NASA

2007 Western States Fire Missions (WSFM)

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Western States Fire Mission Modifications

Back-up battery power increased to 3 hours

Wiring connections from pod to power distribution, GPS antenna, and SatCom system

Infrared Wildfire Scanner
Ground Systems

IKHANA

- Mobile Ground Control Station
  - Dual pilot control station
  - Electronic navigation charts
  - Weather
  - 6 Engineering/Science workstations
  - Range safety workstation
  - Intercom system throughout
  - Overhead mission displays
  - Telephones
  - Remote video from aircraft start-up/shut-down site
  - Downlink video and data recording

- Mobile 2.4m Ku SatCom Antenna
  - Dual redundant receiver/transmitters
2007 Western States Fire Mission Objectives

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- Demonstrate capabilities of UAS to overfly and collect sensor data on widespread fires throughout Western US.
- Demonstrate long-endurance mission capabilities (20-hours+).
- Image multiple fires (greater than 4 fires per mission), to showcase extendable mission configuration and ability to either linger over key fires or station over disparate regional fires.
- Demonstrate new UAV-compatible, autonomous sensor for improved thermal characterization of fires.
- Provide automated, on-board, terrain and geo-rectified sensor imagery over OTH satcom links to national fire personnel and Incident commanders.
- Deliver real-time imagery to (within 10-minutes of acquisition).
- Demonstrate capabilities of OTS technologies (GoogleEarth) to ‘serve’ and display mission-critical sensor data, coincident with other pertinent data elements to facilitate information processing (WX data, ground asset data, other satellite data, R/T video, flight track info, etc).
**Operations Concept**

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- Chase aircraft required below 18k in the U.S. National Airspace (NAS)
- Air traffic control (ATC) used for collision avoidance above 18,000 ft
- NASA Dryden uses restricted airspace to climb to cruise altitude before exiting into the NAS
- Since Ikhana not qualified for Reduced Vertical Separation Minima (RVSM), operations are limited to 18,000 ft to FL 290 or above FL 410
- Transponder and radio communication required

![Diagram of airspace and flight levels]
3 Operational Zones

Each zone includes no more than 3 ARTCC areas
Range Safety Protection Zones

**KEEP-OUT ZONES**

Defined and "Owned" by DFRC Range Safety

Can be changed or updated before or during flight with concurrence of a DFRC Range Safety Officer (RSO)

- NOMINAL AIRCRAFT
- UNHEALTHY AIRCRAFT
Routes A, B, C

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Defined Routes for each Zone

Over/near forested areas

Avoid population areas

Avoid directly above mountains when possible
  • Weather when lost link
Primary Emergency Landing Sites

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Radius = 400 nmi

Minimum Range on Battery Power

Aircraft has single generator

Landing agreements negotiated with each site
Secondary Emergency Landing Sites

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Radius=50 nmi (minimum glide from 23,000 ft)

Over 280 sites identified

Categorized Green, Yellow, Purple, Red by pilots

Selected in unpopulated areas. Abandoned runways, dry lakebeds, flat ground, ditch areas

Primary purpose is to protect public

Actively managed during each mission

“Owned” by DFRC Range Safety and changeable
Example Secondary Emergency Landing Site

Mac Gillivray
Near Adelaida, CA
(Abandoned landing strip)

35° 38' 39.52" N
120° 51' 01.37" W

Elev. 1454 ft
Paved
Length: 3000 ft
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Near Adelaida, CA
(Abandoned landing strip)

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Elev. 1454 ft
Paved
Length: 3000 ft

Heading SOUTHWEST
COA Application Provisions

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- Only for “4-5” flights, 1 per week
  - But… wildfire emergencies could occur that would require quick turnaround and possibly more flights
- Stay 5 nm away from Zone boundaries
- Stay 10 nm away from International borders (Canada, Mexico)
- Public Use aircraft
- NASA self-certifies for airworthiness
• Remain within 75 nm of ‘backbone’ route
• 3 business day mission notification to FAA
  – With “specific routes” identified
• IFR Flight Plan submitted 24 hours in advance
• Flight Plan
  – Point to point is acceptable
    • Application was submitted as a “hub and spoke”
  – in FRD format (fix-radial-distance)
  – No more than 48 elements (fixes + loiter times)
• Mission Planning telecon with affected ATC Centers
  24 hours prior to mission
COA: Special Provisions (con’t)

- No flight into forecasted “moderate or severe” turbulence
- No flight in area where convective SIGMET has been issued
- No flight in area of known or forecast icing
- No flight in area of affected by GPS testing, solar storms or RAIM outages
- Contact list maintained for all ATC Centers and Ikhana GCS
COA: Special Provisions (cont)

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• Lost link procedure
  – Maintain altitude
  – Continue on filed flight plan (the route) for 15 min
    • Does not mean “keep going straight ahead for 15 minutes”
    • If in a loiter area, stay in there for at least 15 minutes
  – Squawk 7600
  – Aircraft will turn right, if it has to retrace the flight plan
  – Aircraft will return to R-2508/R-2515 the way it came out (usually)
Approved COA Area
1st Fire Mission 8/16/07
9.5 hours
1400 nmi

2nd Fire Mission 8/29/07
16.1 hours
2500 nmi

3rd Fire Mission 9/7/07
20 hours
3200 nmi

4th Fire Mission 9/27/07
10 hours
1800 nmi
Delivered real-time data to Incident Command on Zaca; well received, clamored for more data

Director, Fire and Aviation Management, USFS, R5: “I was standing in Area Command for the Zaca incident on the morning of the first flight. Our conversation surrounded the "fog of war" existing due to an inversion on the southeast corner of the fire... the incident management teams did not know where the fire was, and that information was critical to modify their strategy and initiate action. The intel provided by the UAV, real time and geospatially oriented, answered that critical question and saved precious hours. Yes, indeed, it was a success. I look forward to the eventual inclusion of this technology and platform as a standard component of our arsenal. The reduction in cost, exposure to air crews currently flying infrared sorties, and the real time and extended nature of the intel provided are all advantageous to our mission. Thank you and all those with the foresight before who saw the potential and reached out in cooperation to make it a reality.”
IKHANA

- Real-time ATC routing around poor weather saved the mission
- Collected and transmitted real-time fire data on eight fires spread through CA (Jackrabbit), ID (Trapper Ridge, Castle Rock, Granite Creek, and Hardscrabble), MT (WH Fire), and WY (Columbine Fire).
- Made repeat passes over each, spending most time over Castle Rock, as this was a high priority fire for US, threatening Ketchum and Sun Valley, ID.
- Delivered real-time data to Incident Command on Castle Rock; used for operations and redeployment of resources on the fire based on our data.
- Collected coincident UAV data with a MODIS satellite data overpass on castle Rock…major science accomplishment
- Tremendous amount of national publicity for NASA, USFS, and FAA.
WSFM #3 - September 7-8, 2007

IKHANA

- Collected and transmitted real-time fire data on eleven fires spread through CA (Butler, North, Fairmont, Grouse, Lick, Bald, Moonlight, Zaca), OR (GW & Big Basin Fires), and WA (Domke Lake and South Omak Fires),
- Made repeat passes over most, (total of 18 fire visits) spending significant time over high priority fires (Lick, Moonlight, and GW)
California Emergency Wildfire Response

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- Oct 20-21: High winds (>50 MPH) drive wildfires in 4 southern California counties
- Oct 22nd: Ikhana team began preparation for a possible fire mission
- Two impediments to launching a mission
  - Failed hard drive in the wildfire sensor
  - Ikhana wings being modified for fiber-optic wing sensor demonstration
    - Tiger team assembled to assess airworthiness

Paint removed along 2 strips

Patched with flexible rubber tape
California Emergency Wildfire Response

Oct 22nd - Monday
- Ikhana Project team contacted by California Office of Emergency Services requesting imagery of Southern California wildfires
  - Kim Zagaris, Chief Fire and Rescue Branch
  - 500,000 people evacuated
  - More than 11 fires burning
- Planning telecons held with NASA teams and USFS
- FAA notified
- Range safety office began reviewing population centers around fire areas
- NASA Ames and USFS teams deploy to Southern California
- Wing repair completed

Oct 23rd - Tuesday
- Sensor hard drive repaired and verified
- FAA extended 75 nm COA limit to the south
  - Could not extend COA to within 10 nm of Mexican border (Harris fire)
- Mission plan submitted to FAA
- Tech Brief of mission plan delivered to NASA Dryden Management

Oct 24th - Wednesday
- Launched 1st emergency response mission @ 9am
Edwards AFB

Grass Valley, Slide

Santiago

Ranch, Buckweed

Rice

Ammo

Poomacha

Witch

Harris

~1350 nmi route
~9 hours
WSFM #5 - Ammo Fire, Oct 24th

Hot spots in yellow
WSFM #6 - Oct. 25th

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Hot spots in yellow

Poomacha / Rice Fires –
3D with Hot Detects

Grass Valley / Slide Fires -
3D with Hot Detects
WSFM #7 - Oct. 26th

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Hot spots in yellow

Santiago Fire – 3D with Hot Detects
WSFM #8 - Ammo Burn Area, Oct. 28th

Sensor optimized for Burn Area Emergency Response (BAER) imagery
WSFM #4-#8 Southern California Results

• Four 9-hr missions flown
  – 5 day period covering Wednesday, Thursday, Friday, Sunday
  – Post flight debrief with DFRC team
  – Post flight/preflight brief with FAA HQ and LA Center

• Air Traffic Control gave excellent support
  – Mission plans flown in reverse
  – Real time requests for revisits of active fires
  – Added new fire during mission
  – Moved fire loiter points as fires moved

• Thermal infrared imagery delivered in near real-time (5 to 15 minutes) to:
  – Emergency ops: FEMA, NIFC, NorthCom, California EOC
  – Individual Fire Incident Commands

• Ventura County Fire Chief reported:
  – “Intel” was used tactically to fight the fires
  – “Intel” was used strategically to prioritize fires and allocate resources between fires
  – “Intel” was used to allow some fires to burn into each other
2007 WSFM Challenges

- GPS Testing – 250+ nm RADIUS
  - Nellis Range
  - China Lake

- C-band frequency access
  - Competing with Gray Butte Operations

- Emergency landing site permission

- Weather
  - Wind
  - Clouds
  - Icing
  - Thunderstorms

- Airfield use outside of normal operating hours

- Long missions
Credit where Credit is Due

IKHANA

• THE FAA HQ UAPO (UAS) Office
  • Not possible without GREAT cooperation and communication

• FAA ATC Centers and Controllers
  • Los Angeles, Oakland, Seattle, Salt Lake, Albuquerque, Denver

• USAF
  • Gray Butte for Command/Control frequency flexibility
  • Nellis Range for GPS Testing flexibility

• DFRC Range Safety Office (RSO) - Population Keep-out Zones

• Secondary Emergency Landing Site Selection Team
  • Project mgmt, RSO, Pilots, Operations
  • Identified, analyzed, categorized, prioritized, and cataloged over 280 sites

• General Atomics