Science Mission Directorate

Suborbital Science Program

R&A Retreat
30 March 2006
Cheryl Yuhas

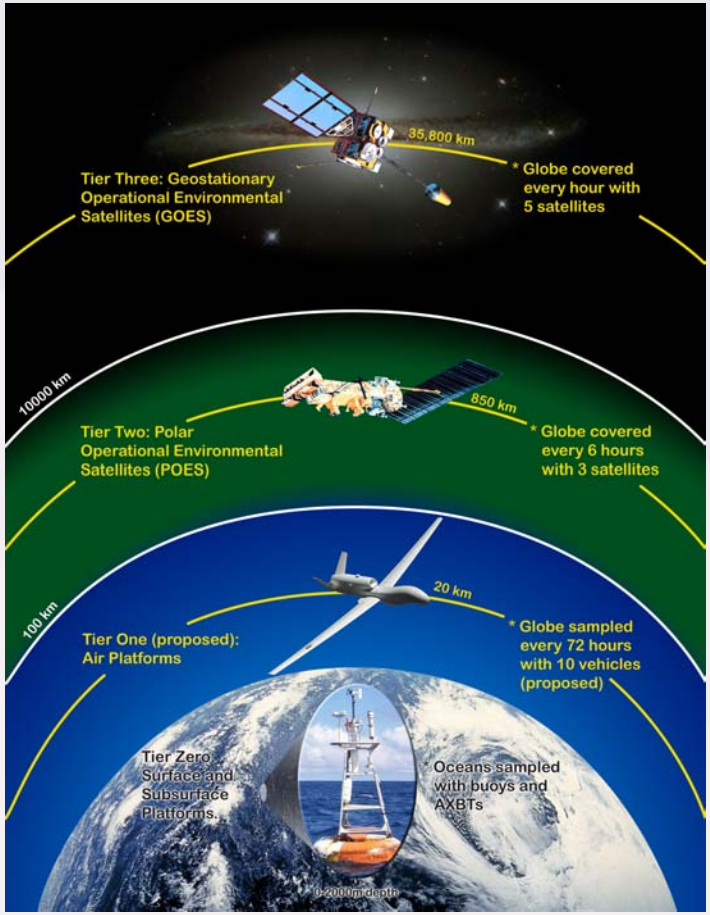
Suborbital Science Programs

Add to the understanding and prediction of the Earth system. Suborbital observations fill time and space gap between surface observing networks and orbital platforms.

Sounding Rocket Program

Balloon Program

Aircraft & UAS Program



Objectives

- Development of new space sensors and new remote-sensing techniques.
- Satellite calibration/validation.
- Targeted observations of ephemeral phenomena with variable temporal and spatial scales.
- Atmosphere/near-space in-situ observations.
- Improvement and evaluation of predictive Earth process models using satellite data.
- Next-generation scientists with hands-on sensor hardware and field experiment experience.

Restructure Objectives

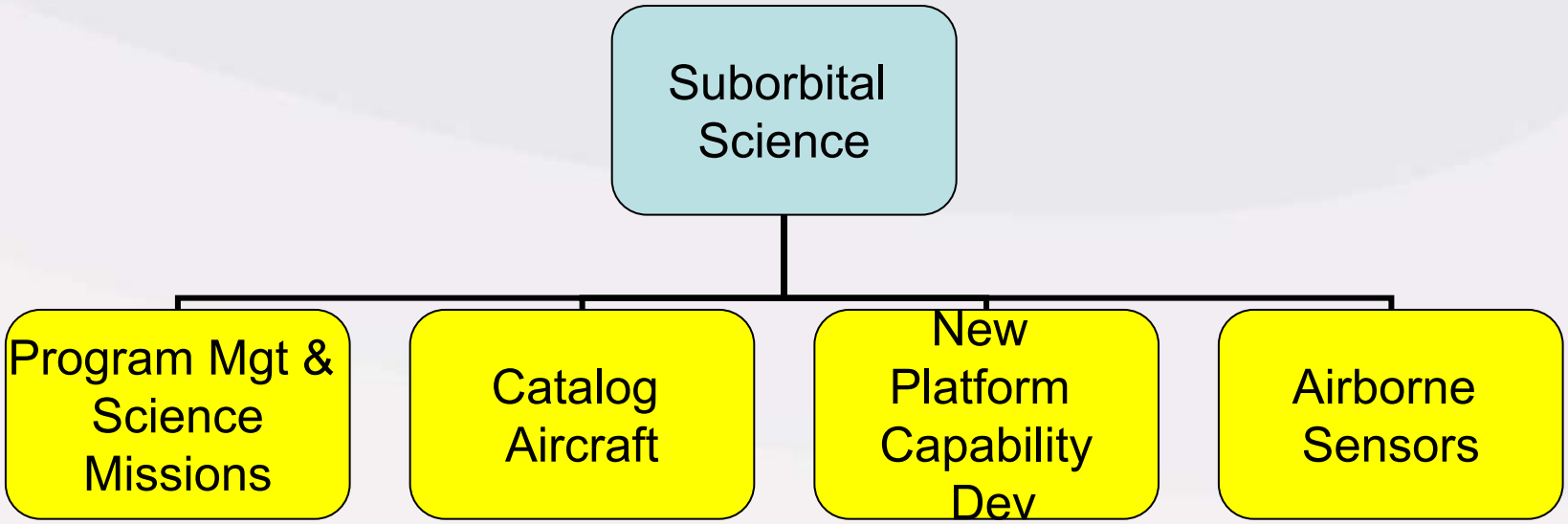
- Support focused science missions for satellite cal/val and process understanding
- Maintain and evolve an adaptive suite of platforms selected according to requirements of the science focus areas.
- Infuse new airborne technologies based on advances and developments in aeronautics, information technologies and sensor systems.
- Transfer proven capabilities to research, operational or commercial operators as widely available facilities for community-driven experiments or operational decision support systems.

Program Overview

- Successful science missions accomplished & new capabilities introduced
- New structure & team in place, with added focus on technology infusion of new capabilities
- Renew emphasis on improving reliability and responsiveness now that restructure is complete

Agenda

- ❑Missions
- ❑Aircraft Catalog
- ❑New Technology Platform
- ❑Airborne Sensors
- ❑Interagency activities
- ❑Plans



2005 Suborbital Science Missions

DATE	TITLE	FOCUS AREA	INSTRUMENT	Platform	Location	Investigator
Jan	NASA LBA-NACP Imaging Spec Studies	Carbon	AVIRIS	Twin Otter	HI	Asner
May	Arctic Ice Mapping and ICESAT Cal/Val	Climate	ATM/GPS	Twin Otter	Greenland, Arctic CA	Krabill
Feb-Apr	CARTA-II	Collaboration	MASTER, HYMAP, AVEMS, RC-30	WB-57	Costa Rica	Andres-Diaz
Mar	Lidar RS of Topography and Veg Structure	Collaboration	LVIS	B-200	Costa Rica	Blair
Apr-Nov	NOAA Altair Flt Demo	Collaboration	OC-PMVS, GCOI, DCS, REVEAL	Altair	CA	Fahey
Oct-Nov	Validation of SSMIS w/ CoSMIR	Collaboration	CoSMIR, MAS	ER-2	CA	Wang
Jun-Jul	Isotope Intercomparison	Atm. Comp	IRIS, Harvard H2O, ALIAS, ARGUS, Panther	WB-57	TX	Jensen
Jun	Houston AVE	Atm. Comp	19 sensors	WB-57	TX	Newman
Sept	Hurrican Katriana Damage Assessment	Collaboration	AVIRIS, DCS	WB-57	MS, LA	Suthar
Jan	Polar AVE	Atm. Comp	21 sensors	DC-8	NH	Schoeberl
Sept	Hubbard Glacier and Yakutat Foreland	Climate	ATM/GPS	Twin Otter	AK, CA	Krabill
Oct	Mount St Helens	Earth Surface & Interior	MASTER, Optech Lidar	Caravan	OR	Realmuto, Hook
Jun-Jul	Tropical Cloud Systems and Processes	Weather	9 sensors	ER-2	Costa Rica	Hood

2006 SMD Missions

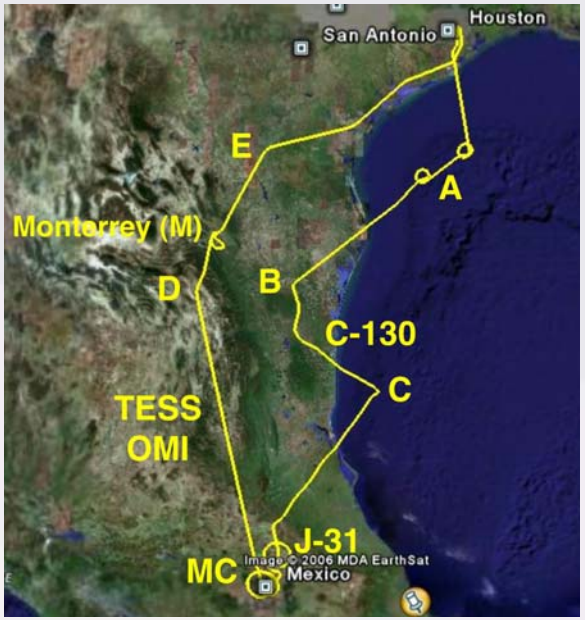
- Costa Rica AVE
- Stardust Re-entry
- INTEX-B
- Arctic 2006
- Maldives AUAV Campaign (NSF w/NOAA & NASA)
- Low-altitude AVIRIS
- Wildfire Response
- Cloudsat/Calipso Validation
- NASA-African Monsoon Multidisciplinary Analysis
- NOAA/NASA Aerosonde low-level hurricane sampling

SUBORBITAL SCIENCE UPDATE - INTEX-B
NASA DC-8, Sky Research J-31, NSF C-130, DOE G-I, LaRC B200

Intercontinental Chemical Transport Experiment (Part B) – Deployment Schedule:

Houston:	Mar 1-20
Hawaii:	Apr 18-27
Alaska:	May 1-12

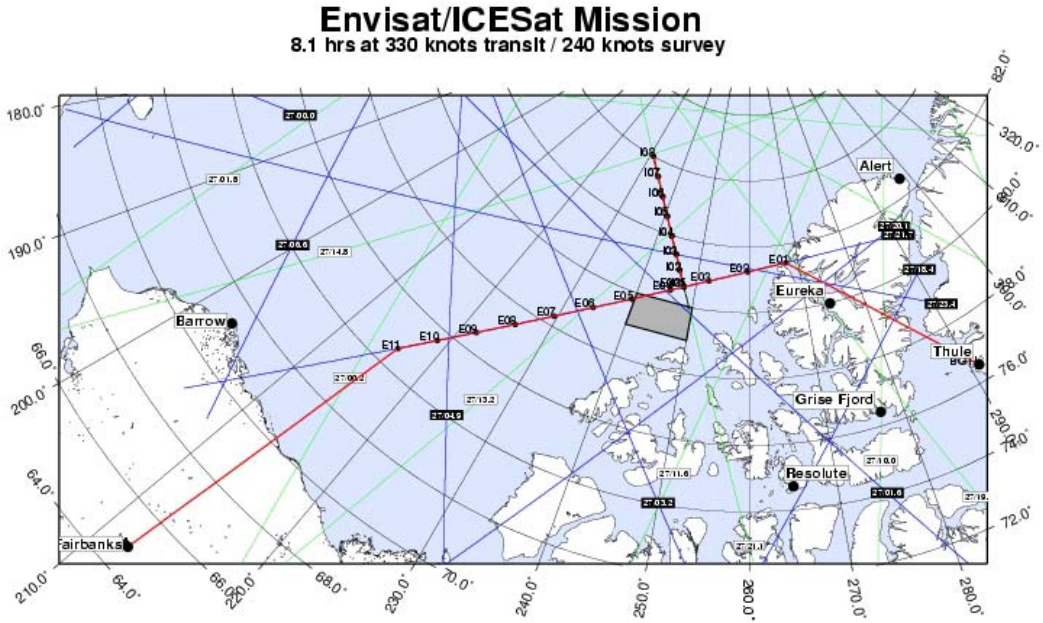
21 sensors
- 11 probes
- 2 lasers
- Species measured:
  - HOX, NOX,HNO4, SO2, O3, HCHO, H2O, CO, CO2, CH4
  - Aerosols



March 19 Flight Plan:
- Intercomparison with NSF C-130
- Coordinated spiral with J-31
- Validation of EOS Aura TES & OMI

INTEX-B Mexico City Pollution from DC-8, Mar 16

SUBORBITAL SCIENCE UPDATE – Arctic 2006
NASA P3-B



Chukchi – 21 Mar

Alaska & Greenland:

- P3-B with Kansas U snow radar, NOAA PSR, IIP D2P radar altimeter, ATM 4 laser altimeter
- Validate EOS Aqua AMSR-E, ICESat, Envisat

SUBORBITAL SCIENCE UPDATE – NSF Maldives Autonomous UAV Campaign, ACR Manta UAS

Maldives Hanimadhoo Island

- 3 Manta UAS in stacked formation, above, in, and below cloud
- Aerosol properties
- Black carbon
- cloud microphysics
- Broadband & spectral irradiances

Manta UAS

- Advanced Ceramics Research, Arizona
- Payload 15 lbs, 775 cu.in.
- Endurance 6+ hours
- Ceiling 16K ft
- Airspeed 40kts

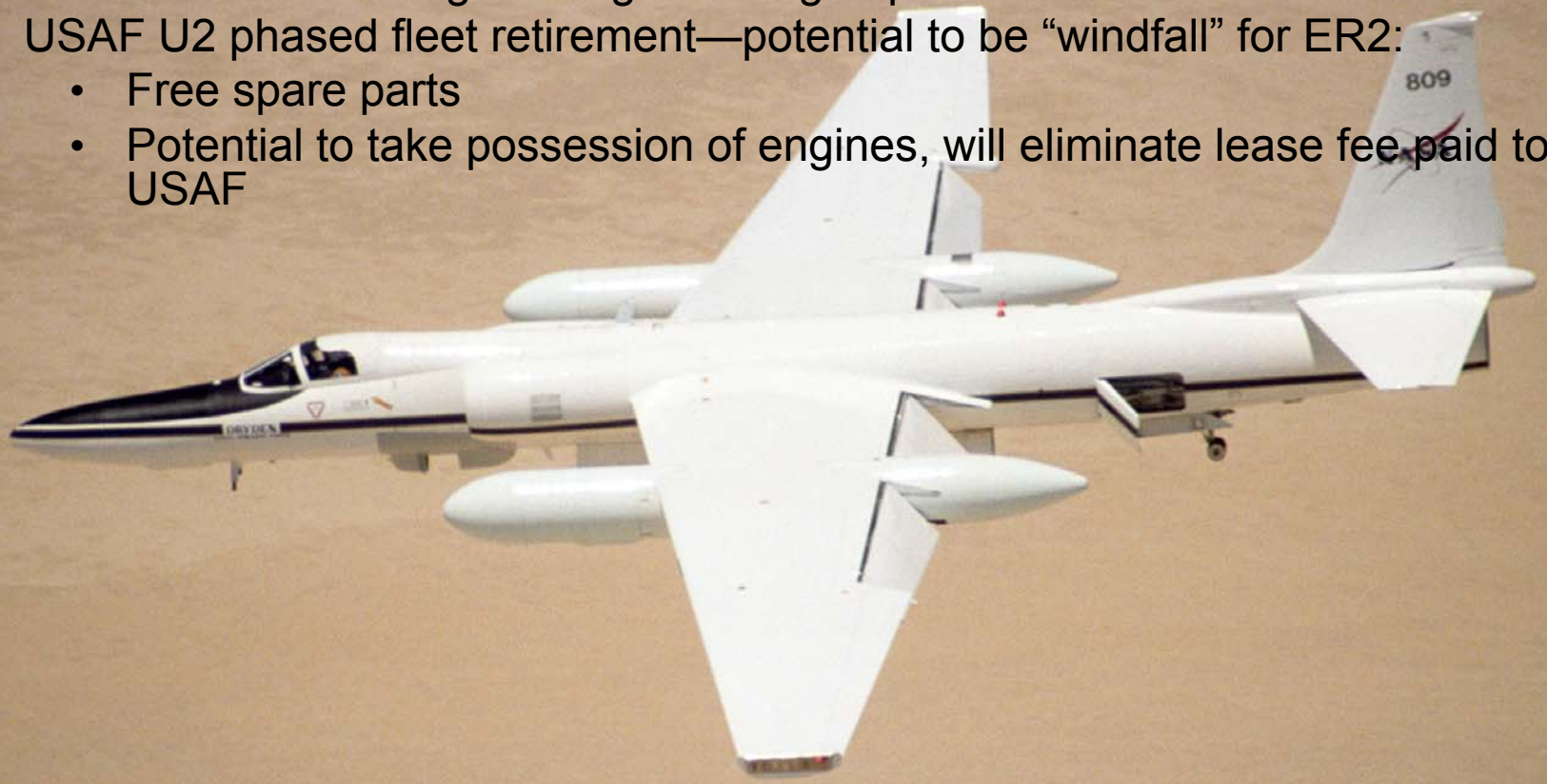
NASA contributed funding, advised on mission success and flight operations procedures. Lessons learned report coming.

Catalog Aircraft

		Hrly Rate
NASA		
ER-2	DFRC	$3700
WB-57	JSC	$3500
DC-8	UND	$5000
P-3	WFF	$3000
Other NASA		
G-3, S-3, Learjet, KingAir		$1K-$4K
Commercial		
Twin Otter/J-31/Caravan		$1K-$2.5K
Other Govt		
DOE, NRL, NSF, NOAA		$2.5K-$8K

ER-2 Update

- Periodic Depot Maintenance (PDM) complete on NASA 806
- New Business Model: Integration of ER2 into Dryden Aircraft Pool
  - More cost savings through sharing of personnel and resources
- USAF U2 phased fleet retirement—potential to be “windfall” for ER2:
  - Free spare parts
  - Potential to take possession of engines, will eliminate lease fee paid to the USAF



WB-57 Upgrades Status

- Avionics Upgrade (accomplished)
- Main Landing Gear Upgrade (in work)
- Gross Weight Increase (in-work – funding approved)
- Superpods (in-work – funding approved)
- Autopilot with RVSM (on hold))

P-3 Back in Service!

- Maintenance issues finally resolved, new aircraft services arranged
- Completed Arctic 2006 mission
- Due for Overhaul within next year

DC-8 Transition - Objective

Establish the National Suborbital Education and Research Center to expand access to and utilization of the DC-8 flying laboratory to a broader segment of the Airborne Science Community. Seek efficiencies in operating cost and explore the effectiveness of collaborative operations embedding a NASA aircraft in a research university setting.

DC-8 Transition - Accomplishments

- Agency team approach to try this new model for airborne research utilizing expertise & capabilities across Centers
- Maintained rigorous safety standards which produced a history of safe DC-8 operations & missions while at Ames and Dryden
- Key experienced maintenance personnel and pilots continued with the program to provide continuity of corporate knowledge
- Safely and successfully executed DC-8 Stardust Mission and first phase of INTEX-B mission

DC-8 Transition - Challenges

- Demonstrating the ability to perform new science on the aircraft while reducing cost to NASA (how large is the science demand for the DC-8 without NASA subsidized rates?)
- Providing a reliable long-term housing plan for the aircraft which is not subject to impact by Air Force priorities
- Delegating appropriate responsibility to UND to allow innovation while preserving standard of excellence in safety and mission success
- Effective management structure clearly defining roles and responsibilities at NASA and UND

New Platform Technology Infusion

Earth Science Capability Demonstrations (ESCD) Project

The ESCD project is a partnership between the Science Mission Directorate and Aeronautics Research Mission Directorate

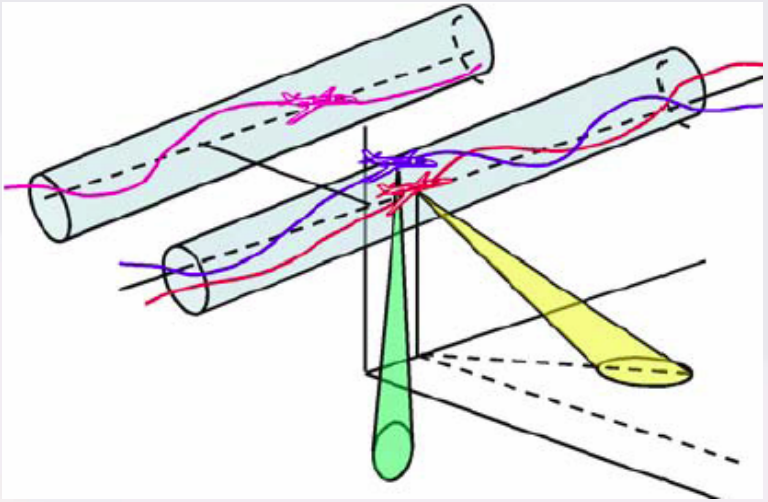
ESCD Projects:

- ❑ Precision Trajectories (UAVSAR)
- ❑ UAS Mission Demonstrations
- ❑ UAS Platforms
- ❑ Civil UAS Capability Assessment
- ❑ Over-the-Horizon Communications Development

Precision Trajectories

Project: Precision Trajectories (component of UAVSAR program)

Objective: Develop & demonstrate precision navigation capability required to support Repeat Pass Interferometry (RPI) data missions



Minimum rqmt - ability to repeatedly navigate the aircraft within a predefined ten meter tube flight path
Ultimate goal - one meter tube precision
Schedule – CDR April 21, First Flight Nov 2006

UAS Mission Demonstrations

- NOAA/NASA Altair UAV Demo (2005)
- NOAA/NASA Aerosonde Ophelia Demo (2005)
- REASoN WRAP Project (2006)
  - Small UAS Demo - June
  - Western States Fire Mission - August
- Joint NOAA/NASA Hurricane Boundary Layer Sampling (2006)
- UAS Aura Validation Experiment (2007)
- Potential IPY experiment (2008?)

UAS Platforms

Objective: Acquire/operate UAS platforms for science missions

2005 Accomplishments:

- Altair lease supported NASA/NOAA UAV Demo Mission
- Ikhana (Predator B)
  - July 06 delivery of Aircraft & Ground Control Station (ARMD Funded)
  - Aircraft to be flown by NASA pilots
- Small UAS: Aerosonde, Sierra
- Global Hawk
  - Completed Operations Concept Study
  - Continued discussions with Air Force to acquire flight test aircraft

Airborne Sensors

Airborne Science & Technology Lab Overview:

Resides in the NASA Ames University-Affiliated Research Center under the Ames Earth Science Division

Staffed by Univ. of California, Santa Cruz

Joint funding from Suborbital, EOS, and other programs

Provides Earth science mission support through:

- Instrument/platform integration services
- Data collections with Digital Tracking Cameras (DCS), MODIS and ASTER Airborne Simulators (MAS, MASTER)
- Community use of POS/AV precision navigation systems
- Development of interface standards & cross-platform portability
- Enabling technologies for UAV instruments & sensor webs
- NIST-traceable calibration lab for spectro-radiometers

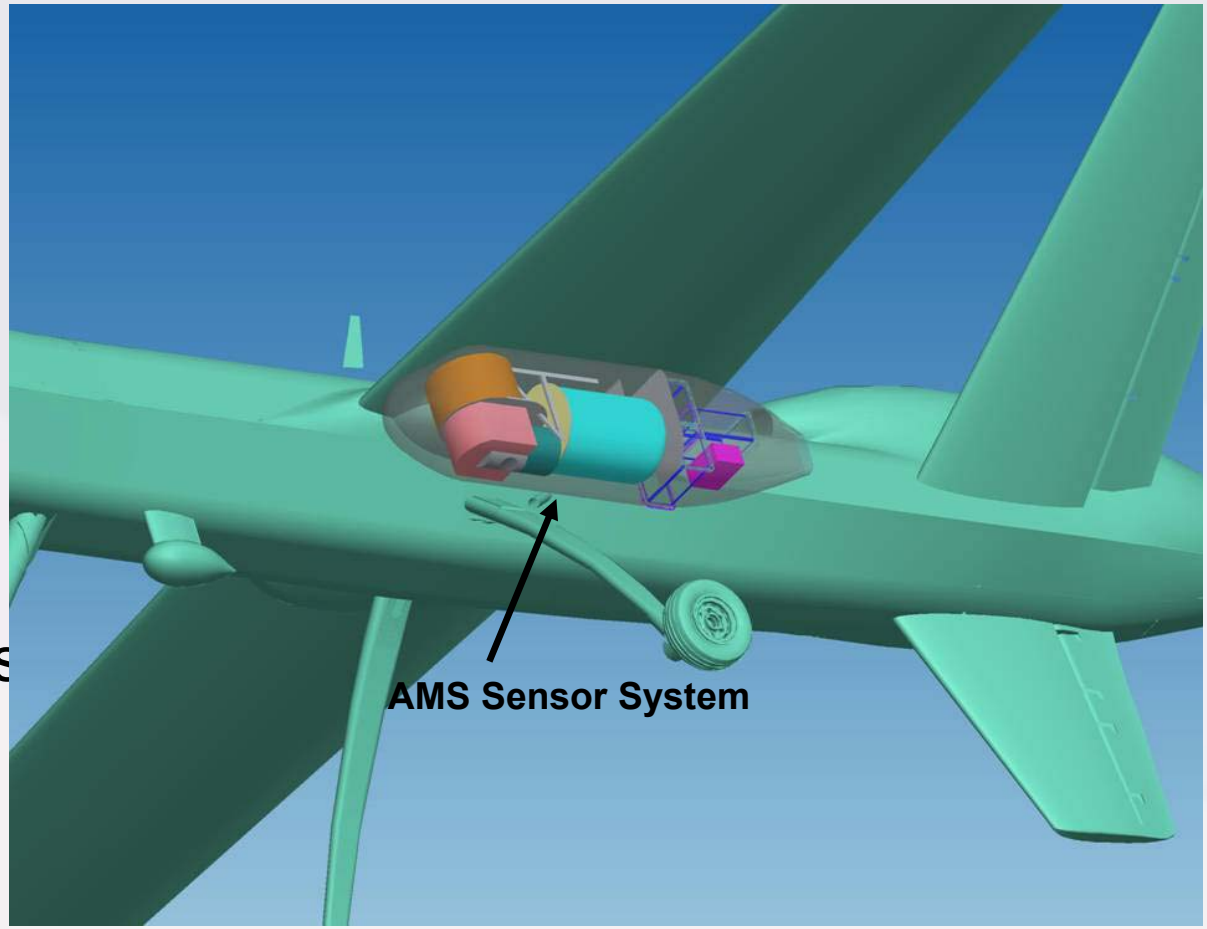
Modular Sensor Pod for Altair or Ikhana (Predator-B)

Design collaboration with DFRC and General Atomics

Modular fairings

Standard electrical & Mechanical interfaces

1,500 lb capacity



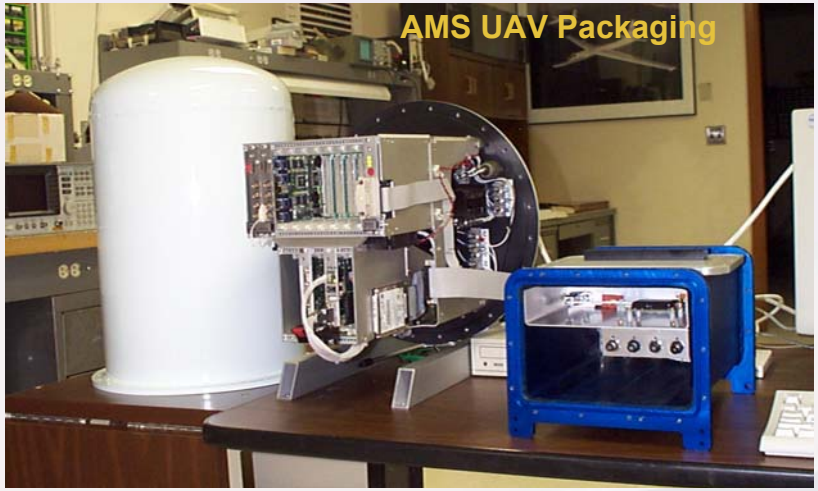
Airborne Sensors

Utility Equipment for the High-Altitude Environment

Pressurized Sub-system Housings (Static tested)

Low-Pressure Heater Unit

Heater-Blower for Altair Pod



Interagency Activities

- NOAA/NASA/DOE collaboration on UAS
  - MOU in final review
  - Workshops http://uas.noaa.gov/interagency/index.html
  - Collaborative missions (Maldives, etc)

- Interagency Coordinating Committee for Airborne Geoscience Research & Applications (ICCAGRA)
  - NSF, NOAA, NRL, ONR/CIRPAS, DOE, USGS
  - Data Systems subcommittee/interoperability standards
  - Next meeting May 23 Monterey, CA at CIRPAS

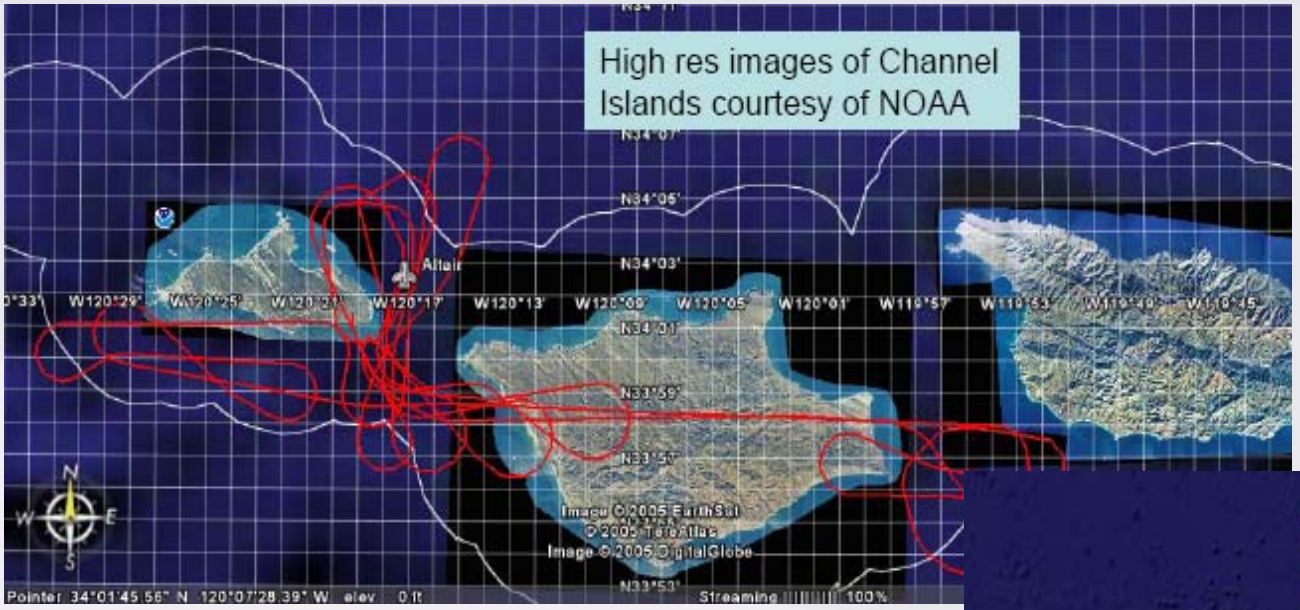
Plans

- Call Letter/website April 7, improve coordination with ROSES
- Studies & Requirements Analyses
  - Congressional UAS Report: March
  - Civil UAS Assessment: April
  - Telemetry/Communications Requirements: May
  - 5-Year plan: June
  - Altair/Ikhana Polar Operations Feasibility Study: September
  - Gap Analysis and Technology Roadmap in 2007
- 2007 platforms anticipated to be same as 2006, with the addition of the Ikhana UAS; priority is to balance platform availability with science mission priorities
- Remaining major 2006 missions:
  - Cloudsat/Calipso Validation
  - N-AMMA
  - Western States Fire
  - NOAA/NASA Aerosonde low-level hurricane sampling

Science Mission Directorate

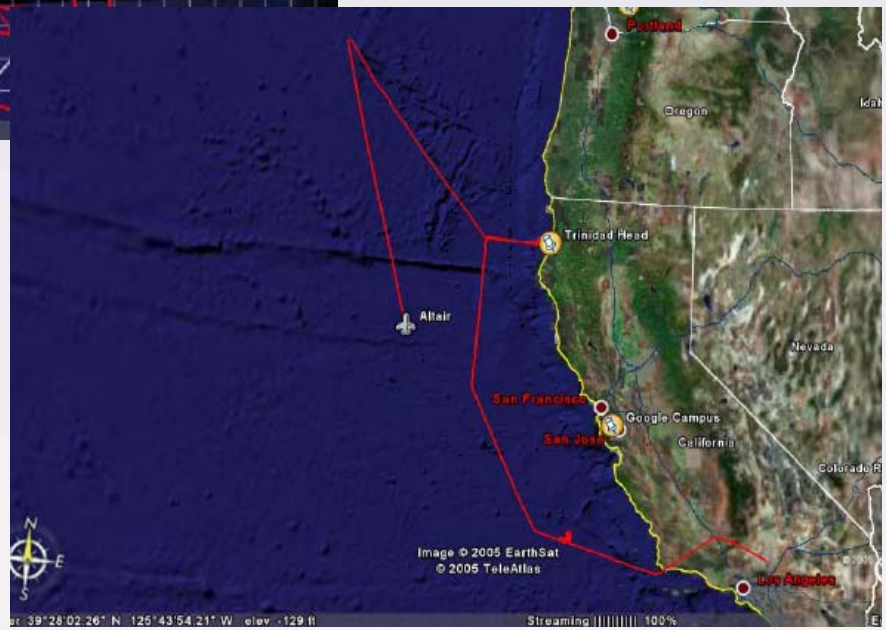
Suborbital Science Backup

NOAA Altair UAV Demo



NASA/NOAA Channel Islands mission

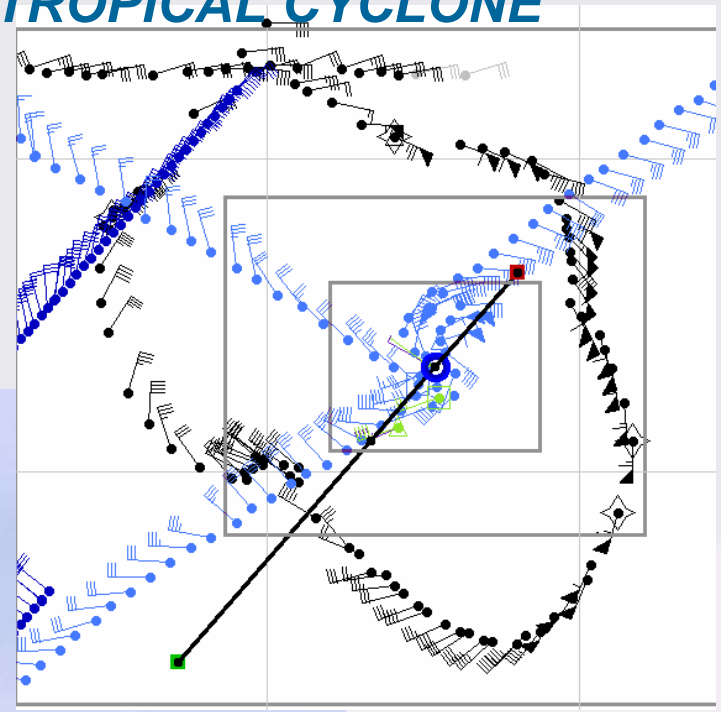
NASA/NOAA 18.4 hour mission



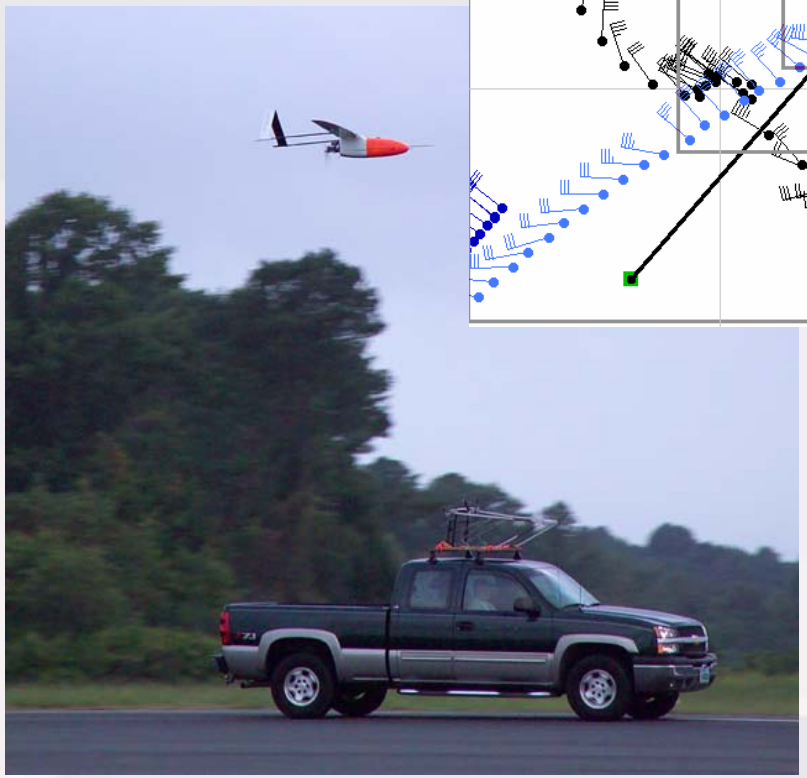
Low-level Hurricane Winds
Aerosonde Flight - Ophelia 16 Sep. 2005

FIRST EVER UAV TO FLY INTO A TROPICAL CYCLONE

•NOAA WP-3D Stepped Frequency Microwave Radiometer (SFMR) Surface winds in light blue, Aerosonde winds in black, buoy winds in dark blue.



•Aerosonde closest approach to wind center was 30 nm southwest and 25 nm northeast. Peak winds at 2500 ft were 65 kt southeast of center and 75 kt north of center.

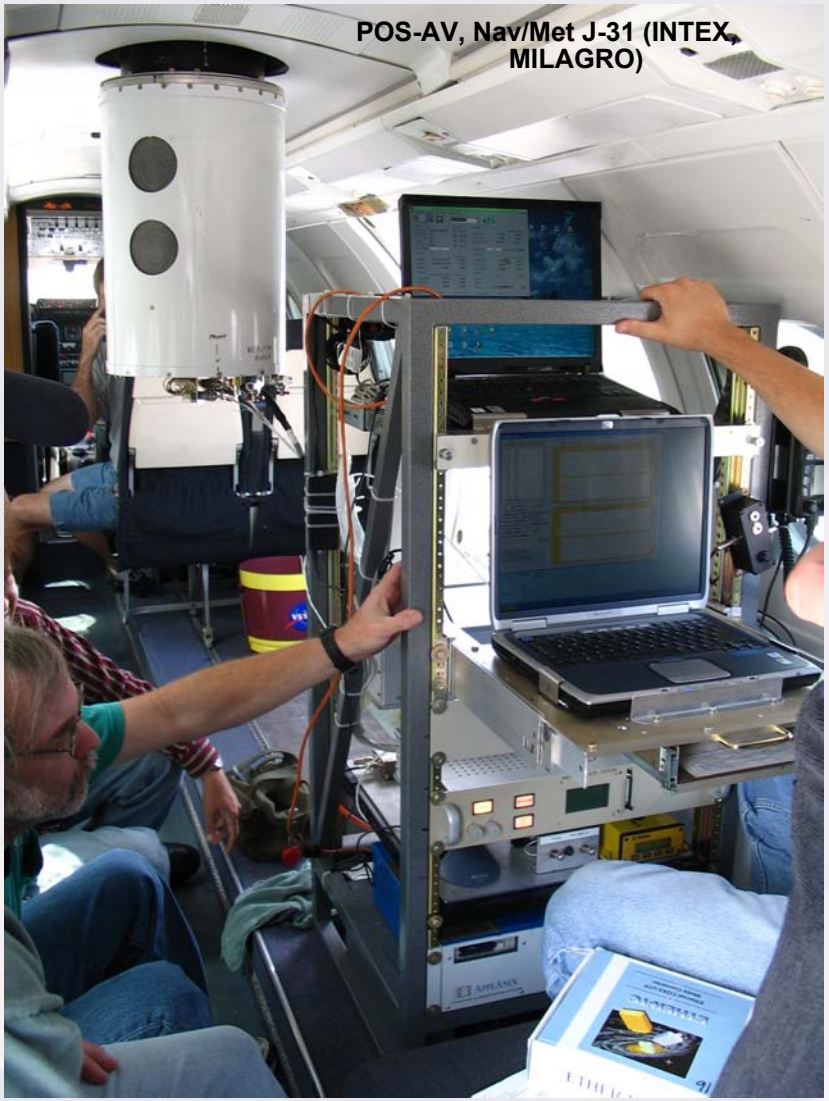


•Excellent agreement was found between buoy, SFMR and Aerosonde winds adjusted to surface values. SFMR winds SW of center were within 10 min of aerosonde.

Science Support: New Instrument Integrations

CAR J-31 (MILAGRO)

DCS Camera Altair (NOAA)



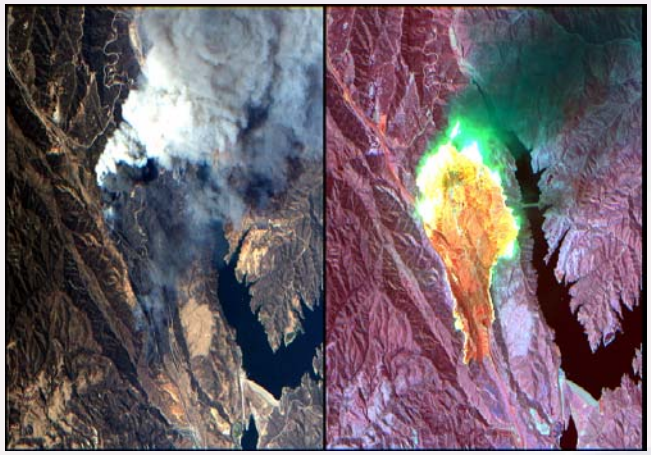
POS-AV, Nav/Met J-31 (INTEX, MILAGRO)

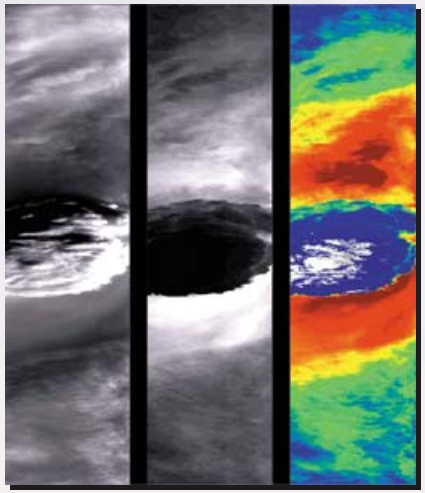
Enabling Technologies

Autonomous Modular Sensor System (AMS)

A technology test-bed for UAV instrumentation, demonstrating:

- **Extended high-altitude operation of electronic subsystems**
- **Autonomous and Sensor Web operating modes**
- **On-board processing for real-time data reduction**
- **Sterling & TE-cooled IR detectors**
- **Compatible with Altair, Ikhana, Global Hawk**
- **Spectrometers for Land, Ocean, Atmospheres**





Enabling Technologies

Telemetry Link Module:

- A Universal Interface to the Altair Ku-Band Telemetry System
- Inputs for >20 instruments; Up To 40 Mbs Throughput
- S/W Configurable, Multiple Interface Protocols
- Fast CPUs & Solid State Storage For Experimenter Data & Algorithms
- Developed under the UAV Wildfire REASON-CAN & AMS Sensor Project
- Initial deployment on the Western States Fire Mission