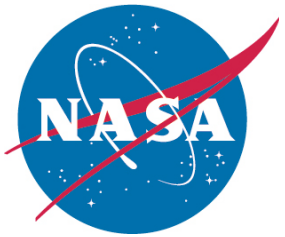
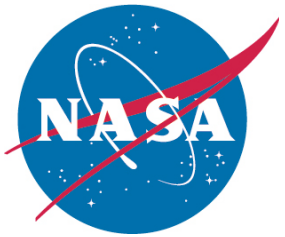


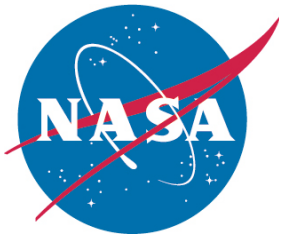
Suborbital Telepresence and Over-the-Horizon Networking

Lawrence C. Freudinger – NASA/Dryden Flight Research Center



Motivation

- **Decision Support**
  - Situational Awareness *with enough time to do something about it*
- **Test & Measurement Activities**
  - Airborne instruments
  - Earth science, space exploration and aeronautics applications
- **Network-centric thinking**
  - Network-distributed operations
  - Network computing: sensor webs
  - Toward easy, affordable, useful networking to/from aircraft



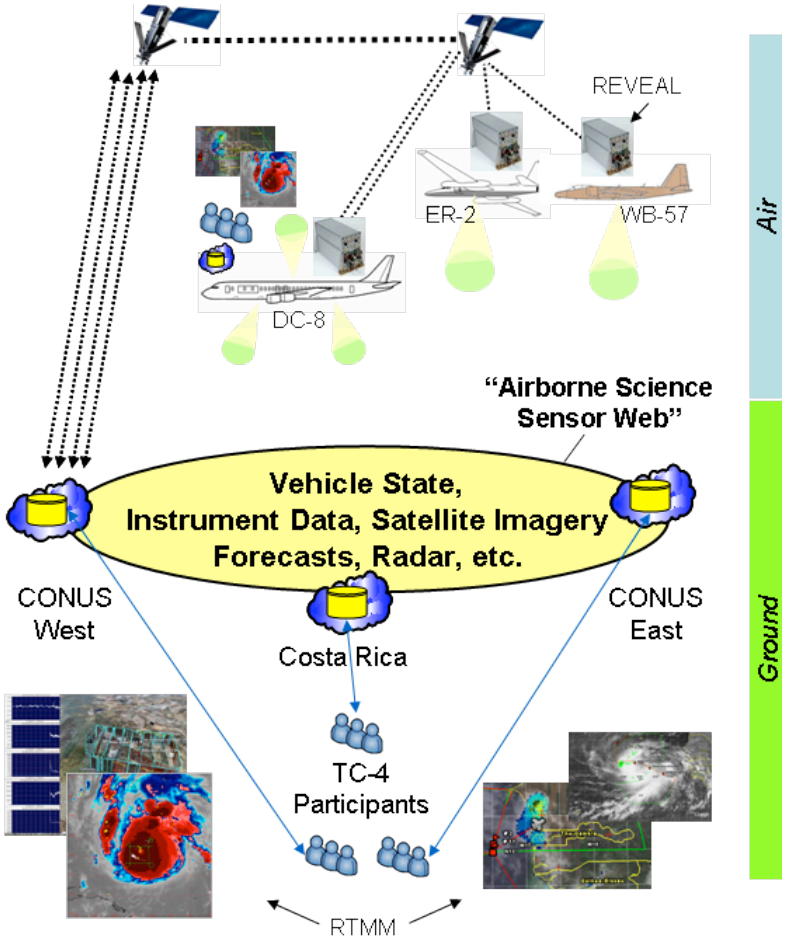
Outline

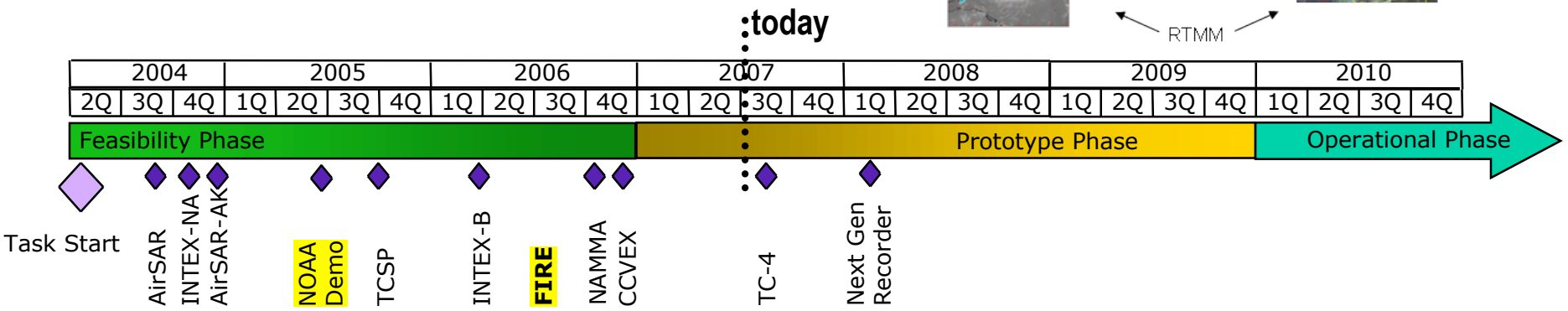
- **Where We Are**
  - **Earth Science Capabilities Demonstrations, Suborbital Telepresence Project**
  - **Recent accomplishments**
- **Next Steps**
  - **Upcoming Mission**
  - **Disruption-Tolerant Networking**

Suborbital Telepresence and Global Test Range

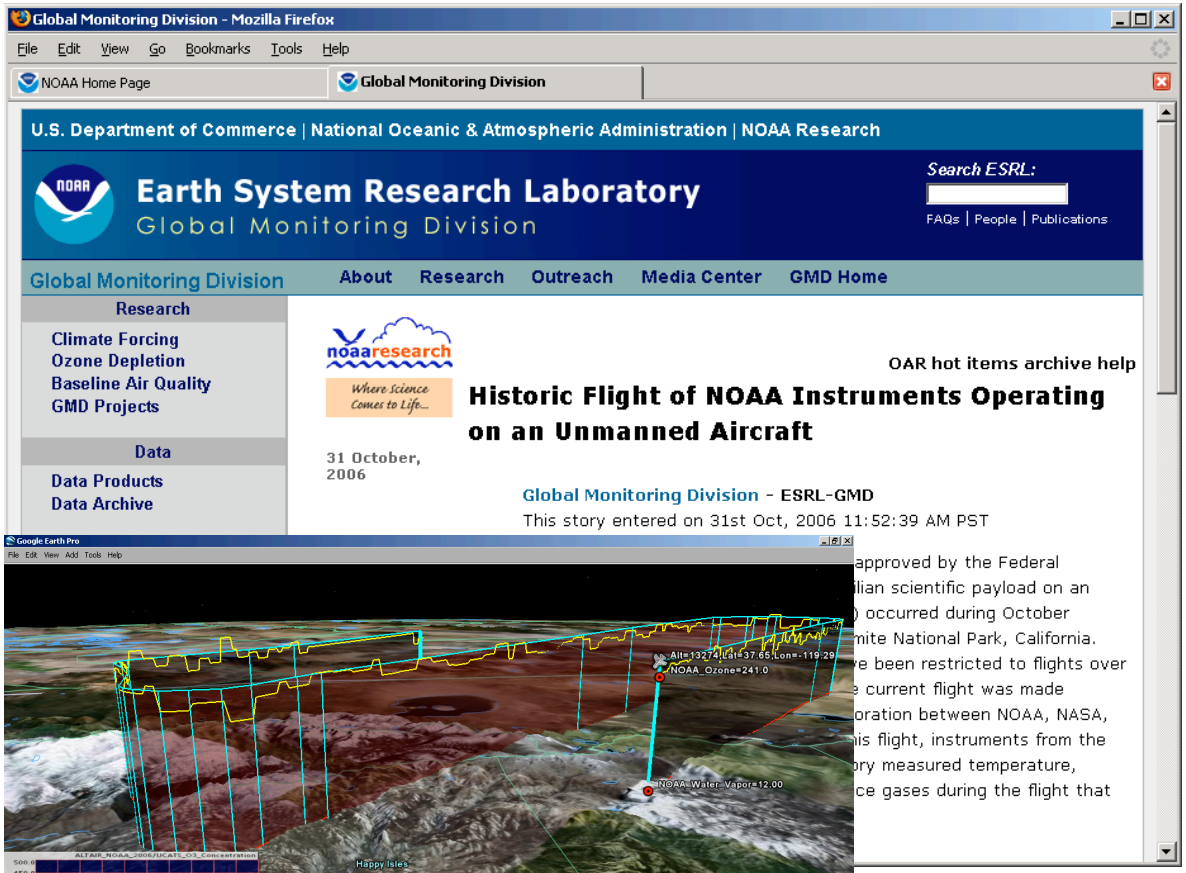
Objectives

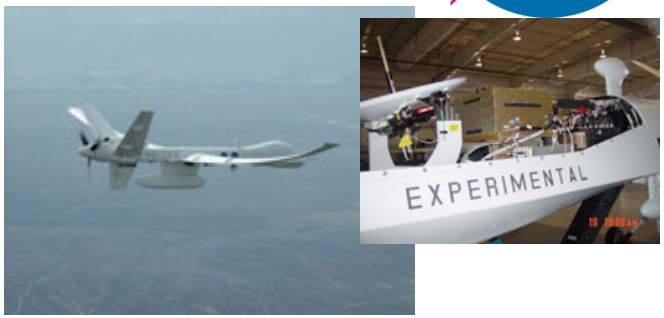
- **Develop/demonstrate low-cost products and services for airborne science**
  - **Sensor web: *i.e.* Instrument interaction/C4I**
  - **Situational awareness, decision support**
  - **Global-Reach Realtime Mission Monitoring**
- **Necessary on future autonomous vehicles, but value in application to *all* platforms**
- **Onboard system focus: payload needs**
  - **Acquisition, integration, recording, processing, communications mgmt services**
- **Terrestrial system focus: operation needs**
  - **Data processing, fusion, distribution, display, playback services**

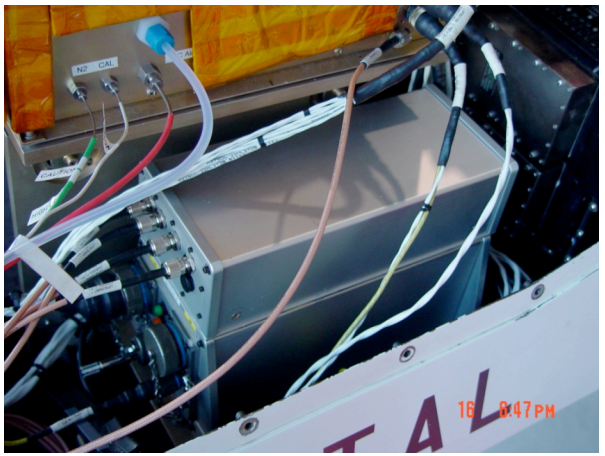


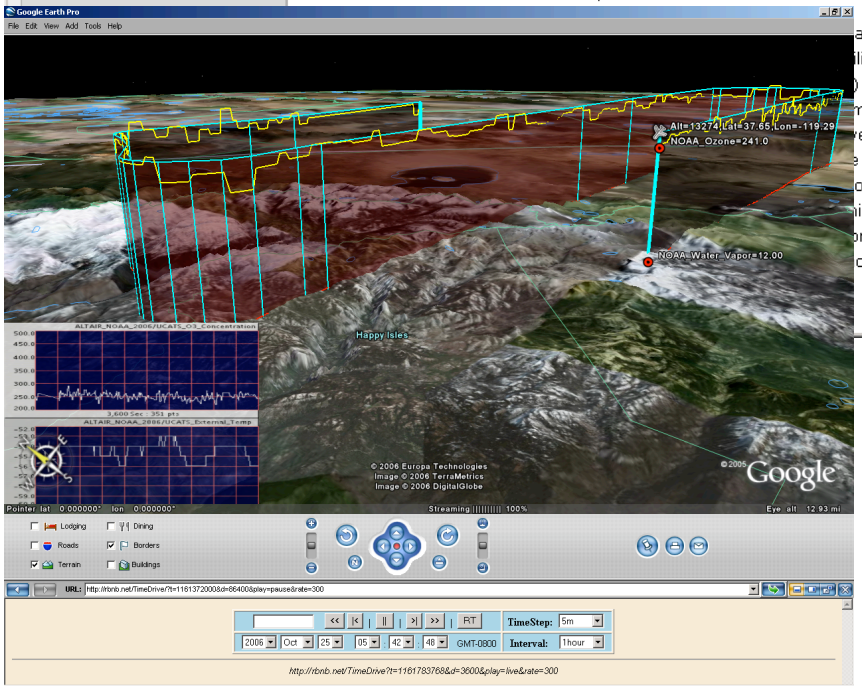


Objective: Demonstrate Capabilities

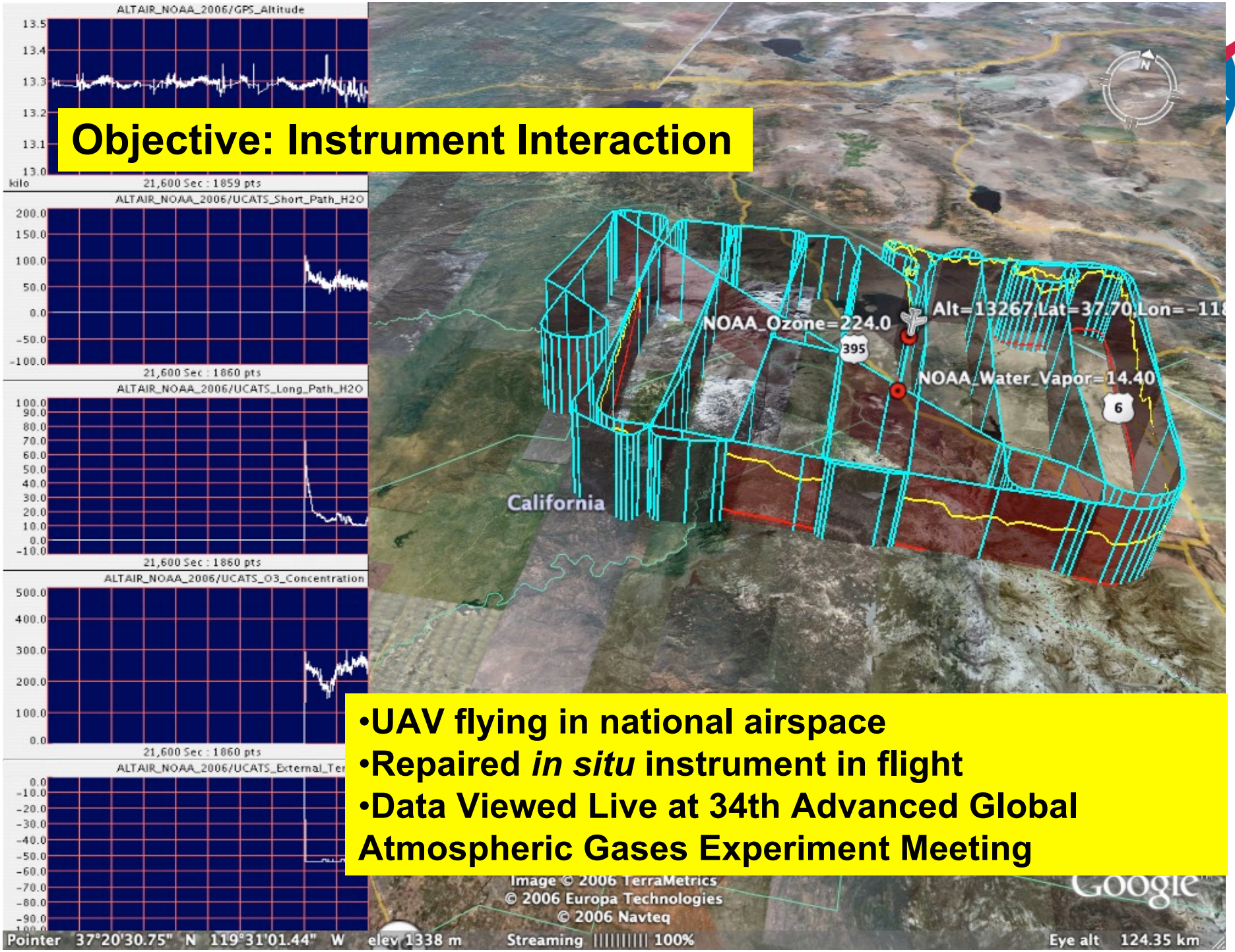








Fire Mission October 2006



Objective: Instrument Interaction

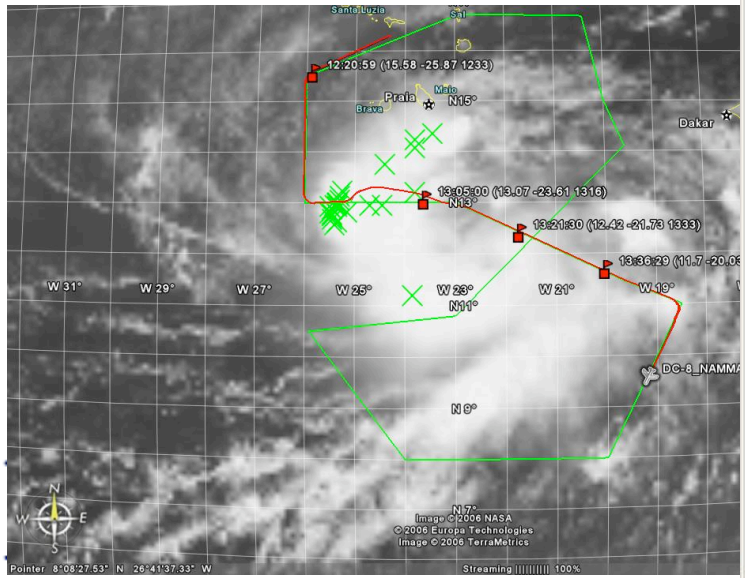
- UAV flying in national airspace
- Repaired *in situ* instrument in flight
- Data Viewed Live at 34th Advanced Global Atmospheric Gases Experiment Meeting

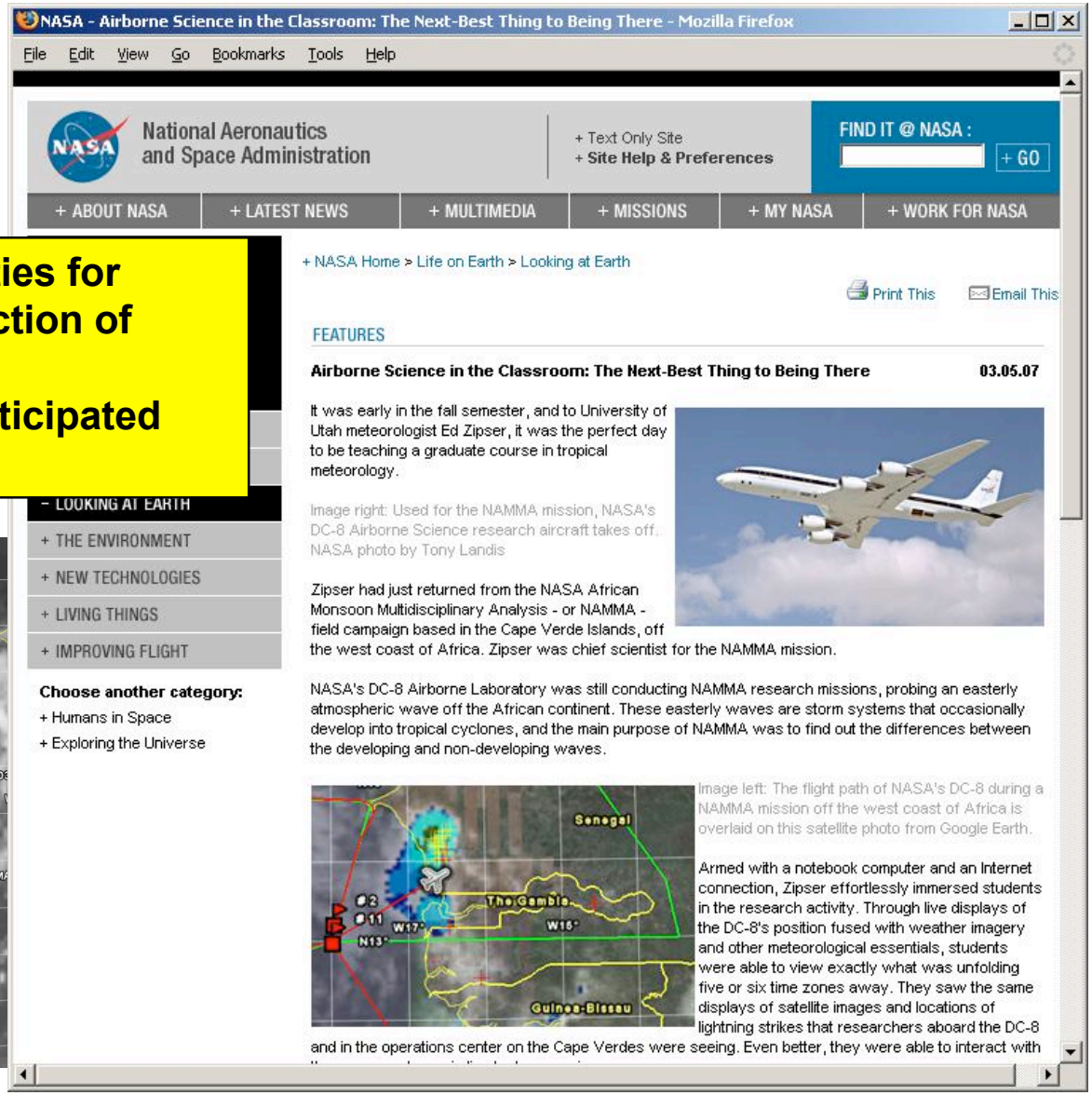
Objectives: Demonstrate Capabilities

Aug/Sep 2006: NASA African Monsoon Multidisciplinary Analysis

"Major step forward in our capabilities for doing real-time monitoring and direction of missions" – Dr. Ed Zipser

• Tropical meteorology students participated from Utah (8 Sep 06)

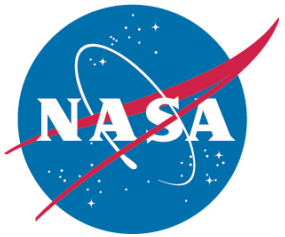




Tropical Composition, Cloud, and Climate Coupling Experiment (TC^4)

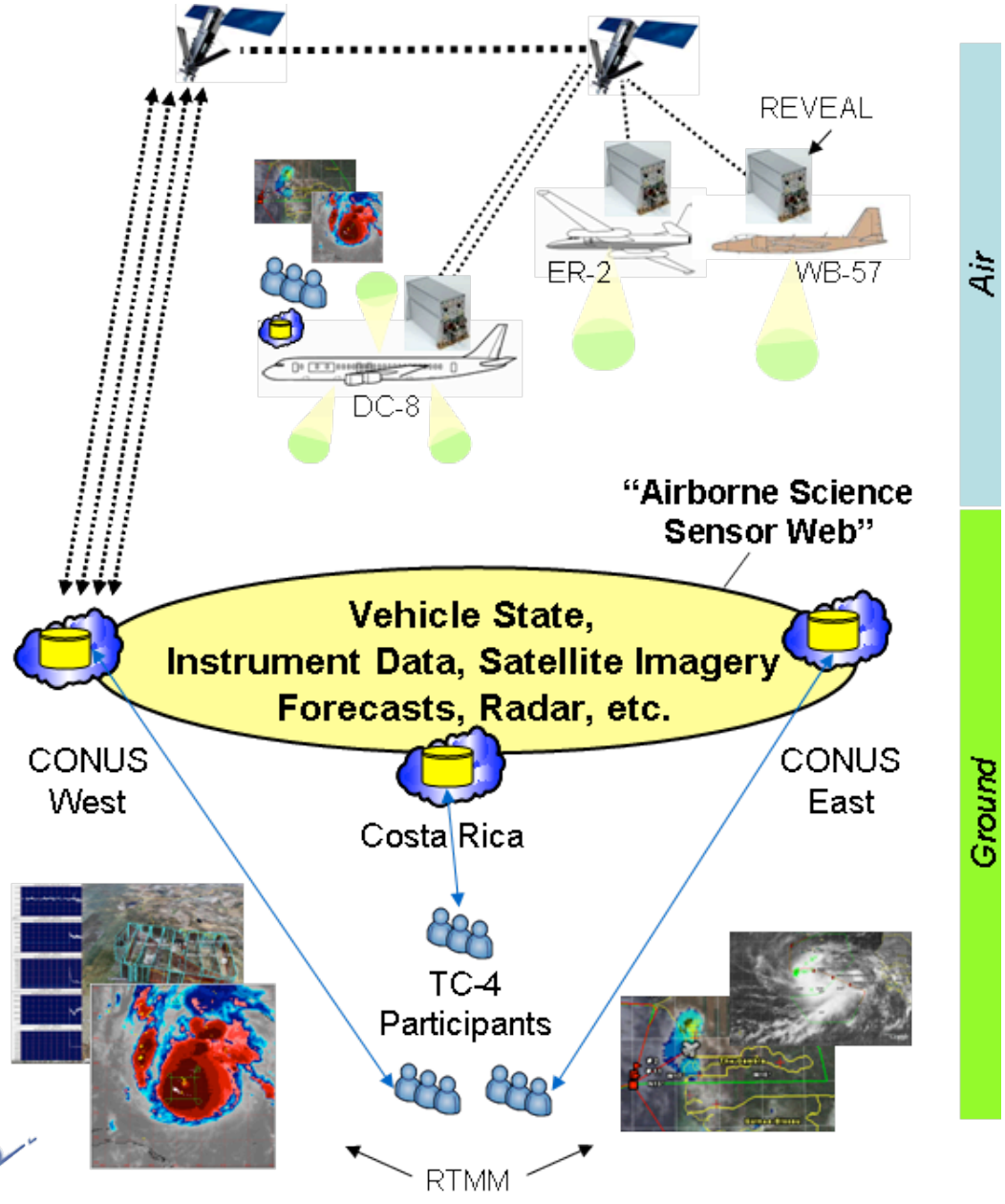
- Costa Rica Operations Jul-Aug, 2007
- Team distributed across Western hemisphere
- Study chemical, physical, dynamic processes in upper troposphere and transition layer between troposphere and stratosphere.
- 3 aircraft in coordinated flights
  - Over and through storms
  - Under A-Train Satellites
- >60 in situ and remote observation instruments
  - Add radar and balloon observations
  - Add predicted observations (forecasts)

NASA Dryden Flight Research Center

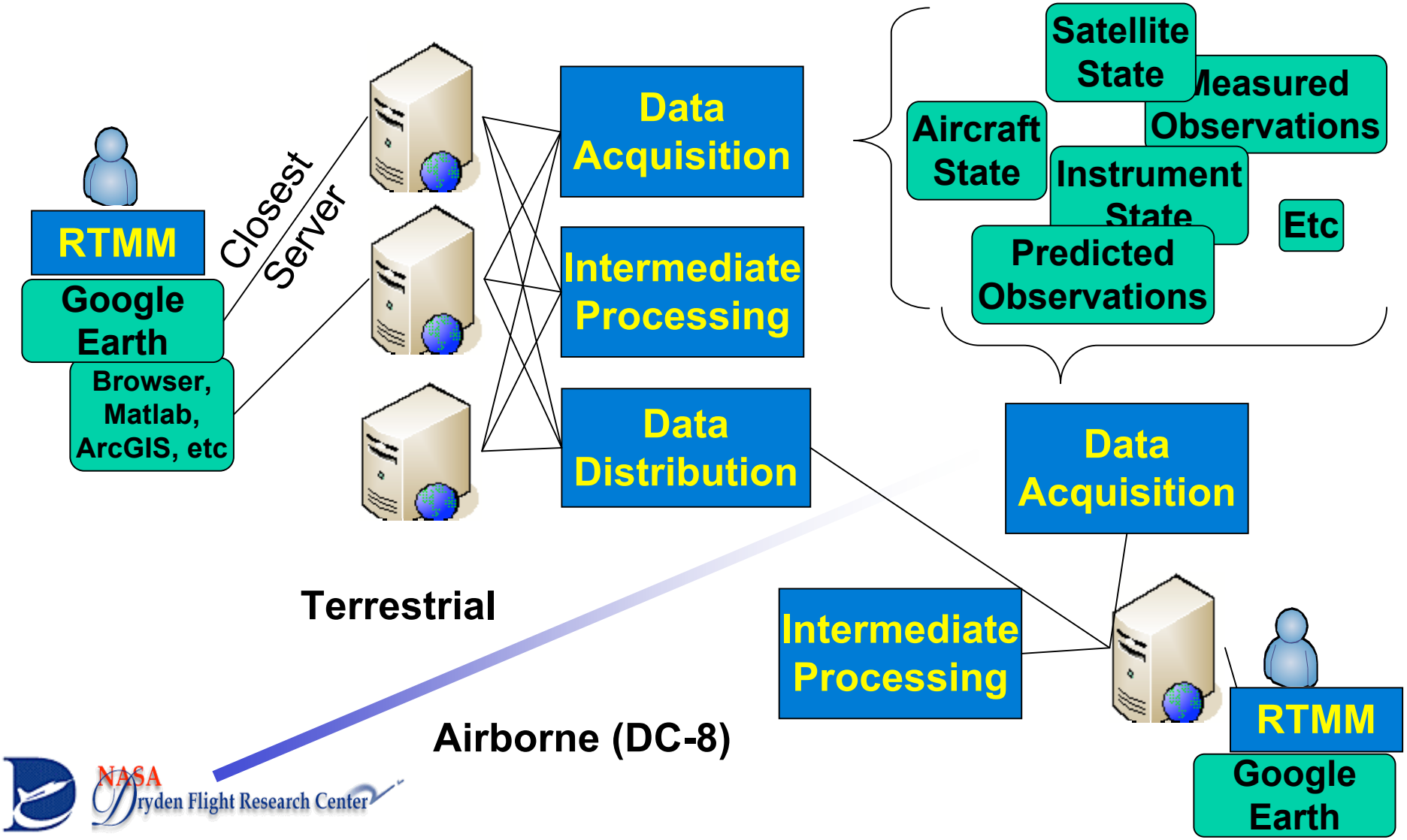


Data Sets for TC^4 Real-time Monitoring

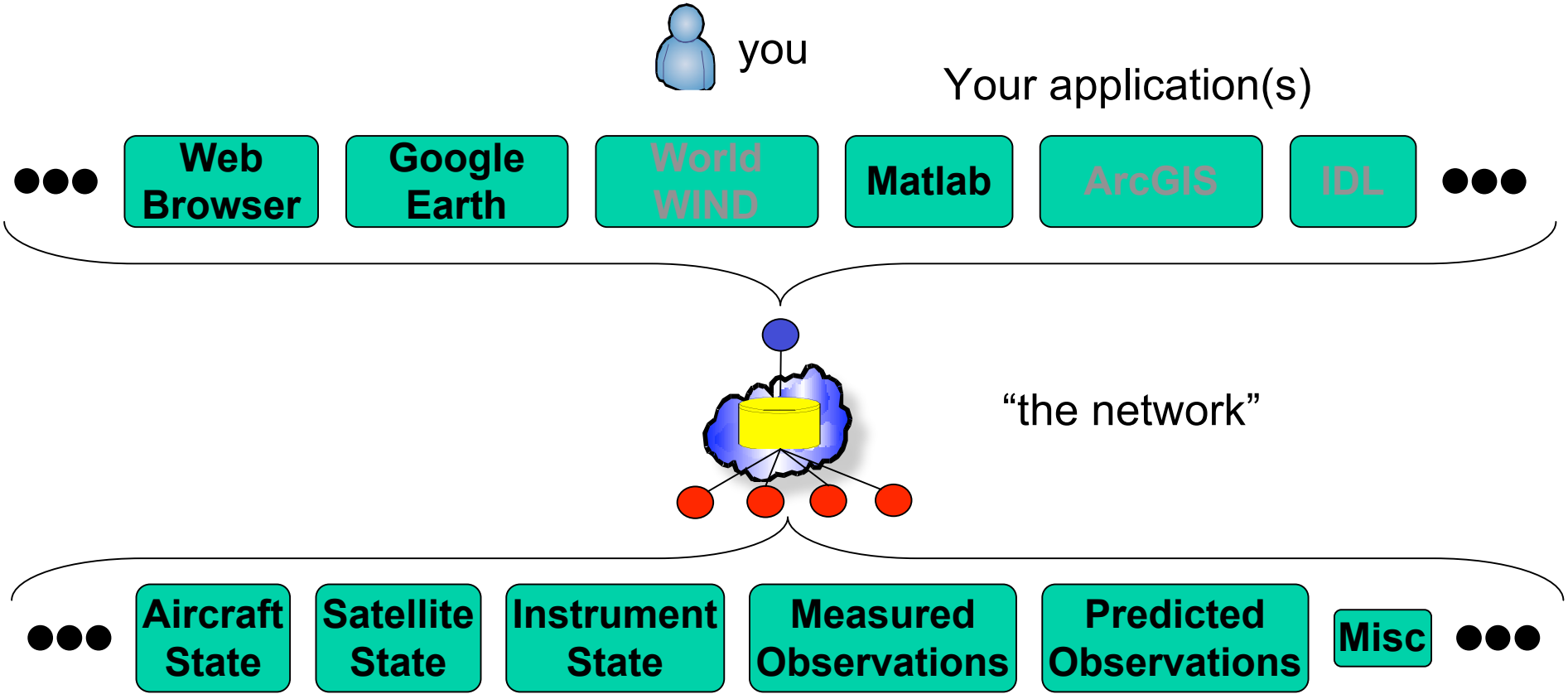
- **Satellite Imagery**
  - GOES-E, GOES-10 (vis, infrared, ~15 min update)
  - Satellite & instrument FOVs – current and predicted tracks
  - Satellite products (e.g., to support postflight activities)
- **Model Output**
  - GEOS-5 & WRF model outputs available
- **Aircraft Instruments**
  - Flight tracks (waypoint and real time tracks)
  - Dropsonde (time/locations and skew-T)
  - Aircraft Instruments: health/status, data, cmd/cntrl (case-by-case) (LASE, Dial, AMPR, MTS, SSFR, PT, CAPS…)
- **Surface and Balloon Observations**
  - Radar (NPOL, SMART)
  - Lightning (Vaisala long range, Costa Rica lightning, WWLLN)
  - TicoSonde
  - Other (NATIVE)
- **Stop-action playback for review and analyses**


REVEAL
ER-2
WB-57
DC-8
Air
"Airborne Science Sensor Web"
Vehicle State,
Instrument Data, Satellite Imagery
Forecasts, Radar, etc.
CONUS West
CONUS East
Costa Rica
TC-4 Participants
RTMM
Ground

TC-4 Notional Architecture

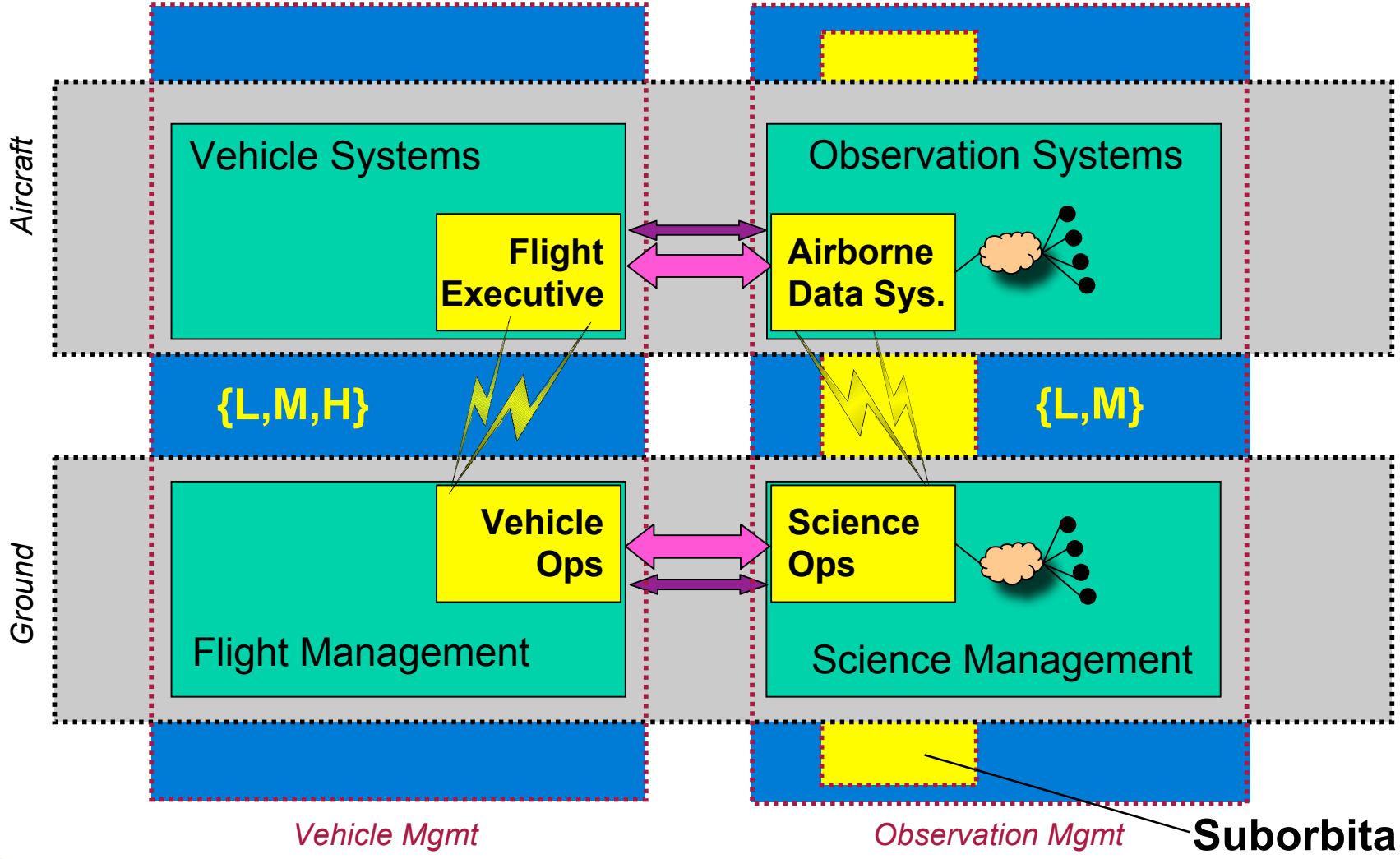


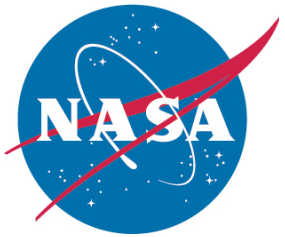
An Application Integration View



All necessary data sources
Heterogeneous distributed sources

Telepresence: Architectural Framework



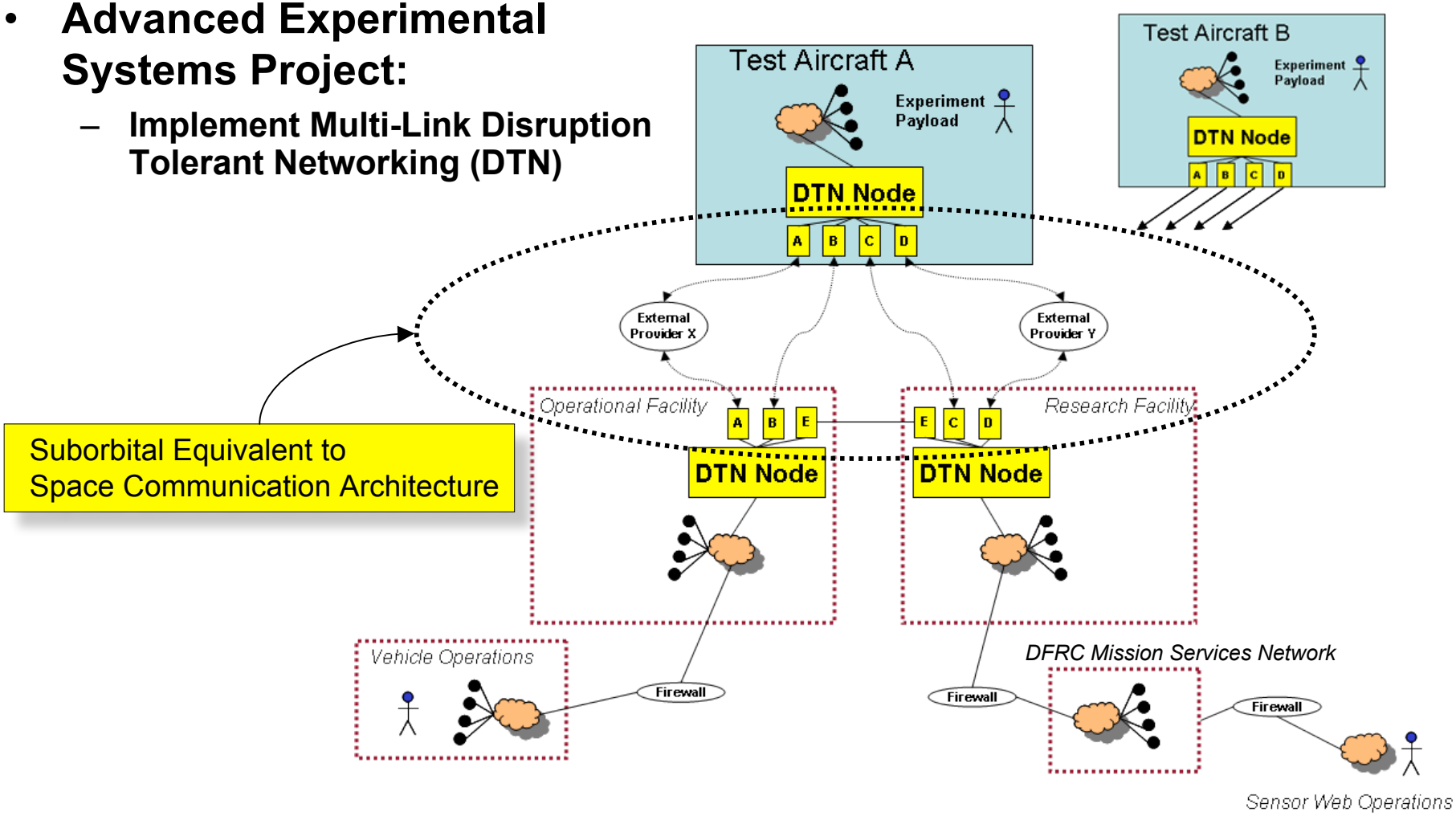


Where to next?

- **Disruption Tolerant Networking (DTN) with aircraft**
  - **Classic Internet protocols (TCP-IP) designed for**
    - "low bit error rate" environments
    - "low latency" environments
    - Symmetric link characteristics
    - End-to-end connectivity in quasi-static topologies
  - **But Internet finally catching up with aerospace and test/measurement needs**
    - Space Communications Protocol Standards (SCPS) Evolving for 15 years
    - Disruption Tolerant Networking R&D efforts expanding rapidly
      - IRTF: DTNRG.ORG
      - Significant DARPA DTN investment
      - Bundle Protocol (BP) Draft Specification v6 available Apr07
    - DTN BP is a store-and-forward overlay network
      - addresses general problem of managing end-to-end management of network transfer where end-to-end connectivity may not exist.
      - Scheduled, opportunistic, and predicted connectivity in dynamic topologies
  - **DTN enables the vehicle payload to be its own autonomous Internet that cooperates with other vehicles and other ground networks as necessary**
    - Long term: The network is a distributed autonomous intelligent system of systems
    - Near Term: better performance, more flexibility, extended line of sight, etc.

Disruption Tolerant Networks

- **Advanced Experimental Systems Project:**
  - **Implement Multi-Link Disruption Tolerant Networking (DTN)**



Concluding Thought: Why Network Computing?

"…to enable men and computers to *cooperate* in making decisions and controlling complex situations without inflexible dependence on predetermined programs"

- J. C. R. Licklider, 1960

IRE Transactions on Human Factors in Electronics,
volume HFE-1, pages 4–11, March 1960. http://memex.org/licklider.pdf

The lack of situational awareness causes lost opportunity.
Decision-support webs are the reason the Internet exists!!!