Fire Fighting from High Altitude

Brent Cobleigh, NASA - DFRC

Dr. Vince Ambrosia, NASA - ARC

W-HALES 2007

(NASA-NICT Joint Workshop on HALE UAV and Wireless Systems)

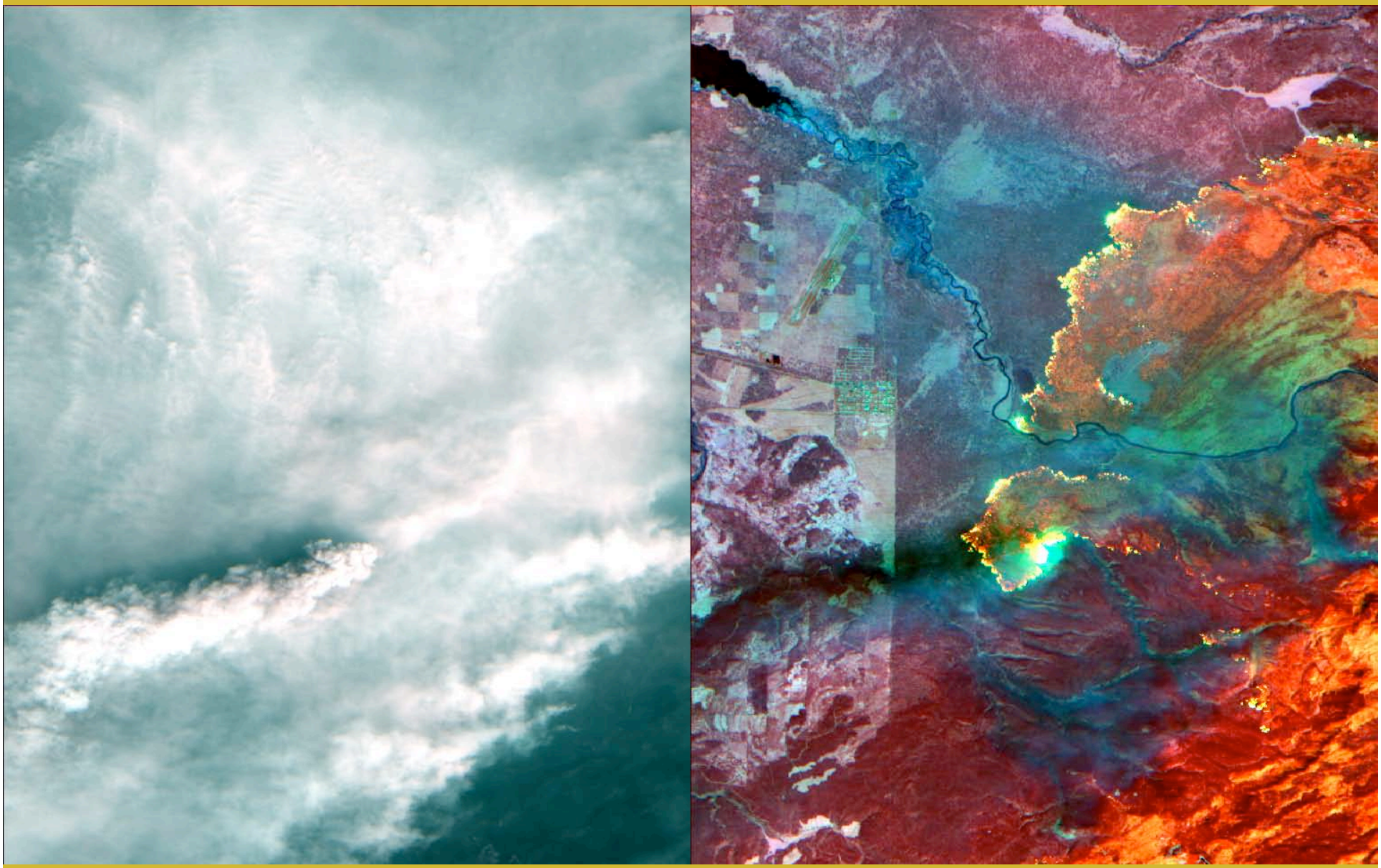
March 7, 2007

Palmdale, CA

GENERAL ATOMICS AERONAUTICAL SYSTEMS

Agenda

- 2006 Western States Fire Mission
- Esperanza Fire
- 2007 Western States Fire Mission

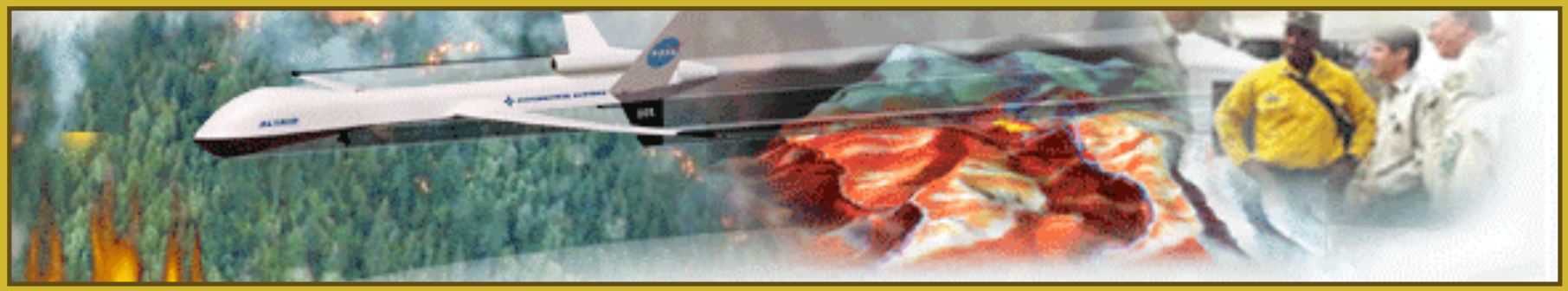


Yellowstone Fire - 1988

(ER-2 visible and IR imagery)

2006 Western States Fire Mission Over-View

- 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.



AMS-Wildfire Scanner

UAV Image Data Flow Diagram
(DRAFT Concept, 6/04)

Airborne Element

Line Scanner

POS/AV IMU/DGPS

Digitizer
Functions:
- Image Data Capture (ADC)
- NAV Data MUX

Shared Disk

Full Res. 200Hz Data (RS-232)

Intelligent Sensor Interface Module
Functions:
- Primary Algorithm Processing
- Thumbnail Generation
- On-Demand Image Subsetting

Sat Com Link
High Speed (Full Res. Image Subsets)

Low Speed (Image Thumbnails, C&C)

Ground Element

Internet End User

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

Shared Disk

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

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

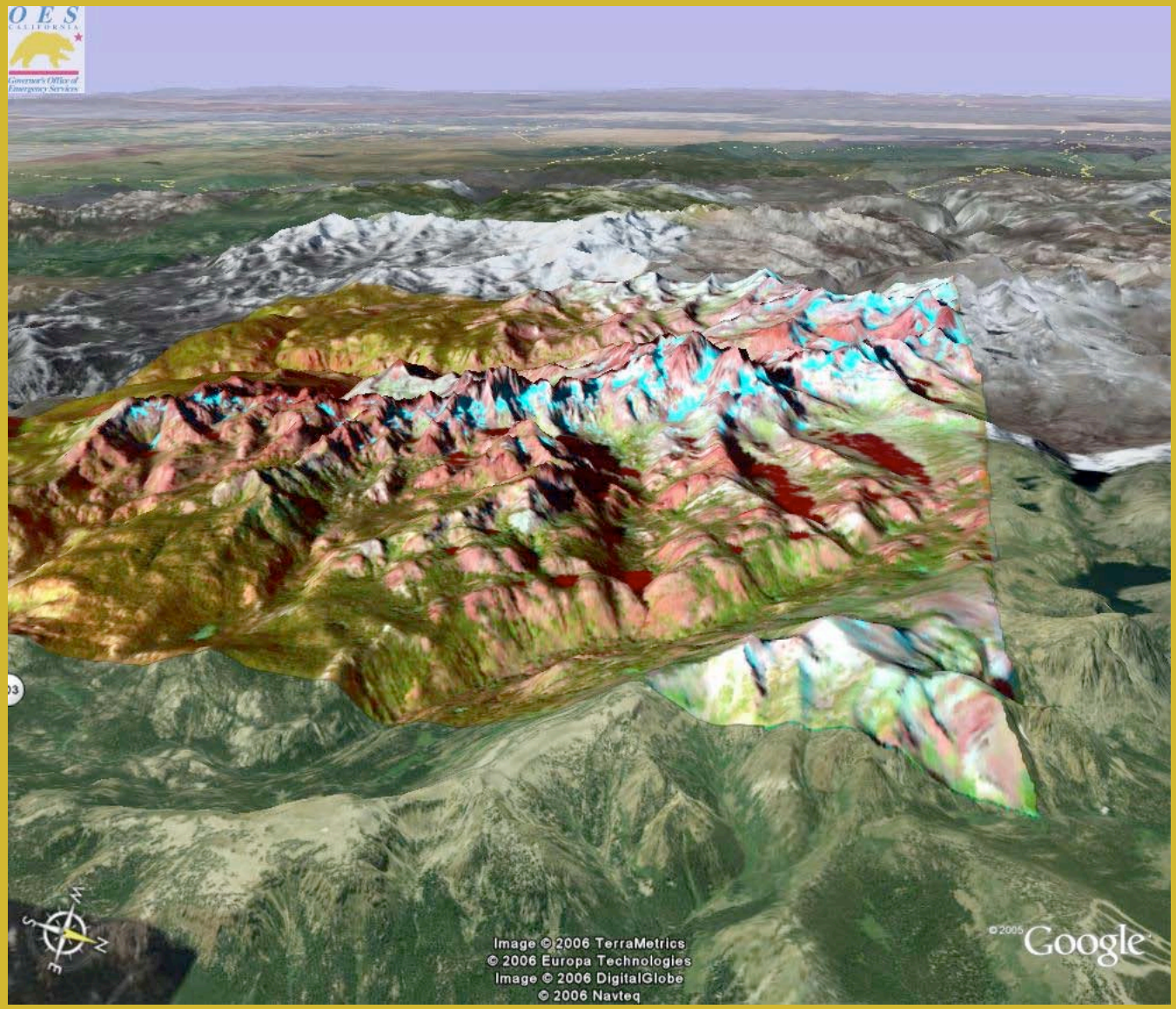
Collect Data Over Extreme Terrain

Data Quality validation, including terrain-rectification

October 24-25 Mission

Sierra Eastern Rampart

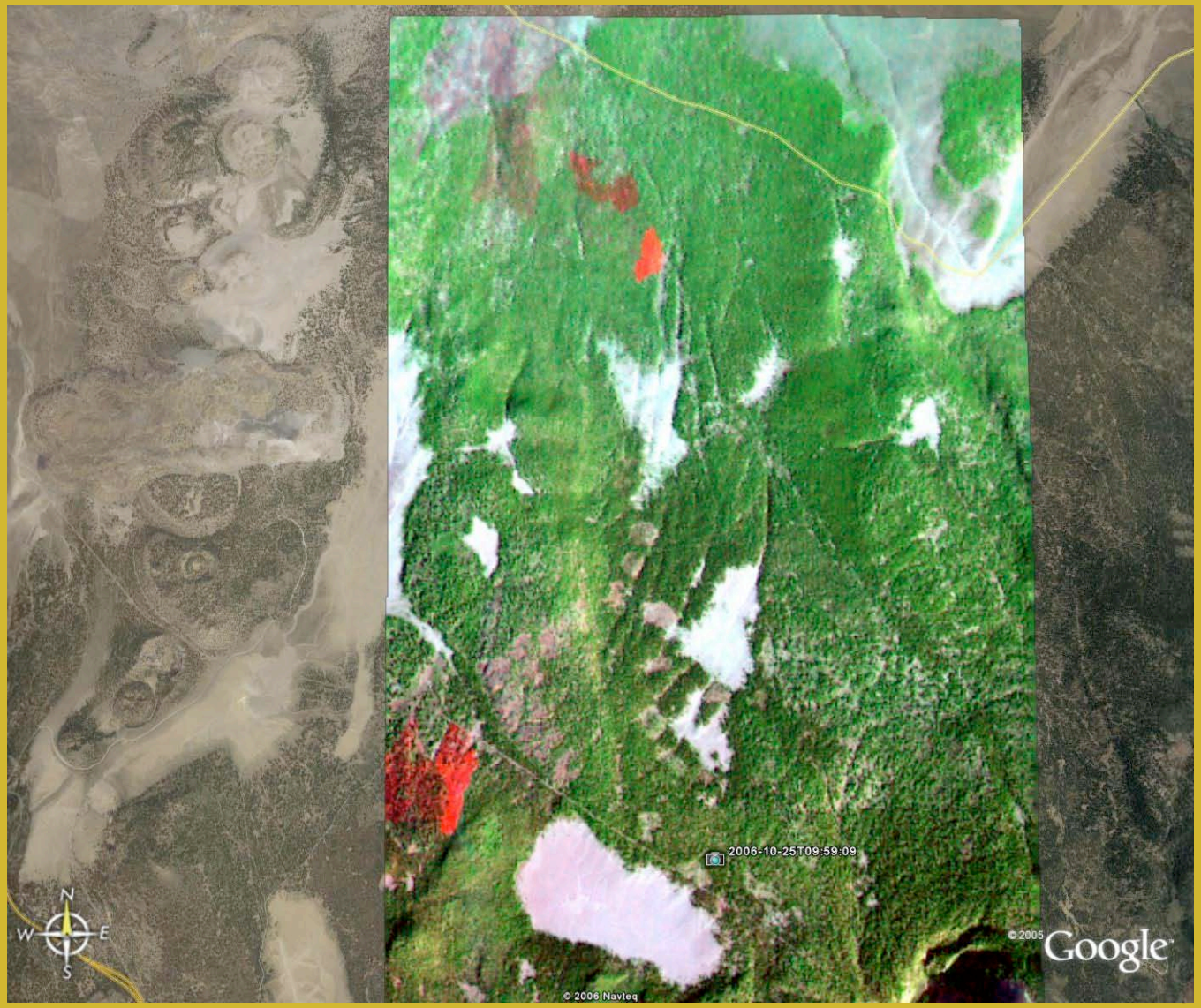
Mt Ritter and Mt Banner



3 Image TIR-IR-VIS Composite

October 24-25 Mission
MODIS Overpass

Two prescribed Fires



Oct 28; 9:30 AM

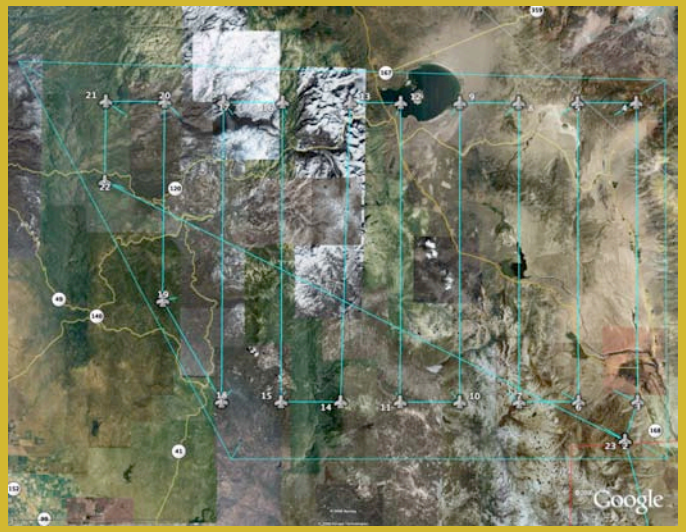
TIR-IR-VIS

October 24-25 Mission Highlights

Mission Endurance: 21:24 Hours

Total Time In NAS: ~17 Hours

Data Collected: **15 Gb of Data**



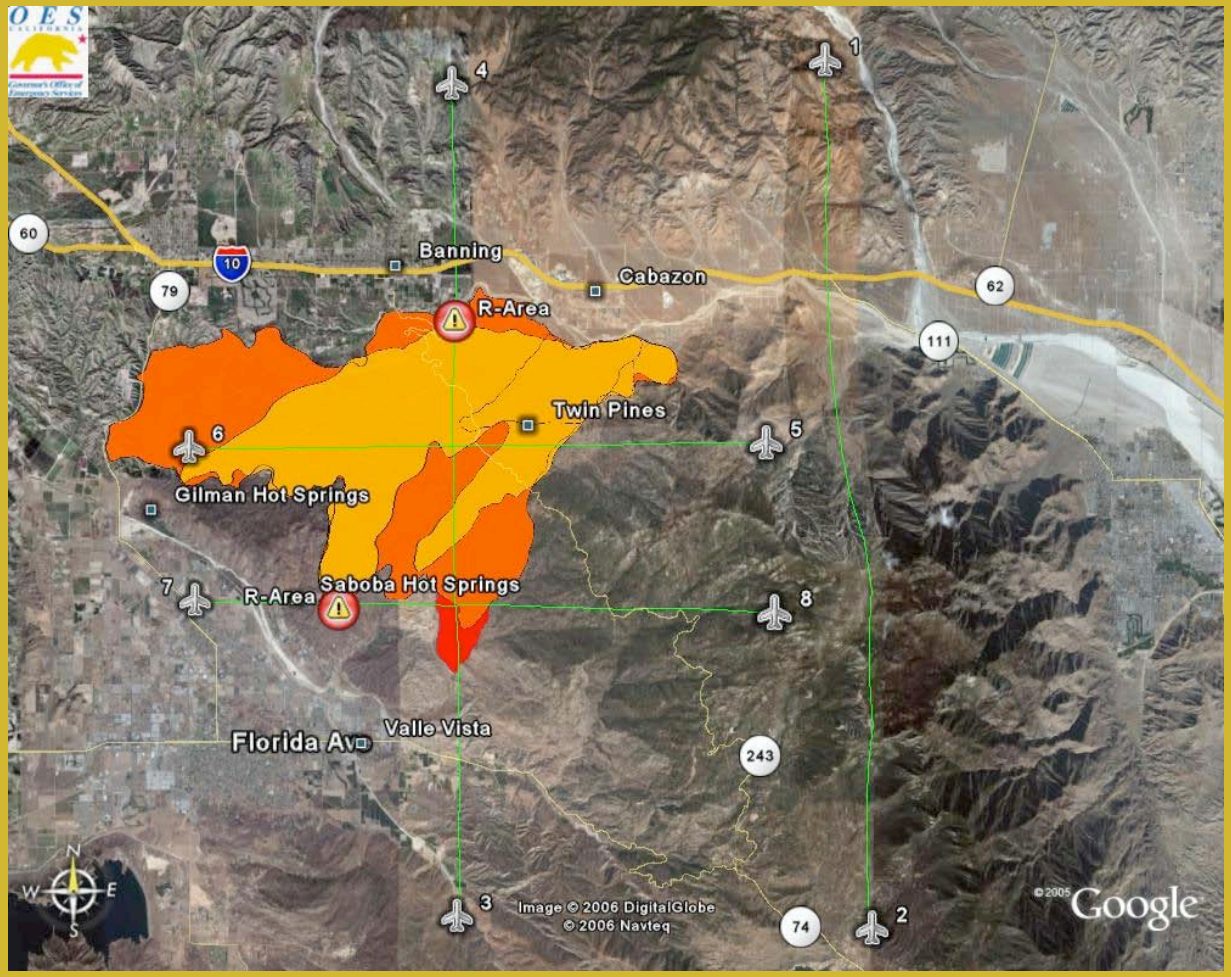
500,000 line of scanner data

192 Images Collected and Transmitted

20 Shape Files Collected and Transmitted

ALTAIR: 68-hours of WRAP mission operations without major flaw, to-date!

October 28-29 Mission
Esperanza Fire, California



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

Fri 1000	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.
Fri 1020	Notified NASA Range Safety of potential mission.
Fri 1028	Notified NASA Dryden Chief Engineer of potential for mission.
Fri 1230-1700	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.
Fri 1235	Emergency funding authorized.
Fri 1400-Sat 0100	Fire Sensor system driven back to Gray Butte from NASA-Dryden. Systems reintegrated into Pod.
Fri 1515	Sent proposed flight plan (from RSO) and emergency procedures to FAA
Fri 1500-1600	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.

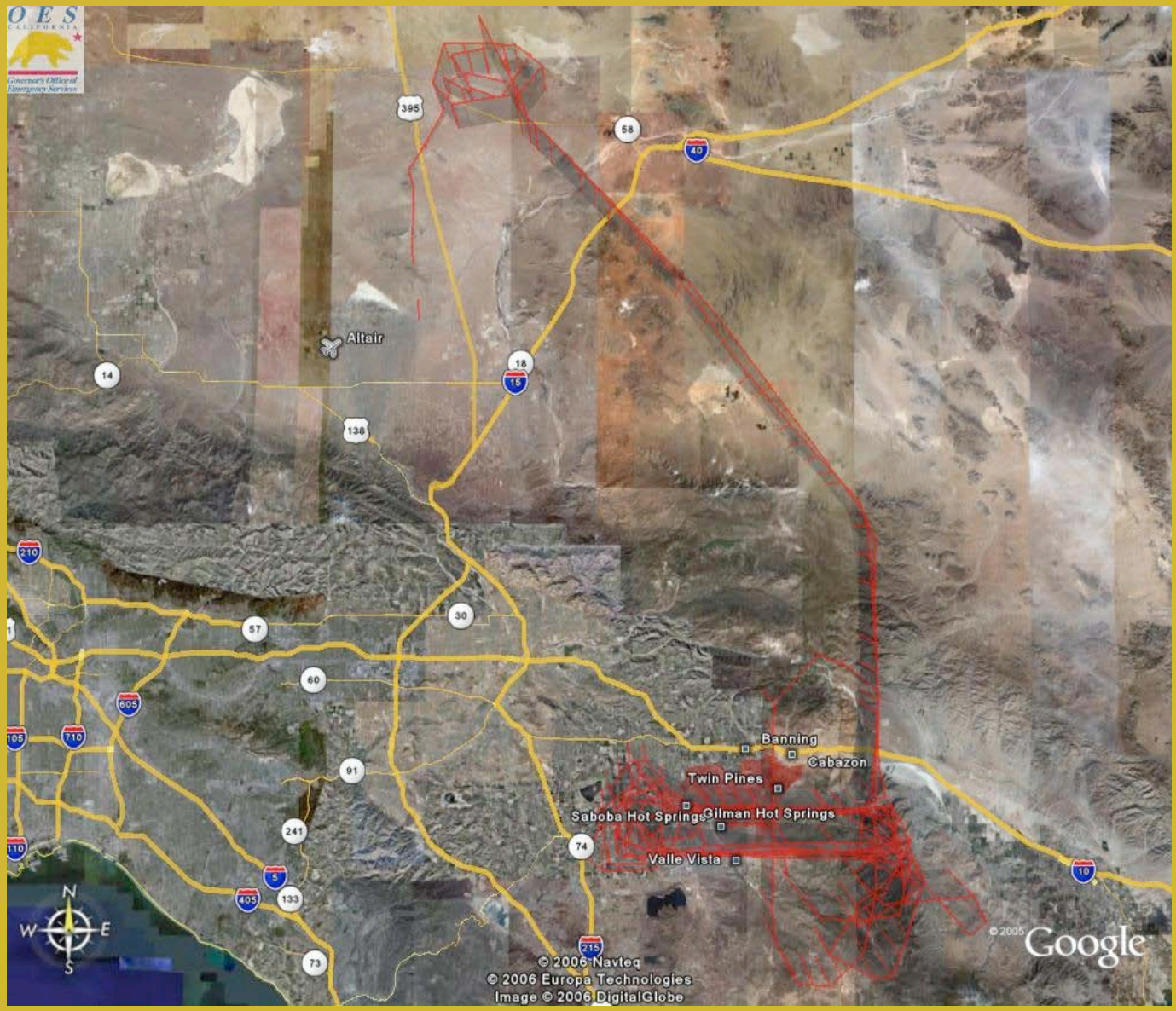
Response to the Esperanza Fire in Southern California -- Timeline Oct 28, 2006

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

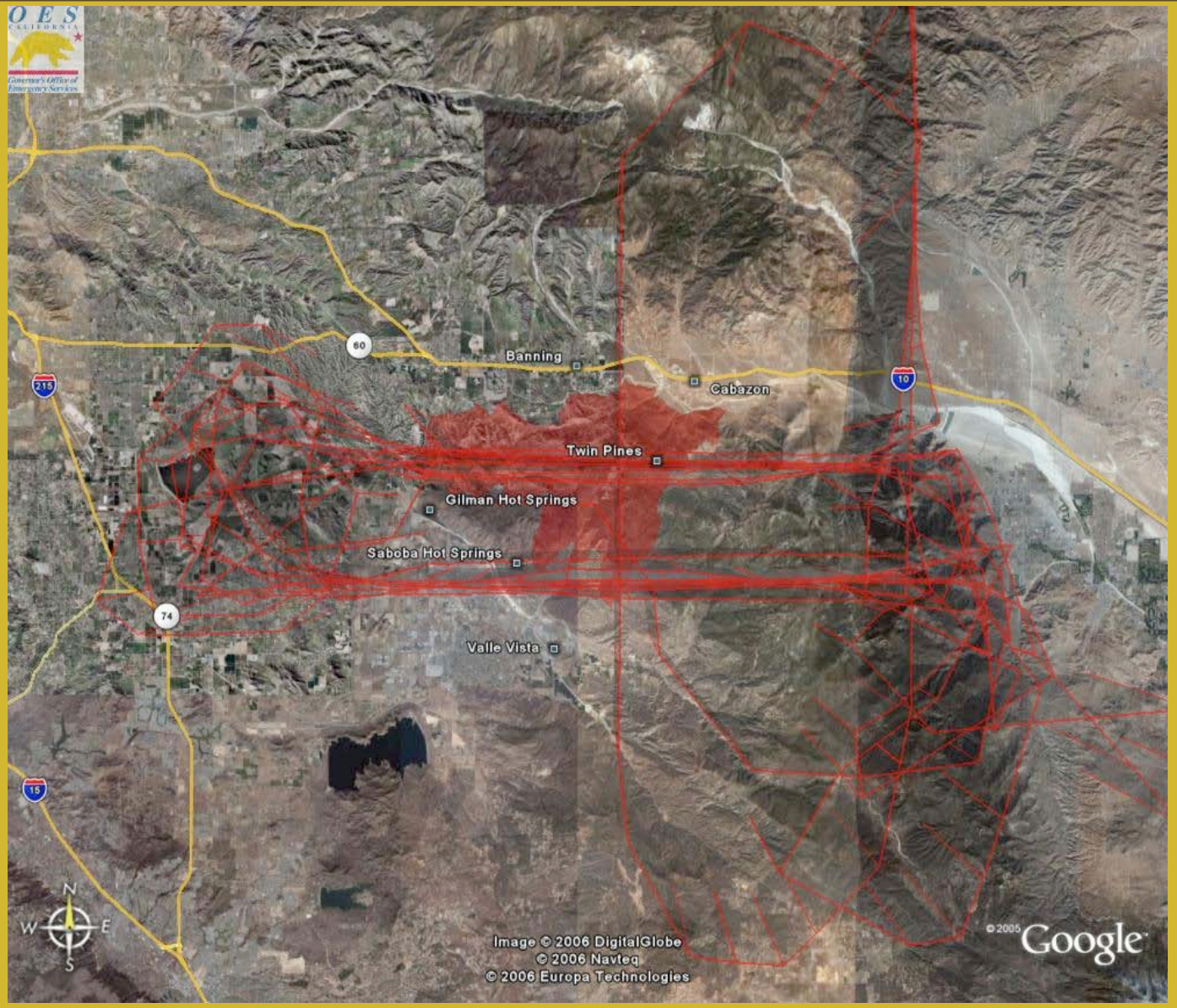
Response to the Esperanza Fire in Southern California -- Timeline Oct 29, 2006

Sat ~1900	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.
Sat ~2000	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.
Sat ~2300	FAA notified that we plan to return to the fire. Flight plan re-filed.
Sun 0000-0730	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.
Sun 0730	Aircraft landed.
Postflight	ARC team and GA PM traveled to Incident Command Center.

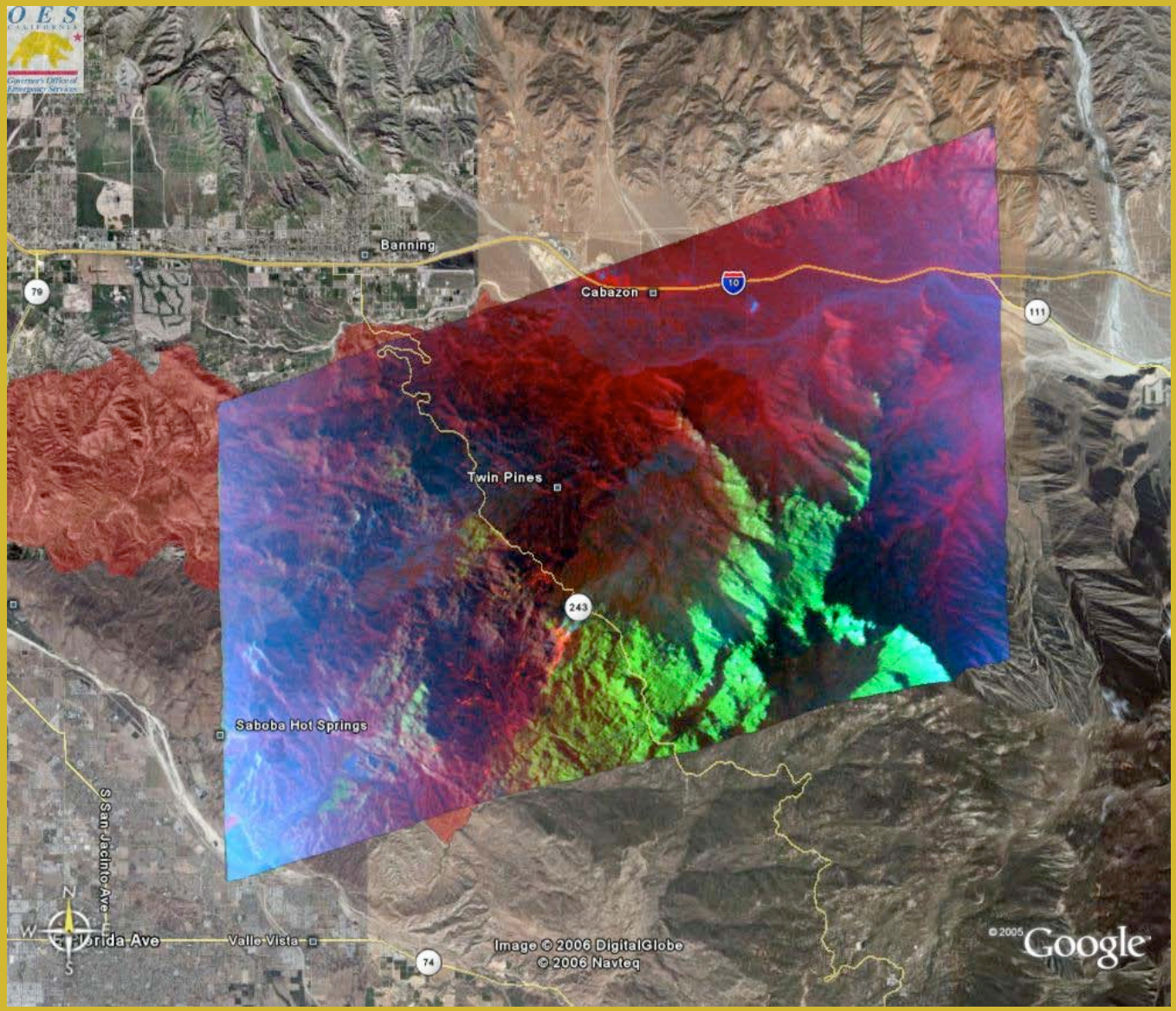
October 28-29 Mission
Esperanza Fire Altair Flight Routing



October 28-29 Mission
Esperanza Fire Altair Over-Flights

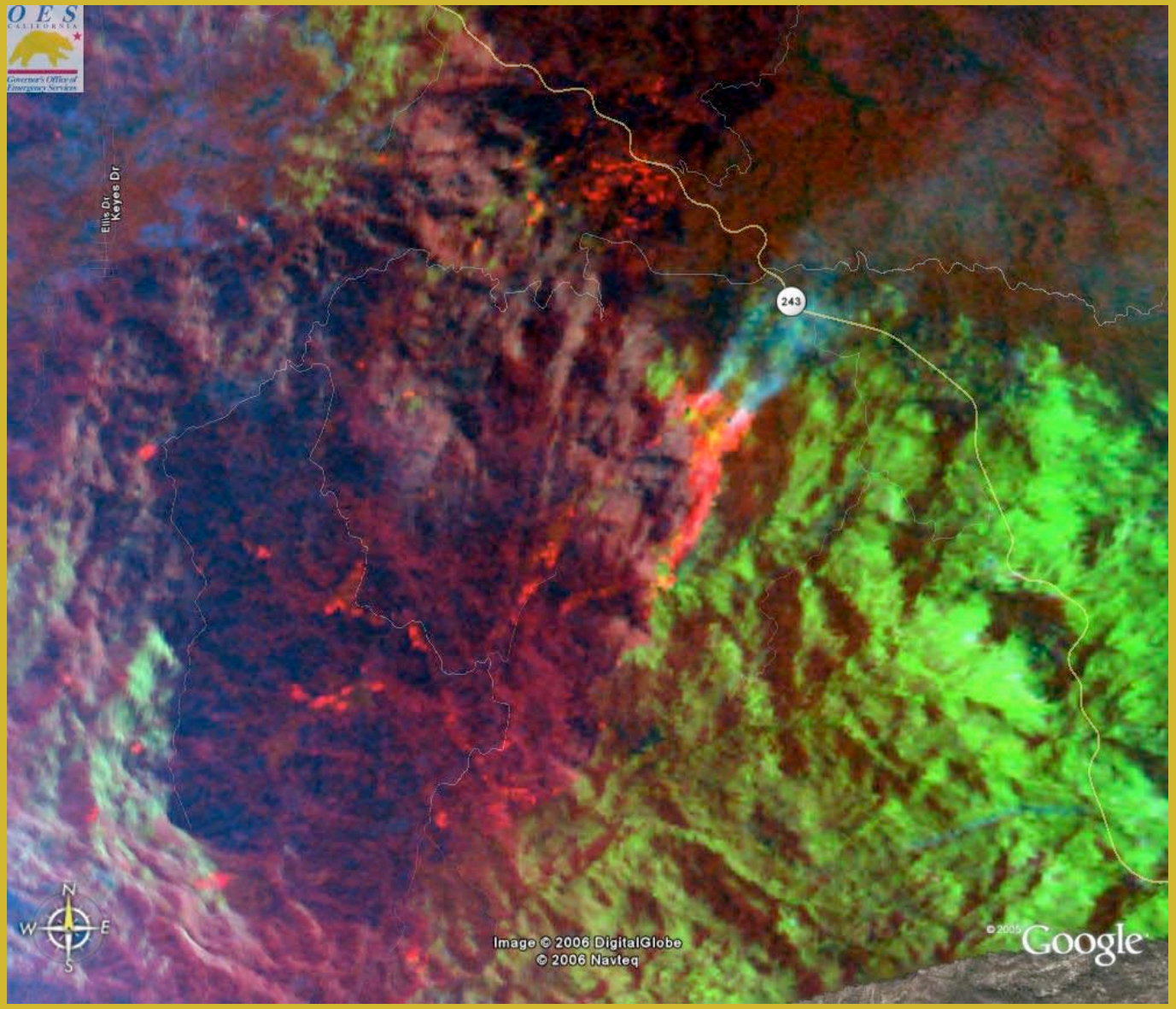


October 28-29 Mission
Esperanza Fire, California

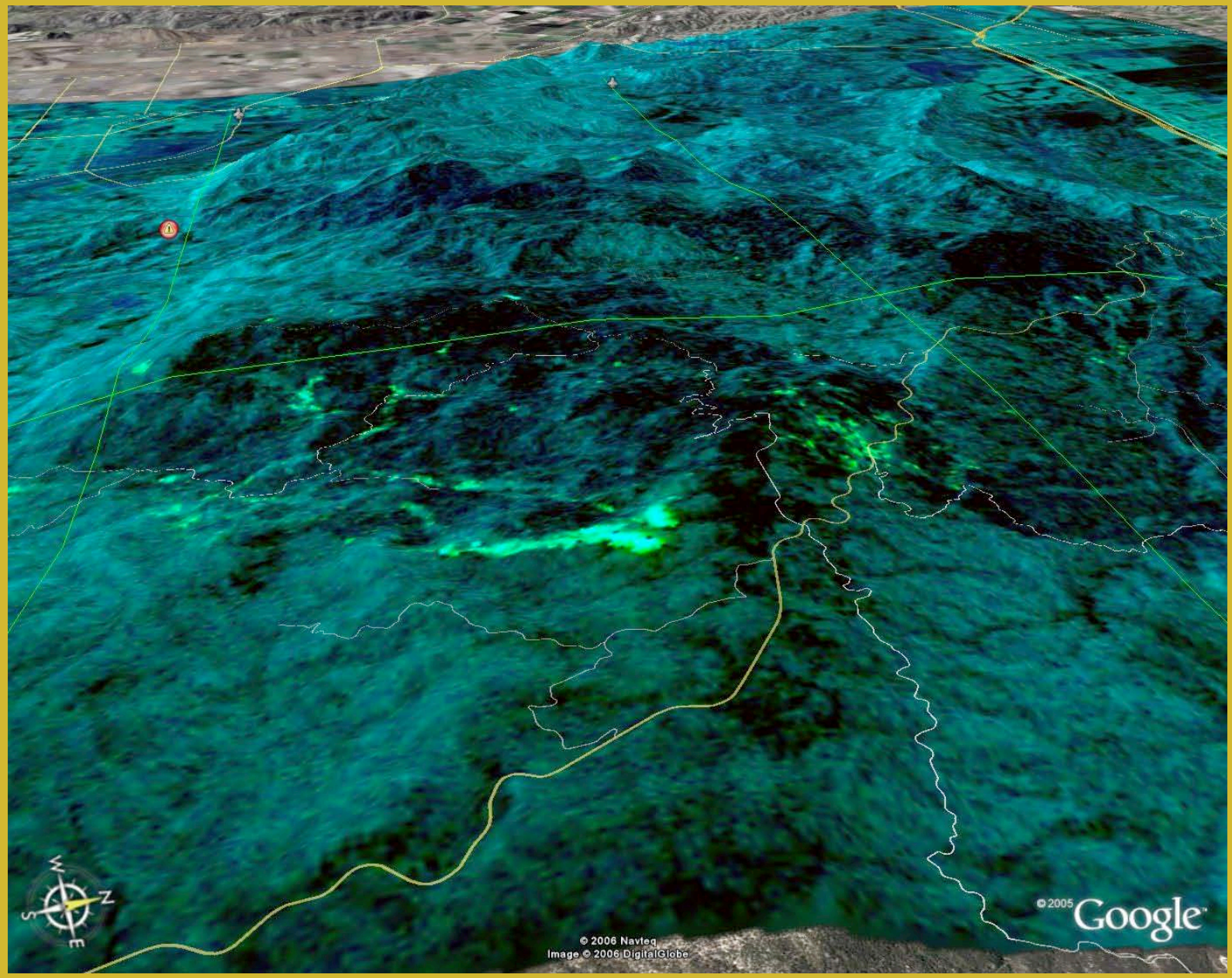


First Image Collected 5:30 PM TIR-IR-VIS Composite

October 28-29 Mission
Esperanza Fire, California

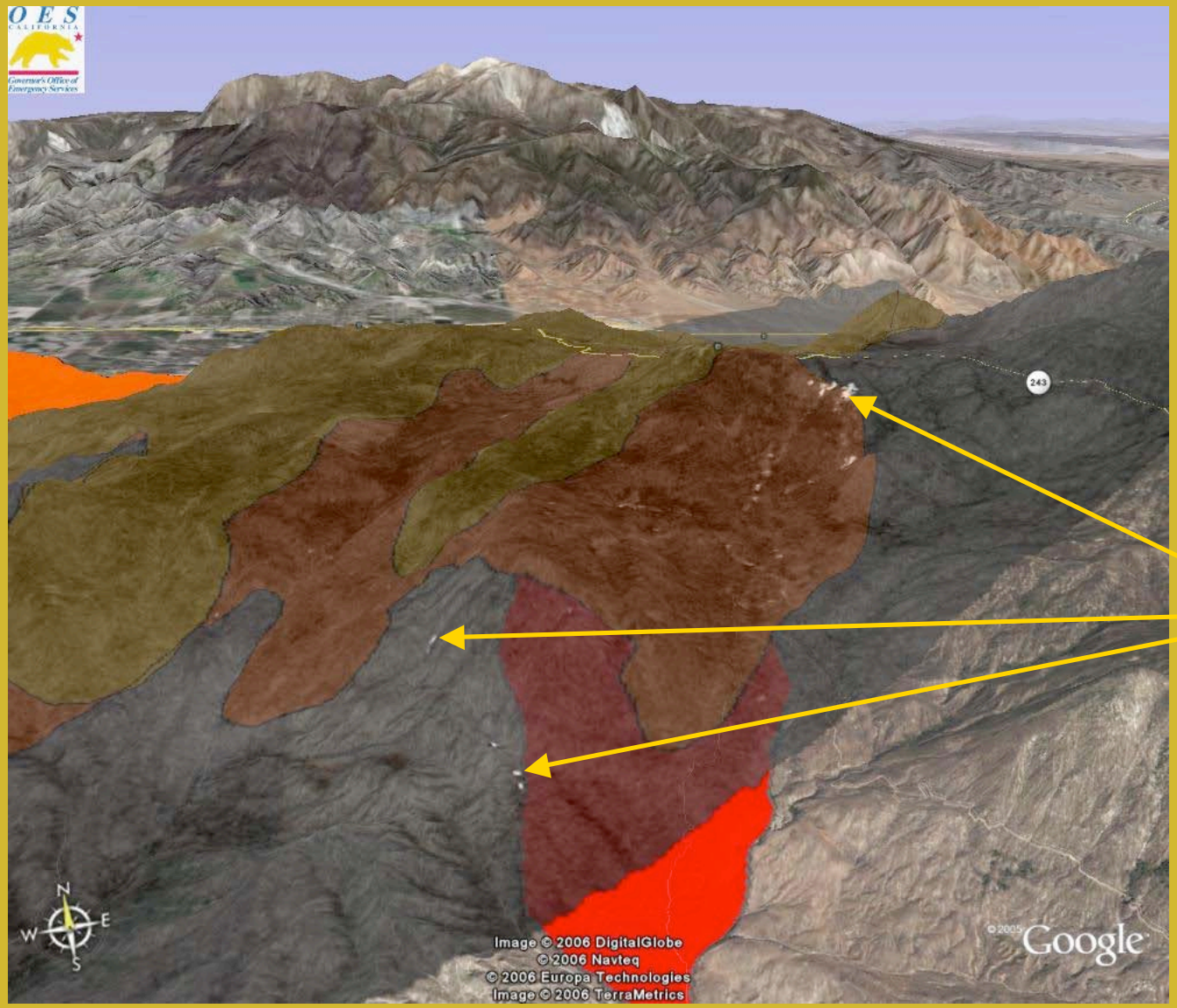


First Image Collected 5:30 PM 12-7-5 Band Composite



Thermal band combination over Esperanza fire (5:45pm)

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

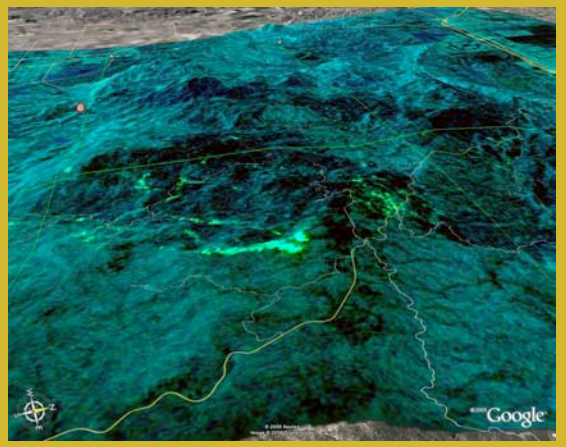
Data Collected:

- **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)



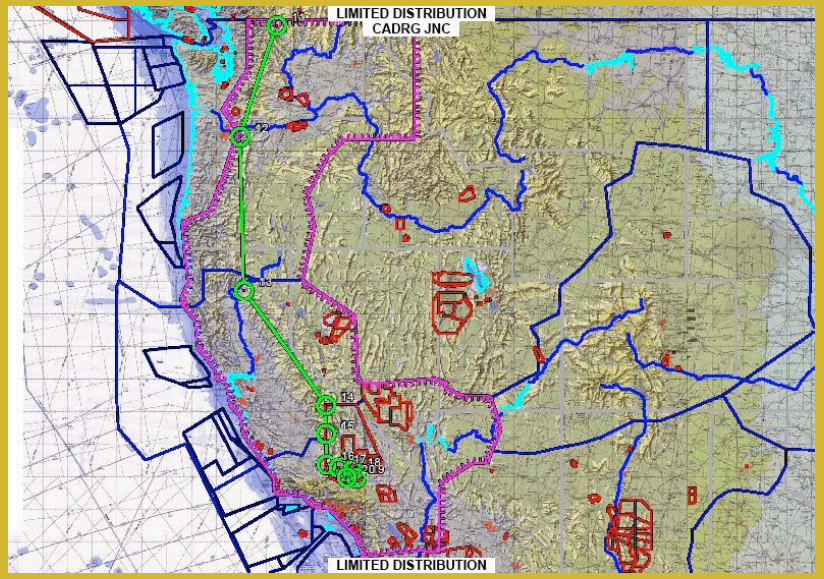
Results from the Esperanza Fire Response

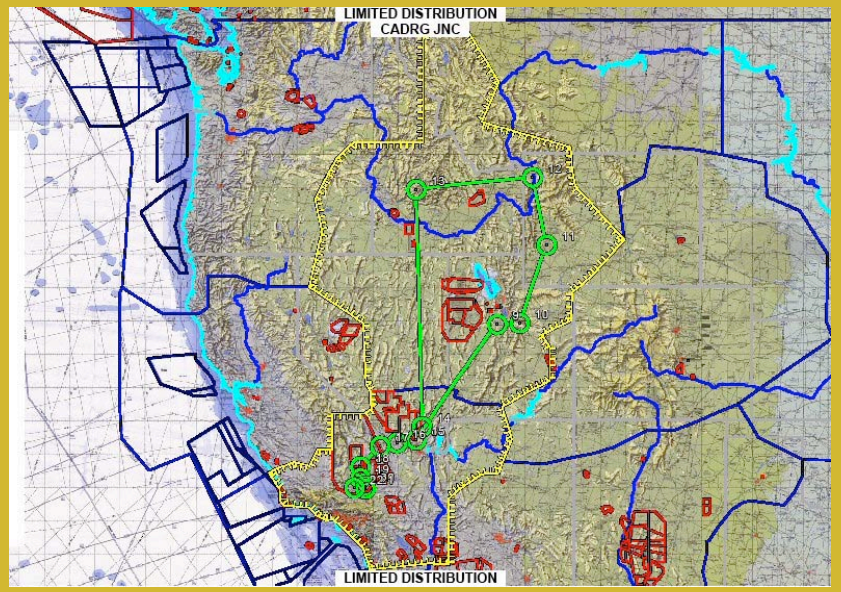
- First Emergency COA for civilian disaster.
  - Process worked very well.
- 94 images (geo- and terrain-corrected) and over 20 hot-spot perimeters were transmitted in real-time from the aircraft to a NASA-Ames server.
- The data and information were re-distributed (in real-time) to a Decision Support 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.

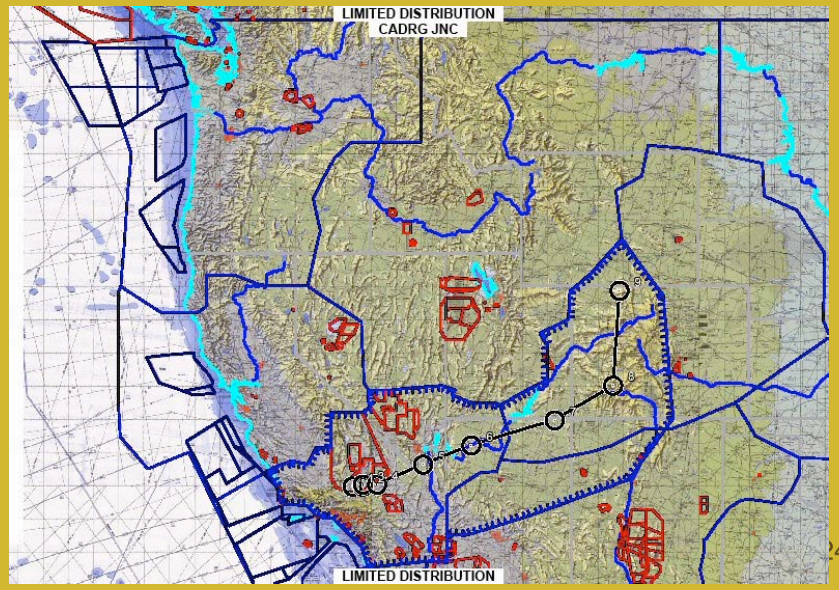
2007 Western States Fire Mission

- 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.

Western States UAS Fire Mission 2007







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