary Savinar, Program Manager
Peter Papadakis, Program Support

Early Fire Detection and Rapid Response
Table of Contents

Early Detection of Wildland Fires and Rapid Response

Executive Summary

Working Group Conclusions

Technology currently exists to provide 24-hour, automated, early detection and precise location of wildland fires in remote areas. Technologies include a satellite system as well as ground-based camera and infrared sensors. Incremental technology improvements can add to the Los Angeles County Fire Department's capability of rapid response and fire suppression. Avionics technology exists to provide improved 24-hour ability for helicopters to fly to any fire location by the most direct route with accurate terrain guidance and direction.

Summary Recommendations

1.) Surveillance Satellite Technology

Recommendation

- Partner with Federal agencies in a pilot program to evaluate the Advanced Hazard Support System employing satellites for early detection and location of wildland fires.

2.) Ground Based Sensor Technology

Recommendation

- Task the Los Angeles County Fire Department to carry out a field test of ground-based visual cameras and infrared sensors to identify suitable technology that meets the County's geographic and operational needs.

3.) Rapid Fire Suppression

Recommendation

- Charge the Los Angeles County Fire Department to evaluate improved helicopter avionics and an updated Automated Vehicle Locator system for improved rapid response and suppression of fires.

4.) Coordination with all Agencies

Recommendation

- Create a task force consisting of all fire agencies in Los Angeles County to agree on one common set of rules of engagement for suppressing fires in the extended wildland urban interface.

Study Summary

The County of Los Angeles Board of Supervisors on January 12, 2010 directed the Quality and Productivity Commission to: "Study and present solutions for establishing an automated early detection system and rapid, all weather, 24-hour response system to suppress forest and brush fires at the source, and report back to the Board in 120 days."

The Commission formed a Board Study Working Group (Working Group) including Commission members, a County of Los Angeles Assistant Fire Chief, and a representative from the Chief Information Office. The Working Group initially examined available databases, contacted key fire professionals and identified national and international commercial vendors for suitable early fire detection systems and equipment for rapid suppression response. Available early detection technologies identified include ground-based sensors, manned and unmanned airborne surveillance, and satellite technologies. Interviews of experts and presentations by commercial vendors identified the advantages and limitations of each system.

The *Advanced Hazard Support System* using satellite surveillance is an important option for early detection of fires. This system would use data from geosynchronous satellites operated in support of national defense. Discussions with federal agencies identified an opportunity for civilian applications of the infrared data stream from these satellites, including automated early detection and precise location of wildland fires. The detection system was successfully tested in Los Angeles County during the early 1990s, but the test was suspended after one year because of funding constraints. This system currently represents an opportunity for a pilot project in Los Angeles County for early detection of fires throughout the extended Los Angeles County wildland urban interface without the need for expensive ground installations.

Other available satellite systems, geared to weather data and other uses, sample any one geographic location infrequently. These systems do not have adequate image resolution to provide early detection or satisfactory location of a fire. Manned and unmanned aircraft are useful in selected applications, but data sampling frequency limits their capacity for early detection.

Multiple vendors are available for ground-based sensor systems capable of automated fire detection and location of fires. Most systems use visual surveillance cameras coupled with smoke or flame pattern recognition software, while others employ infrared sensor technology. Ground-based systems are an effective alternative to a satellite system for early detection and location of fires, but the number of equipment placements could be extensive in Los Angeles County because of area size and the rugged terrain. Testing under field conditions will be needed to make a choice between visual surveillance and infrared technology sensor placements.

When a fire is detected, the Los Angeles County Fire Department has the capability to rapidly respond and suppress wildland fires under all conditions. A fire retardant carrying helicopter can arrive at a fire in 10 to 15 minutes and could arrive at the farthest end of the County in 20 to 25 minutes. To improve helicopter capability, the Working Group identified an added avionics terrain awareness and warning system that could improve all-weather 24-hour rapid fire suppression response. In addition, for ground based assets, updating *Automated Vehicle Locator* technology will help to send the closest vehicle to the fire.

The various fire suppression agencies within Los Angeles County have rules of engagement that are consistent with their mission. However, one common set of rules within the extended wildland urban interface needs to be negotiated to assure rapid suppression of a detected fire before it has the potential to cause extensive damage to urban areas.

Early Detection of Wildland Fires and Rapid Suppression Response

I. BOARD CHARGE TO THE COMMISSION

The Quality and Productivity Commission on January 12, 2010 was directed by the County of Los Angeles Board of Supervisors to study and present solutions for establishing an automated early detection system and rapid, all weather, 24-hour response system to suppress forest and brush fires at the source.

In his motion to conduct the study, Supervisor Michael D. Antonovich stated: "The recent massive and destructive Station Fire cost local Taxpayers $89 million to fight and millions more in infrastructure recovery costs. Tragically, two Los Angeles County firefighters, Fire Captain Ted Hall and Fire Fighter Specialist Arnie Quinones, lost their lives trying to protect their fire suppression camp headquarters during the fifth day of this fire. The Station Fire graphically spotlights the need to study and identify solutions for establishing an automated early detection system and rapid, all weather, 24-hour response system to suppress forest and brush fires at the source."

For purposes of this report, we will refer to forest and brush fires as wildland fires. Wildland fires require firefighting techniques, equipment, and training different from those used in urban areas. In the wildland urban interface, where residential structures are adjacent to or intermixed with native brush or timber vegetation, special fire suppression precautions are needed to prevent loss of life or property.

II. WILDLAND FIRES IN LOS ANGELES COUNTY

Every year, wildland fires in Los Angeles County threaten lives, homes, and natural resources. In the past several years, wildland fires have burned hundreds of thousands of acres, destroyed hundreds of homes, and taken lives within the County. These fires dramatically impact not only the land burned, but also the quality of life of communities, the stability of local economies and the environment, including air quality. The mudslides and flooding caused by the El Nino rainstorms in the foothill communities in the early months of 2010 can be directly attributed to the damage left behind by the Station Fire in 2009. The overall costs associated with wildland fires rise into the hundreds of millions of dollars, as recovery efforts add to the already substantial costs of fire suppression.

Most wildland fires in Los Angeles County ignite from three main sources: downed power lines, arson or accidental ignition. They often begin near roadways. Given their locations, most fires are spotted by the public very soon after they start and are reported to a local 911 dispatcher. In those cases, early detection and response by the appropriate firefighting agency is rapid.

In Los Angeles County, the threat of ignition and spread of wildland fires increases with certain environmental factors: relatively low humidity, an abundance of fuel (dry vegetation), high temperatures and high winds. These factors are most severe during the heightened fire season of the late summer and early fall when the Santa Ana winds occur. The vast expanses of wilderness in the County, including the Angeles National Forest, the Santa Monica Mountains Recreation Area, Catalina and San Clemente Islands, and Griffith Park, are especially vulnerable to wildland fires. Historically, for much of this open space, fires have burned as part of the natural ecosystem. Map I in the Appendix identifies the extensive fire hazard severity zones that pose risks in Los Angeles County. During the heightened fire season, a fire anywhere in the high fire severity zones could quickly spread to the wildland urban interface if suppression is delayed. As a result, the view of the wildland urban interface as a narrow band needs to be reconsidered. The interface should be viewed as an extended region encompassing a broad area where a fire could spread rapidly and destroy homes and property. Unless fires are rapidly suppressed in this extended wildland urban interface, communities and structures in Los Angeles County will be at a heightened risk of destruction.

Southern California as a whole shares the same wildland fire threat as Los Angeles County. As fires over the past several years have demonstrated, wildland fires cross county borders and encroach on a number of fire agencies' jurisdictions. Los Angeles County shares borders with Ventura, Kern, San Bernardino, Riverside and Orange Counties, all of which contain high-risk wildland fire areas. Within Los Angeles County, the Los Angeles County Fire Department (LACoFD), the U.S. Forest Service (Forest Service), and city fire departments respond to wildland fires in their respective jurisdictions. As the fire crosses from one jurisdiction to another, the firefighting agency with responsibility for that jurisdiction assumes the lead and manages the response according to their rules for suppression. Since a fire has the potential to spread rapidly, to protect property and lives within Los Angeles County, wildland fires in neighboring jurisdictions must be detected early and suppressed quickly.

Some of the most destructive fires in recent years began at night when few people were awake to report them. Others began in remote and relatively low-risk areas but spread to threaten urban areas. More effective early detection and rapid response capabilities will provide the LACoFD and other coordinating fire agencies with another valuable tool to combat and ultimately prevent the growth of wildland fires ignited within the County and neighboring communities. Every wildland fire that is quickly contained translates to saved lives, homes, and assets.

Past Wildland Fires and Damages

Every year, wildland fires ignite in Los Angeles County. Fortunately, the majority are extinguished before causing any major damage. These results demonstrate the successful detection and suppression of wildland fires. Still, in every fire season with heightened risk factors, especially Santa Ana winds, wildland fires can grow and consume thousands of acres before they are contained. Often, more than one fire burns at the same time in the County, and firefighting resources must be allocated accordingly. Fires burning in multiple counties simultaneously also impact the distribution of State and National resources to Los Angeles County.

Significant Fires in Los Angeles County 2007-2009

The following information highlights a number of the most significant wildland fires in Los Angeles County from 2007 to 2009. These fires occurred during the heightened fire season when heat, low humidity, and Santa Ana winds were present. The causes of these fires vary, and all were reported by a public 911 call. The Sesnon, Marek and Corral fires either occurred at night or in a remote area. The outcomes of these fires, in particular, might have been mitigated by early detection.

Name	Date	Acres	Cost	Cause
Station Fire	August 2009	160,587	$95,510,000	Arson
Sayre Fire	November 2008	11,262	$13,440,000	Under Invest.
Sesnon Fire	October 2008	14,708	$16,994,000	Power Line
Marek Fire	October 2008	4,824	$ 6,097,000	Under Invest.
Corral Fire	November 2007	4,901	$ 7,133,000	Camp Fire
Canyon Fire	October 2007	4,521	$ 5,800,000	Power Line

Total Suppression Costs of Significant County Fires: **$144,974,000.**

Station Fire

The Station Fire began on August 26, 2009 at approximately 3:30 P.M. in the Angeles National Forest off the Angeles Crest Highway and near the Forest Service ranger station. The cause has been attributed to arson, and a fire accelerant was found at the fire's point of origin. The public detected the fire and called the local 911 dispatcher. The Forest Service began operations as the lead firefighting jurisdictional agency with LACoFD support. The fire was nearly contained by nightfall on the day the fire began. As the lead agency, the Forest Service followed its procedures for suppression. Its rules precluded nighttime aerial water drops, even though LACoFD was capable of nighttime aerial firefighting. The next day the fire continued to spread. By the time of full containment on October 16, 2009, two Los Angeles County firefighters, Fire Captain Ted Hall and Fire Fighter Specialist Arnie Quinones, had lost their lives trying to protect their fire suppression camp headquarters. The fire destroyed 200 structures including 89 residences. Over 160,000 acres (250 square miles) were burned. The Station Fire is the 10th largest in California history and the single largest fire in Los Angeles County history.

Sayre Fire

In November 2008, the Sayre Fire destroyed over 500 mobile homes and over 600 structures (the greatest loss in housing units in Los Angeles County history). The fire was first reported at 10:30 A.M. on the 13000 block of Sayre Street in Sylmar, California. The source of the fire remains unknown. Exceptionally high temperatures, low humidity, abundant dry brush and high winds contributed to the severity and extent of the Sayre Fire. The intensity of the wind at times prevented aircraft from engaging in the fire suppression efforts. Over 10,000 people were asked to evacuate, including patients at Olive View-UCLA Medical Center.

Santa Barbara, Orange and Riverside Counties fought wild land fires at the same time. Governor Schwarzenegger declared a state of emergency in Santa Barbara, Los Angeles, and Orange counties.

Sesnon Fire

The Sesnon Fire, also known as the Porter Ranch Fire, began on October 13, 2008 near the Oil Fields at Oat Mountain after a power line fell on dry brush. The fire spanned Los Angeles and Ventura counties prompting Governor Schwarzenegger to declare a state of emergency. Two other fires burned simultaneously in Southern California, one on the eastern end of the San Fernando Valley (the Marek Fire), and the other in San Diego County.

The Sesnon Fire destroyed 15 residences and 63 outbuildings. Eleven other residences were damaged. A total of 1,377 fire personnel were deployed, and CAL FIRE (The California Department of Forestry and Fire Protection), LACoFD, the Los Angeles City Fire Department, and the Ventura County Fire Department were the responding firefighting agencies.

Marek Fire

The Marek Fire began at approximately 1:58 A.M. the morning of October 12, 2008. The cause remains unknown. Areas impacted over the course of the fire include Little Tujunga, Kagel Canyon and Lakeview Terrace. Over 40 residences and 2 commercial buildings were destroyed.

Corral Fire

The Corral Fire began on November 24, 2007 at approximately 3:30 A.M. as a result of a camp fire in the Malibu area. The incident occurred during a period of high winds and low humidity. Roughly 1,750 firefighters, 45 fire engines, 23 water-dropping helicopters and two fixed-wing aircraft engaged in the suppression effort. The Corral Fire was the only fire burning in Los Angeles County or the surrounding counties at the time, which allowed more resources to be directed to Malibu. In all, 49 homes were destroyed, and another 27 were damaged. Two outbuildings were also destroyed.

Canyon Fire

The Canyon Fire began on October 21, 2007 at 4:50 A.M. in the Malibu Canyon area as a result of a downed power line. Fourteen residences were damaged or destroyed, and another eight structures were destroyed.

III. CURRENT WILDLAND FIRE DETECTION AND RESPONSE

This section addresses fire detection and response capabilities in Los Angeles County, in other parts of the United States, and around the world.

Los Angeles County Fire Department

The main fire agency for Los Angeles County is the County Fire Department. Other agencies include the Forest Service and city fire agencies. For illustrative purposes, the policies and procedures of the LACoFD will serve to demonstrate the process of fire detection and response in the County.

LACoFD, like most fire agencies, has several methods of receiving notification of a wildland fire. The most common method is a call from a residence, business, cell phone or another public agency (fire, law enforcement, road maintenance, etc.). During the heightened fire season, the LACoFD directs resources to patrol certain areas to quickly detect and respond to wildland fires while they are still small.

There are currently no automated early detection systems in use by LACoFD.

Wildland Fire Response Timeline

Initial 911 Call Received by Jurisdictional Law Enforcement Agency

All 911 calls reporting any type of incident are automatically directed to the law enforcement agency nearest the location of the caller. Caller location is determined by type of device used to call. Calls made on landlines are automatically directed to the local law enforcement agency. Most calls made from cell phones are similarly directed.

Roughly 60% of calls originate from landlines and 40% from cell phones. These percentages may vary for brush fires, as many brush fires are spotted by individuals out in the community.

Calls Directed to Los Angeles County Fire Department

Calls reporting an incident that fall under LACoFD jurisdiction (as determined by information gathered from the caller) are redirected to the LACoFD Command and Control Communications Center. These calls are often initially routed to the Sheriff's Department and then rerouted to LACoFD.

The length of time that a call remains with the local dispatcher before it is transferred to the appropriate fire department is not known by LACoFD. The amount of information that the local dispatcher collects before determining the proper agency to address the incident is also unknown by LACoFD; however, it likely includes at a minimum the type of call (fire, paramedics, police request, etc.) and a confirmation of contact information. The 911 dispatcher takes the information from the caller and alerts the appropriate firefighting agency.

Once a call is directed to LACoFD, the goal is to dispatch units to respond to the incident within a minute of receiving the call. This may vary under certain circumstances (for example, if the caller does not speak English or if the necessary information is not easily gathered).

Calls Specific to Wildland Fires

Multiple calls often come in on the same fire. In some cases, these may be interpreted as separate occurrences of fires. Calls reporting wildland fires tend to come in at an early stage of the fire, while it is still relatively small. The public's detection time varies depending on certain factors. Specifically, fires that start at night or in more rural areas are less likely to be reported as quickly as those observed in more urban settings during more active hours of the day. Other factors, such as general visibility can also impact fire report times.

LACoFD Evaluates Response Equipment

After the call is taken, the Computer Aided Dispatch (CAD) system at LACoFD Command and Control Center determines what equipment needs to be sent to the incident. The system analyzes 140 different call types (not exclusively wildland fires, but medical calls as well) and matches the type of call to the nearest available and appropriate resources. The dispatcher confirms or modifies the request. For wildland fires, there is a check with a supervisor before units are sent to ensure the proper resources are allocated. The standard response equipment may change according to environmental conditions. The supervisor's check may add an additional 30 seconds to the response time. For wildland fires, the supervisor as a standard sends the First Alarm (resources listed in the table below) or determines equipment need not be sent at all.

Standard Response Level

First Alarm	Second Alarm
7 Engines	5 Engines
1 Patrol	4 Ground Crews
3 Helicopters (2 with crews)	1 Dozer Team
4 Ground Crews	1 Water Tender
1 Dozer Team	1 Construction Superintendent
1 Water Tender	1 Helitender
3 Superintendents	1 Squad
2 Super Scoopers (seasonal)	1 Helitanker
1 Battalion Chief	1 Battalion Chief
	1 Assistant Chief
	2 Fixed Wing & Second Helitanker at Incident Command (IC) Request

A first alarm wildland fire response is a list of those resources pre-designated to respond to a reported incident with the intent of controlling the fire as quickly as possible and minimizing the area burned. It includes a minimum number of each type of firefighting resource necessary for a coordinated fire attack: engines, crews, bulldozers, helicopters and command staff.

A second alarm wildland fire response adds to the number and type of resources responding on the first alarm as shown in the table.

The idea behind first and second alarm standard response levels is that past experience has identified a minimum number of resources to effectively and safely control and extinguish the majority of reported fires. In addition, they provide command staff with a pre-designated list of resources, especially second alarm resources, so that the fire fighters do not have to spend critical time deciding what they may or may not need.

LACoFD Dispatches Equipment

Fire crews and equipment are dispatched using electronic pagers and radio-based voice commands. Units are sent out according to a station's proximity to the reported fire location. Responding ground units navigate to the incident relying on knowledge of the area or by using standard maps. Ground units do not have computer systems on board. Directions and locations must be memorized or written down by hand. There is no specific protocol dictating procedures on how a unit should navigate to the location of the fire.

Other agencies outside of Los Angeles County use a technology called Automatic Vehicle Locator (AVL) to dispatch units. This technology calculates which units should respond to an incident as determined by a unit's proximity to the incident.

Helicopters dispatched simultaneously with ground units navigate to a fire location using latitude and longitude coordinates calculated based on the caller's location or the reported location of the incident. There are helicopters located strategically throughout the County. In general, they take 10-15 minutes to arrive. If a fire occurs at the farthest end of the County, the longest it would take helicopters to arrive would be 20-25 minutes.

Throughout the United States

U.S. Forest Service

Federal Forest agencies use lookout towers in some areas during high fire season to detect wildland fires. The lookout towers are generally located on the highest peaks with the ability to observe any potential smoke from a fire over many miles. They are staffed mostly by volunteers in the summer months. The Angeles National Forest staffs one tower.

In addition to traditional detection methods, the Forest Service and other international fire monitoring agencies use the MODIS (Moderate-Resolution Imaging Spectroradiometer), a weather satellite, Rapid Response System for wildfire detection. MODIS was developed to provide daily satellite images of landmasses. True-color, photo-like imagery, and false-color imagery are available within a few hours of being collected.

CAL FIRE (California Department of Forestry and Fire Protection)

CAL FIRE is responsible for stewardship and fire protection of over 31 million acres of California's wildlands. The department's firefighters, fire engines and aircraft respond to more than 5,600 wildland fires annually. The department provides various services in 36 of the State's 58 counties. CAL FIRE has support agreements with Los Angeles County for firefighting and equipment as needed.

In most cases, wildland fires are detected and reported by calls from the public. A few years ago, the department was considering a test of the *Fire Hawk* camera system in Shasta County; however, the test was never completed. A camera system was installed to cover El Dorado and Amador Counties. Today, the camera is used to help identify fires, but there is no automatic alarm system to notify CAL FIRE of the presence of a fire. The camera images are used by an operator to verify a public fire report and identify the location and extent of the fire.

Alabama

The Alabama Forestry Commission employs a fleet of airplanes that regularly patrol forest areas during fire season. A toll-free telephone system, separate from the local

911 dispatch, is also available 24 hours a day for the public to call if a wildland fire is spotted.

Montana

The Department of Natural Resources and Conservation's Air Operations fly fixed-wing Cessna 180 airplanes on daily patrol flights during the wildfire season.

Throughout the World

Europe

The European Forest Fire Information System (EFFIS) computes fire risk using meteorological forecast models and satellite imagery. EFFIS-generated maps of forecasted fire danger areas are emailed daily to forest services and civil protection services of the European Union. EFFIS also maintains the European Union fire database and website with the current fire situation.

SFEDONA (Satellite-based FirE DetectiON Automated) system, which is operated by the European Space Agency, aims to design, develop, validate and demonstrate a complete end-to-end fire detection and alerting application. SFEDONA uses fire detection technology based on terrestrial cameras and sensors, data fusion, satellite and wireless communications, and modern information technology software. The system will provide 24/7 monitoring of at-risk areas, quick communication to at-risk interests, and forecasting. The outcome is an integrated system offering fire detection and alert to local governments, regional governments, and other interested agencies. The SFEDONA project was successfully launched on April 15, 2009.

Over 150 Fire Watch visual camera systems are installed in Germany for fire detection.

Southern Africa

The Advanced Fire Information System (AFIS) is an alert and mapping system that provides detection, monitoring and assessment of fires. The system is based on satellite data derived from MODIS (Moderate-Resolution Imaging Spectroradiometer) and Meteosat Second Generation (MSG) satellites. The MODIS sensor can detect fires as small as 160 square feet but only passes over Southern Africa four times a day. The MSG satellite is geostationary and provides 15 minute updates of fires in Africa and Europe but at a coarser resolution.

Alberta, Canada

The government of Alberta employs aerial detection, lightning sensors, lookout sites, ground patrol and infrared scanning provided by various industries during the spring.

Infrared scanning serves as a mapping tool to obtain boundaries of ongoing fires, to determine the most effective location for air tanker drops and to spot-check fires.

IV. COORDINATION WITH CITY, STATE AND FEDERAL JURISDICTIONS

The State of California, including the County of Los Angeles, has one of the most comprehensive sets of interagency coordination agreements in the nation. LACoFD was a founding member in the early 1970's of FIRESCOPE which developed and implemented many of the agreements in place today.

LACoFD has a variety of agreements with surrounding agencies that specifically address responses to wildland fires. The agreements can be divided into two categories: those for initial attack or immediate response (generally the first 24 hours) and those for extended attack on fires that have been burning for a longer time.

The initial action zone (mutual threat zone) agreements are the backbone of the immediate response agreements. The purpose of these agreements is to bring the closest available resources to suppress the fire within the smallest possible area. These agreements identify areas along agency boundaries where each agency agrees to immediately dispatch a predetermined number and type of resources. These areas can be as little as ¼ mile or up to several miles inside the other agency's boundaries. The agreements take into account high frequency fire areas such as near roads and highways. Once resources arrive on scene and begin suppression, fire commanders from involved agencies determine which agency has jurisdictional responsibility. That agency takes the lead in developing the strategic plan and tactical objectives to suppress the fire.

The second type of agreements deals with fires that burn for longer periods of time. All of these agreements, with the exception of the *State of California Master Mutual Aid Agreement*, identify a method of compensation to the agency providing the resources. Essentially the agency requesting the resources agrees to pay a predetermined amount for those resources. The *California Master Mutual Aid Agreement* was signed by the Governor in the 1950s and provides a framework for the various fire agencies throughout the State to provide resources to another jurisdiction during the time of a "disaster" within that community.

Coordination with Cities

LACoFD maintains a variety of agreements with cities in the County. These agreements are structured to send the closest resources to the scene of an emergency incident. They mostly involve the exchange of a single resource on an "as needed" basis. LACoFD has agreements with other fire departments that have the potential for fighting wildland fires. These agreements are specifically designed to allow a rapid response to a wildland fire with the appropriate resources. An example of this type of agreement is the exchange of helicopters between the Los Angeles City Fire

Department and LACoFD. Each agency automatically sends one helicopter to wildland fires in the other's jurisdiction.

Coordination with the State - Cal EMA (California Emergency Management Agency)

LACoFD participates with almost all fire agencies in the State through agreements with Cal EMA. Cal EMA is a State agency that coordinates and facilitates disaster responses throughout the State for both emergency responders and local governments. Chief P. Michael Freeman and the LACoFD have been designated the Region I Coordinator. Region I encompasses the Counties of Los Angeles, Orange, Ventura, Santa Barbara and San Luis Obispo. Through Cal EMA agreements, LACoFD is able to tap into the resources of the other fire departments throughout the State for minimal cost during wildland fire disasters. Cal EMA supplies various fire agencies with fire engines and other equipment. LACoFD currently maintains and staffs five Cal EMA fire engines specifically built for wildland firefighting.

Coordination with the State - CAL FIRE

LACoFD is one of six CAL FIRE Contract Counties. CAL FIRE pays the Department a negotiated amount each year to suppress wildland fires that occur on State Responsibility Land within the County. The current agreement supports 23 fire stations, a bulldozer and several administrative positions. For wildland fires on or threatening State Responsibility Land, LACoFD has access to all of the State resources, including air tankers, additional fire engines and hand crews at no cost. For fires that are not on State Responsibility Land, the Department still has access to all CAL FIRE resources but must reimburse the State for their use.

Coordination with the Federal Government

LACoFD has agreements with the Angeles National Forest which support firefighting responsibility both initial and extended attack on wildland fires in the National Forest. There is a partnership through the "initial action zone" agreements to immediately send resources from both agencies for wildland fires in border jurisdictional areas to keep those fires as small as possible. LACoFD's agreement with the Angeles National Forest also allows access to all wildland fire resources. These include fixed wing air tankers used by the Department of Agriculture (Forest Service), the Bureau of Land Management and the National Park Service.

Future Agreement Considerations

Currently as comprehensive as the coordination agreements are, the various fire agencies will continue to identify future improvements. Local agreements with the Angeles National Forest and other agencies will need to consider:

1) Enhanced fuel (vegetation) management projects along boundary areas

2) More robust fuel management practices surrounding structures and telecommunications sites

3) New technologies for the early detection of wildland fires

4) New technologies for common radio communication

V. GROUND BASED FIRE DETECTION TECHNOLOGIES

The traditional fire detection method is a person seeing a fire and reporting it to the fire department. This method is useful and provides valuable information. Some fire agencies use watch towers manned by volunteers during high fire seasons; however, watch tower placement, availability of personnel, and visibility limit the ability to detect fires on a 24-hour basis.

In many cases, wildland fires are reported by the public using cell phones. If a fire starts near a well-traveled road or near homes the fire will be reported quickly; however, for fires in more remote areas or late at night there could be a significant delay resulting in an uncontrolled spread of the fire. In some instances commercial or private aircraft pilots may see a fire and report the location. A fire viewed from a high altitude is likely to be extensive and not in an early stage for rapid suppression.

Rather than rely on random observations and phone calls to detect fires, new technologies are available today to provide rapid detection of fires on a 24-hour basis, including automatic alarms to fire command centers. These technologies include custom designed fire detection sensors, deployment methods, and communication systems.

The Board of Supervisors' direction to the Commission identified key criteria for fire detection technologies:

Early detection capability
24-hour operation
All weather capability
Automated data analysis

A comparison of detection technologies is shown in Tables I - VI in the Appendix. Details are discussed in subsequent sections of this report.

Stationary Ground-Based Visual Camera Detection Systems

Stationary ground-based fire detection systems are available using visual surveillance cameras designed to generate a video or still frame images. Most sample a full 360-

degree view in a few minutes. The images are analyzed automatically for characteristics of smoke or flame. When a smoke or fire pattern is identified an alarm is triggered in the fire command center for action. A dispatcher can review the images to verify the fire and dispatch fire fighting resources.

Systems available from vendors include both specially designed as well as commonly available high-end surveillance cameras to gather the visual images. Table VI of the Appendix provides a check list to identify which systems meet the criteria established by the Board of Supervisors. Most of the systems are being used successfully in selected worldwide locations. All the vendors have detailed web sites describing the detection and data analysis system as well as communication with the fire command center.

For a more detailed view typical of this group of detectors, the Working Group invited Wildland Detection Systems and Forest Guard representatives to present details of their products and services.

Wildland Detection Systems

The Wildland Detection Systems approach is designed to provide rapid detection of wildland fires using visible range optical cameras. It uses commercial off-the-shelf analog network cameras or it can use existing installed cameras. The theory of the system is that smoke is the first visible indication of a fire. Trees and other topographical factors can hide the flames until the fire has grown and is possibly out of control. In some cases there is smoke before any flames are visible. With rapid detection in the first 5-15 minutes, the fire can be extinguished quickly with moderate equipment requirements.

The key technology is an early smoke detection program based on mathematical analysis of streaming video. The monitoring system includes video cameras installed on detection towers with the video stream sent to the control center. The system analyzes and evaluates the image reducing it to its mathematical components and provides the capability to identify each micro component, edge and movement within the image. Analysis of successive images identifies wildland fire smoke and differentiates it from similar images.

The system is configured as a local area network with up to 16 camera feeds monitored simultaneously at the coordinating Surveillance Center. Each camera has a potential ten mile range for detection covering 300 square miles. The communication system can be microwave, internet protocol, or fiber optic cable. The system progresses through multiple steps in the detection process. Once the smoke is confirmed by the system, an audible and visual alarm is issued. The operator is able to examine the alert area by manual zoom or panning the camera, decide on the appropriate response, issue notifications and dispatch suppression resources. The system can detect a fire in less than five minutes and can operate day or night. At night, flames are analyzed by the system. The system can be programmed to issue automatic notifications to remote individuals or systems, but, the final alarm and dispatch disposition is reserved for the operator. The system uses geographic map location to identify the location of the fire.

Currently Wildland Detection Systems has 70 installations on four continents with 150,000 hours of successful commercial deployment. The cost of each camera is approximately $15,000 unit plus the cost of the control center and $15,000 for software.

Forest Guard

A High Performance Wireless Research Network (HPWREN) available in San Diego County is in use to assist public safety agencies in hard to reach areas. The Network can connect cameras, meteorological sensors, and alert systems located on several mountain top towers to provide first responders and rural community members with real time images, environmental conditions, and public safety alerts throughout the County. For instance, the 2007 Harris Fire was closely monitored by CAL FIRE and the Sheriff's department using network connected cameras atop Lyons Peak.

With the high speed network in place, Frank Vernon and Graham Kent, researchers at the University of California, San Diego, began to explore the possibilities of creating a network-connected camera system for early detection of wildland fires. In cooperation with Sony Corporation, a prototype high resolution solar powered camera was produced and successfully tested for early detection of fires. The camera takes a series of high resolution still frames for a full 360 degree view. An observer can view the images and detect a fire in the early stage.

Further exploration of fire detection continued with the relocation of Graham Kent to the University of Nevada, Reno where he is leading the installation, testing and maintenance of a novel approach to monitor forest fires and other environmental data with the prototype camera system.

The prototype Sony 360-degree camera was installed at Tahoe City, California and connected to the internet. A group of students in Meadow Vista, California identified a novel concept called Forest Guard to monitor the forest. This system uses a closed circuit television transmission to send live pictures of the forest to a computer screen saver or desktop that is available to users around the world. The pictures enable citizen firewatchers to quickly raise an alarm if a fire is seen. Firefighters will be able to better monitor the fire, to deploy resources and warn residents who may be in the path of the fire.

The novel approach is still under exploration, but the idea of giving the public a way to see a fire in the early stages and make the alert is intriguing. However, the "Watch the Forest" internet feed will require more testing to assure a robust method of early fire detection.

Stationary Ground-Based Infrared Cameras

An alternative sensor for detection of fires relies on infrared radiation emitted by flames. The details of the two systems in this category are identified in the Appendix and summarized in Table II. The check list in Table VI identifies how these systems meet the Board requirements.

A presentation to the Working Group by Ambient Control Systems, describing the Fire Alert system, provided details about this class of sensors. The Fire Scout system has an additional capability of sensing ultraviolet emission from dropped power line arcing. Details are available in detection technologies and Table II in the Appendix.

Fire Alert-Ambient Control Systems

Ambient Control Systems has recently made a proposal to the Santa Barbara County Montecito Fire Department for installation of an early warning wildland fire detection system. The Ambient representatives described the proposed system and provided additional details of sensor operation for Los Angeles County conditions.

The sensors are a foot-long metal cylinder about five inches in diameter containing a mirror stepping system that directs emissions characteristic of a fire onto an infrared detector. The sensors are mounted on a tall pole to provide an unobstructed view of other sensors to connect the network. The fire sensors are solar powered and have a life span of about 20 years. The detection range is over six miles. Usually placing a fire alert sensor every square mile will allow the sensors in the monitored area to immediately generate an alarm as soon as a fire starts. Each sensor system costs about $22,000.

The sensors horizontal view is divided into 36 steps each having a 10 degree view. One rotation takes four minutes. The rotating mirror searches for any unexpected changes in heat for the surrounding atmosphere. When a fire signature is detected in any of the steps an alarm is transmitted to a control center using radio signals over a wireless network. It then enters into a map update mode looking for additional fire signatures. Once the update is completed, it sends a map update showing all 10 degree steps where a fire was detected. Other sensors in the network will see the heat signature as well and by triangulation will provide precise coordinates of the fire. The progress of the fire will be followed to provide perimeter data for suppression activities, as well as community wide warning of a fire's location.

The sensor array can be tied to a server-based command center to provide a centralized alert notification location as well as situational information. The combination of the Fire Alert detection system and the Vigilys Situational Awareness system enables fire responders to mount rapid and accurate suppression. In the monitored area, a fire will be reported within 10 seconds of detection, and the alarm will be sent automatically, with an average latency of one minute.

Other Stationary Ground-Based Detection Systems

A camera system developed in Portugal uses visual images combined with optical spectroscopy to detect a fire. The system is called Forest Fire Finder by Ingenious Systems. The details of the system are shown in the Appendix in Table III.

Specially designed observation units are mounted on poles above the tree tops to gain a wide area view. The units combine a special pan and zoom camera, meteorological equipment, and an optical spectrometer for automatic fire detection. The communication system is web based. A fire is detected by looking for optical characteristics of organic smoke that excludes industrial smoke. Once a fire is detected, visual images and meteorological data can be transmitted to the command center. Two or more observation units are needed to obtain a precise location of the fire. The system can detect fires primarily during the day. There is only one installation of the system in Portugal.

A presentation to the Working Group by Flame Sniffer representatives provided information on an interesting home protection technology that has the potential to be a broad area fire detection system. Flame Sniffer technology uses Wireless Sensor Posts to detect a fire. The posts include multiple sensors: an ionization smoke sensor, a photoelectric smoke sensor, 360 degree infrared sensors, a heat sensor and wind speed and direction sensor. The posts are battery powered. All the sensors are scanned every five minutes and transmit their signal to a server. If any sensor is activated a fire signal is sent.

The posts are small and cost about $2,000. Each post can cover about a 1,000 foot radius; so many posts would be required for any large area. For home protection only about four posts may be needed to sense a fire and to trigger a high volume water spray system to protect the home. A homeowner with a Flame Sniffer home protection system would likely feel comfortable to leave as a fire advances knowing that the home would be protected.

Additional information about Flame Sniffer is available in the Appendix and in Table III.

Topography Mapping-Light Detection and Ranging (LiDAR)

Los Angeles County has been mapped using LiDAR to create a 3-D profile of the terrain of Los Angeles County. LiDAR uses optical remote sensing to measure properties of scattered light to determine surface topography, tree heights and other information about a distant target.

This technology was used to create a map of Los Angeles County wildland areas that can serve as a tool to plan for installation of a ground-based early wildland fire detection system. It can be used by LACoFD for planning purposes for fire suppression by ground and aerial units.

Existing Surveillance Camera Installations

The Los Angeles County Internal Services Department currently has 14 cameras installed on existing communication towers for security purposes. See Map II for the location of existing tower locations with cameras. A few of these cameras are in locations suitable for fire detection of wildland fires. The cameras are powered and have an existing communication link to a control center. Use of these cameras jointly for security and fire detection is a possibility. For automated detection of fires the camera feeds could be combined with software for smoke detection and an alarm sent to the Fire Command and Control Center. Using these existing cameras could provide a low cost way to explore early fire detection in a selected part of the County.

VI. AIRCRAFT AND SATELLITE FIRE DETECTION SYSTEMS

Manned Aircraft

Wildfire Airborne Sensor Program (WASP)

The Wildfire Airborne Sensor Program (WASP) was created by the Laboratory for Imagining Algorithms and Systems. WASP's mission is the detection and monitoring of wildfires from an aircraft at an altitude of up to 12,000 feet. WASP is currently flown on a twin-engine Piper Navajo aircraft. WASP has three Indigo Phoenix infrared imagers and one Geospatial Systems KCM-11 high-resolution visible camera mounted in a sensor head that looks down through a hole in the aircraft. It also has positioning devices to determine the exact position and orientation of the imagers and the aircraft when each image is captured. WASP was designed to detect fires of various sizes from a flight over the target area. The acquired data from the image is geo-located, so it can also apply or overlay data from other sources using standard tools.

Unmanned Aircraft:

A number of companies have developed unmanned aerial vehicles (UAVs), or surveillance drones, with 24-hour, all-weather capabilities. Commercial and public use of these drones, for now, is limited by Federal Aviation Administration (FAA) regulations.

Insitu

Insitu is a provider of field-proven, unmanned aircraft systems that enable the capture of real-time intelligence, surveillance, and reconnaissance data. Integrator is the newest addition to Insitu's unmanned aircraft offerings. Integrator has the capacity to capture high-resolution images both day and night. Beyond line-of-sight (BLOS) capability enables control of Integrator from anywhere in the world using satellite communication.

Satellite Systems

Ground-based and aerial fire detection systems and methods have certain restrictions on their capabilities since they operate on or close to the surface of the Earth. Space-based systems (satellites) operate free of these restrictions as they operate with an unimpeded look-down capability with an almost unencumbered view of the Earth's surface.

Satellites that may be used for fire detection are of two basic types: (1) geosynchronous satellites which orbit the Earth 22,500 miles high and (2) near-Earth satellites which orbit in the range of 500 miles above Earth. Geosynchronous satellites travel in equatorial orbits at an orbital speed which matches the rotation speed of the Earth, meaning they are always over the same point on Earth with a 24-hour viewing capability. Near-Earth satellites travel in polar orbits while the Earth rotates below them, meaning they view the same point on Earth several times daily but not all the time.

Several countries have geosynchronous or near-Earth satellites, or both, for communications, weather (evaluation and forecasting) and national defense purposes. None of these satellites has a specific wildland fire detection purpose. Some have the sensor capabilities needed to detect fire and smoke. The most numerous of these are weather satellites. Since we are concerned with wildland fires in the United States, the following discussion of weather satellite capabilities will focus on those flown by United States government agencies.

Weather satellites are used primarily to monitor the weather and climate of the Earth, using visible and infrared sensors. Visible images are created by sensing sunlight reflected from clouds and land masses. Smoke will be detected in a similar fashion.

The infrared sensors will sense any heat radiated from the surface, and with the appropriate spectral sensitivity sensor, a fire pattern will be observed even through a smoke plume. Weather is an important consideration in the ignition, spreading and fighting of wildland fires; however, limited image resolution and infrequent sampling of any one location limits the value of weather satellites for early detection of fires.

NOAA, NASA and DOD Weather Satellites

Weather satellites are operated by three United States government agencies: the National Oceanic and Atmospheric Administration (NOAA) for its National Weather Service, the National Aeronautical and Space Administration (NASA) and the Department of Defense (DOD). They encompass both geosynchronous and near-Earth satellites. Two geosynchronous satellites feed a continuous (24 hour) stream of meteorological data to Earth for analysis. The images cover a hemisphere, so the ability to detect wildland fires (flame or smoke) in a specific place is limited because of poor image resolution.

Near-Earth satellites, orbiting closer to Earth and surveying a smaller area, have better sensor capability to detect fire and smoke from wildland fires. The problem for fire detection with these satellites is twofold, one being their orbits and the second their restricted time of observation. Since these satellites are in polar orbits, with the Earth rotating under them, their orbits allow them to survey the entire earth twice daily (always in daylight), so they are over the United States only part of a 24-hour period. This means that if a satellite had just passed over an area and before a fire starts, it would not be capable of detecting fire for 12 hours. Since there is more than one satellite in each orbit, this time gap may not be as long as 12 hours, but long enough to hamper early detection of a fire.

Department of Defense Satellites of the Defense Support Program (DSP)

As a part of the study, the Working Group invited Aerospace Corporation to present their ideas of any new technology that could be applied to detect wildland fires in an early stage. Aerospace representatives presented their capabilities in systems architecture and integration as well as surveillance capabilities using unmanned aircraft. In addition, we learned that the Defense Support Satellite (DSP) system, currently in operation, represents a promising option. The primary mission of this satellite system is for national defense to detect missile launches on a world-wide basis. The infrared image resolution and ten-second sampling times are consistent with early fire detection requirements. The infrared sensors on the satellites constantly look for the telltale signature of a flame from a missile launch with automatic analysis of the data. Since a missile flame has characteristics similar to a wildland fire, the system can readily detect fires.

In the 1990s, the Aerospace Corporation developed a system to use the infrared detection capabilities of DSP to detect and study fires and volcanic activity without interfering with the primary mission of DSP. The capabilities of DSP were compared to both types of weather satellites and data from other analyses.

The use of DSP in connection with wildland fires was analyzed with the objective of assessing the value of DSPs 10-second sampling time and high resolution data. The satellite data were found to possess a useful capability under dry atmospheric conditions without significant cloud cover. These are the conditions when wildfires are most likely to occur in Southern California

Aerospace Corporation analyzed the Topanga-Malibu and other fires in 1993, all of which caused extensive loss and damage. The analysis covered the potential of DSP satellites for timely detection of the fires and how its signals could be used to alert authorities to the existence of the fire. Data showed DSP sensor detection of the Topanga-Malibu fire three to five minutes after the 911 calls began, with a detection time for other fires of zero to 14 minutes after the first calls. In densely populated Los Angeles County areas, 911 calls tend to be made very soon after the start of a fire, which could put them ahead of detection and warning by the DSP satellites. In remote areas without this rapid 911 reporting, the DSP capability for rapid fire detection and alert would allow for faster response by fire fighters.

In 1994 following the devastating wildland fires of the previous year, LACoFD contacted the Aerospace Corporation in El Segundo, California to investigate the use of Defense Support Program (DSP) satellite early warning technology to provide wide area early detection capability for wildland fires in the County.

The investigation concluded that fires could be detected early using the DSP data, especially in the remote areas of the County. Although the detection system operated adequately for about one year, federal funding constraints halted further work. However, the emerging use of cell phones would still provide for early wildland fire detection for over 90% of the reported incidents, especially those in the urban interface areas of the County.

In the Working Group meeting with the Aerospace representatives, they said that they still believe the system developed more than 15 years ago is viable for early detection of wildland fires. Such a system once implemented and funded, could cover the entire United States.

National Geospatial Intelligence Agency (NGA)

In the fall of 2007, NGA provided over 150 geospatial intelligence products to the Federal Emergency Management Agency (FEMA) in support of combating California wildfires. NGA supplied damage assessments of major infrastructure in the area and assessments of areas still on fire and where the fire had been extinguished. This information was uploaded to the nga-earth.org website as a way for the public to see the damage without returning to the area. This product assisted firefighters and other first responders with relief efforts.

Advanced Hazard Support System

The NGA has a Civil Applications Committee in place to help identify technology applications that can provide capabilities for civilian use. This Committee is reviewing the DSP and other military satellite surveillance system capabilities to determine if civilian applications can be identified. The program is called the Advanced Hazard Support System. Applications include fire detection, fire progress, earthquake research, homeland security, national emergency response and other informational needs. The Forest Service and the U.S. Geological Survey are interested in civilian applications of this satellite surveillance technology.

Early detection of wildland fires is one area that the Civil Applications Committee is evaluating. The Working Group suggested to the Civil Applications Committee that the federal agencies conduct a pilot study of fire detection in Los Angeles County using the DSP satellite system during the 2010 fire season to test the capability of the system for early wildland fire detection. When this proves successful, the satellite detection capability would be applicable to other jurisdictions in the nation.

VII. RAPID SUPPRESSION

The existing personnel, procedures and equipment available to LACoFD provide a solid base for rapid suppression of wildland fires. The details of coordination with all other agencies and of response capabilities have been described in previous sections of this report.

Reaching a detected fire at its source with enough suppression capability to stop or slow it requires optimally stationed standby helicopters as well as ground crews to fully contain the fire. The helicopters must be ready to reach rugged terrain by the most direct route possible, likely in darkness, to drop suppression material directly on the fire. Currently available improved avionics would enhance the ability of helicopters to fly a more direct route to the fire.

The Working Group invited Sandel Avionics to present information about an improved avionics terrain awareness and warning system. Using this avionics equipment, a pilot test will be able to find a safe and fast route to the fire as well routes to the nearest water replenishment sites.

A response using helicopters often may be the fastest way to suppress a fire, but ground crews also play a vital role for rapid suppression depending on location of the fire. With automated vehicle locator equipment on each engine tied into the dispatch system, the closest ground equipment could be dispatched to the fire. Today, an updated system is needed to allow dispatching resources based on location of the vehicle.

Terrain Awareness and Warning System for Helicopters

During the presentation to the Working Group, Sandel Avionics described its improved Terrain Awareness and Warning System (TAWS) for helicopters. This system will allow digital mapping combined with GPS to "see" the terrain around the aircraft including bridges, power lines and other obstacles. Pilots will be able to fly between ridges to the fire and see the best path out after a drop. With this technology a pilot can go from base directly to the fire, in darkness, make a drop and then be directed to the nearest water source to pick up the next load and return. The single box unit can replace the existing radar altimeter for ease of installation without significant modification to the instrument panel. Operational training requirements are modest. The unit will function in all weather conditions; however, the pilot must consider wind conditions. Each avionics unit costs less than $20,000 per helicopter plus training costs. There are other vendors selling similar systems.

LACoFD is in the process of installing the various components for the helicopter TAWS in one of its helicopters. Although the system is currently certificated in other types of aircraft, FAA certification is needed specifically for helicopters flown by the LACoFD.

Automatic Vehicle Locator

An Automatic Vehicle Locator (AVL) system provides an up-to-date location information system for emergency vehicles. The AVL system consists of a GPS receiver on the emergency vehicle, a communications link between the vehicle and the dispatcher, and personal computer-based tracking software for dispatch. The communication system is usually a radio or cellular network similar to the one used by cellular telephone systems.

A key advantage of an AVL system is the ability to identify the location of the equipment, and send the location to a Computer Aided Dispatch Computer System (CAD). By knowing the location of the units and availability, the dispatcher can send the closest and available apparatus and equipment to the scene of an emergency incident.

The LACoFD currently has AVL technology installed on each of the response vehicles. Vehicle locations and availability can be identified using information from the CAD system, but the age of the current CAD system does not allow for the dispatching of resources at this time. Several proposals are underway to update the system, but no timelines have been identified.

VIII. COMMON SET OF RULES

The rules for carrying out fire suppression activities are usually defined by individual agencies such as the Forest Service, CAL FIRE, LACoFD or other local fire agencies. Although in many cases the fire suppression approach is the same, specific agencies may have rules tailored for their mission that may not be beneficial for other agencies. For example, the Forest Service does not allow aerial suppression activities at night, whereas LACoFD will engage a fire at night using water dropping helicopters. A key concern in the LACDoFD is the proximity of the fire to the wildland urban interface, the closer the fire the greater need for immediate action to suppress it.

For fires in remote areas far from the wildland urban interface, differences in fire suppression rules are not a primary concern. For example, if a fire starts in a remote area under the jurisdiction of the Forest Service, their rules apply regardless of what other agencies are engaged. If a fire is close to the wildland urban interface and the fire can quickly move to residential areas, differences in rules may impede rapid suppression.

An important issue is the extent to which residential communities interface with adjacent forest areas. Encroachment of residences into what was once remote forest is an ongoing fact in Los Angeles County, as well as other counties. This growth extends the urban interface deeper into the wildlands and increases the risks from even remote fires.

To minimize losses when dealing with people's lives and property, all firefighting agencies in Los Angeles County need to take into account the enlargement of the wildland urban interface and the impact their fire suppression rules may have on a fire spreading. Accordingly, the specific agencies such as, LACoFD, Forest Service, CAL FIRE, need to agree upon the extent of the wildland urban interfaces. These agencies must establish common rules of engagement in fighting fires in proximity to the extended wildland urban interface.

X. FINDINGS

Technologies currently exist to provide 24-hour, automated detection of wildland fires. These technologies include ground-based, aerial, and satellite surveillance systems.

Fire Detection Technologies and Pilot Programs

- No fire agency in the United States has a fully-functional, 24-hour automated system for early detection of wildland fires.
- Defense Support Program (DSP) geosynchronous satellites have a demonstrated capability for early, 24-hour automated detection and precise location of wildland fires with a detection time within minutes from the start of the fire.

- Aerospace Corporation has a Los Angeles County DSP data center and knowledgeable personnel for data handling that could be used in a pilot study for early detection of wildland fires.
- Specialized DSP satellites use infrared sensors and work best in low humidity conditions, like the conditions seen in Southern California during the high fire season with Santa Ana winds.
- Ground-based visual camera detection systems can be typical pan-and-zoom or high resolution fixed cameras, depending on the terrain to be scanned. Some systems include automated detection of smoke during the day and flames at night and can show the GPS location of a fire.
- One ground-based surveillance camera detection system has over 70 installations in a number of countries.
- Many countries use commercial surveillance camera systems for wildland fire detection.
- Commercial image analysis software exists. Developers claim this software can automatically detect the smoke patterns during the day and flames at night.
- Ground-based infrared fire detection systems can provide automated detection and the GPS location of a fire.
- Surveillance camera output to the web is being tested at the University of Nevada, Reno to see if the public can provide early detection of wildland fires.
- Several fire agencies with jurisdictions in Southern California are examining systems for early detection of wildland fires.
- CAL FIRE has a surveillance camera installed for Amador and El Dorado Counties for visual observation of selected areas of the forest.
- A commercial ground-based infrared system is being tested in the San Diego area using a sensor that detects both flame and ultraviolet light arising from power line arcing.
- Ground-based systems can be combined with meteorological data sensors for improved fire progress forecasting.
- Some jurisdictions worldwide use manned and unmanned aircraft for detection of wildland fires during fire season.
- Manned watchtowers are currently used for fire detection in parts of the United States during fire season.
- Power for any ground-based system can come from existing communication towers, batteries or solar cells.

<u>Current Fire Detection and Suppression in Los Angeles County</u>

- The LACoFD, as well as other agencies throughout the United States, is often alerted to the presence of a wildland fire by public calls to the local 911 dispatcher.
- LACoFD has joint suppression plans in place with all neighboring jurisdictions.
- LACoFD is able to provide rapid, all-weather, 24-hour suppression of wildland fires.

- LACoFD suppression helicopters are on alert and can take off in about 10 minutes in response to an alarm.
- LACoFD ground and air crews are strategically stationed in key locations during fire season and can be activated to rapidly respond to an alarm.
- Arrival times of LACoFD suppression teams to the fire site, either by air or ground, will depend on the distance from the dispatch point to the location of the fire.
- All potential wildland fires within Los Angeles County can be reached by LACoFD helicopters within 25 minutes of takeoff.

Early Fire Detection Opportunities in Los Angeles County

- LACoFD has detailed maps of previous fires and high-danger fire areas that could be used to identify a pilot test area for an early detection system and subsequent rapid suppression response.
- The topography of Los Angeles County's wildland areas has been mapped by LiDAR.
- LiDAR maps can be used to plan placement of ground-based fire sensors for full coverage of the wildlands.
- Los Angeles County currently has 14 remote-controlled surveillance cameras installed on communication towers that could be paired with wildland fire detection software. At least three of these cameras are located in forest areas at risk for wildland fires.
- Detection systems can be designed to communicate via satellite or standard communication networks.
- The Los Angeles County Fire Command and Control Center can accommodate an early fire detection system alarm.
- LACoFD capability can be enhanced by improved avionics in the water dropping helicopter fleet.

Challenges to Implementation in Los Angeles County

- Los Angeles County represents a large monitoring area and any ground-based system for early detection of wildland fires will be a substantial undertaking.
- All ground-based sensor systems will require maintenance to keep sensor components operational.
- To prevent destructive encroachment of fires into the Los Angeles County wildlands urban interface, early fire detection needs to include all neighboring jurisdictions.
- Some fire agencies within Los Angeles County have differing rules for fighting fires.

X. RECOMMENDATIONS

1.) Surveillance Satellite Technology

Recommendations

- Partner with Federal agencies in a pilot program to evaluate the Advanced Hazard Support System employing satellites for early detection and location of wildland fires.
  - Work with the National Geospatial Intelligence Agency Civil Applications Committee and other appropriate federal agencies to select data for the geographic coordinates corresponding to Los Angeles County for detection of fires during the coming 2010 fire season.
    - Request the agencies to task the satellite data center to use the currently available data automation methods to sense the fire and location, and send an alarm to the Los Angeles County Fire Command center for suppression action.
    - Evaluate the results at the end of the current fire season for future application to Los Angeles County and other agencies in the United States interested in early detection of wildland fires.
    - On a successful completion of the pilot program, work should continue with Federal agencies to establish an ongoing automated method for early fire detection in Los Angeles County.

2.) Ground-Based Sensor Technology

Recommendations

- Task the Los Angeles County Fire Department to carry out a field test of ground-based visual surveillance cameras and infrared detection sensors to identify suitable technology that meets the County's geographic and operational needs.
    - Carry out a preliminary evaluation of visual and infrared sensors to identify benefits for Los Angeles County conditions.
    - Identify pilot test areas for evaluation of selected ground-based sensor systems for early detection of wildland fires.
        - Select sensor systems for the pilot test.
        - Explore using existing ISD communication tower locations for camera placements.
        - Examine the effectiveness of sensor coverage using available LiDAR maps of the pilot area.
        - Evaluate results and cost considerations for extended implementation in other areas of the County.

3.) Rapid Fire Suppression

Recommendation

- Charge the LACoFD to evaluate improved helicopter avionics and an updated Automated Vehicle Locator system for improved rapid response and suppression of fires.

4.) Coordination with all Agencies

Recommendation

- Create a task force consisting of all fire agencies in Los Angeles County to agree on one common set of rules of engagement for suppressing fires in the extended wildland urban interface.

APPENDIX

Detection Technologies

I. Ground-Based Systems

Wildland Detection Systems

Wildland Detection Systems provides rapid detection of wildfires through visible range optical cameras. The system is compatible with Internet Protocol, analog and previously installed cameras. Smoke is the first visible indication of a wildfire. Trees and other topographical factors obscure the flames until the fire is grown and on the verge of being out of control. Rapid detection, in the first 5 to 15 minutes, will allow the fire to be extinguished quickly and with the appropriate equipment.

Wildland Detection Systems uses an early smoke detection program based on mathematical analysis of streaming video. The monitoring system includes video cameras installed on towers (detection towers) with the video stream from each camera sent to the control center. The system analyses and evaluates the image reducing it to its mathematical components. This provides the system with the capability to identify each micro component, edge and movement within the image. Analysis of successive images identifies smoke and differentiates it from other similar images.

Detection Time
2.5 minutes average detection time.

All-Weather Capability
Detects both smoke and flames during day and night. Visibility will be impacted by atmospheric conditions.

Initial Cost
$15,000 for each camera package and $15,000 for software

Coverage Area
10 miles per camera, or 300 square miles per camera, and 4800 square miles per system.

GPS Coordinate Accuracy
Claims accuracy, does not specify exactly how accurate. Determines the GPS coordinates using reference or Google maps.

Automation Level
Highly automated. The system detects smoke or flames and sends an alarm to the Command & Control center where an operator can confirm what the system detected on a monitoring screen.

Type of Detection (Fire, Smoke, Etc.)
Smoke and flame recognition software

Interface with Fire Agency
The system is configured as a local area network with up to 16 camera feeds monitored simultaneously at the coordinating Surveillance Center. The system progresses through multiple steps in the detection process. Once the smoke is confirmed, an audible and visual alarm is issued. The operator is able to examine the alert area by manual control, decide the appropriate response, issue notifications and/or dispatch suppression resources. While the system can be programmed to issue automatic notifications to remote individuals or systems, the final alarm/dispatch is reserved for the operator.

Limitations
Camera vibration or movement may affect analysis of smoke or flame.

Fire Watch International

Fire Watch is a ground-based, digital, remote surveillance system for the early detection of wildland fires. It is able to keep larger forested areas under permanent surveillance and to determine the development of smoke within these areas. The input data are displayed and evaluated by means of a connection with a Central Office. Should the source of a fire be detected the operator will send out an alarm. By sending this alarm the relevant fire agency will also receive concrete geographical data regarding the source of the fire, which can be precisely located by means of a cross bearing. The system is well suited for the protection of ecological systems and artificial landscapes and is able to contribute substantially to the protection of the environment. Over 150 systems have been installed in Germany in four federal states.

Detection Time
Up to 10 min. during daytime/16 min. during nighttime

All Weather Capability
Works both day and night. Visibility will be impacted by atmospheric conditions.

Size of Fire at Detection
Claims to detect smoke clouds of 10 x 10 meters, at a distance of 10km. This depends on the ability of the operator monitoring the images.

Coverage Area
Covers 360° with a distance of 9 miles.

GPS Coordinate Accuracy

Location is not given by system. GPS coordinates must be determined by an operator interpreting the image on the monitor. Cross-bearing images from multiple cameras can help pinpoint the location.

Automation Level
End result of system is a series of 360˚ panoramas every 10 minutes. An operator must interpret the data.

Sampling Frequency
Every 10-16 minutes

Type of Detection (Fire, Smoke, Etc.)
Smoke during the day or flames at night.

Interface with Fire Agency
Central office that gathers data from system notifies appropriate fire agency.

Limitations
Cameras take 10 minutes to rotate a full 360˚, taking a picture every 10 degrees for a panorama of 36 individual images. Image interpretation and course of action must be determined by local dispatcher.

Forest Guard

Forest Guard is a program designed to pair cameras in wildland areas with the public on computers monitoring the forest. Solar powered cameras mounted on poles would be continuously panning and would be linked by Ethernet radios to a hub. The hub computer would then take the snapshots from the cameras (a "live" feed) and store them in a web server on the internet. A free "Forest Guard" screen saver would be offered to anyone to put on their computer to monitor the forest. According to the developers of Forest Guard, nothing spots smoke better than a human. When a viewer spots smoke, he or she would press a key on the computer and Forest Guard would notify the local fire agency.

Firehawk

The Firehawk fire detection system consists of a camera mounted on top of a tower. The distance the camera can see varies with atmospheric conditions, and whether the camera is looking into the sun. "It's not unusual to see 20 to 30 miles," said Bill Holmes, Amador-El Dorado unit chief for the California Department of Forestry and Fire Protection. "The camera spotted a fire in Lincoln one day, which is probably 50 to 60 miles away." The system also includes a video monitor, and software that detects potential fires. The Firehawk camera rotates 360 degrees every three minutes and analyzes 21 vectors, or windows, per rotation, day and night. If the software analyzing the camera data detects changes related to what a fire, or smoke from a fire, looks like, it activates an alarm at the dispatch center. The dispatcher then looks at the Firehawk video monitor's live camera feed and uses a joystick to manually tilt or zoom in the camera to visually check the smoke trail. When the trail is found, the software's computer mapping function uses the camera's images to provide an exact location of the smoke source.

Detection Time
Claims within minutes

All Weather Capability
Day and night capability. Visibility will depend on atmospheric conditions.

Initial Cost
One camera, one video monitor, two computer screens, keyboard, joystick and hundreds of feet of cable amounted to $10,000

Coverage Area
360 degrees, with a minimum range of 6-8km. Fires have been detected at distances of 50 miles.

GPS Coordinate Accuracy
High

Automation Level
Alert is sent out to Firehawk software operator who can then control the camera(s) with a joystick and then contact appropriate fire teams

Sampling Frequency
Cameras and software running 24/7, a full 360 degree turn is completed in under four minutes

Type of Detection (Fire, Smoke, etc.)
Fire and smoke

Interface with Fire Agency
Firehawk software operator notifies fire agency if appropriate

ForestWatch

ForestWatch is a forest fire detection and decision support system that is being field tested in actual South African operations. An array of individual cameras covering 60,000 acres can link wirelessly to an operations center. Smart embedded systems at the camera towers reduce the required date transmission bandwidth, provide image stabilization and enhanced image quality. ForestWatch provides automated detection which can be fine-tuned for a range of conditions including night detection. The system allows operators to focus their attention on fewer events. The operator has built-in tools to assist in identification of fires and management of existing fires. A geo-referencing system allows a fire to be accurately positioned on a map of the area. Archive footage can be used for post mortem analysis of fire events, and performance monitoring is available to determine the reliability of the camera system.

Detection Time
About 12 minutes

All Weather Capability
Works day and night. Visibility will be impacted by atmospheric conditions.

Size of Fire at Detection
Can detect smoke from less than one acre fire, at a distance of 10 miles. The final alarm call depends on the ability of the operator monitoring the images.

Coverage Area
Covers 360˚ with a distance of 10 miles.

GPS Coordinate Accuracy
Location is not given by system. GPS coordinates must be determined by an operator interpreting the image on the monitor or cross-bearing images from multiple cameras.

Automation Level
A series of 360˚ are analyzed for smoke to alert an operator who must interpret the data.

Sampling Frequency
Every 6-12 minutes

Type of Detection (Fire, Smoke, Etc.)
Smoke during the day or flames at night.

Interface with Fire Agency
System operator notifies appropriate fire agency.

Limitations
Cameras take up to 12 minutes to rotate a full 360˚ to provide images. Final image interpretation and course of action must be determined by local dispatcher. Road dust, clouds and cloud shadow movement can create false alarms for a fire.

II. Ground-Based Infrared Cameras

Fire Alert by Ambient Control System

This is a ground based camera system for early wildland fire detection that can also map and track the fire perimeter in real-time. Fire Alert is mounted on a 15 to 20 foot pole and will withstand normal fire temperatures. This system is based on infrared imaging for fire detection and no visual image is provided to the fire agency. These cameras can detect a 4 ft. x 4 ft. area from a distance of ¼ mile. The system is self-contained and needs no outside power source. Fire Alert should last around 20 years and it works continuously.

Detection Time
360˚ rotation in less than 4 minutes

Type of Detection (Fire, Smoke, Etc.)
Infrared sensing of flames

All Weather Capability
Works in all-weather and fire conditions, temperatures from 31 degrees F to 149 degrees F. It works both day and night and in varying atmospheric conditions, since infrared detection is not impacted by clouds or smoke.

Initial Cost
$22,000 for the hardware

Coverage Area
Six-mile radius per camera

GPS Coordinate Accuracy
High GPS accuracy.

Automation Level
High. There are no images for a person to interpret or verify. An alarm is simply sent to the agency with the GPS coordinates.

Sampling Frequency
360˚ rotation in less than 4 minutes

Interface with Fire Agency
Information directly uplinked to satellite with onboard Iridium modem, and the information is then delivered electronically to the Emergency Operations Center and aircraft.

Limitations
The system does not detect smoke. There is no optical view for operator interpretation of the data stream. For rugged terrain a large number of cameras would be needed..

Fire Scout

Fire Scout is a system that aims to detect small fires before they become large and uncontainable. The sensors used by Fire Scout are called X3. The X3 detects both flame and power line arcing by the ultraviolet light these events radiate. The X3 sensors are solar powered, and can potentially run several years without maintenance. X3s can also be provided with wireless phone dialers that call authorities when a fire is detected. When an X3 spots a fire, the transmitter instantly relays this message to a phone dialer. Most commonly, these systems are used for homes. If detection is needed where no homes are present, a wireless network of solar-powered X3s can relay the location of arcing and/or flames to a central dispatcher. This is particularly important along power lines, for example, or in forested areas.

Downed power lines cause a significant number of forest fires each year. A network of solar-powered Fire Scout X3s along distribution lines can continuously watch for arcing, and report in real time the grid coordinates where arcing is detected. When winds, snow or ice drive a tree into contact with power lines, the X3 arching report alerts the utility to the need for better clearances. By sending crews to investigate, subsequent power outages can be prevented. In times of high fire danger, any arcing report takes on increased urgency; it can be used to alert firefighters and then shut down power for their protection if necessary.

Detection Time
180˚ continual monitoring. No specific time given.

Type of Detection (Fire, Smoke, Etc.)
Infrared and power line arcing

All Weather Capability
As an infrared system, it is equally effective both day and night, and is designed for use in high-wind conditions.

Size of Fire at Detection
With a clear line of sight, it can detect a 4 foot fire at ¼ mile.

Coverage Area
For flame, it can detect a small fire up to ¼ mile away. It can detect power line arcing at up to 1 mile away. There is an 180˚ field of view with no moving parts.

GPS Coordinate Accuracy
It reports the system location only, usually the home address where the system is installed.

Automation Level
Medium: The alarm is not part of the fire agency, but a call is received like any other 911 call.

Sampling Frequency
Continual, stationary sampling of 180˚

Interface with Fire Agency
When an X3 spots fire, the transmitter instantly relays this message to the phone dialer inside the home. The dialer alerts the homeowner with a piercing audible alarm, while it dials up to four phone numbers programmed into the dialer. A recorded message then provides the name and address of the homeowner, along with the message that a fire has been detected. Up to four X3s can report to a single dialer, so a home can be protected from the approach of fire on all sides. While this dialer system can be used independently by a homeowner, a network of such systems across an entire fire district or neighborhood is the most cost-effective way to avoid losing homes to catastrophic fires in high winds.

Limitations
This system is not directly integrated into a fire agency and is designed primarily for home use. There are no optical views for image interpretation. It is most effective near power lines.

III. Other Ground-Based Sensor Systems

Forest Fire Finder by Ingenious Solutions

Forest Fire Finder (FFF or F3) is a system that allows a positive and precise identification of the fire location (coordinates) as well as provides images of the fire. It also collects atmospheric data, provides valuable reference points for the ground teams, and climatic conditions for an accurate adaptation of the fire fighting techniques.

The FFF working principle is based on a chemical analysis of the atmosphere by an optical spectrometry system. This means that the system analyzes the way the sun light is absorbed by the atmosphere. This absorption depends of the atmosphere chemical composition and has unique characteristics in the presence of smoke.

Thus, the system is able to recognize organic smoke (burnt trees), distinguish it from industrial smoke (factories, tires, etc.) up to a distance of 15 km and decide, in a completely autonomous way, whether there is a reason to send a fire alert.

In case of a fire alert, the FFF provides additional information, such as the precise location, detection photograph and atmospheric data, which are sent to a control center. From there, these alerts are forwarded to the closest fire incident center or vehicles. By being connected to a locator device it may indicate the fastest route to get to the fire location.

Detection Time
As soon as smoke is detected by the sensor camera.

Type of Detection (Fire, Smoke, etc.)
Smoke as a function of atmospheric light absorption

All Weather Capability
Works only during daylight.

Coverage Area
Up to 700 square km, 360º horizontal scan and -45º up to 90º vertical scan.

GPS Coordinate Accuracy
Coordinates determined automatically when two or more units detect a fire.

Automation Level
Fire Alarm automatically set and the following information is sent: Fire coordinates, real time images of the event and weather sensor data including temperature, humidity, wind direction and speed and atmospheric pressure and rain fall.

Interface with Fire Agency
Alarm is sent to fire agency by system

Limitations
Works only in daylight.

Flame Sniffer

Flame Sniffer technology focuses solely on early detection. The Flame Sniffer Early Warning Network was designed to provide a cost-effective, failsafe solution in all possible areas where wildfire threat is prevalent. The Flame Sniffer mission is to identify the location and direction of a wildfire as soon as possible to prevent it from spreading. The Flame Sniffer Wireless Sensor Post (WSP) was engineered to be completely self sufficient, self-powered and multisensory. Deployed as part of a meshed network of WSP's, each post requires no human intervention to operate.

Each sensor post is made from high temperature plastic that can withstand 519 degrees Fahrenheit direct heat before failure may occur. Multiple sensor technologies are included in each post. Self-powered through batteries, each WSP requires no hard wiring thus expanding the network coverage and simplifying installation in the most remote areas. This system uses stable and reliable Radio Frequency communications to send and receive messages. Messages and alerts are sent through other posts as well as directly through each WSP's dedicated wireless Ethernet connection.

Detection Time
Every 5 minutes each WSP scans all sensors and transmits their status along with a test signal to the Flame Sniffer server.

All Weather Capability
Flame Sniffer does not rely on visibility, so weather will not impact the system.

Coverage Area
Each WSP detects wildland fire and ember attacks within a 1,000 foot radius.

GPS Coordinate Accuracy
All WSP's have transmitting and receiving ability so that they can communicate with each other, pinpointing the exact location and direction of a wildland fire.

Automation Level
If any sensor is activated an alert is transmitted immediately to the Flame Sniffer server. If any sensor does not transmit a test code in 5 minutes, the WSP will send a failure signal to the server.

Type of Detection (Fire, Smoke, etc.)
Ionization smoke sensor, photo electric smoke sensor, 360 degree infrared sensor, heat sensor, wind speed and direction sensor.

Interface with Fire Agency
Alerts and current conditions are automatically sent from WSPs via any or all of the following: email, SMS, XML and phone calls. WSP status and alerts are available anytime through a browser as well as on social media if desired. Alerts are delivered directly onto Fire Department consoles.

Limitations
For a land area like Los Angeles County, a large number of WSPs would need to be installed for complete coverage.

Tables and Maps

Table I - Ground-Based Visual Cameras

System	Detection Time/Sampling Frequency	Detection Type	Coverage/ Camera*	24-Hour All-Weather**	GPS Accuracy	Automation Level	Advantage	Limitation
Wildland Detection System	2.5 minute average/ continual analysis	Smoke/ Flame using software	10 miles	Day/night	High	High: Alarm to agency	Software works with off-the-shelf/pre-installed cameras	Camera motion can affect image analysis
Fire Watch International	360° rotation every 10-16 minutes	Smoke using software	12 miles	Day	Low: Visual by operator	Low: Visual monitoring needed	Panorama imaging	Operator interpretation needed. Some false alarms
Forest Guard	Depends on frequency of use	Anything visible	N/A	Only what is visible to a person	Low: estimated using reference points	Low: Needs viewer participation	Cost effective High public participation	No guarantee 24-hr observation. Stationary, single view per camera
Firehawk	360° rotation every 3 minutes, 21 images/rotation	Smoke/ flame using software	At least 4-5 miles, maximum 50 miles	Day/night	High	High: Alarm to alert operator	Tilt and zoom Operator monitoring	Atmospheric conditions may limit view
Forest Watch	360° rotation, 6-12 minutes	Smoke/ flame using software	6 miles, maximum 20 miles	Day/night	High: Geo-referencing	High: Alarm to alert operator	Joystick, manual tilt and zoom. System and operator performance monitoring	Some false alarms. Operator interpretation needed

Table II - Ground-Based Infrared Cameras

System	Detection Time/Sampling Frequency	Detection Type	Coverage/ Camera*	24-Hour All-Weather**	GPS Accuracy	Automation Level	Advantage	Limitation
Fire *Alert*	360° rotation every 4 minutes	Infrared sensor of flame	6 miles	Day/night	High	High: No operator interpretation of image	High precision at close range	Does not detect smoke. Non-optical "view"
Fire Scout	180° continual stationary monitoring	Ultraviolet, flame and power line arching	Up to 1 mile	Day/night	Low: Reports system location only	Med.: Alarm not integrated with fire agency	Preventative fire advantage for power line arcing	Not integrated into fire agency. Non-optical "view". Homeowner oriented, most effective near power lines

Table III – Other Ground-Based Sensor Systems

System	Detection Time/Sampling Frequency	Detection Type	Coverage/ Camera*	24-Hour All-Weather**	GPS Accuracy	Automation Level	Advantage	Limitation
Forest Fire Finder	Continual, 360°	Smoke/ function of atmos. light absorption	9 miles	Day, wind may limit function	High	High: Alarm to agency	Distinguishes organic/inorganic smoke. Weather sensor data included	Daytime only Must be mounted on a pole and the system weighs 65lbs.
Flame Sniffer	Full scan every 5 minutes	Ionization smoke, infrared, heat, wind	1,000 foot radius	Yes	High	High	Extremely durable system with complex capabilities	Would require an extensive network for full coverage

Table IV - Manned and Unmanned Aircraft

System	Detection Time/Sampling Frequency	Detection Type	Coverage	24-Hour All-Weather	GPS Accuracy	Automation Level	Advantage	Limitation
Manned	Continual Sampling, detection depends on aircraft location	Smoke, flame, or infrared	Area the aircraft flies over	Day/night, wind may affect flight	High	Low: pilot must fly aircraft, detection automated	Birds-eye view of territory, can target high-risk areas	Pilot required, detection depends on location of aircraft
Unmanned	Continual Sampling, detection depends on aircraft location	Smoke, flame, or infrared	Area the aircraft flies over	Day/night, wind may affect flight	High	Medium: aircraft flown remotely, detection automated	Birds-eye view of territory can target high-risk areas. Small, light-weight, remote controlled	Must be controlled and monitored. Detection depends on location of aircraft

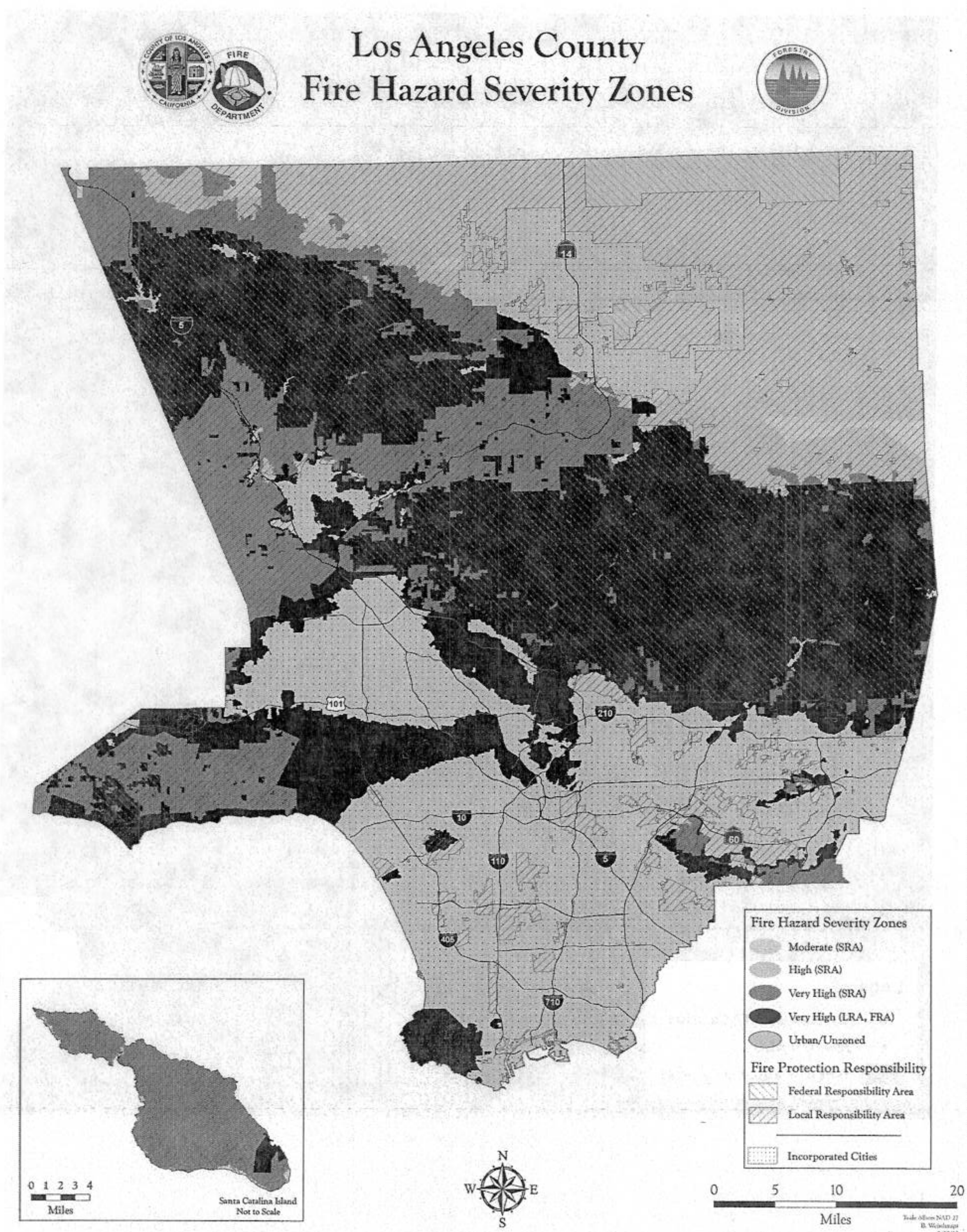
Table V - Satellite Systems

Satellite System	Detection Time/Sampling Frequency	Detection Type	Coverage	24-Hour All-Weather	GPS Accuracy	Automation Level	Advantage	Limitation
NOAA and NASA Weather	Twice daily	Smoke or flame	Hemispheric at low resolution	Twice daily, clouds limiting	High, if a fire is detected	High	Could provide images of larger fires, not effective for detection	Low resolution, low sampling frequency, extremely limited detection capability
DOD Defense Support Program	Scans every 10 seconds, sends data every 15 minutes	Flame	Global, could focus on U.S. or local area	Yes	High	High	Could provide highly accurate images of small fires without jurisdictional limitations	Requires cooperation of Federal agencies

Table VI - All Systems, Board Requirements

System	Early Detection	24-Hour	All-Weather	Automated
Ground-Based Visual Cameras	✓	✓	✓	✓
Ground-Based Infrared Cameras	✓	✓	✓	✓
Other Ground-Based Sensor Systems	✓	✓		✓
Manned Aircraft				✓
Unmanned Aircraft				✓
Weather Satellites				✓
DOD/DSP Satellites	✓	✓	✓	✓

Map I - Fire Hazard Severity Zones



Map II - LA County Tower Location