Fire Fighting from High Altitude

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March 7, 2007
Palmdale, CA
Agenda

- 2006 Western States Fire Mission
- Esperanza Fire
- 2007 Western States Fire Mission
Yellowstone Fire - 1988
(ER-2 visible and IR imagery)
After about 5 months of complex negotiations, the FAA granted NASA a Certificate of Authorization (COA) for flight in the National Air Space (NAS). Due to a number of complications, research flights were limited to “prescribed” burns in the Yosemite National Park and Forest.

- Flight profile objectives established by ARC / USFS.
- Flight Corridors established – working with FAA.
- August 16th, 2006; DFRC Range; System Check-Out Flight.
- October 11/12; DFRC Range (2508); System Analysis Flight.
- October 24/25; Yosemite NP & Vicinity; FAA Familiarization in NAS.

Over-flights of actual wild fires would have to wait until the 2007 fire season.

Immediately following the mission, the Fire Mission payload was removed.
UAV Image Data Flow Diagram

**Airborne Element**
- **Line Scanner**
- **POS/AV IMU/DGPS**

**Digitizer**
- **Image Data Capture (ADC)**
- **NAV Data MUX**

**Web Server**
- **GIS User Interface**
- **Image Server: Level-2 GEOTIF Thumbnails**
- **Track Map Server**

**Ground Element**
- **Internet/End User**
- **Shared Disk**

**Ground Computer**
- **Functions:**
  - Geo-Correction Processing
  - Query Handling
  - Science Algorithm Processing
  - Sensor C&C

**Sat Com Link**
- **High Speed (Full Res. Image Subsets)**
- **Low Speed (Image Thumbnails, C&C)**
- **Full Res. 200Hz Data (RS-232)**

**Product QA/QC**
- **DEM/DOQ Database**
- **ARC Earth Science Div.**
- **Airborne Sensor Facility**

**Functions:**
- **Airborne Element:**
  - Image Data Capture (ADC)
  - NAV Data MUX

- **Ground Element:**
  - GIS User Interface
  - Image Server: Level-2 GEOTIF Thumbnails

- **Ground Computer:**
  - Geo-Correction Processing
  - Query Handling
  - Science Algorithm Processing
  - Sensor C&C

- **Sat Com Link:**
  - High Speed (Full Res. Image Subsets)
  - Low Speed (Image Thumbnails, C&C)
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- **Product QA/QC:**
  - DEM/DOQ Database
  - ARC Earth Science Div.
  - Airborne Sensor Facility
October 24-25 Mission: Yosemite NP and NF >>> In The NAS For First Time!!

Mission Objectives:
Extend mission to NAS
Mission endurance: +20hr at altitude (FL430)
Fly “Paint-the-Box” missions and “wind-vector” lines
Over-fly NPS / USFS Prescribed Fires in Vicinity
MODIS Coincident Under-fly
Collect Data Over Extreme Terrain
Data Quality validation, including terrain-rectification
October 24-25 Mission

Sierra Eastern Rampart
Mt Ritter and Mt Banner

3 Image TIR-IR-VIS Composite
October 24-25 Mission MODIS Overpass

Oct 28; 9:30 AM
TIR-IR-VIS

Two prescribed Fires
October 24-25 Mission Highlights

Mission Endurance: 21:24 Hours
Total Time In NAS: ~17 Hours
Data Collected:
- 15 Gb of Data
- 500,000 line of scanner data
- 192 Images Collected and Transmitted
- 20 Shape Files Collected and Transmitted

ALTAIM: 68-hours of WRAP mission operations without major flaw, to-date!
Mission Objectives:

Support CA-OES Request for UAS Flight with AMS-Wildfire System

Emergency COA Allowed by FAA from Oct 28-30th

First UAS Allowed Over Populated Area

Transmit Data to ICC

Underfly MODIS Overpass Times

Operate Safely in NAS
### Response to the Esperanza Fire in Southern California -- Timeline Oct 27, 2006

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fri 1000</td>
<td>Received request from CA Governor’s Office of Emergency Services to conduct thermal imaging mission. Initial discussions with FAA indicate willingness to activate emergency COA process. Dozens of calls over next hour to confirm FAA willingness, contract approach and funding, GA/DFRC/ARC ability to support, and a plan for integration.</td>
</tr>
<tr>
<td>Fri 1020</td>
<td>Notified NASA Range Safety of potential mission.</td>
</tr>
<tr>
<td>Fri 1028</td>
<td>Notified NASA Dryden Chief Engineer of potential for mission.</td>
</tr>
<tr>
<td>Fri 1230-1700</td>
<td>Operations and Range Safety worked on mission with FAA and Range Safety. Plan to use same operations plan/rules as previous week’s Yosemite mission.</td>
</tr>
<tr>
<td>Fri 1235</td>
<td>Emergency funding authorized.</td>
</tr>
<tr>
<td>Fri 1400-Sat 0100</td>
<td>Fire Sensor system driven back to Gray Butte from NASA-Dryden. Systems reintegrated into Pod.</td>
</tr>
<tr>
<td>Fri 1515</td>
<td>Sent proposed flight plan (from RSO) and emergency procedures to FAA</td>
</tr>
<tr>
<td>Fri 1500-1600</td>
<td>Technical Brief began, issues discussed with NASA, General Atomics project team, and Dryden senior management team. Range safety presented initial findings. Flight request (up to 2 flights) approved subject to range safety analysis.</td>
</tr>
</tbody>
</table>
## Response to the Esperanza Fire in Southern California -- Timeline Oct 28, 2006

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<th>Event</th>
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<tr>
<td>Fri 1600-2300</td>
<td>Final Mission planning and Estimation of casualty analysis completed.</td>
</tr>
<tr>
<td>Fri 1800</td>
<td>FAA indicates COA approval is likely</td>
</tr>
<tr>
<td>Fri 1930</td>
<td>The Deputy Director of CA Emergency Operations and Incident Command Center reaffirm requested imagery to Governors Chief of Staff.</td>
</tr>
<tr>
<td>Fri 2100</td>
<td>Received FAA COA amendment</td>
</tr>
<tr>
<td>Sat 0600-1200</td>
<td>Pod installed on aircraft, instrument checks completed, aircraft weight and balance. No Issues.</td>
</tr>
<tr>
<td>Sat 0730</td>
<td>Discussed mission with Dryden Center Director. He indicated that he would approve the mission.</td>
</tr>
<tr>
<td>Sat 1200</td>
<td>Aircraft pre-flight started.</td>
</tr>
<tr>
<td>Sat 1430</td>
<td>Crew Brief at Gray Butte. No issues. Weather conditions excellent.</td>
</tr>
<tr>
<td>Sat 1545</td>
<td>Takeoff (15 minutes early), climb-out in R-2515 to 43k</td>
</tr>
<tr>
<td>Sat ~1715</td>
<td>Exit R-2515 to Esperanza Fire.</td>
</tr>
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### Response to the Esperanza Fire in Southern California -- Timeline Oct 29, 2006

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<th>Time</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>2300</td>
<td>FAA notified that we plan to return to the fire. Flight plan re-filed.</td>
</tr>
<tr>
<td>0730</td>
<td>Aircraft departed R-2515 and returned to the fire. Many passes made over the fire. Data sent in near real-time to Incident Command Center.</td>
</tr>
<tr>
<td>0730</td>
<td>Aircraft landed.</td>
</tr>
<tr>
<td>Postflight</td>
<td>ARC team and GA PM traveled to Incident Command Center.</td>
</tr>
<tr>
<td>0000-0730</td>
<td>Aircraft returned to R-2515 and aircraft climbed to approximately 40k ft. GA Operations management required a 2 hour loiter at this altitude before proceeding back to the fire.</td>
</tr>
<tr>
<td>1900</td>
<td>Flight crew did not enable heater. Since the aircraft was also on C-band line of sight, loss link was not initiated. However, voice Comm with ATC was lost. Per mission rules, ATC notified by phone and aircraft returned to R-2515. Heater enabled when discovered.</td>
</tr>
<tr>
<td>~1900</td>
<td>After descending to 9k ft, Ku warmed up and began working again. Heater enabled and aircraft climbed to approximately 40k ft. GA Operations management required a 2 hour loiter at this altitude before proceeding back to the fire.</td>
</tr>
<tr>
<td>~1900</td>
<td>After completing 4 passes over fire (excellent data), Ku SatCom system stopped transmitting due to cold temps (known problem). Flight crew did not enable heater. Since the aircraft was also on C-band line of sight, loss link was not initiated. However, voice Comm with ATC was lost. Per mission rules, ATC notified by phone and aircraft returned to R-2515. Heater enabled when discovered.</td>
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October 28-29 Mission
Esperanza Fire Altair Flight Routing
October 28-29 Mission Esperanza Fire Altair Over-Flights
October 28-29 Mission
Esperanza Fire, California

First Image Collected
5:30 PM
TIR-IR-VIS Composite
October 28-29 Mission
Esperanza Fire, California

First Image
Collected
5:30 PM
12-7-5 Band
Composite
October 28-29 Mission
Esperanza Fire

Blend of TIR data over fire perimeter 3D perspective.

Notice fire extending beyond perimeter (in white)
October 28-29 Mission Highlights

Mission Endurance: 16:27 Hours
Total Time In NAS: ~10 Hours

Data Collected:
- 94 Images Collected and Transmitted
- 44 Shape Files Collected and Transmitted
- 20 Flight Tracks over the fire

One Coincident MODIS overpass collection (2:34 AM)

First Emergency COA Granted For UAS Mission in NAS

Delivered Data to IC and to CA-OES (Sacramento, CA)
Results from the Esperanza Fire Response

- First Emergency COA for civilian disaster.
  - Process worked very well.
- 94 images (geo- and terrain-corrected) and over 20 hot-spot perimeters were transmitted in real-time from the aircraft to a NASA-Ames server.
- The data and information were re-distributed (in real-time) to a Decision Support System (DSS) within Google Earth, enabling access to the data by the fire mapping teams.
- Science team met with California Department of Forestry (CDF) Plans Chief, Infrared Mapping Group, and Chief CDF.
  - Downlink data was available to them all night.
  - Data products were used for planning and morning briefings.
  - Got a good impression of how the command center works and how the data can integrate in the future.
  - Requested meeting to discuss future collaboration.
- CA Emergency Operations Center expressed interest in follow-up collaboration during the mission.
- Press releases from NASA, GA, FAA.
- Delivered feedback to FAA on the mission / lessons learned.
2007 Western States Fire Mission

- By the conclusion of the 2006 Western States Fire Mission, all of the technical and procedural elements had been developed.
- Even prior to the conclusion of the 2006 Western States Fire Mission a decision had been made to develop a 2007 Western States Fire Mission.
- The Esperanza Fire was extremely encouraging to everyone involved and key organizations observed the true potential and importance of this type of capability.
- An initial meeting with the FAA to discuss the COA and the routes in the NAS that would be allowed was very positive.
- NASA filed a COA application last week with the FAA for these missions.
Define three mission regions and routes of operation in Western US.

Regions must cross only 3 ARTCC boundaries.

Establish flight plan 3 days in advance; modify one day in advance.

Allow real-time vectoring to emerging targets.
Western States UAS Fire Mission 2007

Operations on NASA’s Ikhana UAS

Pod Installs Under In-Bound Wing Mount Point