# Disaster Management Applications – Fire

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**ABSTRACT**

Recent developments in the use of innovative Unmanned Aerial Vehicles (UAV's), improved thermal sensing systems, data communications telemetry, and information extraction and processing have considerably improved the ability of disaster managers to provide quick decision-making during hazardous events. The development of tools for rapid-response and mitigation provide the necessary elements to improve an Incident Command Team's decision support structure, particularly in mitigating wildfire effects. Advanced concept mission planning, flight and sensor demonstrations and technology infusion elements, all related to pushing the utilization of UAV platforms and advanced sensor and telemetry payloads are highlighted and discussed in the paper. Future developments toward every day use of UAV's and sensor payloads particularly oriented towards supporting fire mitigation efforts.

## INTRODUCTION

The National Aeronautics and Space Administration (NASA) tasked with developing UAV utility in the aerospace and research community, has embarked on an ambitious program to push the technological "envelope" of UAV use in research and applications. The NASA program seeks to develop and flight-demonstrate remotely piloted aircraft for cost-effective science missions.

Further goals are to demonstrate the utility of UAVs in situations that would be deemed most appropriate for the technology. These parallel applications efforts seek to "concept-prove" UAVs as data gathering platforms to agencies and public entities in need of such technology.

Since the mission of UAVs is to provide an unmanned airborne platform in situations that would put a pilot at risk, the use of UAVs in both data gathering over wildfires and possibly as a airborne fire-suppression tool are enticing.

A series of research and development and demonstration missions, utilizing UAV platforms and thermal imaging payloads have been coordinated by NASA-Ames researchers to demonstrate "cutting edge" technologies in platform performance, sensor design, data telemetry and image manipulation. These experiments are focused on demonstrating technologies necessary to provide real-time fire information to a disaster manager on the ground.

### FiRE Demonstration Mission

NASA-Ames Research Center, at Moffett Field, California, is leading the NASA UAV applications activities and recently completed a demonstration of the UAV as a wildfire remote sensing platform, gathering thermal data over fires and relaying that information through a satellite communications telemetry system in real-time to fire management personnel on the ground)(Figure 1). The First Response Experiment (FiRE) demonstrated a complete end-to-end mission for collecting thermal image data from a UAV (General Atomics Aeronautical Systems, Inc. (GA-ASI) ALTUS II® platform, telemetering the data through communications satellites in real-time, geo-rectification and information processing on the ground, and dissemination of the data through the World Wide Web (WWW). This demonstration project was the first in a series to further enhance and expand the capabilities of UAV platforms, imaging systems and telemetry technologies to support fire mitigation efforts (Ambrosia *et al*., 2003; Brass *et al*., 2002; Ambrosia *et al*., 1998).

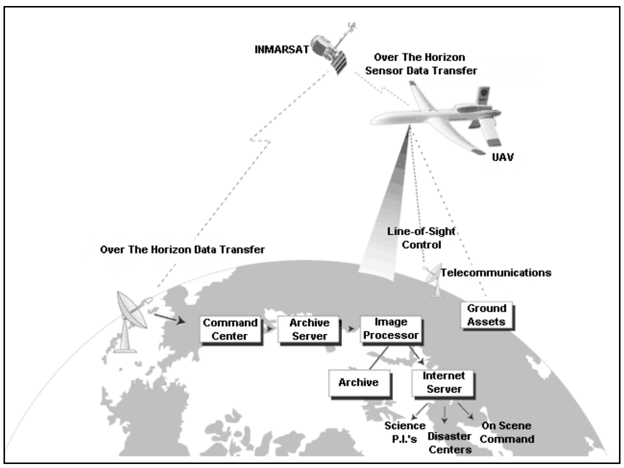


**Figure 1.** FiRE Demonstration Concept Plan. Thermal image data, collected aboard a UAV is telemetered over-the-horizon through an orbiting communications satellite to a data command center. At the center, imagery is geo-rectified in near real-time and redistributed through the web to various users, including the Incident Command Team.

The FiRE experiment demonstrated operations of a UAV over a small prescribed fire, and the subsequent operation of a remotely-operated thermal imaging payload, over-the-horizon telemetry and image manipulation; all within the confines of controlled airspace (Figure 2).

The initial FiRE experiment has further led to significant interest in advancing both the concepts and technology of UAVs, sensors and telemetry to provide improved information to a disaster manager in a shorter period of time. By formulating new flight criteria, mission concepts, improved sensor payload operations and innovative data communications schemes, as well as improved software for handing real-time, on-board geo-rectification procedures, the NASA-Ames team of researchers will to demonstrate a series of missions that will provide the impetus and enhance the demand and utility of UAVs.

**Figure 2.** The ALTUS II® UAV containing the NASA-Ames AIRDAS imaging payload on low pass prior to landing. Flames and smoke from the controlled burn, ignited earlier, can be seen below the aircraft.

Planned future mission enhancements includes the participation of a partnering agency (USDA – Forest Service) to provide "real-world" experience in day-to-day operations of thermal imaging systems over major wildfires in the United States. The main objective of these collaborative efforts is to enhance the capabilities of disaster managers and Incident Command Teams to more quickly and effectively make decisions regarding wildfire suppression activities.

### FiRE II Demonstration Mission

Following the successful completion of the FiRE demonstration mission in September 2001, the NASA-Ames research team began exploring the requirements for follow-on missions to demonstrate new innovative imaging payload configurations, telemetry, improved image manipulation software and extended "capabilities" of a UAV platform.

The FiRE II mission has been planned for late 2003 /early 2004 and encompasses a number of "enhancements" to the earlier FiRE mission. The FiRE II demonstration objective is to fly in commercial airspace and collect thermal infrared imaging data over a "natural" wildfire. This mission would require the aircraft to be integrated with the AIRDAS scanner and "scrambled" soon after a fire is identified. Initial plans are to acquire data over fires within a 50-mile radius of El Mirage, California. This 50-mile range allows for the UAV (ALTUS II®) to glide-return to the GA-ASI flight facility in the event of a failure of the aircraft power plant. The 50-mile range allows access to candidate wildfires in the surrounding San Gabriel Mountains and into the Los Angeles basin (Figure 3).

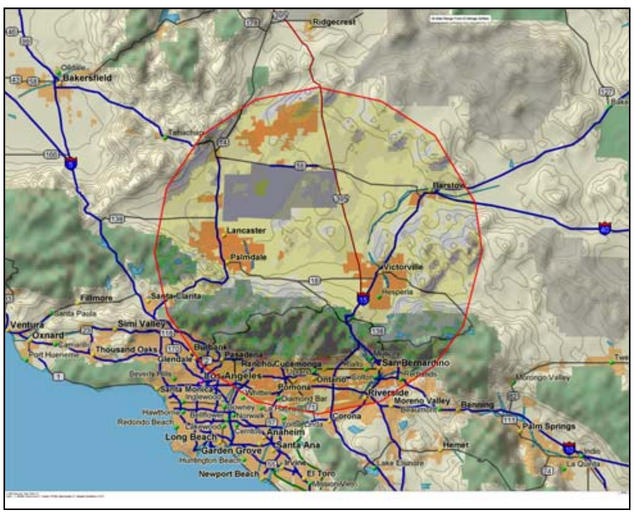


**Figure 3.** Fifty-mile flight radius coverage capability centered at General Atomics Flight Facility, El Mirage, CA. Fires within the front range of the San Gabriel Mountains of the L.A. Basin are within this radial coverage, including portions of Santa Clarita and Riverside, California.

The FiRE II mission would further push the technology advancements by remaining aloft for a few hours, operating in civilian airspace with other commercial aircraft, operate at much higher altitudes and demonstrate improved geo-rectification procedures for information extraction. The planned mission is to operate between 20-50K feet altitude, well beyond the requirements of the earlier FiRE mission (3-6K feet). This higher mission altitude necessitated alterations to the AIRDAS instrument configuration to allow for environmental conditions found at those altitude ranges. The instrument was laboratory tested in temperature gradient "cold" chambers at NASA-Ames to verify electronics operations and to alter the configuration of components that failed these environmental tests. Thermal detector cooling systems were changed (from LN2 cooling) to allow longer duration, unattended, instrument operations for AIRDAS. This modification involved the incorporation of Sterling detector cooling.

The FiRE II mission will continue to utilize the NERA M4 World Communicator satellite communications antennas for telemetry of AIRDAS data from the UAV platform (ALTUS II® airframe) through the INMARSAT commercial telecommunications satellite over-the-horizon to an image data station or Incident Command Center. The antennas are mounted in opposing fairings on the forward fuselage of the ALTUS II®, on either side of the payload bay (Figure 4). This telemetry configuration allows for 64 Kbs data communications throughput rates, with an expected upgrade to +300 Kbs in late 2003/04.

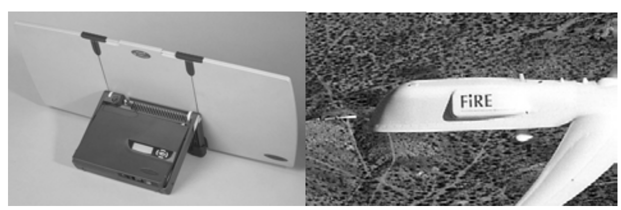


**Figure 4.** (a) NERA M4 portable satellite terminal phased-array antenna. The antennas are approximately 340mm by 774mm by 12mm (depth). Data throughput is 64 Kbs. (b) The antennas (one on each side of the UAV fuselage at the FiRE logo) were installed at an appropriate intercept angle for satellite communications.

The FiRE II mission will allow demonstration of UAV performance in national airspace, leading to certification of future missions, ultimately leading to "file-and-fly" capabilities with FAA approval over greater sections of domestic airspace. The mission will also demonstrate longer duration missions and provide guidance on imaging payload performance criteria at higher altitudes. As a "stepping stone" demonstration mission, the FiRE II experiment will showcase UAV and thermal imaging payload performance during more robust mission requirements than were demonstrated in the FiRE experiment.

**Western States FiRE Mission**

The Western States Fire demonstration mission is currently planned for late summer of 2004. NASA-Ames researchers are currently configuring the payload (AIRDAS) for an extended range / extended duration mission to showcase real-time delivery of thermal fire information over numerous fires extending throughout a large continental area and for a +24-hour mission period (Figure 5).

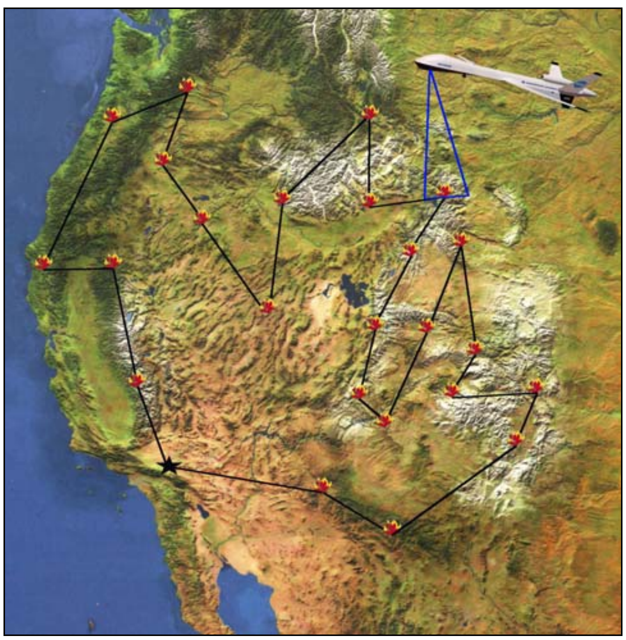

**Figure 5.** Theoretical flight profile for a +24-hour, +4200 nautical mile fire "reconnaissance mission over the western U.S. utilizing the GA-ASI ALTAIR® UAV platform with the AIRDAS Thermal scanner payload.

The Western States mission will be flown with the new GA-ASI-built ALTAIR® platform, which has extended payload, range, altitude, and telemetry capabilities (General Atomics Aeronautical Systems, Inc., 2001)(Figure 6)(Table 1).

**Figure 6.** GA-ASI ALTAIR® UAV. The ALTAIR® is an offshoot of the Predator UAV and allows larger payload capabilities, higher altitude, longer range and extended mission duration.

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| **Dimensions** | Wing Span 84 ft.; Length 36.2 ft.; Height 11.8 ft. |
| **Weights** | Max Fuel Wt. 3500 lb; Payload Wt. 750 lb.; Max GTOW 7700 lbs. |
| **Propulsion** | 700 BHP TPE331-10 Allied Signal Turboprop with McCauley 3-bladed, hydraulic, constant speed, variable/reverse pitch propeller |
| **Performance** | Max Altitude: 55,000 ft.; Endurance: 32 Hours (with 700 lb payload); Cruise/Loiter Speed 144 KIAS; Range: 4500 nm |
| **Payload Specs** | Size: 80"L x 35"H x 40"W, (Adaptable); Max Wt. 750 lbs., Payload |
| **Navigation** | Three integrated IMUs and three Differential GPS (optional P-code) |
| **Avionics** | C-Band LOS Range: 100 nm; 500 Kbs Ku-band OTH Operations; autonomous flight (no datalink) |

**Table 1.** GA-ASI ALTAIR UAV specifications.

The ALTAIR® will be tasked in-flight to over-fly various fires scattered throughout the western U.S. AIRDAS data, collected aboard the UAV will be telemetered via a large capacity data communications telemetry system

(500 Kbs) to the ground and to the National Interagency Fire Center (NIFC) in Boise, Idaho. Real-time image geo-rectification will be performed and the fire image information will be distributed to Incident Command Centers at individual fire complexes.

**FINAL REMARKS**

The UAV FiRE "heritage" demonstration R&D projects showcase new and emerging technologies for providing rapid information support mechanisms on disaster and hazard scenarios. Utilizing innovative UAV platforms allow data collection over large areas during extended mission operations, beyond the capabilities of manned aircraft. Developments in enhanced thermal imaging payloads allows for pertinent, critical information to be derived on fire characteristics and behavior, allowing more informed decisions to be made by the disaster manager. Improving data communications telemetry technology allows larger information data sets to be forwarded to appropriate disaster management facilities. Faster computing capabilities allows for more rapid geo-rectification of data, which, in turn, speeds up data integration and map overlay within applicable GIS systems. All these technological advancements provide the disaster community with the ability to make more informed and rapid decisions on fires and other hazards.

The disaster management community is on the cusp of a great technological leap forward, enabled by advancements in airborne platforms (particularly UAVs), sensor and imaging systems, telemetry, and information processing and product delivery. The authors are committed to assisting and enhancing the development of these supporting technologies for use by the disaster management community.

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**REFERENCES**

Ambrosia, V.G., Steven S. Wegener, Donald V. Sullivan, Sally W. Buechel, Stephen E. Dunagan, James A. Brass, Jay Stoneburner, 2003. *Demonstrating UAV-Acquired Real-Time Thermal Data Over Fires,* <u>Photogrammetric Engineering and Remote Sensing</u>, 69(4): 391-402.

Ambrosia, V.G., S.W. Buechel, J.A. Brass, J.R. Peterson, R.H. Davies, R.J. Kane and S. Spain, 1998. An Integration of Remote Sensing, GIS, and Information Distribution for Wildfire Detection and Management, *Photogrammetric Engineering and Remote Sensing*, 64(10): 977-985.

Brass, J.A., V.G. Ambrosia, R.S. Dann, R.G. Higgins, E. Hildum, J. McIntire, P.J. Riggan, S. Schoenung, R. Slye, D.V. Sullivan, S. Tolley, R. Vogler, S. Wegener, 2001. First Response Experiment (FiRE) Using An Uninhabited Aerial Vehicle (UAV), *Proceedings of 5th International Airborne Remote Sensing Conference*, 17-20 September, San Francisco, California, CD paper no. 56, pp 1-9.

General Atomics Aeronautical Systems, Inc., 2001. ALTAIR Experimenter's Handbook, Publication #ASI-00194C, pp. i-F6.