NASA Experience with UAS Science Applications

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Agenda

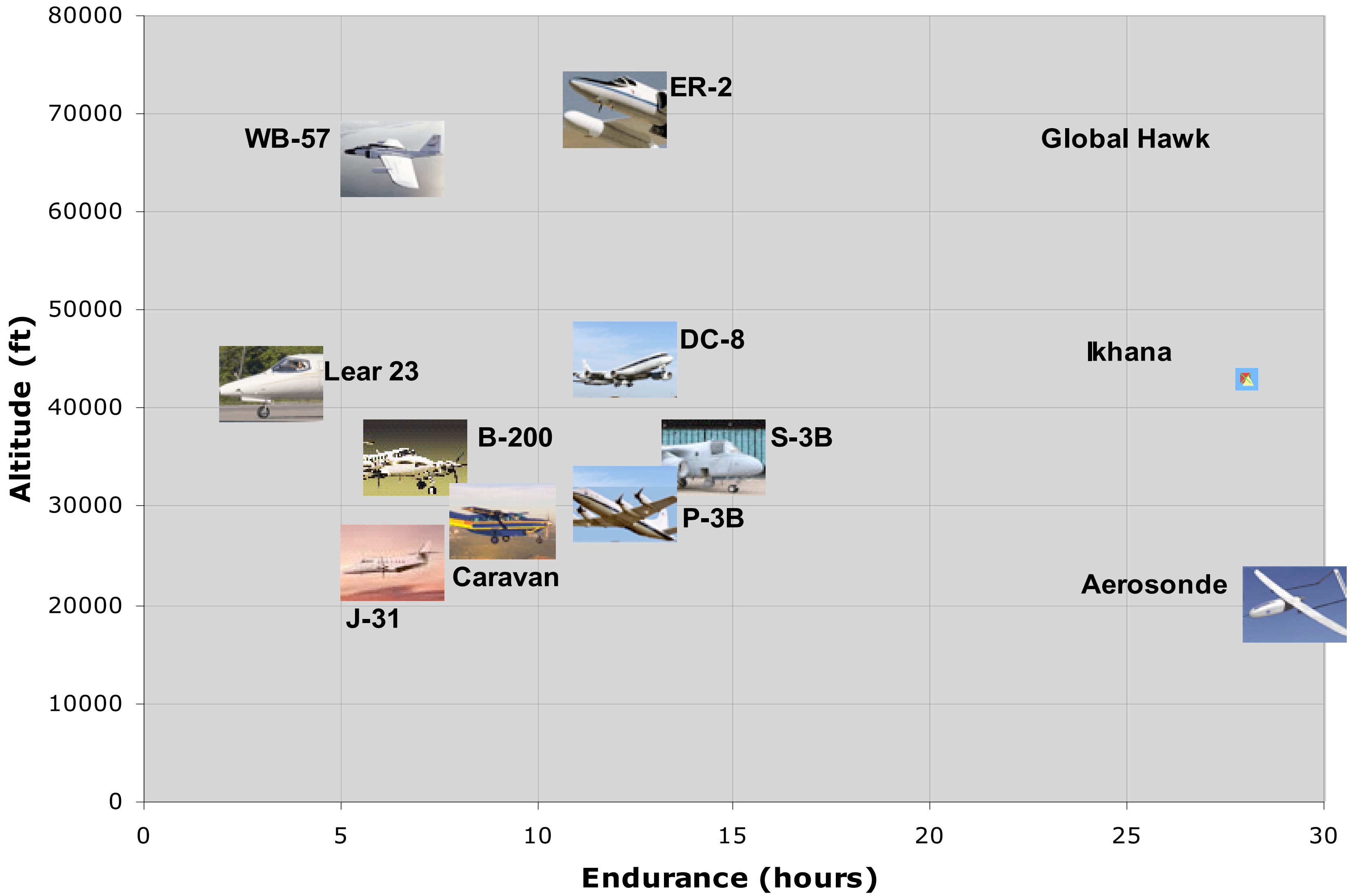
- Background
- Science demonstration missions
  - USCG Alaska
  - NOAA Channel Islands
  - Western States Fire
  - Esperanza Fire
- Current Status of NASA Dryden UAS Science Platforms
- Summary

Background

- NASA Sub-Orbital Science Program
  - Objectives
    - Development of space-based sensors
    - Satellite calibration/validation
    - Ephemeral phenomena
    - Atmosphere/near-space in-situ observations
    - Improve Earth process models
  - Aircraft Platforms
    - Traditional: ER-2's, DC-8, WB-57's, others
    - New Technology: UAS's

- Why Unmanned Aerial Systems (UAS's) for Science Missions ?
  - Unique capabilities
    - duration
    - range
  - Operations in hazardous locations
    - extended polar missions
    - volcanic plumes, hurricane
  - Implications for the future of environmental monitoring & response missions

NASA Science Aircraft Endurance



Science UAS Development Challenges

- Science missions impose unique requirements on UAS vehicles and operations
  - Access to national/international airspace
  - Unusual flight profiles
  - Reconfigurable sensor installations
  - Cost control
  - <u>Global</u> tele-presence for instrument command and control

- Conducting representative, scientific missions is the best way to push the technology
  - Confirm performance and capabilities
  - Expose limitations and unexpected issues
  - Progressive build-up of mission complexity
  - Engage the science community

> ***" Flight research separates the 'real from the imagined' and makes known the 'overlooked and unexpected' "***
>
> ***Hugh L. Dryden***

USCG Alaskan Maritime Surveillance

- Objective: Evaluate use of a UAS for intelligence, surveillance, and reconnaissance (ISR) operations

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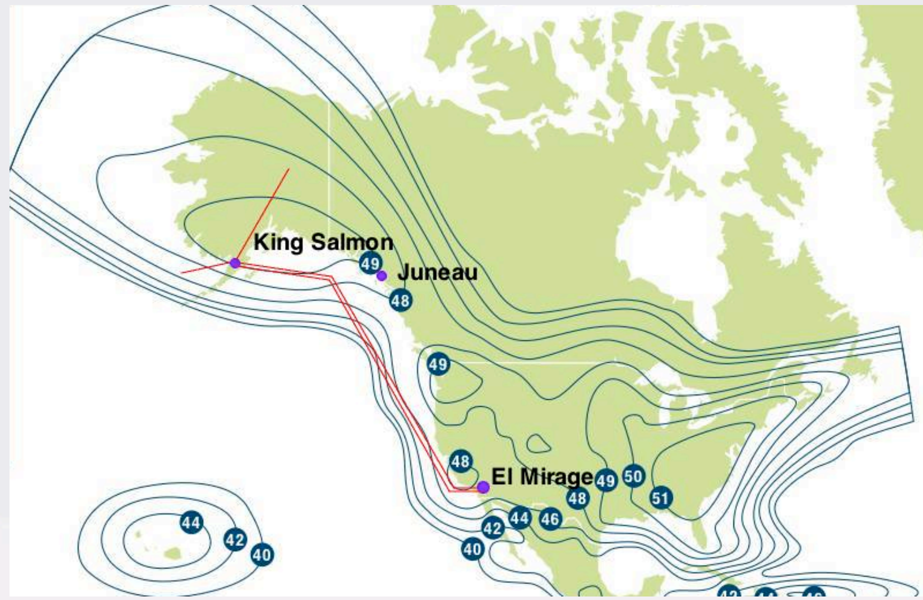
- Overview
  - United States Coast Guard (USCG), NASA, GA, and others
  - General Atomics Altair (high-altitude Predator B derivative)
  - Payload
    - surface surveillance radar, . . .
    - internal integration
  - Flight Operations: Summer, 2004
    - Self deployment from California to Alaska
    - Launch and recovery team operating remote from mission operations center in Juneau
    - Over the horizon shore to ship communications relay

USCG Alaskan Maritime Surveillance

- Major Accomplishments
  - Long-range, remote deployment of aircraft, crews, and project team
  - Multiple aircraft control and communication hand-offs
  - Established Northern latitude limit for geostationary satellite data link
  - Provided streaming video to support Alaska wildfire management

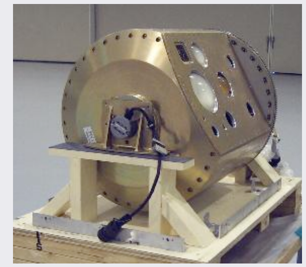


- Issues : Reduced Mission Scope
  - Sensor integration complications
  - High latitude satellite coverage less than anticipated
  - Flight limitations due to low satellite elevation angle

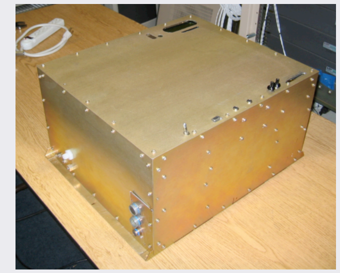
NOAA/NASA UAV Demonstration Project

- Objective: Evaluate the use of a UAV for future science and operational requirements
  - Atmospheric research
    - sample low-level Eastern Pacific jets
  - Atmospheric research
    - coastal mapping, wildlife monitoring, marine enforcement

- Overview
  - NOAA, NASA joint project
  - General Atomics Altair
  - Internal payload integration
  - Flight operations
    Spring, 2005 and Fall, 2005
    - Flights in National Air Space (NAS) under Certificate of Authorization (COA)
      - primarily at FL430
      - descents below 18,000 ft escorted by chase plane



Ocean Color & Passive Microwave Vertical Sounder

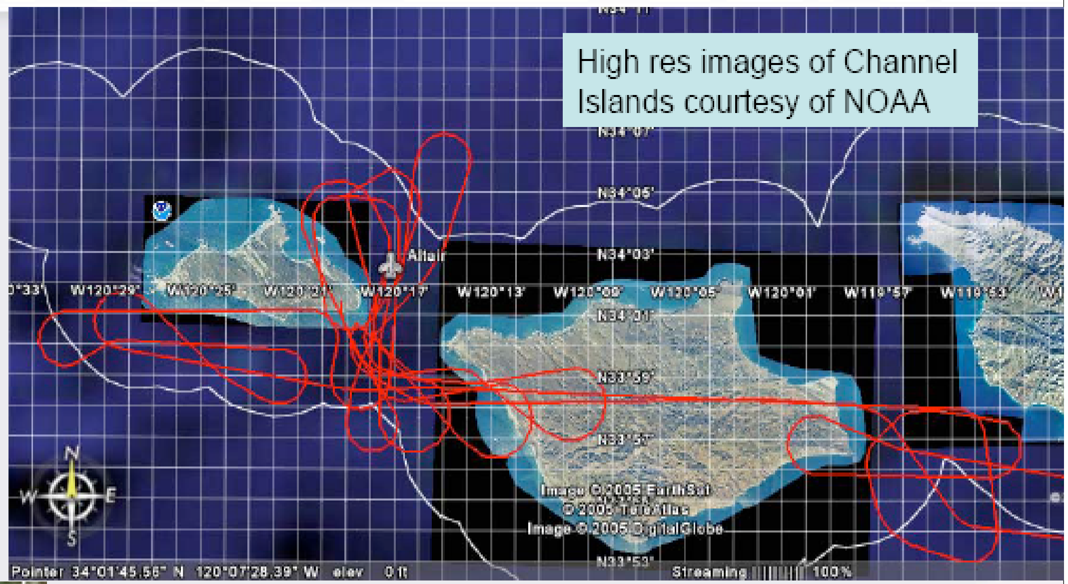


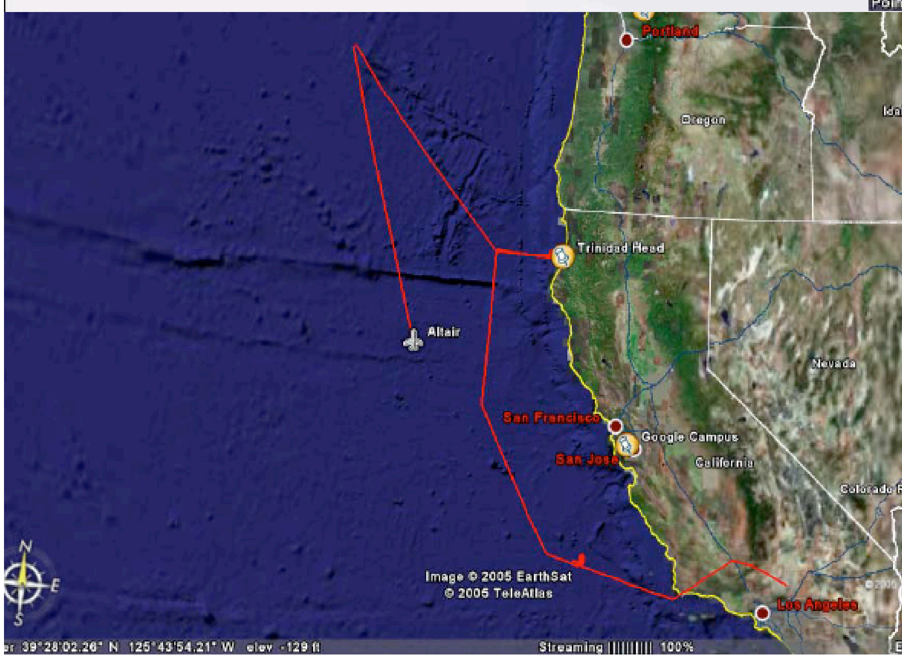
Gas Chromatograph & Ozone Sensor

Altair integrated with NOAA science payload

NOAA/NASA UAV Demonstration Project

- Major Accomplishments
  - 20 hour missions
  - over 2500 miles of ocean coverage
  - UAS in the National Airspace with FAA experimental type certificate





- Issues
  - Airspace coordination complications
  - UAS systems reliability under extended high altitude operation
  - Complexity of internal payload integration

Western States Fire Mission

- Objective: Identify and monitor wildfire events throughout the Western United States and provide near real-time products to field units

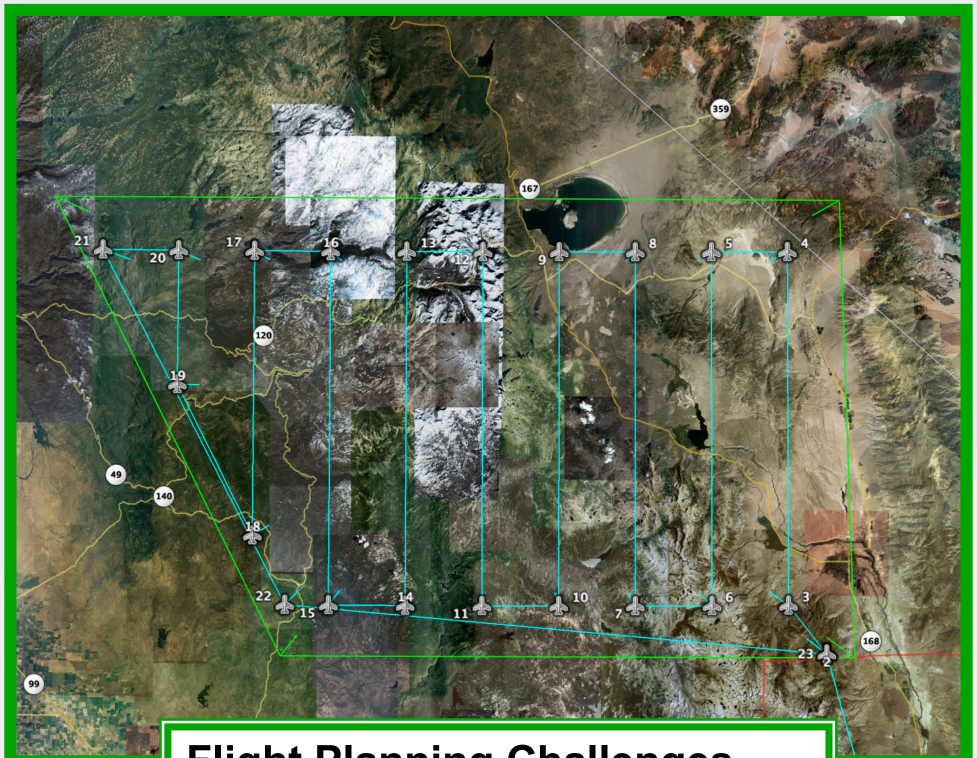
- Overview
  - NASA, USFS, NOAA, GA partnership
  - General Atomics Altair with centerline pod
  - Payload
    - Wildfire sensor – Developed at NASA Ames
      - 13 spectral bands optimized for fire characterization
      - Fully autonomous
    - near real-time data transfer
      - on-board processing (geo-rectification)
      - overlayed with Google-Earth imagery
      - internet access by end users
    - in-situ atmospheric sampling
    - experiment command and control from ground

  - Flight operations: Fall, 2006
    - XX flights from base at Grey Butte, CA; primarily in military airspace
    - Only 1 flight into National Air Space (NAS), always at FL430

Western States Fire Mission

- Major Accomplishments
  - grid patterns over Yosemite National Park
  - re-direction based on satellite data
  - 23 hour flights
  - coordination with satellite overpasses
  - outstanding data quality
  - demonstrated the importance of virtual presence for experimenters

- Issues: Reduced Mission Scope
  - FAA processes in transition
  - complex risk management issues



Flight Planning Challenges
- FAA control boundaries
- Special use airspace
- E_C calcs (avoid pop. centers)
- Contingency routing
- Alternate and emerg. landing sites

Esperanza Fire Emergency Response

- California Office of Emergency Services requested NASA assistance
  - 40,000 acres (62 sq mi)
  - 5 firefighters killed
  - 34 homes destroyed

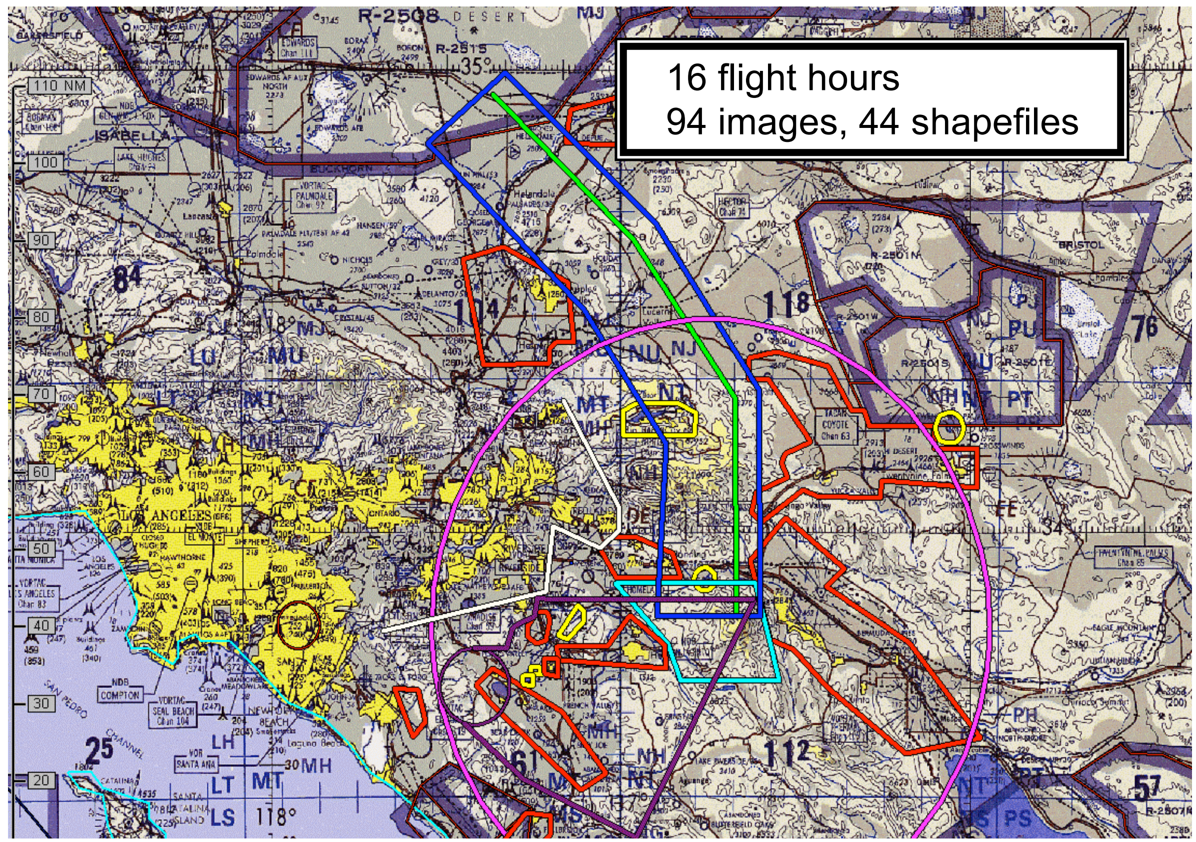
- First use of FAA Emergency COA for civilian disaster response

Esperanza Fire Emergency Response

- Friday, Oct. 27 10:00 AM - Received request

- Saturday at 3:45 PM – Aircraft launched
  - FIRE sensor returned to Grey Butte and installed on A/C
  - Ground safety analyses
  - Requested and received FAA approval
  - Aircraft prepared for flight

- Sunday 7:30 AM - Landing



Ikhana (Predator B)

A NASA Unmanned Aerial System
Supporting Long-Duration Earth Science Missions

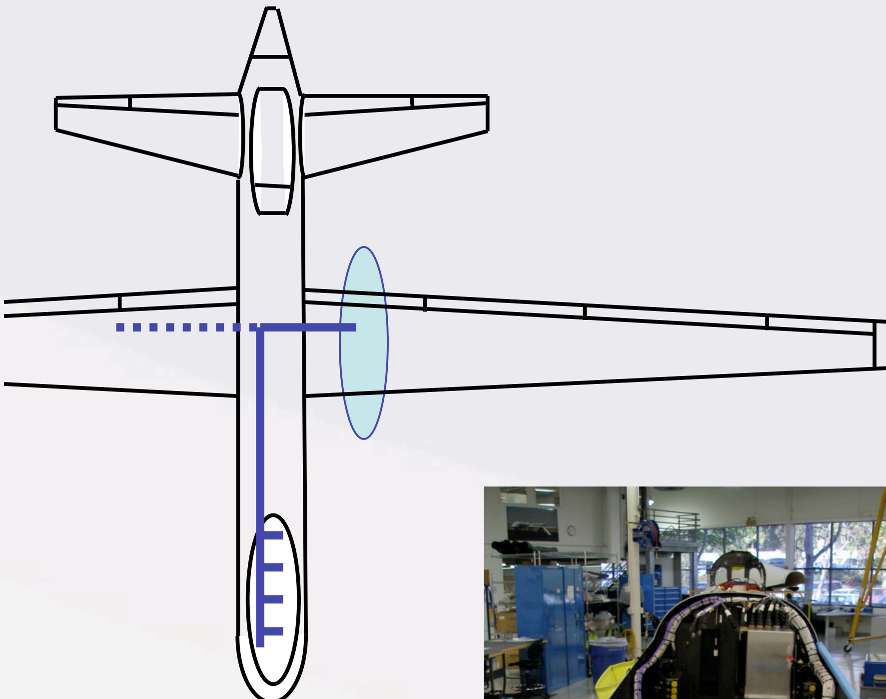
'Mission ready' in July, 2007

Capabilities

- Endurance > 24 hours
- Altitude > 40,000 ft
- Payload > 2,000 lbs (750 in pod)
- Range 3,500 nautical miles

- Highly reliable UAS
  - Standard MQ-9 w/digital engine control
  - Triple redundant flight control systems, dual redundant power & networks
  - Predator family has logged over 200,000 hours

Ikhana (Predator B)

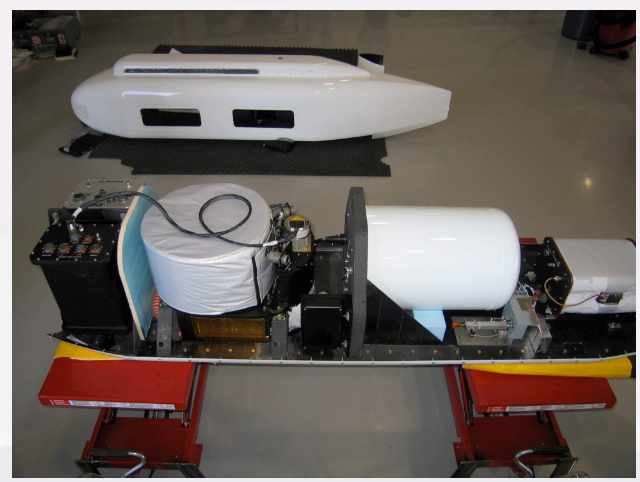


Payload Areas

- Wing-mounted pods
- Avionics Bay
  - Payload Tray
  - Chin compartment

Experimenter Network

- Ethernet network connecting avionics bay and remote pods
- Communications, recording, downlink, time code, aircraft state data



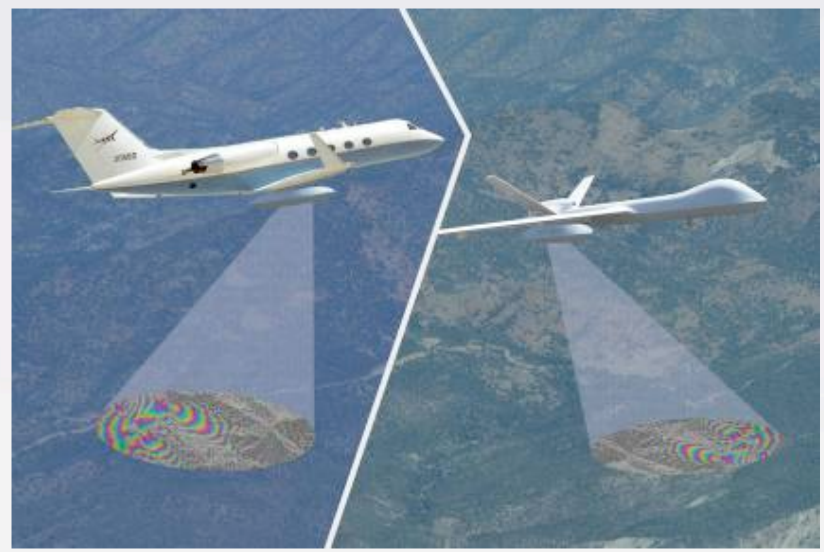
Ikhana (Predator B)

Other Mission Support Features

- Experimenter network and data system
- Mobile ground control station
  - Ku Satcom for over the horizon missions
  - 6 experiment monitoring stations
- Airborne Research Test System
  - 3 processor research flight control and/or mission computer
  - allows autonomous control of the aircraft and some systems
  - able to host research control laws

UAV Synthetic Aperture Radar (UAVSAR)

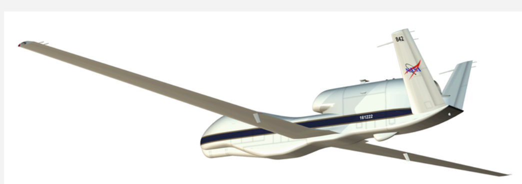
- Objective: Advanced airborne SAR capability
  - autonomous operation
  - interferometry products
- Radar development - NASA JPL
- Aircraft modifications and flight testing – NASA Dryden
  - Development activity on G-3
  - Instrument housed in external pod
  - A/C precision navigation for
    - repeat pass interferometry
    - flight path control to within +/- 5 m
- Portable to Predator B class UAS
  - long duration for continuous event monitoring
  - high altitude for long uninterrupted flight lines



Global Hawk

Capabilities
- Endurance > 30 hours
- Altitude 65,000 ft
- Payload > 1,500 lbs
- Highly reliable, mature UAS

Mission Support Features
- Multiple payload locations
  - 40 ft^3 pressurized
  - 62 ft^3 un-pressurized
  - Can accommodate wing pods (future)
- Flies above conventional air traffic
- Fully autonomous control system, take-off to landing



Related Technologies

- Sub-orbital Tele-presence (Airborne Sensor Web)
  - Develop/demonstrate low-cost services for science payloads
    - ♣ Situational awareness
    - ♣ Decision support; productivity
    - ♣ Sensor web: *i.e.* Instrument interaction/C4I
  - Applicable to all suborbital platforms, but special significance for UAS

- Access to airspace
  - Near-term expectations (next five years or so)
    - ♣ Certificate of Authorization processes
  - Long-term
    - ♣ Rules and procedures for UAS certification and routine operation in the national air space
    - ♣ Technology development

Summary

- Unmanned Aerial Systems offer great potential for Earth science missions of the future
- Performing representative science missions has been critical to understanding and guiding UAS technology implementation
- New platform and sensor capabilities are under development
- A follow-on to the Western States Fire Mission will be conducted in Summer, 2007 with the NASA Ikhana aircraft