Making Robot Planes Useful for Scientific Investigation of Earth

Past and present UAV Flight Programs at NASA Dryden Flight Research Center

Chris Jennison
NASA Project Manager

NASA's Science Mission

SUBORBITAL SCIENCE PROGRAM

Understanding and Protecting Our Home Planet

Overarching Science Questions

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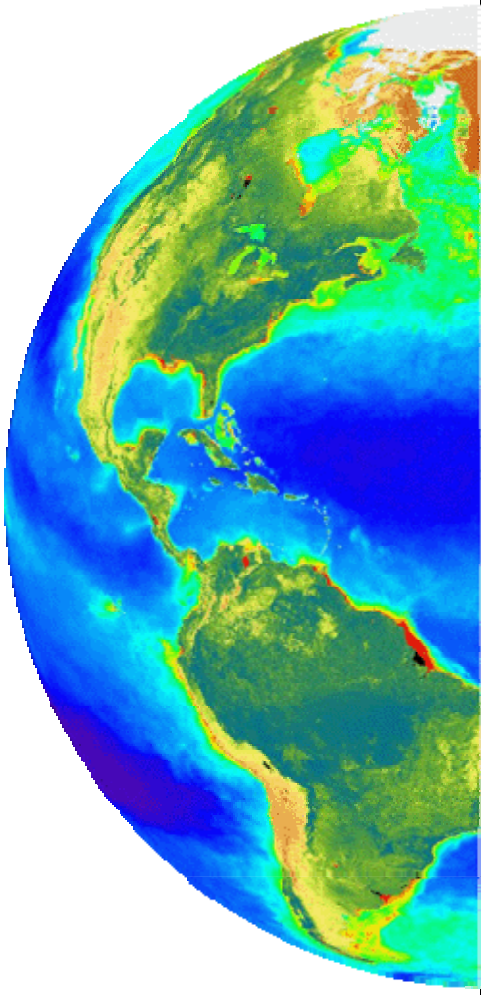
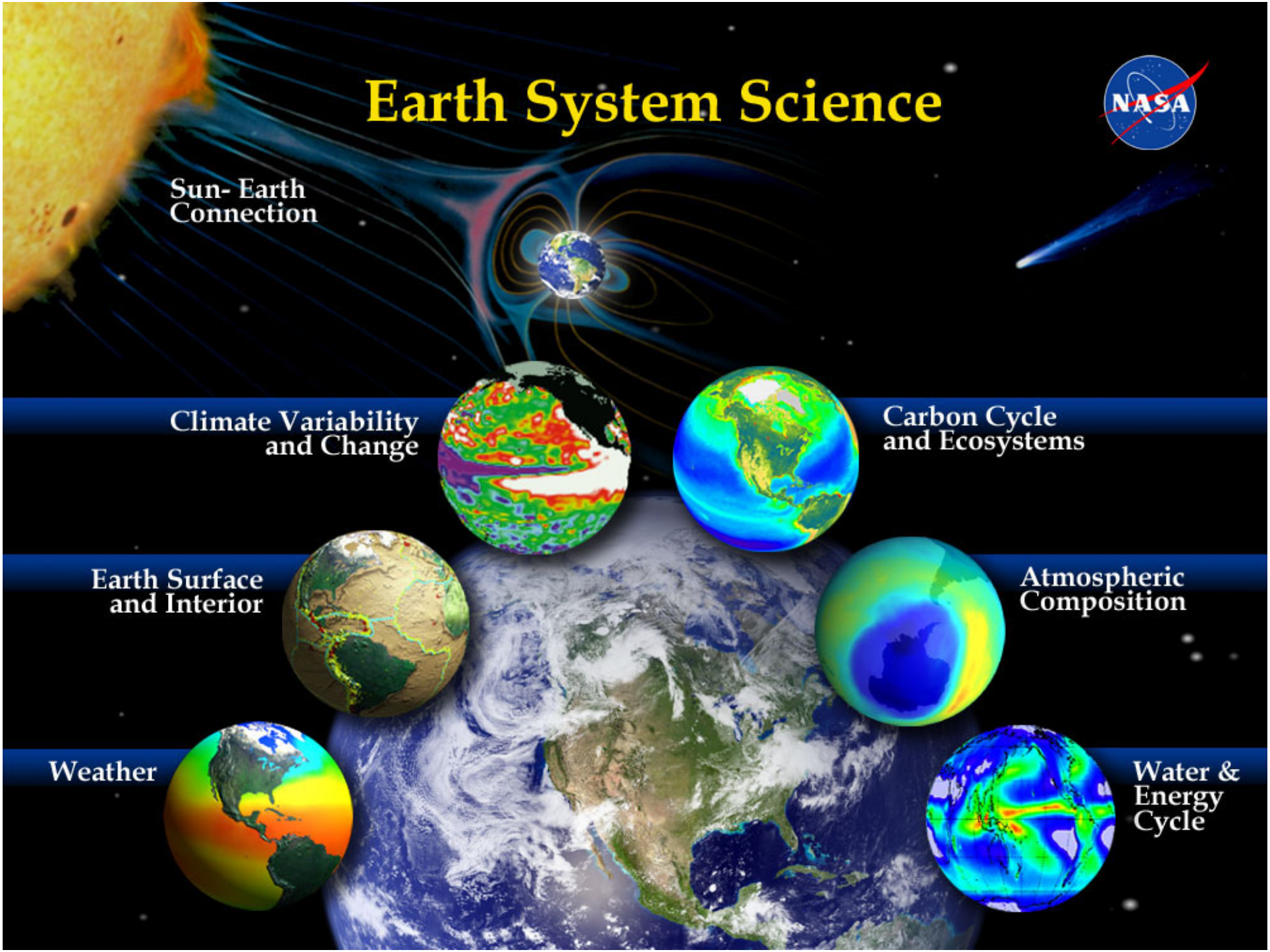
How is the Earth changing and what are the consequences of life on Earth?

- How is the global Earth system ***changing***?
- What are the primary **forcings** of the Earth system?
- How does the Earth system ***respond*** to natural and human-induced changes?
- What are the ***consequences*** of changes in the Earth system for human civilization?
- How well can we ***predict*** future changes in the Earth system?




Earth System Science
NASA
Sun- Earth Connection
Climate Variability and Change
Carbon Cycle and Ecosystems
Earth Surface and Interior
Atmospheric Composition
Weather
Water & Energy Cycle

Earth Observation from Space Today

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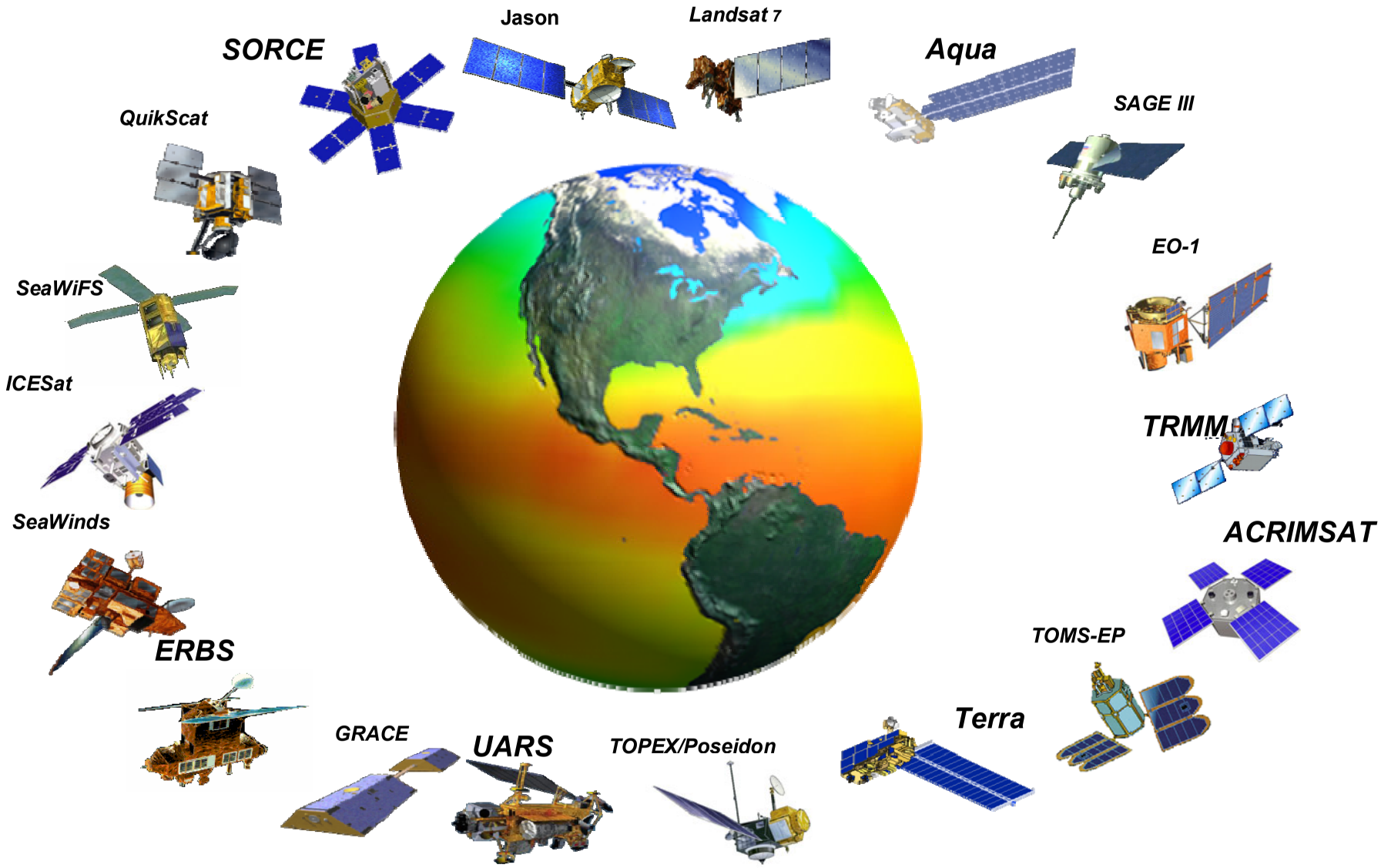
We have given the world its first capability to study the Earth as a system



Earth Observation from the Atmosphere

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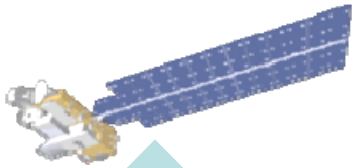
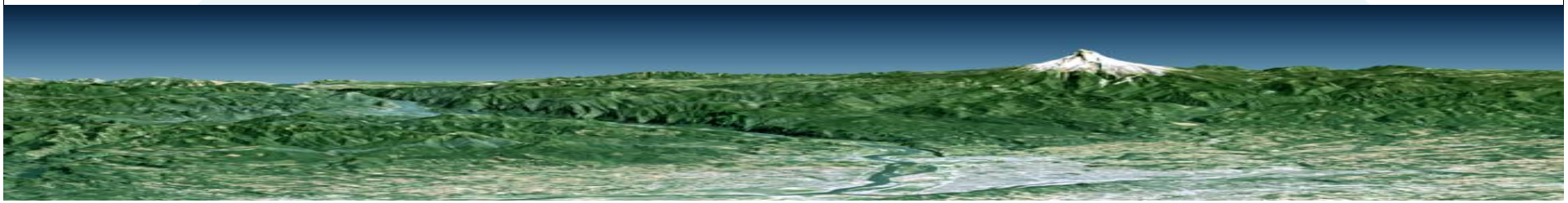
Aircraft link global perspective of satellites with local context





With a Variety of Remote Sensing Technologies

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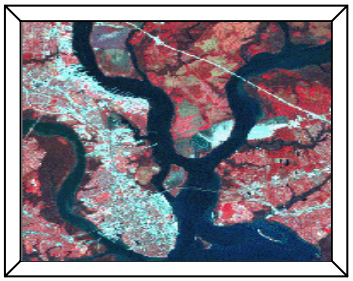
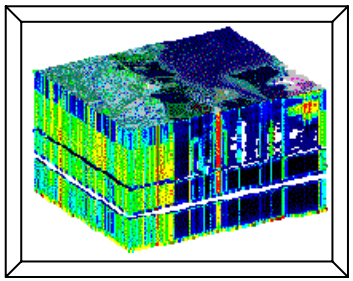
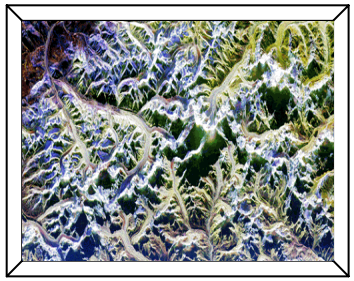


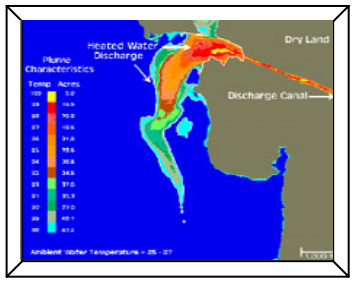
Multispectral



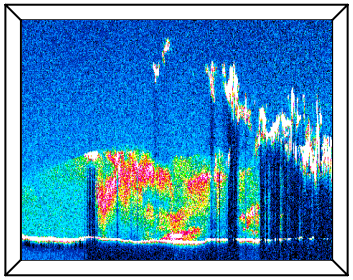
Hyperspectral



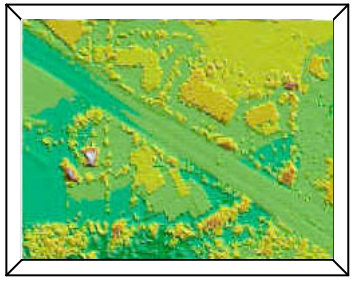
RADAR / SAR



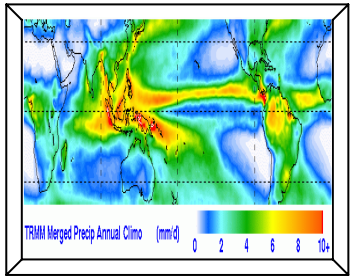
Thermal



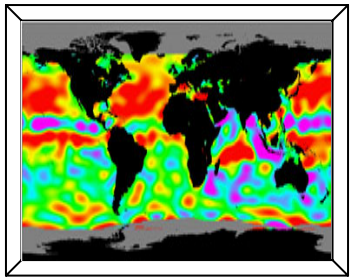
Atmospheric LIDAR



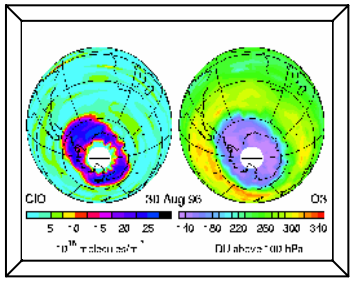
Surface LIDAR



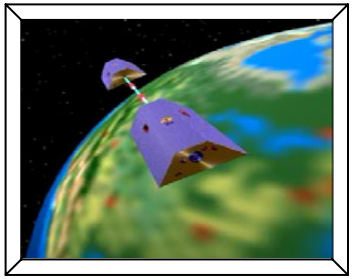
Passive Microwave



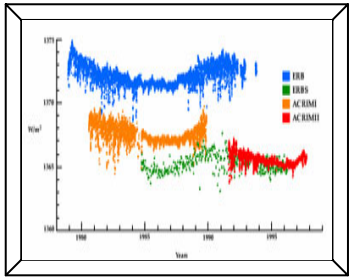
RADAR Altimetry



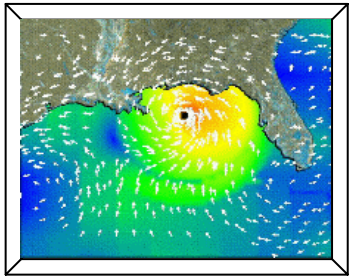
Limb Sounding



Microwave Ranging



Irradiance/Photometry



Scatterometry

Why Unmanned Airplanes?

Current suborbital platforms have limitations unmanned airplanes do not have

ERAST 1994-2004

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Environmental Research Aircraft and Sensor Technology Program

- The purpose for this new thrust was to someday enable aircraft companies to build UAV's that can carry out science missions that would be either impractical or impossible for NASA's current fleet of science platform aircraft. These missions have been called the "dull", "dirty", and "dangerous".

- A partnership of:
  - NASA Langley Research Center
  - NASA Ames Research Center
  - NASA Dryden Flight Research Center
  - NASA Glenn Research Center
  - AeroVironment, Inc.
  - Aurora Flight Sciences
  - AmTech
  - General Atomics Aeronautical Systems Inc.

Perseus

Proteus

Altus

Altus

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Pathfinder

Helios

Helios with Fuel Cell

Helios - Pushed Beyond Unknown Limits

Record Setting High Altitude Configuration

Long Endurance Configuration

In-Flight Break-Up

Helios Wreckage On the Water

Today - ESCD

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Earth Science Capability Demonstration

- The goal is to develop capabilities for global-reach Earth science
  - Intelligent observation instruments
  - Near autonomous suborbital platforms
  - Network-distributed
  - Aligned with a future global Earth Observation systems-of-systems

- Core capability by 2010

Aircraft Fleet

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Altair (lease)

Predator-B (own)

Proteus (lease)

2005 Mission Demonstration

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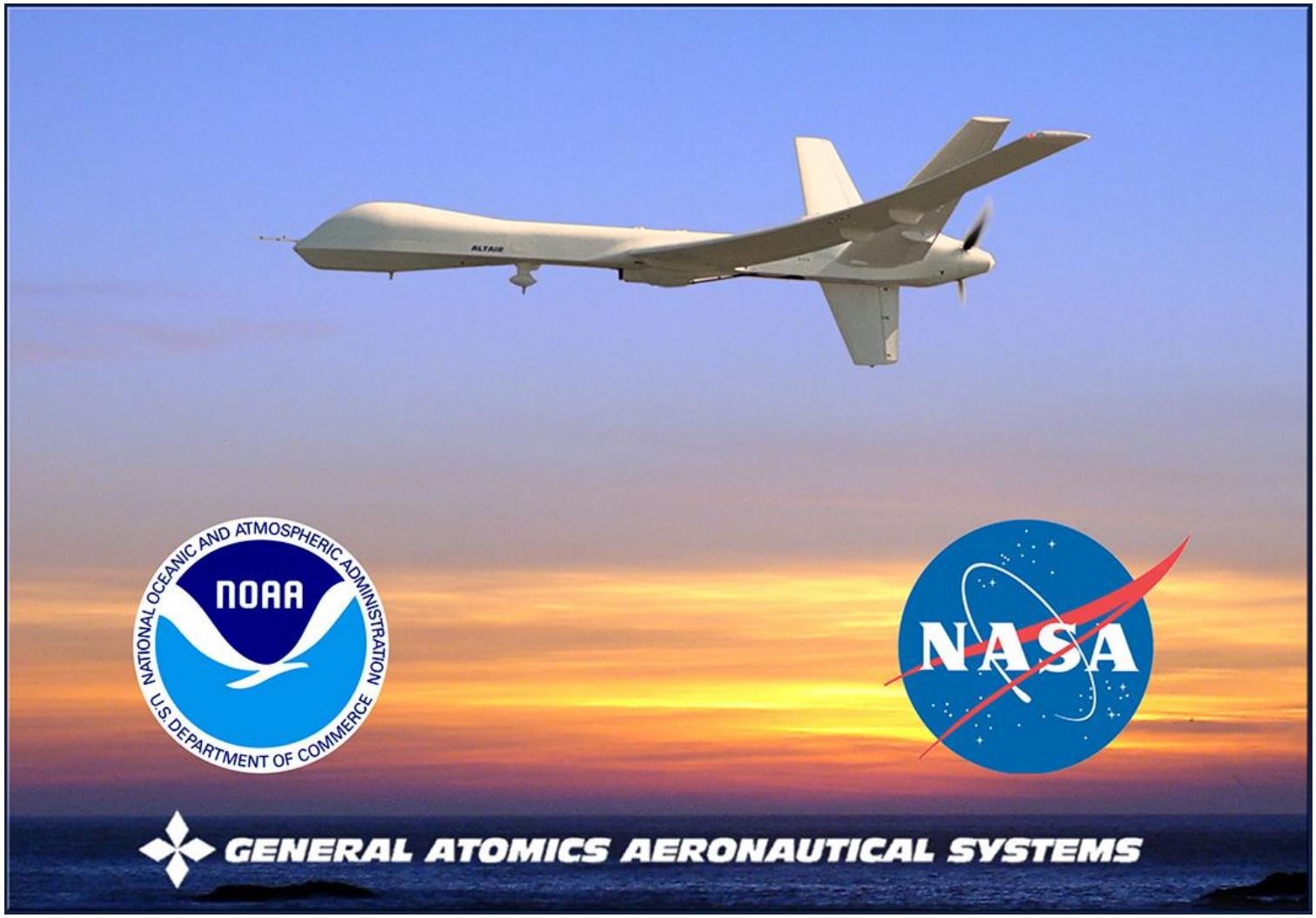
Altair: NASA/NOAA Mission



2006 Mission Demonstration

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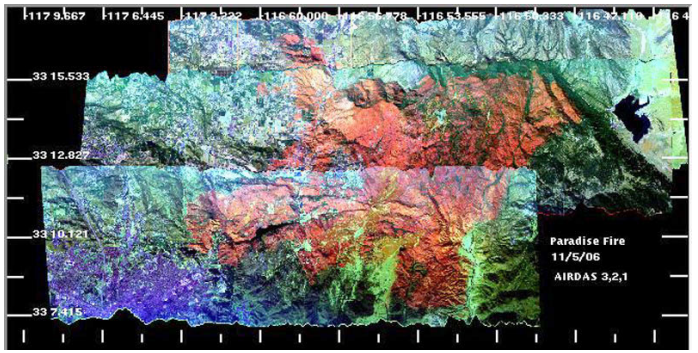
Altair: NASA/USFS Western States Fire Mission

- Multi-spectral scanner to locate and map known and unknown fires in National Forest during 2006 fire season
- Thermo geo-rectified imagery provided to the National Interagency Fire Center in near real-time
- Sensors pod-mounted for quicker aircraft reconfiguration
- Aircraft will be tasked in similar fashion to other USFS assets
  - Can operate day and night

- Will be ready to respond from So. California to Montana
- Long duration over-land operation in the NAS will provide challenges



2006 Technology Development

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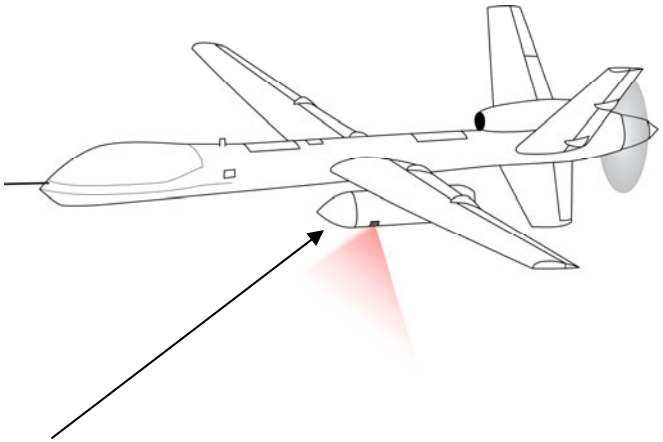
Intelligent Mission Management
Integrated Vehicle System Management

- Initial mods will include a research system that can “command” the aircraft and “network” with onboard sensors and ground-based systems.
- Design of modifications will allow “rapid” reconfiguration
- Major demo for 2007 in progress
  - Requirements tied to actual autonomous fire hunting/mapping mission with USFS
  - Integrates sensors, autonomous mission planning, automated contingency management, and re-tasking
  - Ground-based Collaborative Decision Environment will be based at Interagency Fire Command Center
  - Advanced system management

Predator-B



Mission-specific sensors are pod-mounted

2007 Technology Development

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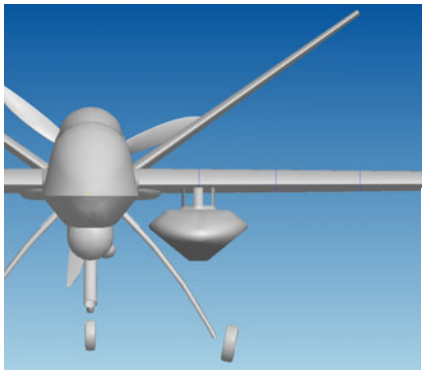
Precision Trajectory for Repeat Pass Interferometry

- Airborne Repeat Pass Interferometry Synthetic Aperture Radar (SAR) requires precision trajectory control (+/- 5m)
  - Measure the surface deformation of volcanoes, glaciers, earthquakes, and fault lines
- Utilizes Global Differential GPS requiring satellite link
- Sensor pod-mounted for later transition to UAV
- Flight on G-III UAV surrogate used to develop and demonstrate SAR and precision navigation/control
- UAV surrogate used due to:
  - Large flight hours expected, >100 hrs of development/calibration
  - Ability to fly over areas of interest on short notice
- SAR, SAR-Pod, and aircraft modifications in-work
  - Demos in 2007, transition to UAV in 2009



SAR Pod on Predator-B

G-III UAV Surrogate