

**Suborbital Science
Program**

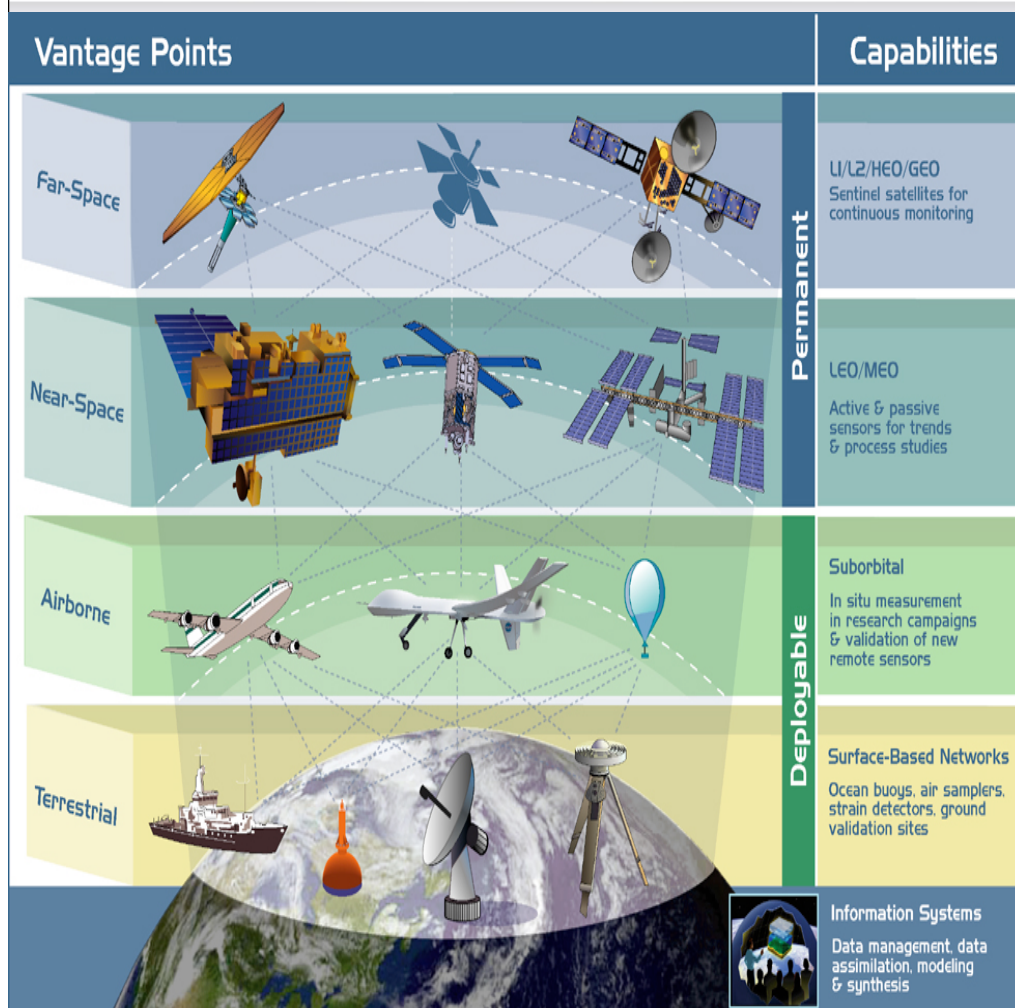
Dryden Flight Research Center

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NASA Dryden Flight Research Center
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Airborne Science Program



Program Objectives: Satellite Calibration and Validation

Provide methods to perform the cal/val requirements for Earth Observing System satellites

New Sensor Development

Provide methods to reduce risk for new sensor concepts and algorithm development prior to committing sensors to operations

Process Studies

Facilitate the acquisition of high spatial/temporal resolution focused measurements that are required to understand small atmospheric and surface structures which generate powerful Earth system effects

Airborne Networking

Develop disruption-tolerant networking to enable integrated multiple scale measurements of critical environmental features



Internal & External Program Drivers

- NASA Science Plan
- National Research Council Decadal Survey
- NASA Advisory Committee, Earth Science Subcommittee
- Global Earth Observation System of Systems
- Climate Change Science Initiative
- Ocean Action Plan

Alan Stern on Airborne Science:

“pennies on the dollar compared to satellite missions”

NOBEL Laureates with Airborne Science connections:

**Sherry Rowland, Mario Molina, Paul Crutzen, George Smoot,
John Mather**



Dryden Flight Research Center - Overview

Dryden supports the NASA Airborne Science Program and the nation in the following elements:

ER-2

Provide this unique, high altitude research platform to the science community

G-3

Provide a flexible, mid-range platform to the science community

DC-8

Flying laboratory, provide heavy lift platform and multiple instrument capability

Ikhana (Predator B) & Global Hawk

Provide access to developmental UAS capability

REVEAL

Disruption-tolerant airborne networking over-the-horizon

ER-2

Capabilities

- Endurance > 10 hours
- Ceiling > 70,000 ft
- Payload 2,600 lbs
- Range > 4,000 nautical miles

Mission Support Features

- Multiple locations for payload instruments
- Pressurized and un-pressurized compartments
- Standardized cockpit control panel for activation and control of payload instruments.
- Iridium communications system
- World-wide deployment experience

FY06 Activity

- Over 170 science flight hours
- CALIPSO/Cloudsat Validation
- AVIRIS/REVEAL
- Large Area Collectors



Background and Status

- U-2 and ER-2 aircraft have been a mainstay of NASA airborne sciences since 1971
- Over 100 science instruments integrated
- Continuous capability improvements
- Two aircraft currently available for:
 - Remote sensing
 - Satellite calibration/validation
 - In-situ measurements and atmospheric sampling
 - Instrument demonstration, test and evaluation

Ikhana (Predator B)

Capabilities

Endurance: 30 hours

Ceiling altitude > 40,000 ft

Payload > 2,000 lbs (750 in pod)

Range: 3,500 nautical miles

Standard MQ-9 w/digital engine control

Mission Support Features

Airborne Research Test System

- enables effective flight control research

Mobile ground control station

- supports campaign deployment

External experimenter pod

- rapid/flexible experiment integration



Status

'Mission Ready' date - June, 2007

- A/C delivered in Nov. 2007
- NASA pilots/crew in training
- NASA unique systems in progress

First Science Campaign:

- Western States Fire Mission
- August, 2007

Cost- sharing with non-SMD projects



Global Hawk - Overview

Capabilities

Endurance > 30 hours

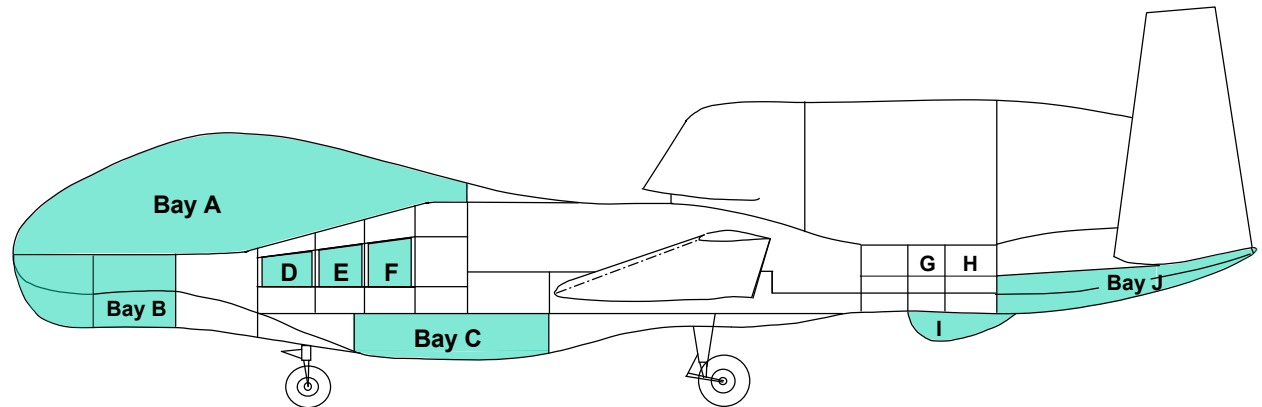
Range > 11,000 nmi

Altitude 65,000 ft

Payload > 1,500 lbs

DC Power 2.0 KW

AC Power 8.3 KVA



Mission Support Features

Multiple payload locations.

- Pressurized and un-pressurized.
- Can accommodate wing pods (future).

REVEAL system with ethernet network on the aircraft for payload C2/status.

Fully autonomous control system, take-off to landing.

Redundant LOS and BLOS aircraft command and control comm links.

Redundant BLOS ATC comm links.



G-3 UAVSAR Overview

- **Mission Objective**

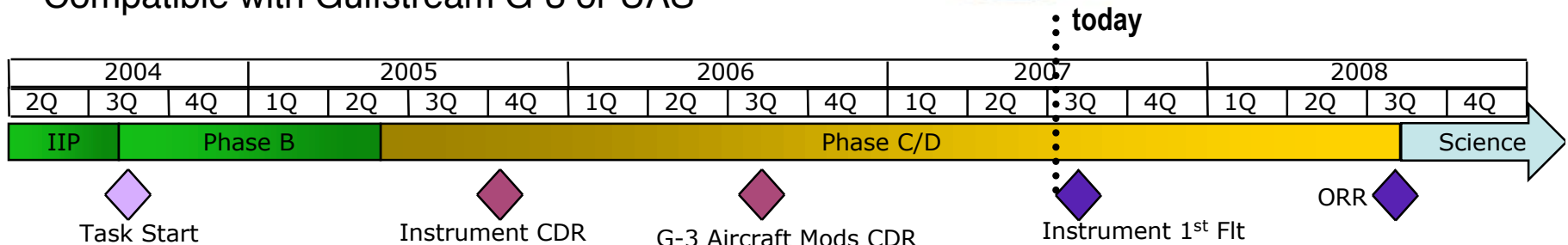
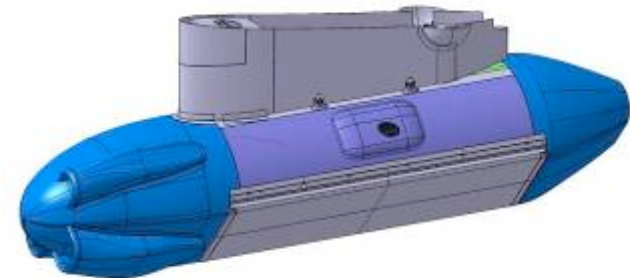
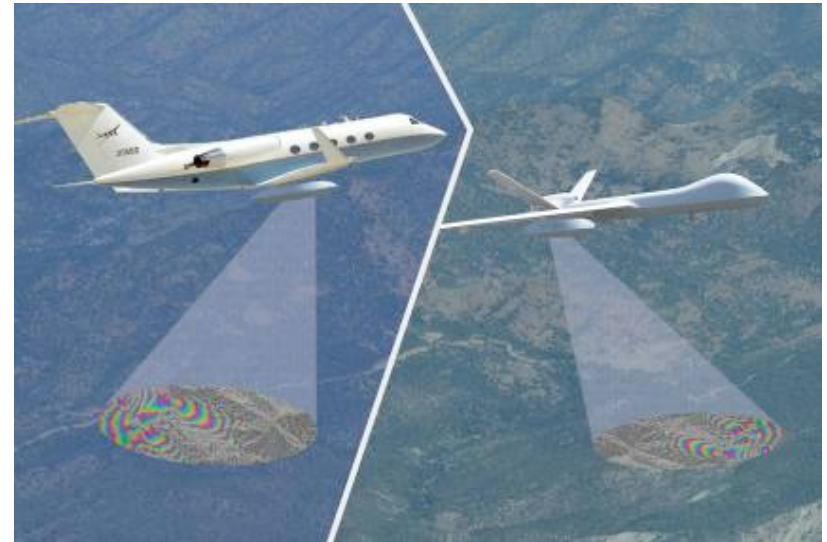
- Provide new capability for solid earth science
 - Airborne repeat-pass radar imaging
 - Interferometric mapping of deforming surfaces

- **Organization**

- Program Office: ESTO
- Instrument Dev. Lead: JPL
- Platform Dev. Lead: DFRC

- **Description**

- Pod mounted instrument
- < 10 m tube flight path using JPL real-time DGPS and Dryden Platform Precision Autopilot
- Compatible with Gulfstream G-3 or UAS



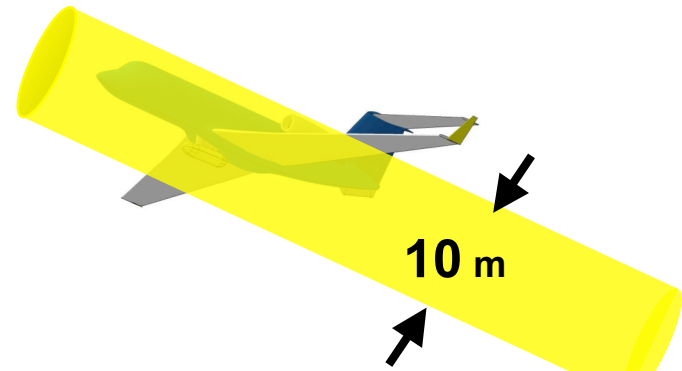
G-3/UAVSAR Technical Progress

Instrument Checkout Progressing @ JPL

- Electronic components integrated
- Pod integration complete
- L-Band testing in progress
- Expect delivery of Ka Band instrument by end of October

System Flight Tests on G-3 progress @ DFRC

- Ground clearance tests for developmental flight series complete
- Pylon/Pod flight envelope cleared
- Phase 1 flight thermal control tests complete
- Precision Autopilot flight tests complete

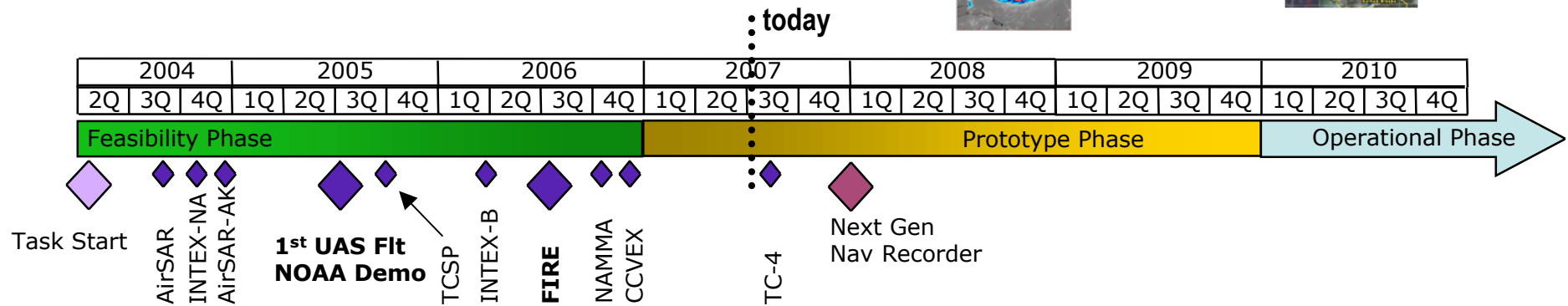
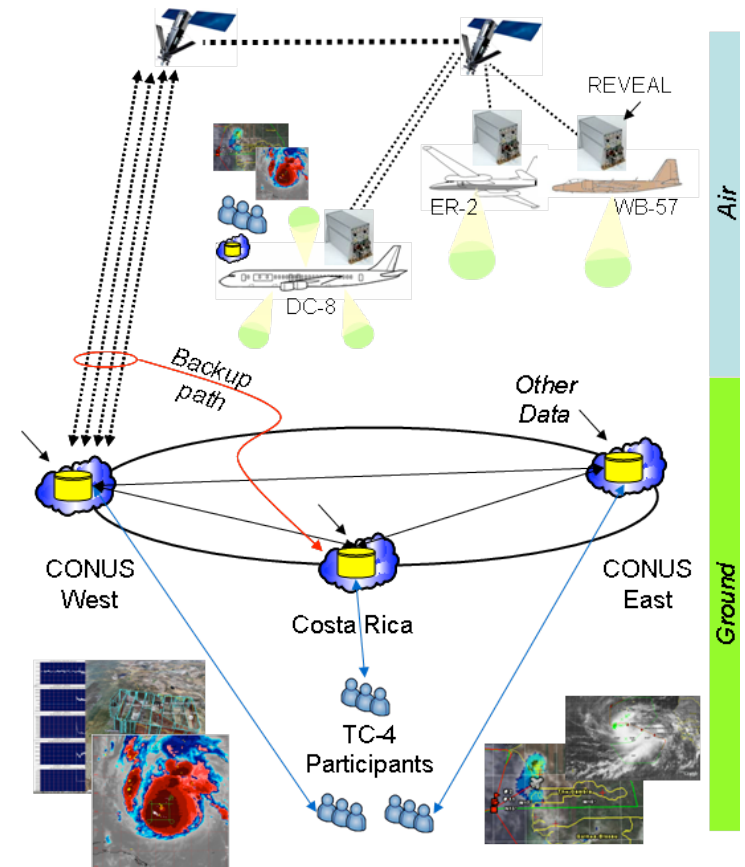


10m flight path precision is demonstrated, based on recent flight tests

Suborbital Telepresence

Objectives

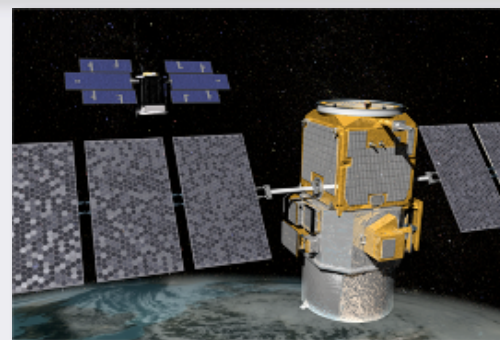
- Develop/demonstrate low-cost services for science payloads
 - Situational awareness
 - Decision support; productivity
 - Sensor web: *i.e.* Instrument interaction/C4I
- Applicable to all suborbital platforms, but special significance for UAS applications



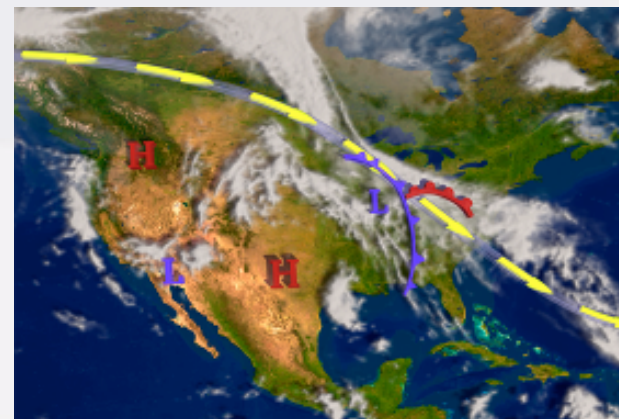
CloudSat CALIPSO Validation Experiment (CC-Vex)

Dates & Location:	24 Jul - 14 Aug 2006: Atlanta, GA
Mission Objective:	Cloudsat CALIPSO validation
PI:	Trepte, LaRC (CALIPSO) Mace, Univ.Utah (CloudSat)
Sponsor:	ESD, Satellite Validation
Platforms:	ER-2, LaRC B-200, WMI Lear

- CloudSat / CALIPSO launched 28 Apr 2006
- 12 comparison flights by ER-2, 4 at night
- B-200 King Air - 3 flights
- Lear - 7 flights
- Measurements of: thick and thin cirrus, mid-layer clouds, precipitating clouds, clouds with ice, water, and mixed phases, and aerosols.
- Results lead to improvements in satellite data products released in Dec 2006.



CloudSat and CALIPSO pairing set a new standard in terms of precision placement of Earth-orbiting satellites. Both satellites look at the same clouds in the atmosphere.



Understanding clouds and their influence on weather and climate presents significant challenges; Yellow curve shows satellite overpass



Esperanza Fire

Oct 27, 2006: CA OES requests NASA assistance

- 40,000 acres (62 sq mi)
- 5 firefighters killed
- 34 homes destroyed

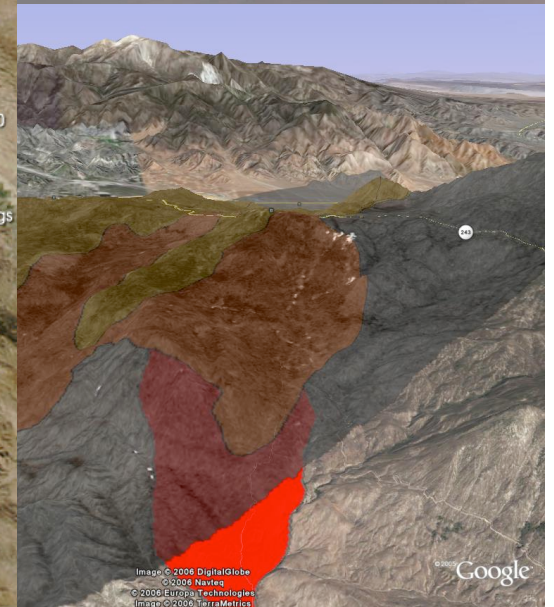
Oct 28, 2006: Altair UAV deployed

- 16:27 flight hours
- 94 images, 44 shapefiles
- Incident Command

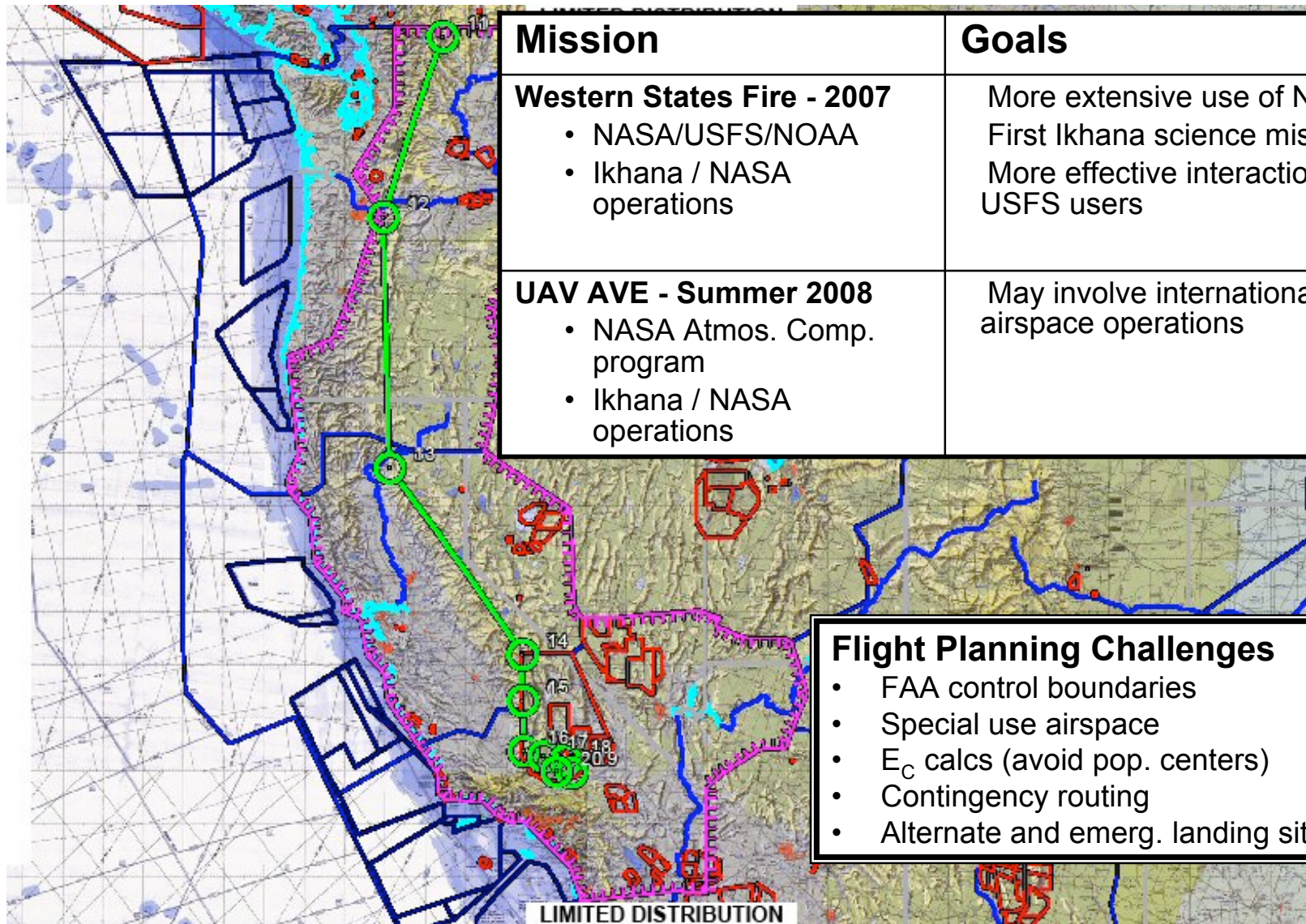


“Getting real time UAS data to Incident Command Center was one of two major accomplishments this past year” (Director, CA Dept. Forestry)

“If we had NASA’s technology earlier, we could have gotten fires under control sooner.” (Director, CA Office of Emergency Service)



Mission Demonstrations - Planned



Mission

Western States Fire - 2007

- NASA/USFS/NOAA
- Ikhana / NASA operations

UAV AVE - Summer 2008

- NASA Atmos. Comp. program
- Ikhana / NASA operations

Goals

More extensive use of NAS
First Ikhana science mission
More effective interaction with USFS users

May involve international airspace operations

Flight Planning Challenges

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

Special Studies

UAS for Polar Science Missions

- Concept study for UAS Arctic and Antarctic science mission scenarios
 - Feasibility, preliminary risk assessment, cost estimates
 - Predator B and Global Hawk
 - IPY time frame and beyond
 - Results provided in white paper (includes SBU)

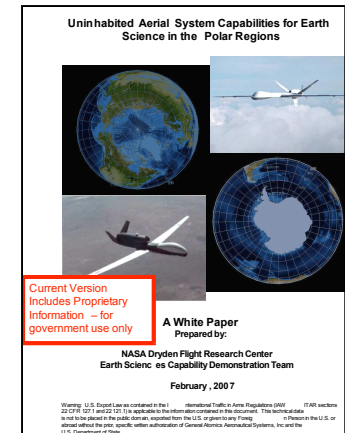
FAA Collaborations

- Outgrowth from ACCESS 5 and recent UAS mission experiences
- Near-term expectations (5 years or so)
 - More effective use of the COA process, expand mission complexity
- Long-term approach
 - Support FAA UAS policy development efforts (domestic and international)
 - Make NASA aircraft and expertise available to develop supporting technologies

Surrogate Satellites

- Sustained aircraft ops to provide near-continuous coverage of a region
- Capitalize on UAS range/endurance and cost benefits
- Blend dedicated use of surrogate satellites with cyclic suborbital science requirements to maximize cost sharing

Beyond current scope of the Suborbital Science Program, but potentially a cost-effective augmentation to space-based Earth observatories



New Technology - Summary

G-3 UAVSAR

- A promising new capability for the science community

Ikhana

- NASA operations as a Suborbital science platform to begin this Summer

Global Hawk

- NASA operations could begin as early as 2008 pending partnership development

Suborbital Telepresence

- Phased development of airborne sensor web components with critical campaign support to TC-4

Mission Demonstrations

- Develop 'real-world' UAS experience through progressively sophisticated science missions

Studies

- Advanced planning for new mission opportunities