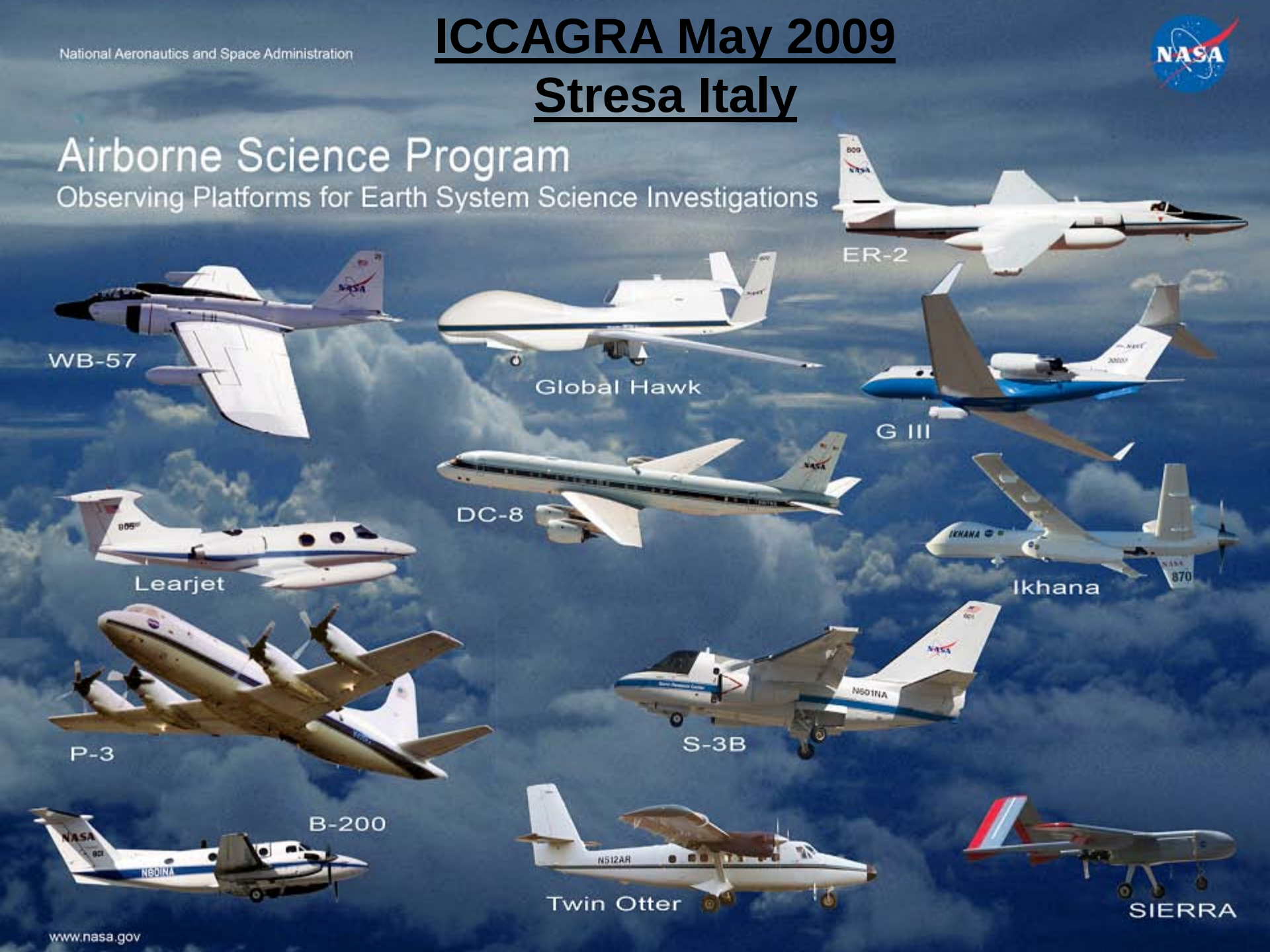
ICCAGRA May 2009
Stresa Italy



Airborne Science Program

Airborne Science Program
Andrew Roberts
Dep: Randy Albertson
Functions:
Portfolio Mgmt,
Grants Studies and Report rqmnts
Education and Outreach,
Facilities, Testbeds and Operations

LaRC – Catalog Aircraft
B-200

GRC – Catalog Aircraft
S-3, Lear, Twin Otter, T-34

ARC ASP Program
Matt Fladeland

Functions:
Studies and Reports, Earth Science Project Office, Airborne Sensor Development Lab, Science Mission Mgmt, Sierra

DFRC ASP Program
Bob Curry
Dep Jaques Vaschon

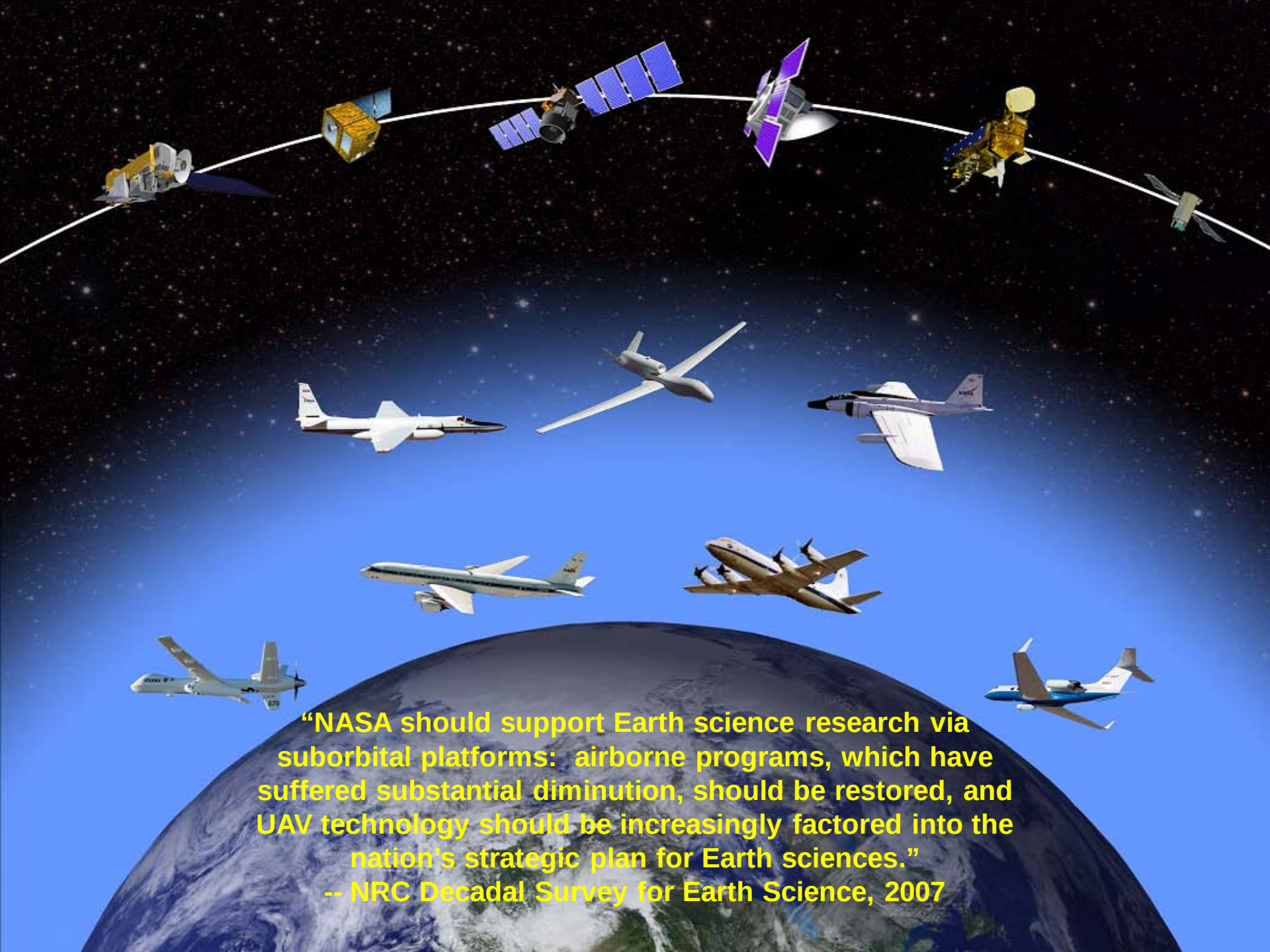
Functions:
DC-8/NSERC, ER-2, Ikhana, Global Hawk, G-III, DAOF

WFF ASP Program
George Postell
Dep Anthony Guillory

Functions:
P-3, Catalog mgmt, small UAV, Reports, Budget Mgmt support

JSC ASP Program
Ken Cockrell
Dep Kevin Lesenski

Functions:
WB-57,
Mission Support Programs

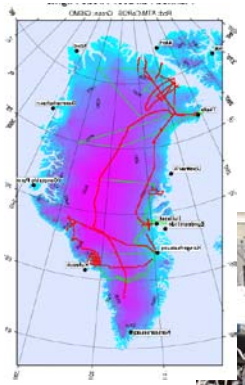


“NASA should support Earth science research via suborbital platforms: airborne programs, which have suffered substantial diminution, should be restored, and UAV technology should be increasingly factored into the nation’s strategic plan for Earth sciences.”

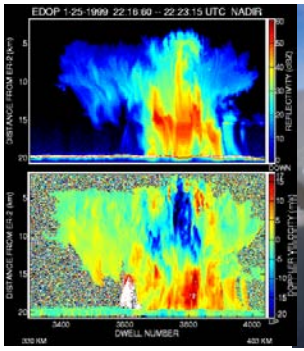
-- NRC Decadal Survey for Earth Science, 2007

Program Objectives

Satellite Calibration and Validation
Provide platforms to enable essential calibration measurements for the Earth observing satellites, and the validation of data retrieval algorithms.



New Sensor Development
Provide sub-orbital flight opportunities to test and refine new instrument technologies/algorithms, and reduce risk prior to committing sensors for launch into space.



Process Studies
Obtain high-resolution temporal and spatial measurements of complex local processes, which can be coupled to global satellite observations for a better understanding of the complete Earth system.

Development of Next-Generation Scientists and Engineers
Foster the development of our future workforce with the hands-on involvement of graduate students, and young scientists/engineers in all aspects of ongoing Earth science investigations.

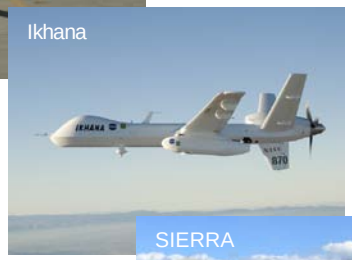
New Technologies

Platforms:

Global Hawk UAS: Long-range, high altitude heavy-lift aircraft with 30+ hour endurance

Ikhana UAS: Medium altitude Predator-B with 24 hour endurance

SIERRA UAS: Low altitude, easily deployable, with 100 Lb. payload



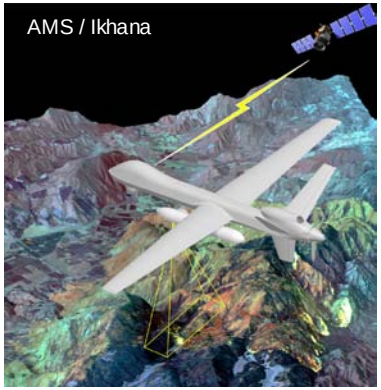
Sensor Systems:

G-III/UAV-SAR: L- and Ka-Band Interferometric polarimetric Synthetic Aperture Radar

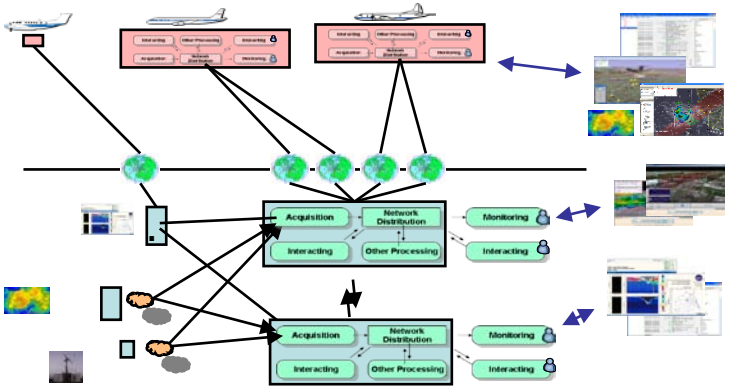
UAS AMS: IR sensor for fires & hurricanes, genera and transmits image products autonomously

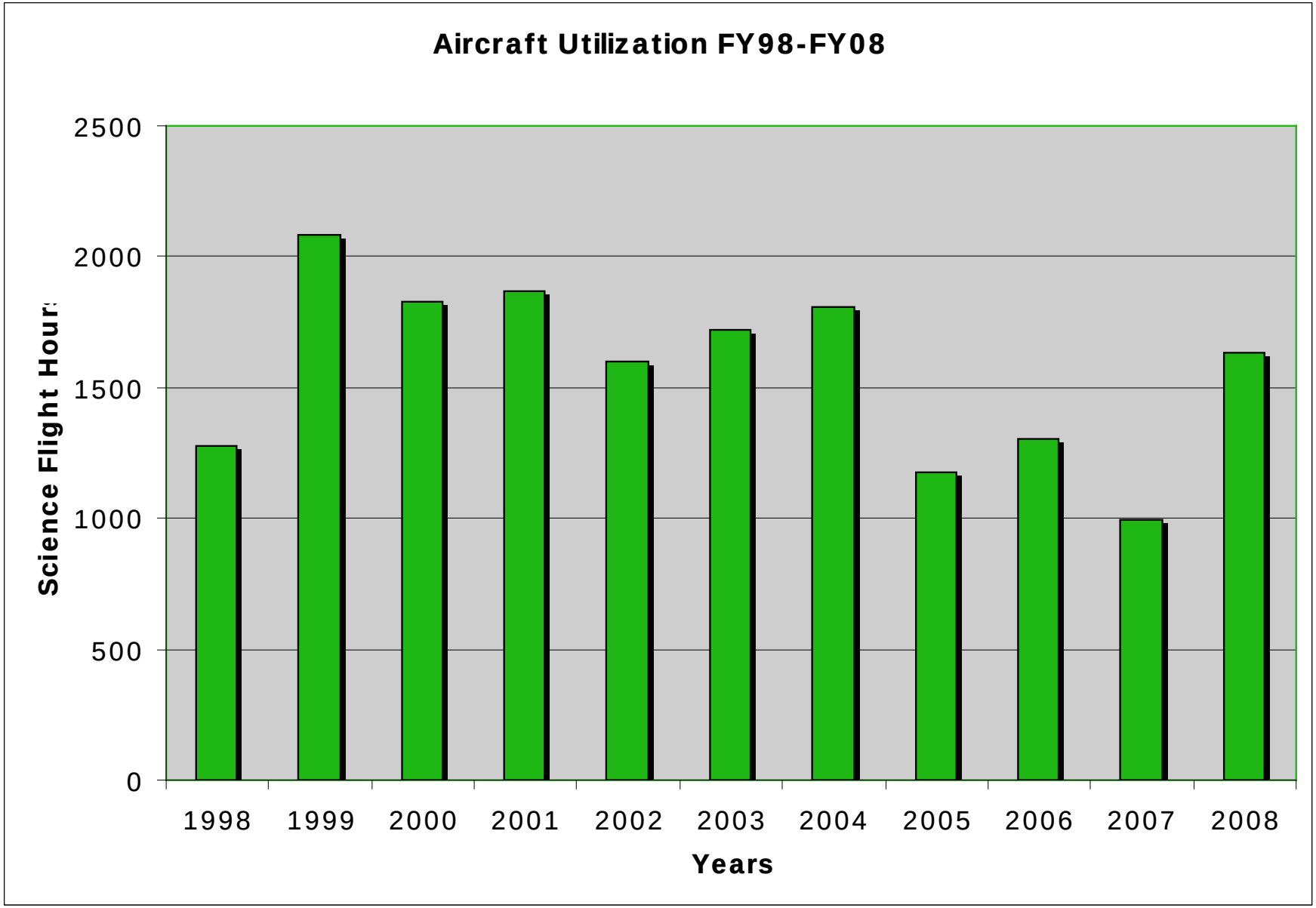
Real-Time Data Systems:

New science data web portal will allow P.I.s to monitor missions and interact with sensors in real-time via sat-com links and the Internet.



Airborne Science Sensor Web




Aircraft Utilization FY98-FY08
Science Flight Hours
2500
2000
1500
1000
500
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Years

CY08 ESD Airborne Missions

• Airborne Visible-Infrared Imaging Spectrometer (AVIRIS)	Twin Otter	59 hours
• Cold Land Processes Experiment II	Twin Otter	233 hours
• Arctic Research of the Composition of the Tropophere from Aircraft and Satellites (ARCTAS)	P-3, DC-8, B-200	263 hours
• California Air Resources Board (CARB)	P-3, DC-8, B-200	50 hours
• ARCTAS Summer	P-3, DC-8, B-200	225 hours
• High Spectral Resolution LIDAR Calipso/Cloudsat Cal/Val	B-200	76 hours
• MASTER Simulator North America	ER-2, B-200, TO	138 hours
• AVIRIS North America	ER-2, Twin Otter	74 hours
• Passive Active L/S-band radar (PALS)	Twin Otter	92 hours
• Newly-operating and validated instruments comparison exp.	WB-57	9 hours
• Western States Fire Mission 08	Ikhana	20 hours
• Arctic Mechanisms of Interactions between surface and atm	DC-8	59 hours
• ACCLAIM	B-200	34 hours
• UAVSAR baseline	G-III	156 hours
• ATM/PARIS Antarctica	P-3	69 hours
• Ice Roughness Profilometer testflights	SIERRA	20 hours
• Soil moisture Active/Passive Validation Experiment (SMAP-VEX)	P-3	18 hours
• CO2 Laser Sounder	Lear 25	16 hours
• Land vegetation imaging sensore (LVIS)	B-200	36 hours
• Geostationary Imaging Fabry-Perot Spectrometer (GIFS)	P-3	20 hours
• **Total**	**1667 hours 367 Sorties Flown**	

(Denotes new instrument development)

66% increase from 2007

Arctic Research of the Composition of the Troposphere from Aircraft and Satellites

(ARCTAS)

A NASA contribution to IPY and the international POLARCAT initiative

http://cloud1.arc.nasa.gov/arctas

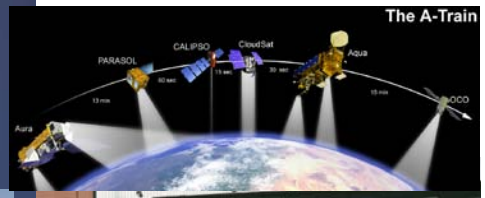
Conducted in spring and summer 2008 with the following foci:

1. **Long-range transport of pollution to the Arctic** (including arctic haze, tropospheric ozone, and persistent pollutants such as mercury)
2. **Boreal forest fires** (implications for atmospheric composition and climate)
3. **Aerosol radiative forcing** (from arctic haze, boreal fires, surface-deposited black carbon, and other perturbations)
4. **Chemical processes** (with focus on ozone, aerosols, mercury, and halogens)

April 2008: ***Fairbanks and Barrow, Alaska; Thule, Greenland***

July 2008: ***Cold Lake, Alberta; Yellowknife, NW Territories***

Partners: ***NASA, NOAA, DOE, NSF, Canada, France, Germany***

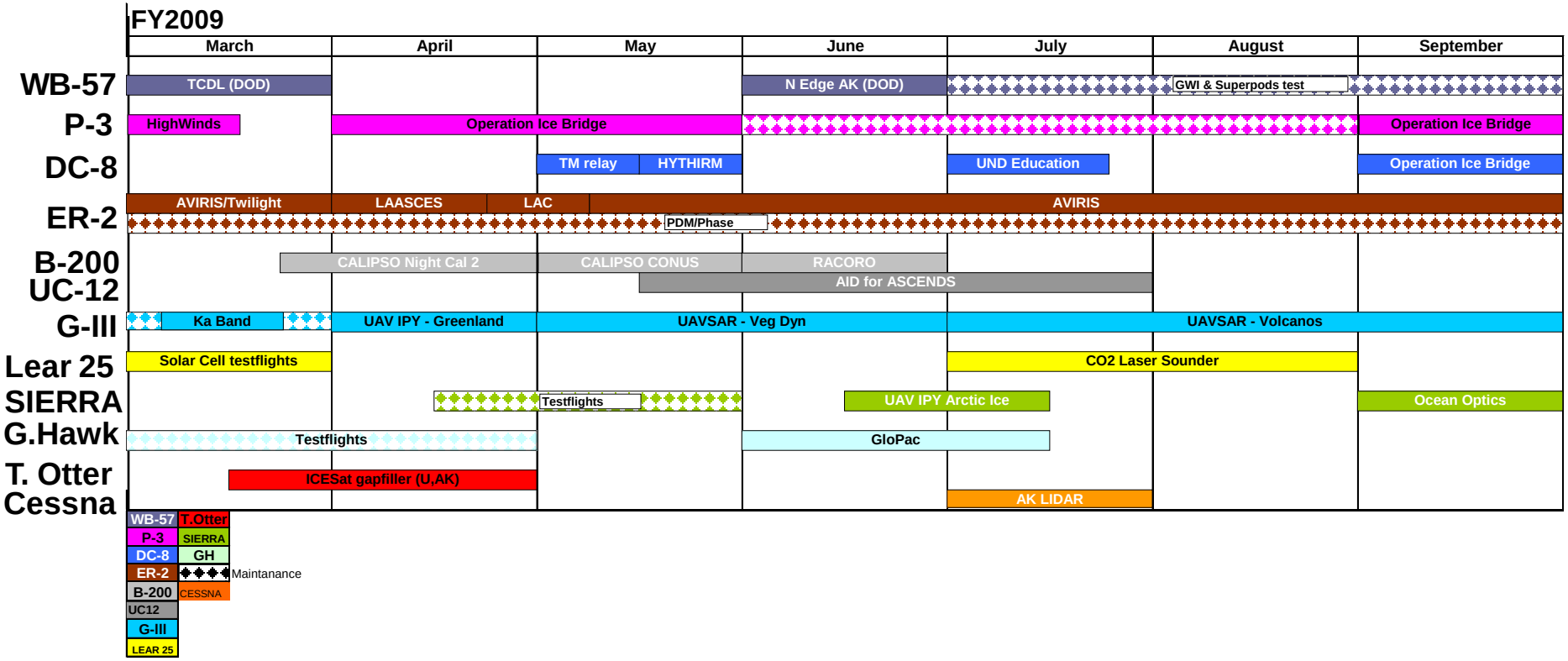


ARCTAS Campaign Summary

		Spring	CARB	Summer	Total	Planned Hours
DC-8	Sorties	12	4	12	28	183
	Hours	84.3	31.7	68.1	184.1	
P-3	Sorties	14	3	13	30	175
	Hours	80.4	19.2	78.9	178.5	
B-200	Sorties	29	0	25	54	175
	Hours	98.1	0	77.9	176	
Total	Sorties	55	7	50	112	533
	Hours	262.8	50.9	224.9	538.6	

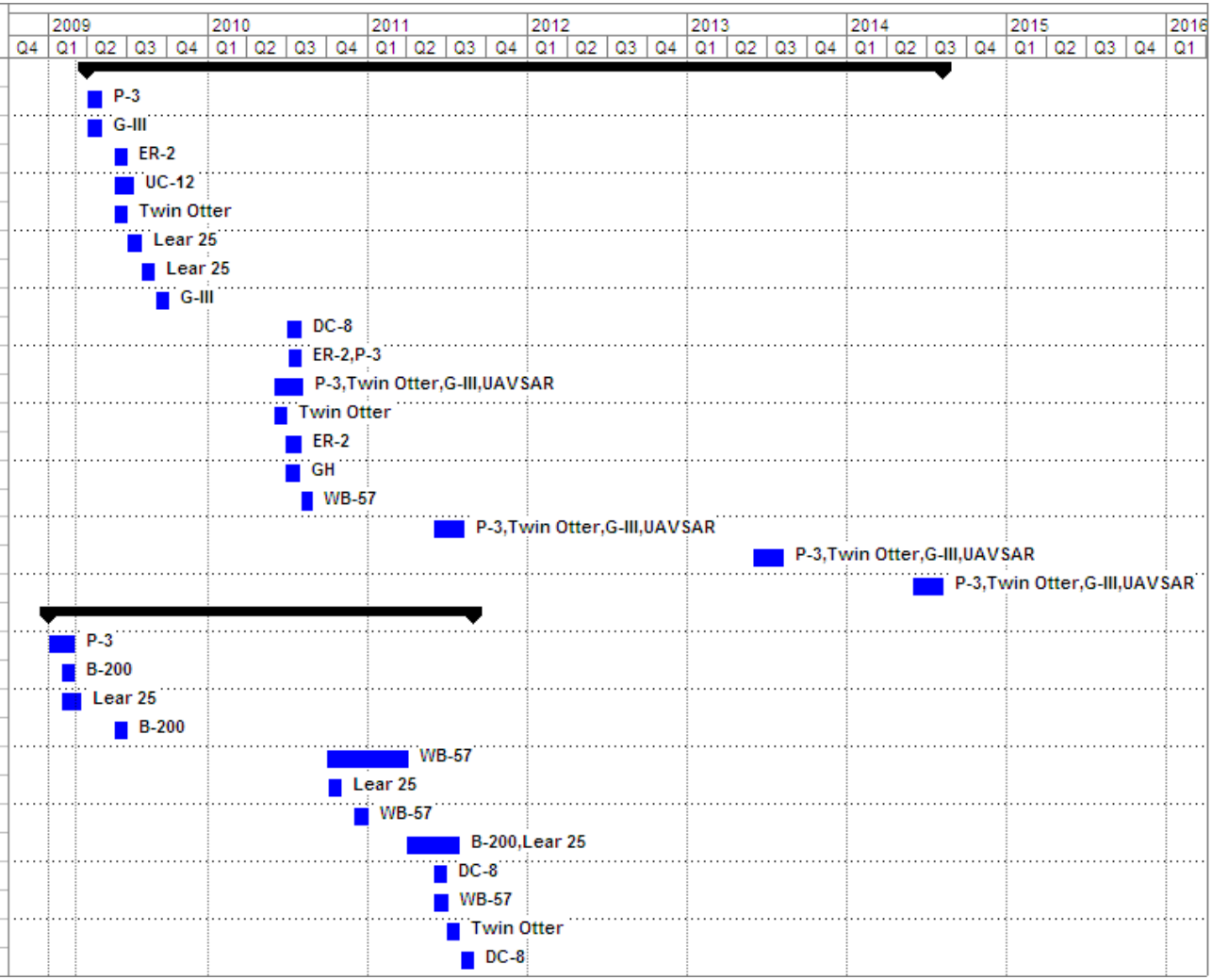
Example of large mission metrics

NASA SMD ESD Airborne Science Program Near Term Schedule

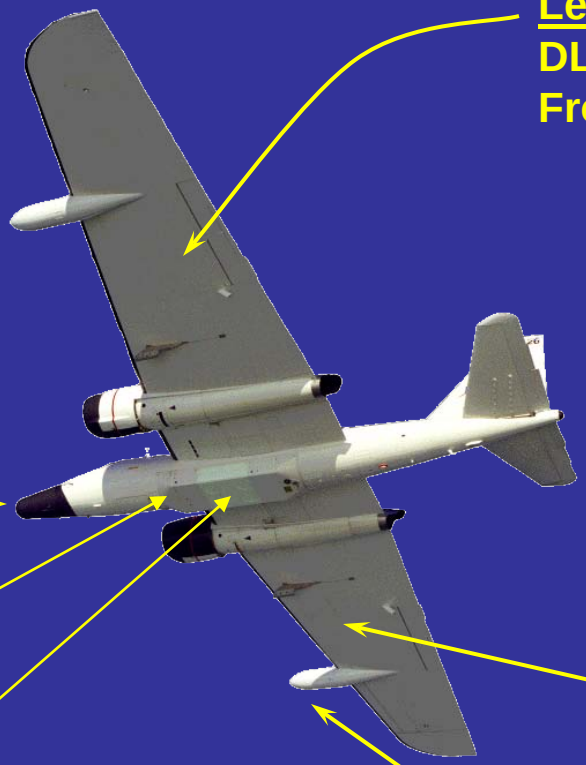


Decadal Survey Flight & Instrument Development

ID	Task Name
45	**Decadal Survey Mission Support**
46	ICESat II - ATM/SIMPL
47	SWOT - UAVSAR-Ka
48	HyspIRI - AVIRIS/MASTER
49	ASCENDS - Browell
50	ASCENDS - Spiers
51	ASCENDS - Abshire
52	CLARREO - INFLAME
53	DESDynI - UAVSAR
54	ASCENDS - Browell/Abshire/Spiers
55	ACE - 3 polarimeters
56	SMAPVEX-10
57	DESDynI - LVIS/Steerable Lidar
58	ACE - HSRL
59	SWOT - HAMSR
60	GEOCAPE - FTS/simulator
61	SMAPVEX-11
62	SMAPVEX 13
63	SMAPVEX 14
64	**Instrument Incubator Program**
65	HiWinds - Heymsfeld
66	INFLAME - Mlynczak
67	SIMPL - Harding
68	GOLD - Hair
69	Wind Lidar - Kavaya
70	SMLA - Yu
71	BA Wind Lidar - Grund
72	CO2 laser sounder - Abshire
73	CO2 Lidar - Heaps
74	MW limb sounder - Stek
75	HyTES - Hook
76	SWIR Imaging Polarimeter - Diner



NOVICE WB-57 Payload 2008



Left Wing Hatches
DLH (Diskin, Langley)
Frostpoint (Gao, NOAA)

Nose
MMS (Bui, Ames)

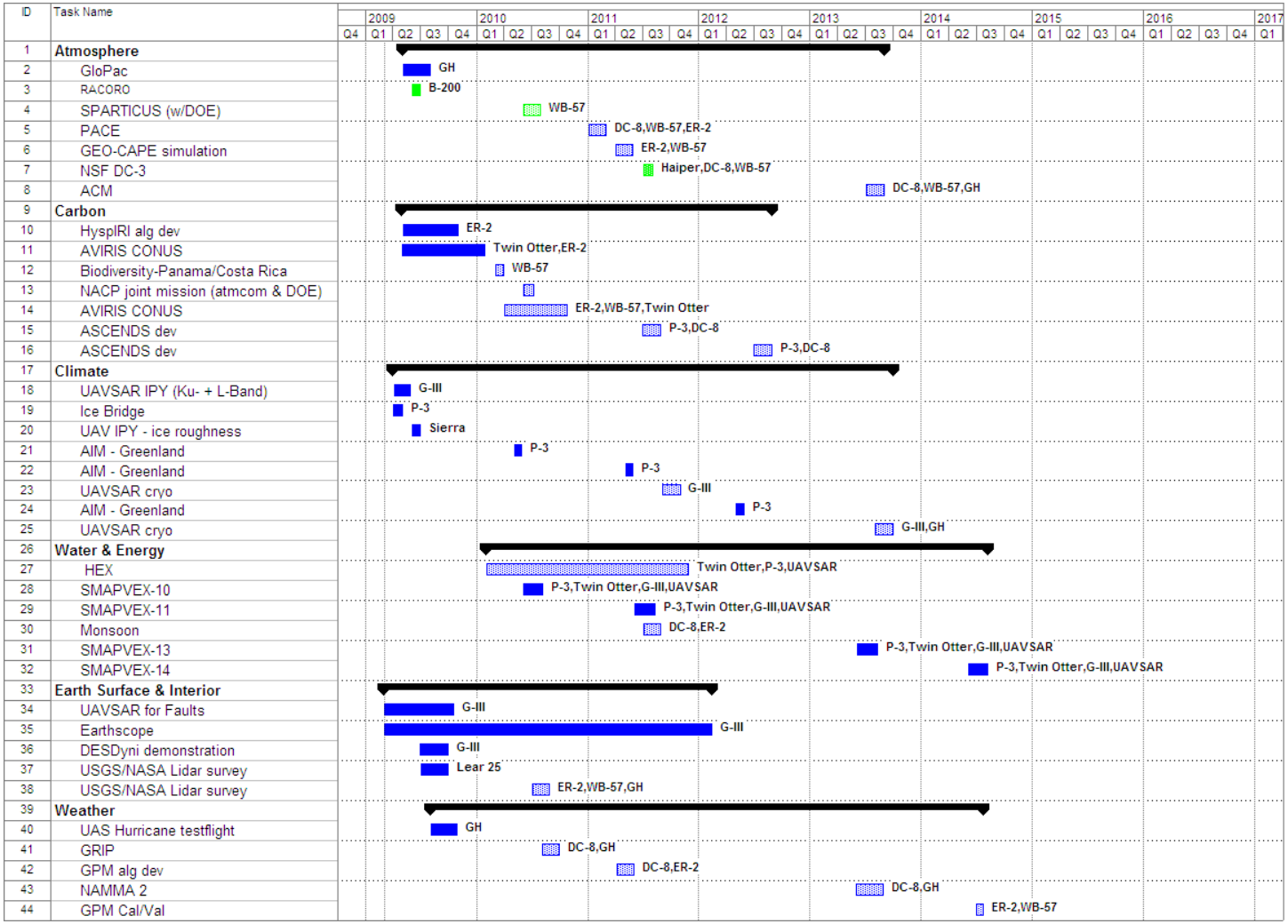
Forward Transition
Old Ozone (Gao, NOAA)

Right Wing Hatches
DCS (Ames)

Pallets
Pallet 1: TILDE/HHH (Witinski, Harvard)
Pallet 2: Argus (Loewenstein, Ames)
NOBALT (Podolske, Ames)
Pallet 3: UAS Ozone (Gao, NOAA)
Pallet 4: QCLS (Wofsy, Harvard)

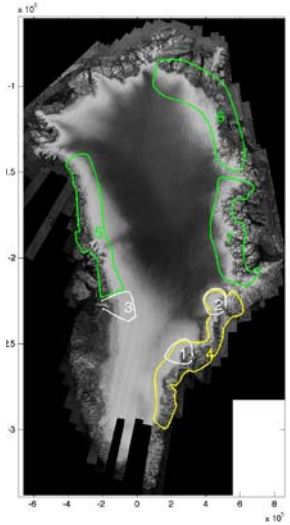
Right Wing Pod
Lyman Alpha
(Anderson, Harvard)

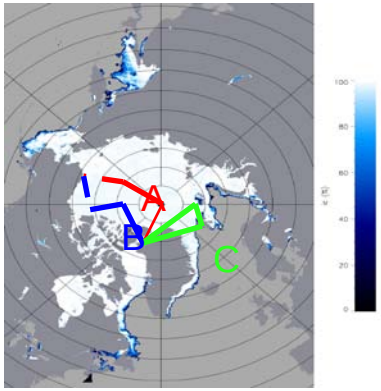
R & A 5-Year Flight Schedule

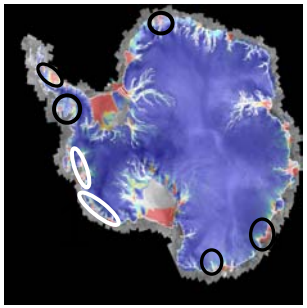


Operation Ice Bridge: Spring 2009 ICESat gapfiller

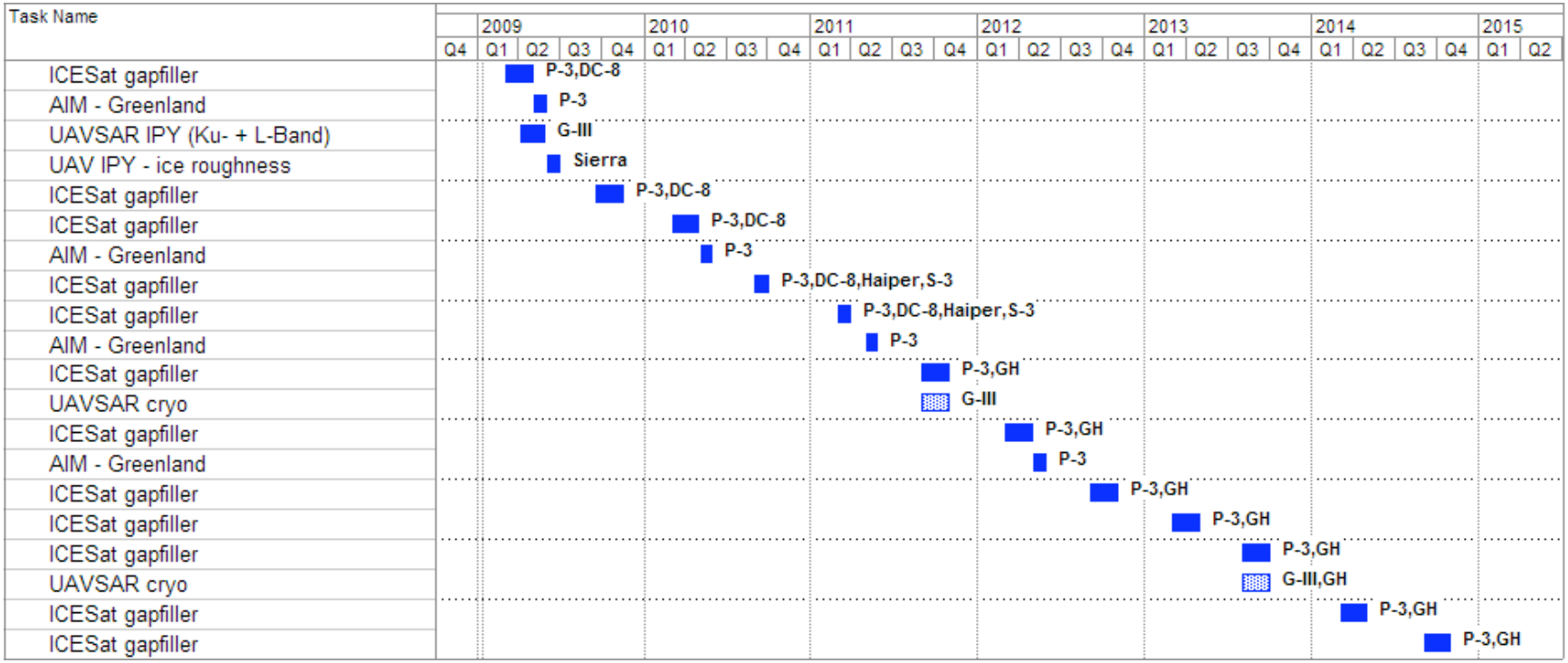
- The Airborne Science Program has developed a 6-yr strategy for collecting ICESat-like data from aircraft for regions of scientific interest
- The spring 2009 flights will extend and bolster the existing Greenland P-3/ATM (Krabill) missions and include the PARIS (Raney) RADAR sounder and LVIS (Blair).
- If funding is approved, the Spring campaign will be repeated over Greenland, and the DC-8 will fly ATM, LVIS, and KU RADAR sounder (Gogineni)
- Extended coverage of Antarctica will be facilitated by the NSF G-V HIAPER, and the Global Hawk in 2010 & 2011 respectively.
- IIP and AIST instruments will be included as they successfully mature evaluate and improve measurements (SIMPL, MFFL, SMLA)

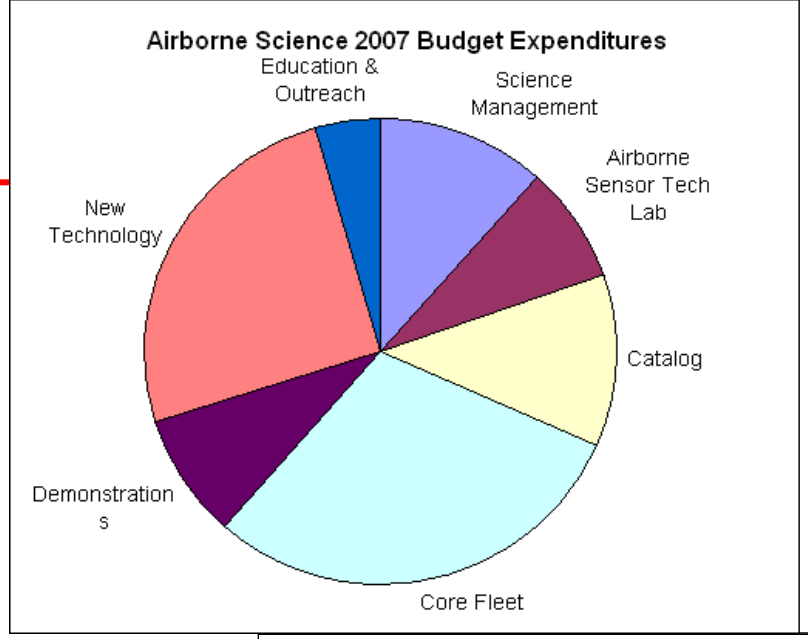


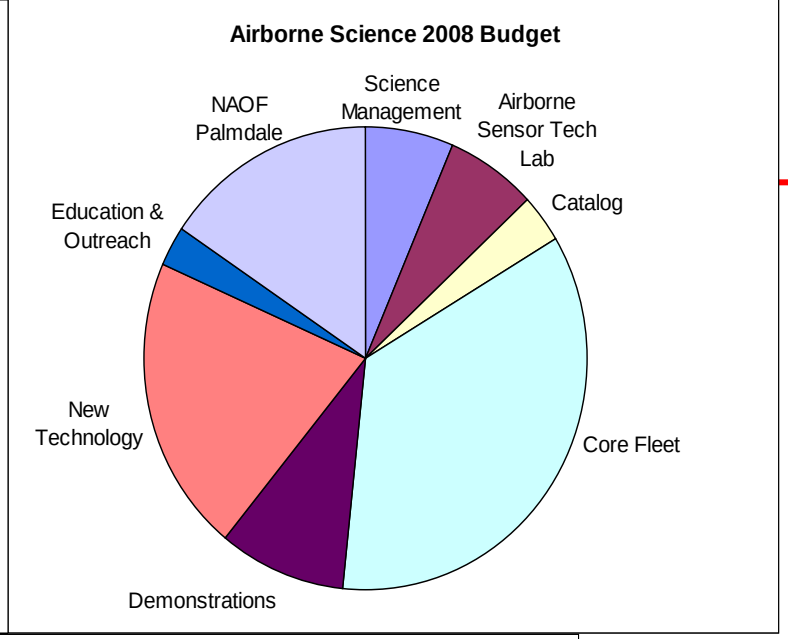


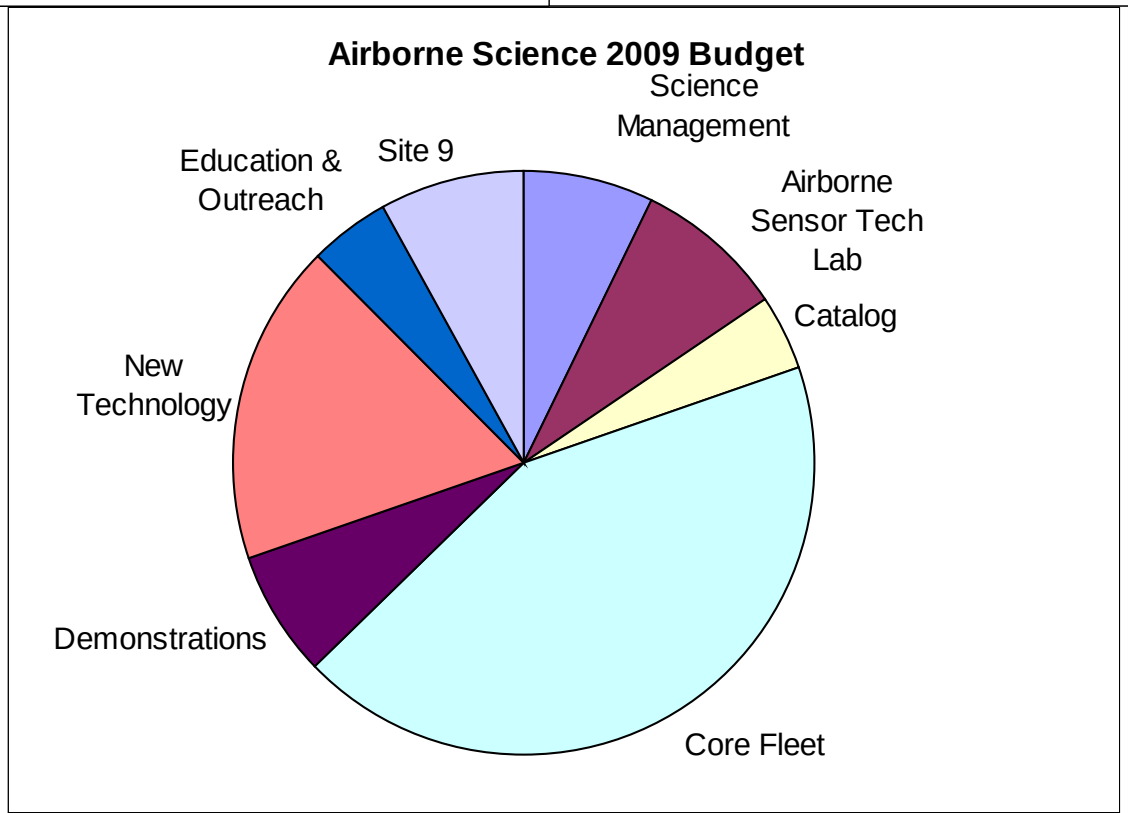


A schedule of ICESat Ice Bridge Missions in addition to currently planned missions




Airborne Science 2007 Budget Expenditures
Education & Outreach
Science Management
Airborne Sensor Tech Lab
Catalog
Core Fleet
Demonstration s
New Technology

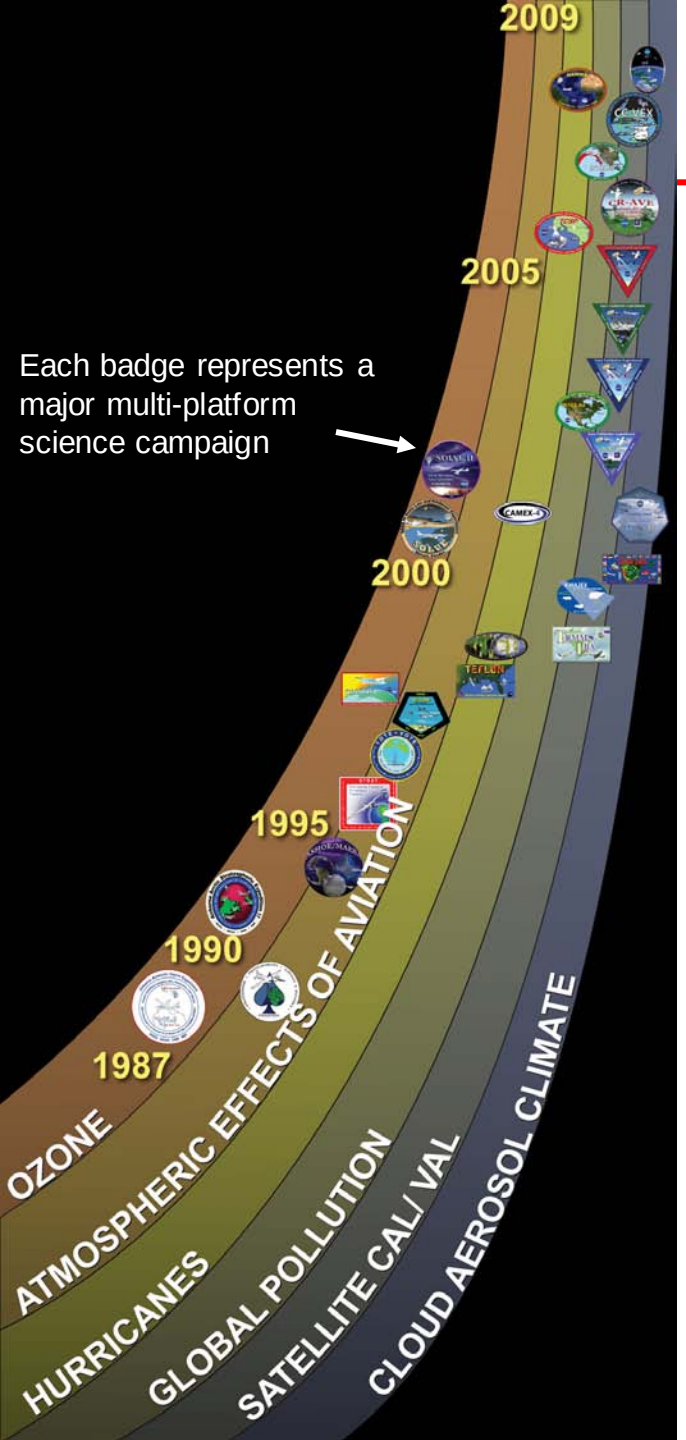

Airborne Science 2008 Budget
NAOF Palmdale
Science Management
Airborne Sensor Tech Lab
Catalog
Core Fleet
Demonstrations
New Technology
Education & Outreach


Airborne Science 2009 Budget
Science Management
Site 9
Education & Outreach
Airborne Sensor Tech Lab
Catalog
Core Fleet
Demonstrations
New Technology

Potential Direction of ASP

- **Establish a core ASP engineering capability in the centers,** more FTE's/WYE, BPA. Reduce integration cost to the investigator
- **Reduce ESD User Fee** by having a larger share in the ASP Budget for Operations
- **Sensor Portability**
  - New Data Distribution System based on IWGADTS standards in Core fleet
  - Started Intercenter Integration Guide for experimenters
- **Need to update old infrastructure**
  - WB-57 Engines, Autopilot – maintainability (vanished support, tubes and no other engine users), comply with RVSM, a 25% improvement in range and endurance, Increased altitude +~5000 ft
  - P-3 Autopilot, Props, wing panels and lavatory, upgrades, again maintainability
  - DC-8 in 20 years DC-8's will be much harder to maintain we should start the process of developing a replacement, for example a 777ER can fly 9000nm compared to 5300 nm for the DC-8, burns half the fuel and has 3X the payload capability. Should start the studies
  - New Fuel Heat Systems for the WB-57, ER-2 and Global Hawk
- **Global Hawk infrastructure**
  - Deployable station – potentially setup WFF to support East Coast Operations
  - Second GH Ops Center
  - Spare parts for fly away kit

A Long History of Worldwide Science Field Campaigns



Supporting: stratospheric/tropospheric chemistry, cryospheric science, hurricane observations, atmospheric physics/radiation, terrestrial biosphere studies, satellite cal/val, and instrument development.

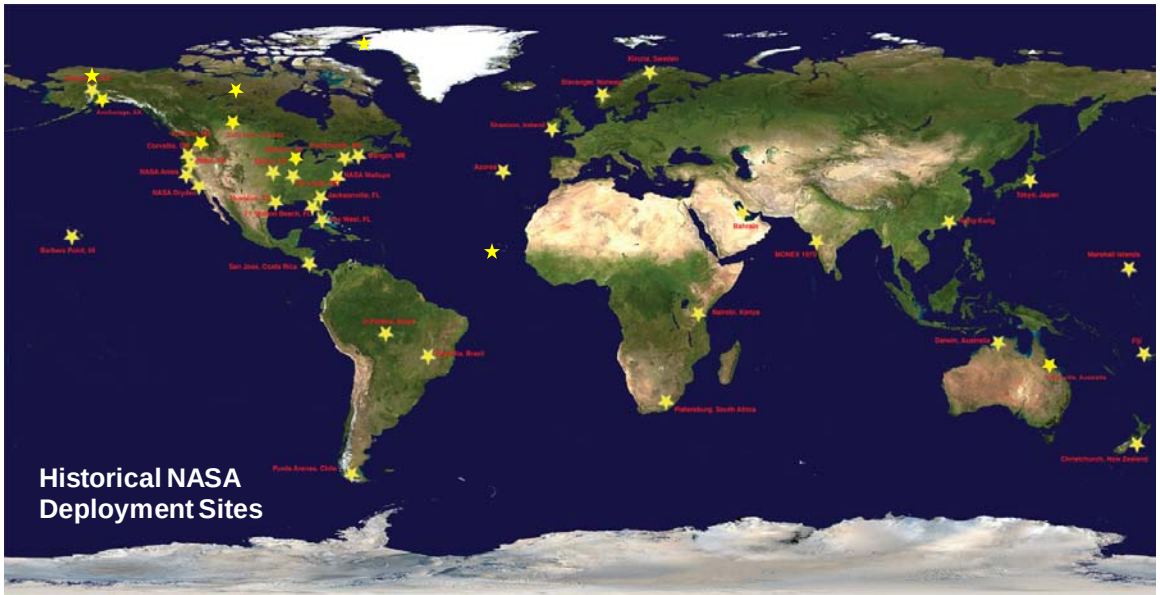
Outstanding examples of accomplishments in each area:

Process Study - Atmospheric chemistry - "smoking gun" for stratospheric chemistry from AAOE demonstrates role of chlorine in destroying polar ozone

Environmental Characterizations - airborne lidar observations of the Greenland ice sheet; and the effects of large-scale biomass burning in the Amazon & S. Africa

Satellite Validation - CRYSTAL/FACE: detailed in situ observations of clouds being observed from satellites; SAFARI 2000: validating MODIS aerosol algorithms

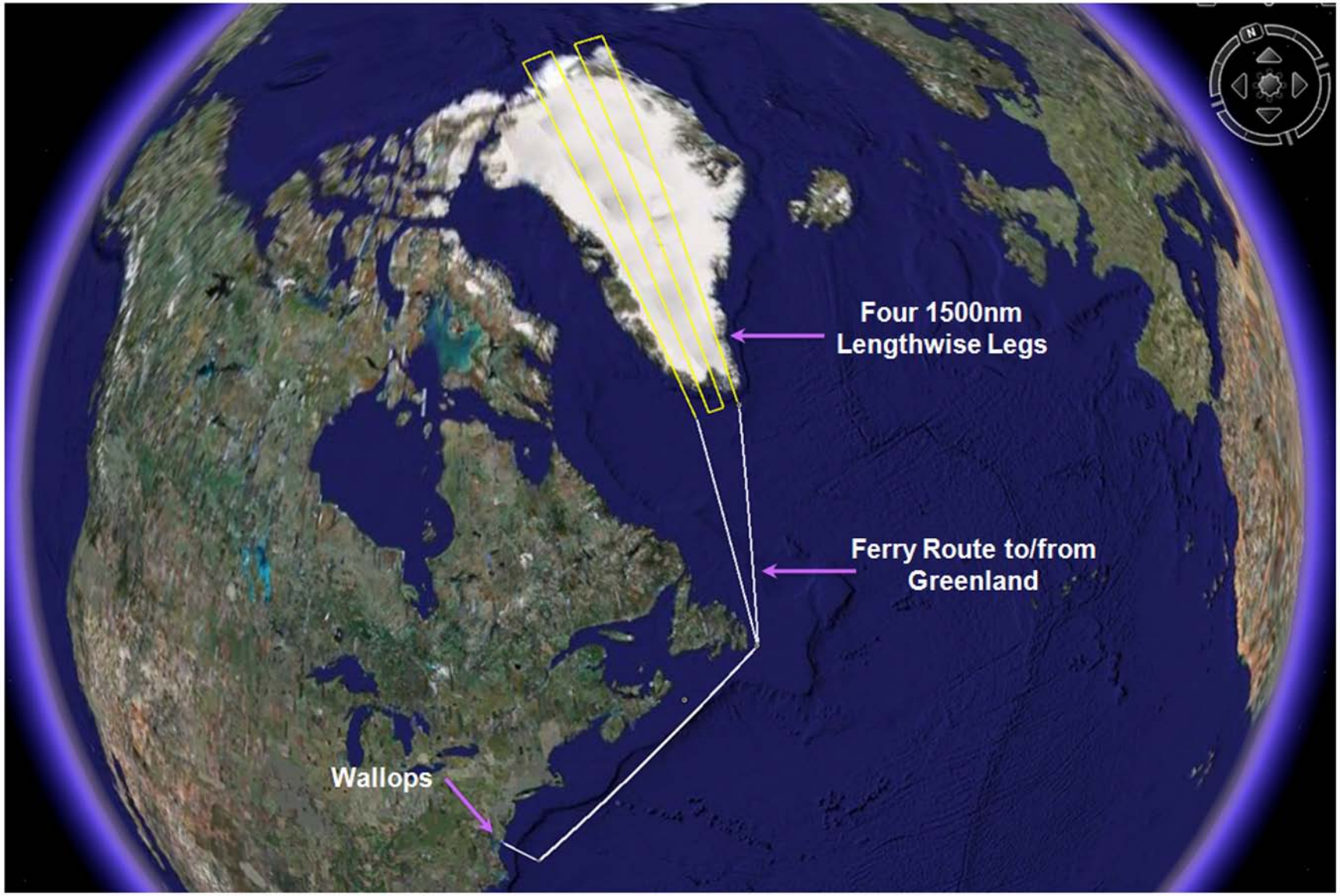
Instrumentation R&D - initial tests of remote sensing technologies: Aquarius/sea surface salinity sensor; ICESat/Lidars; TRMM/Doppler Radars; & many others



Back-up Material

NASA Global Hawk
Operational Est. – Greenland ICE Flights

NASA Wallops used for Remote-site Launch & Recovery



Flight Requests Completed

- FY06 36 FRs for 1307hrs
- FY07 34 FRs for 996hrs
- FY08 44 FRs for 1667 hrs

Airborne Science Program as investigators fill out flight requests for each research activity. Many times to minimize our flight costs for data collection we are able to incorporate multiple flight requests into one mission. As you can see there were 44 flight requests completed in FY08 and we flew 20 missions with 367 sorties.

Organizations supported by NASA ASP since 2006

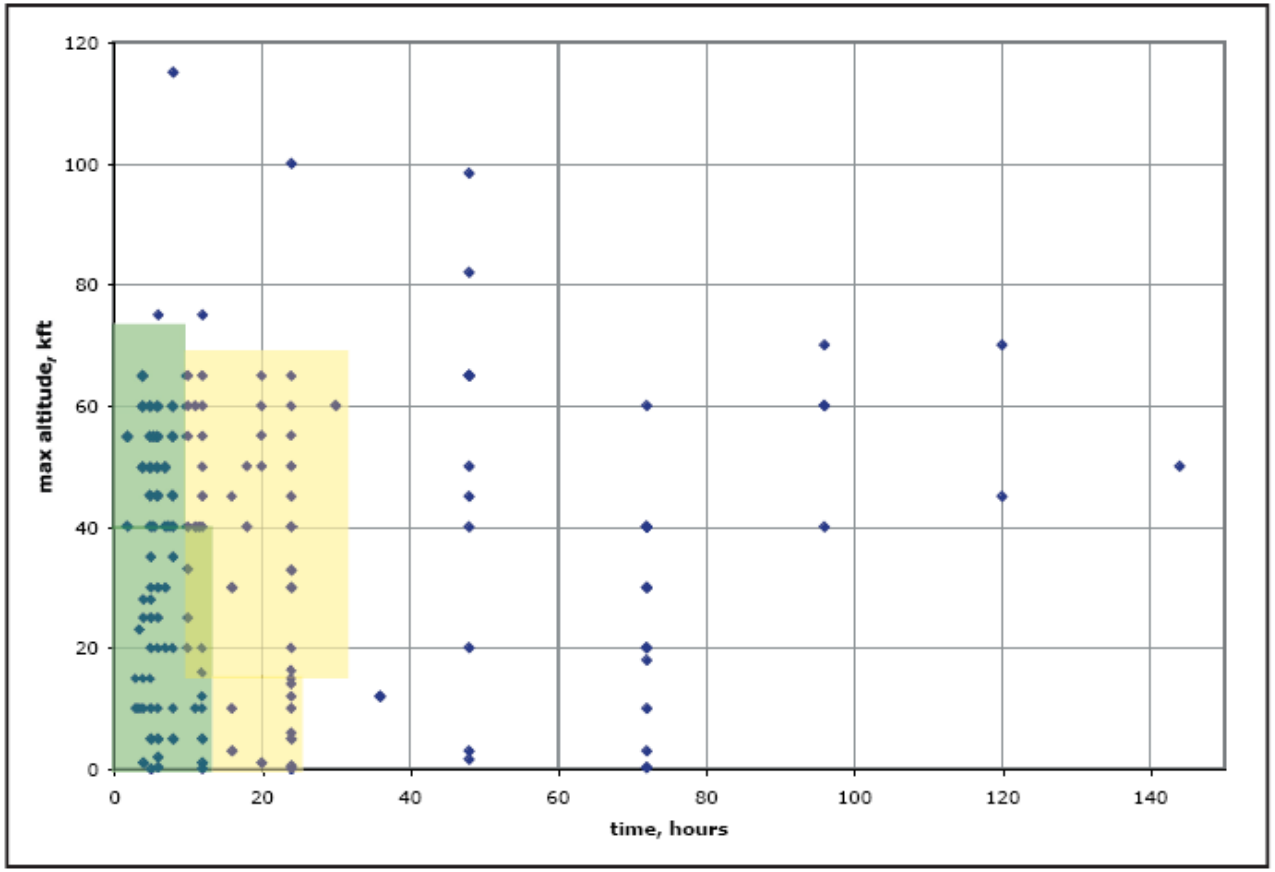
Institutes & Universities

- Byrd Polar Research Center
- Carnegie Institute
- Johns Hopkins University
- University of Kansas
- University of Maryland
- UC Santa Cruz
- UC Davis
- UC Santa Barbara
- UC Irvine
- UC Berkeley
- Desert Research Institute
- Monterey Bay Aquarium Institute
- NCAR
- University of New Hampshire
- Naval Postgraduate School
- University of Colorado at Boulder
- SETI
- University of Wisconsin
- Denver University
- University of Florida
- Harvard
- Penn State
- UCAR
- University of North Dakota

Government partners

- NASA Ames Research Center
- NASA Goddard Space Flight Center
- NASA Jet Propulsion Laboratory
- NASA Langley Research Center
- NASA Glenn Research Center
- NASA Johnson Space Center
- Department of Energy
- National Oceanic and Atmospheric Administration
- Department of Defense

Aircraft Support of Required Measurements



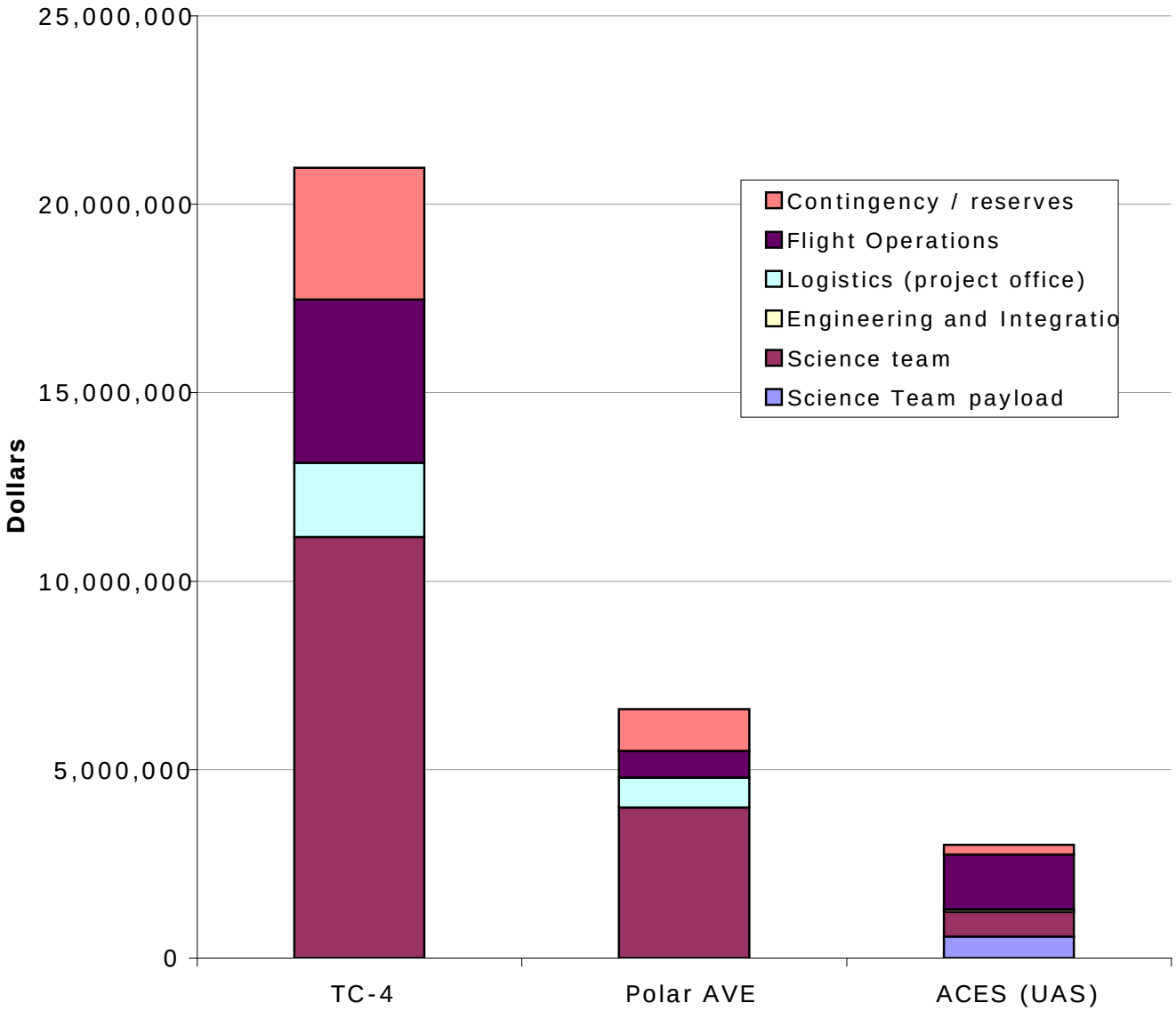
Summary of the National Science Objectives, established by the six focus areas, for sustained suborbital Earth Science observation requirements, 50% covered by manned aircraft another 30% covered by our unmanned aircraft and 20% still uncovered until new platforms become operational

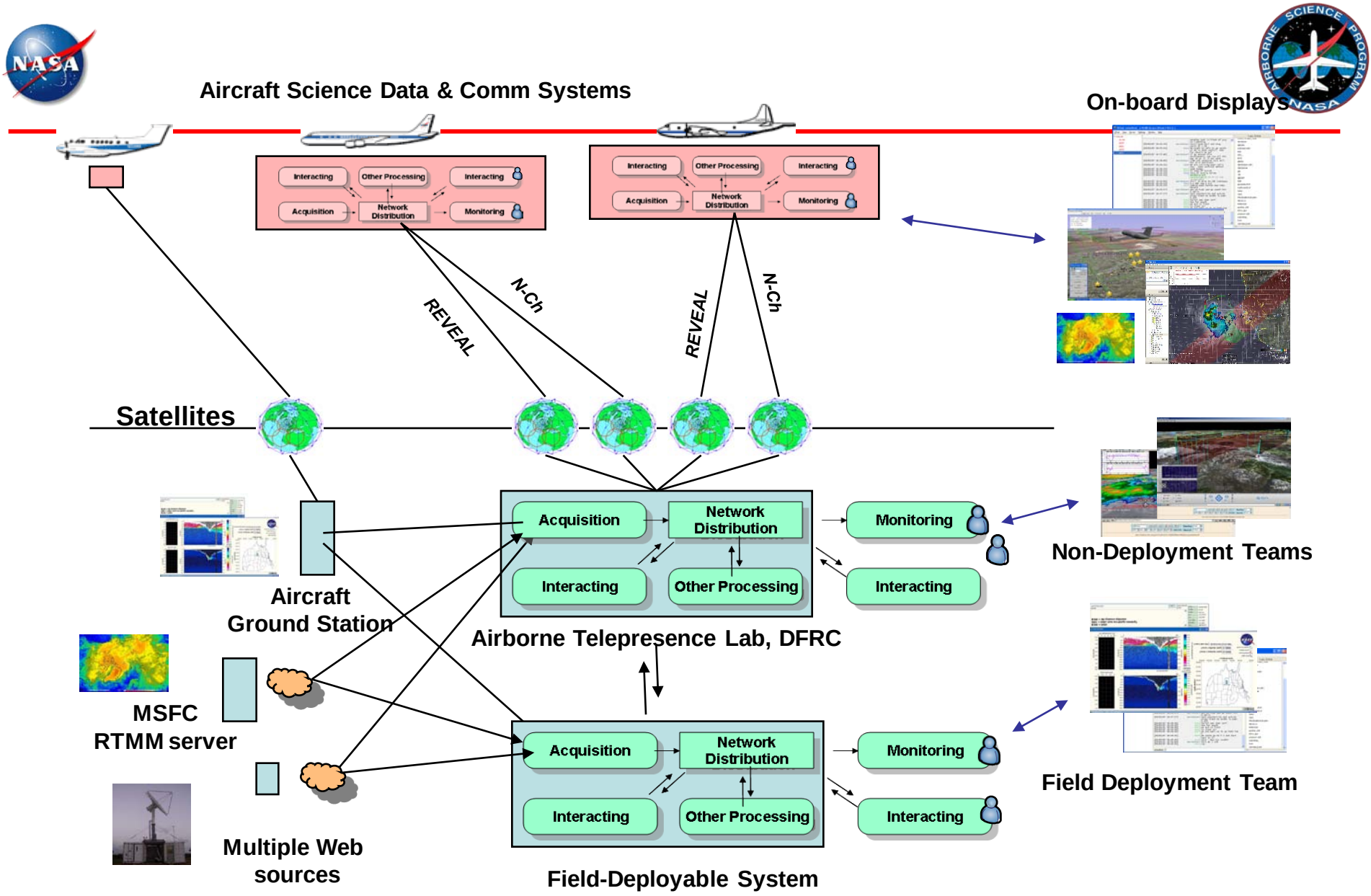
NRC Decadal Survey for Earth Science:
(released 16 January 2007)

Space-based observations provide a global view of many Earth system processes; however, satellite observations have a number of limitations, including spatial and temporal resolution and the inability to observe certain parts of the Earth. Hence, they do not provide a picture of the Earth system that is sufficient for understanding key physical, chemical, and biological processes.

Recommendation: NASA should support Earth science research via suborbital platforms: airborne programs, **which have suffered substantial diminution, should be restored, and UAV technology should be increasingly factored into the nation's strategic plan for Earth sciences.**

Cost Components of Representative Large, Medium and Airborne Missions





Notional Airborne Science Real-time Data & Communications Architecture

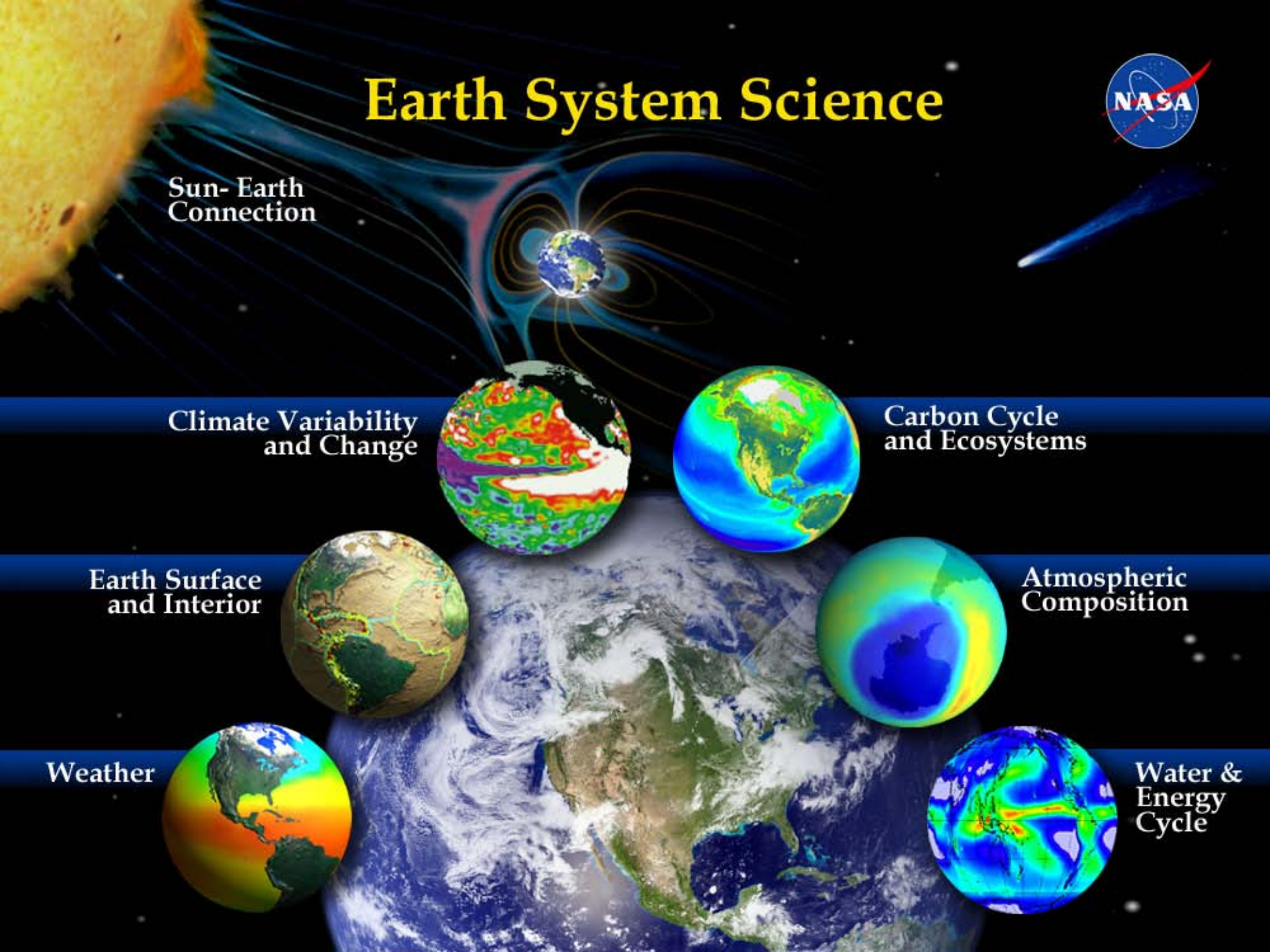
Airborne Science Program Operations

Core Airborne Systems:
ER-2, WB-57, DC-8, P-3, G-III

New Technology Airborne Systems
Global Hawk, Sierra, OTH

Catalog Airborne Systems (Utilized)
B-200 (LaRC, DOE, etc), S-3 (GRC), Learjet (GRC), Twin Otter, Caravan, Aerosonde, etc

Airborne Sensor Facility, Mission/Campaign Management

Over 50 aircraft available to the Program

Earth System Science