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# NREN Roadmap

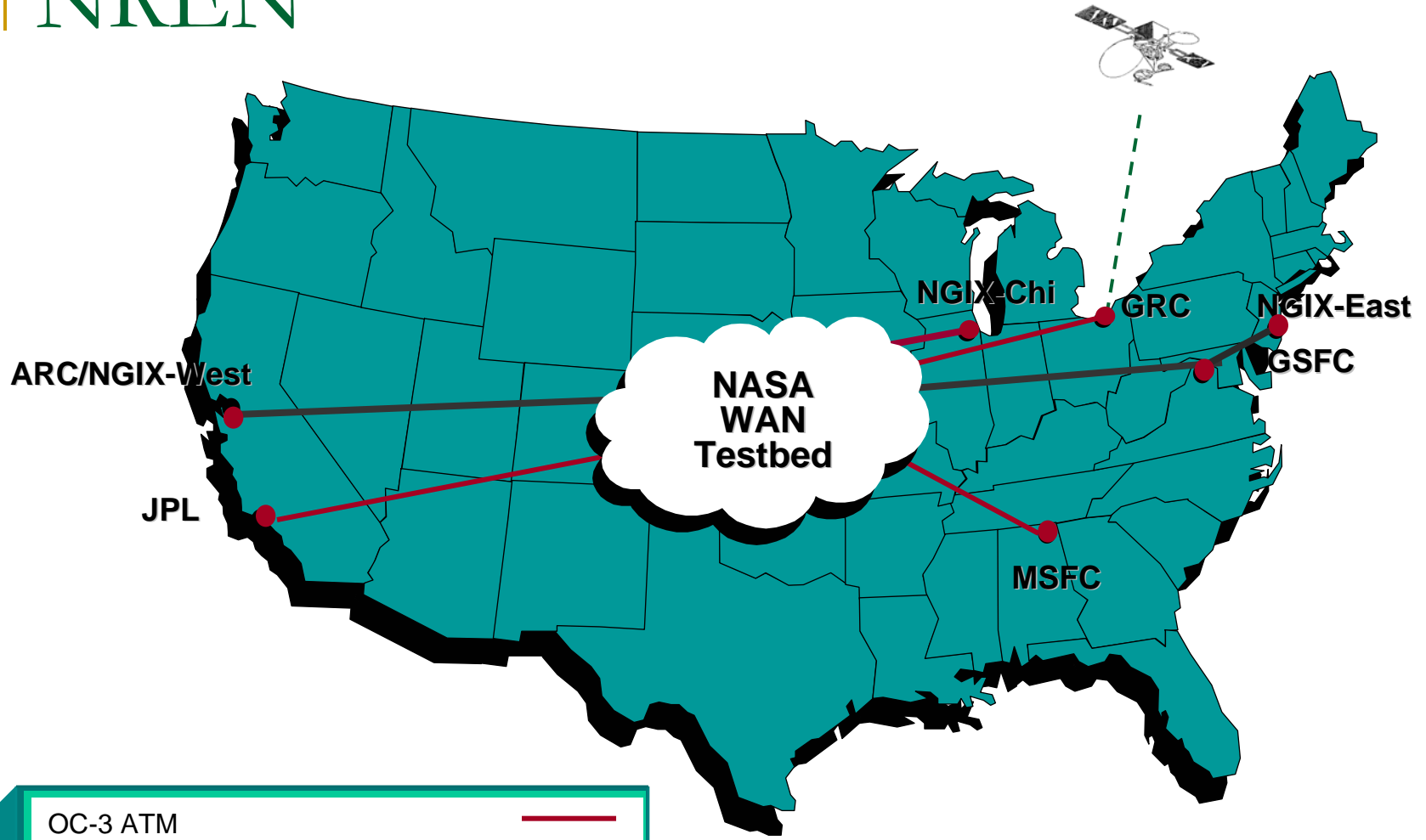
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JET Roadmap Workshop

13-15 April 2004

Kevin L. Jones

# NREN



|                                 |       |
|---------------------------------|-------|
| OC-3 ATM                        | —     |
| OC-12 ATM                       | —     |
| Hybrid Ground Station (35 Mbps) | ..... |

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# Network Drivers

- Applications with increased bandwidth requirements
  - Increasing bandwidth on backbone
    - 1 Gbps - FY 04
    - 1-10 Gbps – FY 05
    - 10 Gbps – FY06
  - IPv6
  - Network Security
  - Nomadic Networking
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# Application Drivers

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- Real-time Application Requirements
  - Space Communications
  - Field Applications

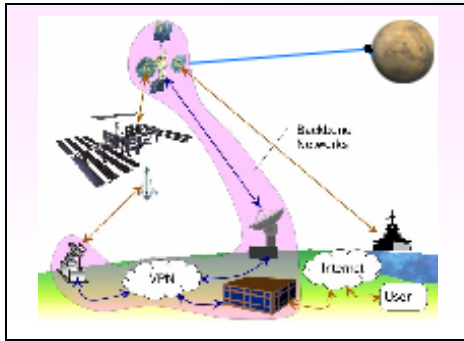
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# Real-Time Networking Applications

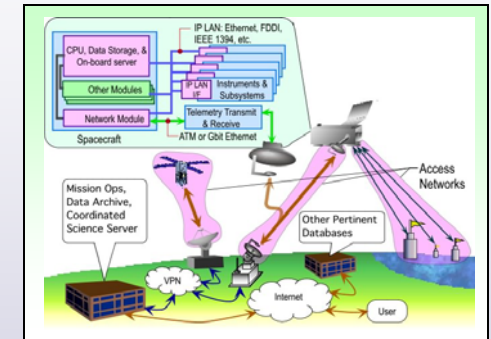
- Requirements of Real-Time Networking Applications
    - Reduced collaborative interaction time between distributed users or processes
      - Low network latency
    - Consistent temporal delivery of data
      - Low network jitter
    - Distributed Interaction / Visualization of Large Data Sets (*What if multiple parties wanted to interact with the data at the same time*)
      - High Bandwidth
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# Space Communications

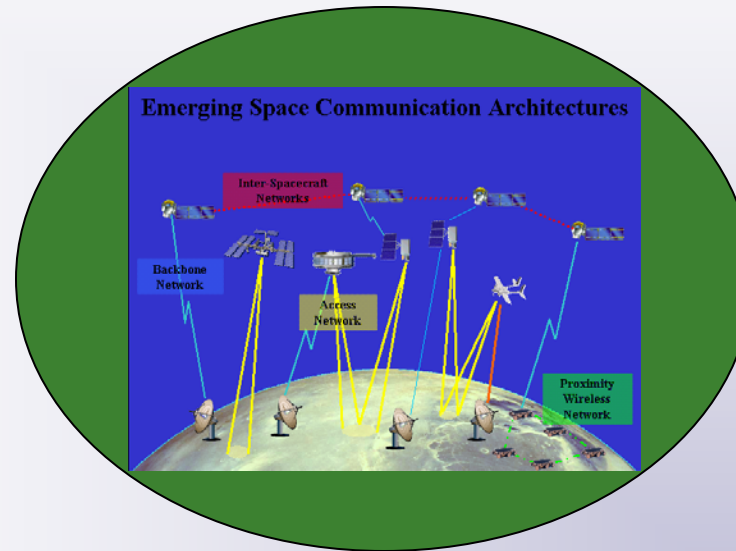
## High Rate Backbone Networks



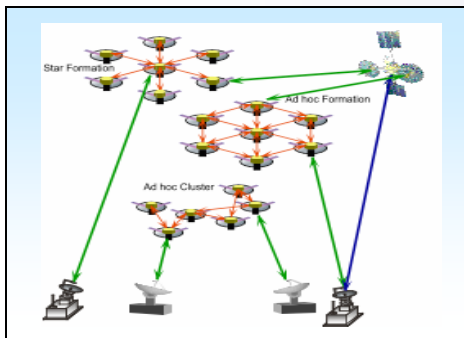
## Flexible Access Networks



## Emerging Space Communication Architectures

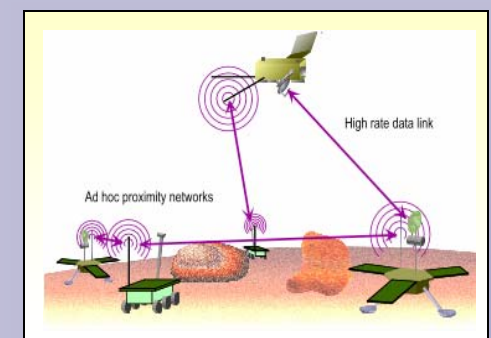


## Inter-spacecraft Cooperative Networks

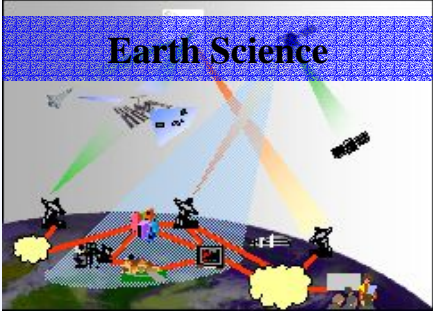
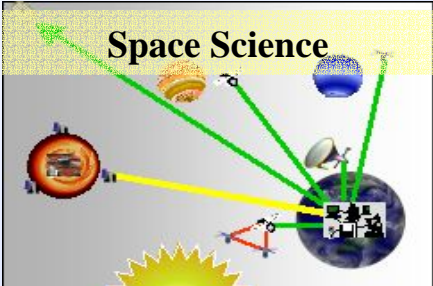



## Intelligent Communication Architectures

## Proximity Wireless Networks



# NASA Space Communications Long Term Vision and Requirements

| Enterprise   | Links                        | 2001              | 2010                          | 2020+                        |
|--|------------------------------|-------------------|-------------------------------|------------------------------|
|  <p><b>Earth Science</b></p>  | LEO Spacecraft (Direct Link) | X-Band / 150 Mbps | 10 Gbps gateway<br>1 Gbps D/L | 100 Gbps                     |
|  | GEO Spacecraft (Direct Link) | 150 Mbps          | 10 Gbps                       | 100 Gbps                     |
|  | Multi-spacecraft links       | 4 Mbps            | 45 Mbps                       | 155 Mbps                     |
|  | Sensor Webs                  | 100 bits/sec      | Multiple links of A, B, C, D  | Multiple links of A, B, C, D |
|  <p><b>Space Science</b></p> | Mars                         | 100 Kbps (X-Band) | 1 Mbps (Ka-Band)              | 10 Mbps (Ka-Band)            |
|  | Outer planet                 | 1.4k-250k         | 1.4k-12k                      | 1.4k-12k                     |
|  | Multi-spacecraft Networks    | 4 Mbps            | 45 Mbps                       | 155 Mbps                     |
|  <p><b>HEDS</b></p>         | Shuttle                      | 50 Mbps           | 50 Mbps                       | 50 Mbps                      |
|  | International Space Station  | 48 Mbps           | 150 Mbps by 2005              | 300 Mbps                     |
|  | Mars Exploration             | -                 | 5 Mbps                        | 10 Mbps                      |

# ESTIMATING THE CIRCULATION AND CLIMATE OF THE OCEAN (ECCO)

## ■ Scientific Vision

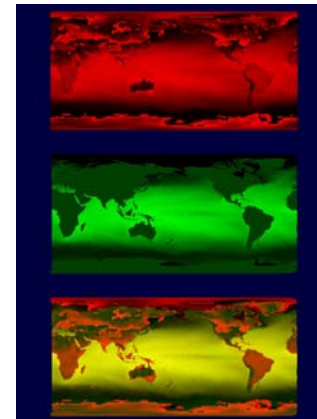
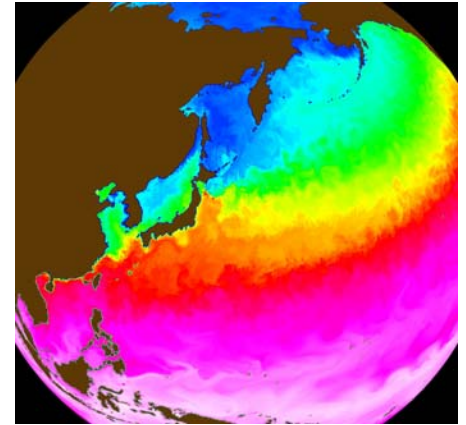
- Improve understanding of large-scale ocean dynamics via large-scale high-resolution simulation modeling. Assimilate real-time satellite observation data directly into large-scale simulation models.

## ■ Application Description

- The goal is to conduct large-scale ocean modeling using an advanced supercomputer system, located at NASA Ames. Terabyte data files for each simulation run must be transmitted from JPL to ARC prior to each run. Visualization techniques are applied to the simulation results and the resulting information is made available for distribution.

## ■ Locations

- NASA Ames, Jet Propulsion Laboratory, MIT, Scripps Institution of Oceanography





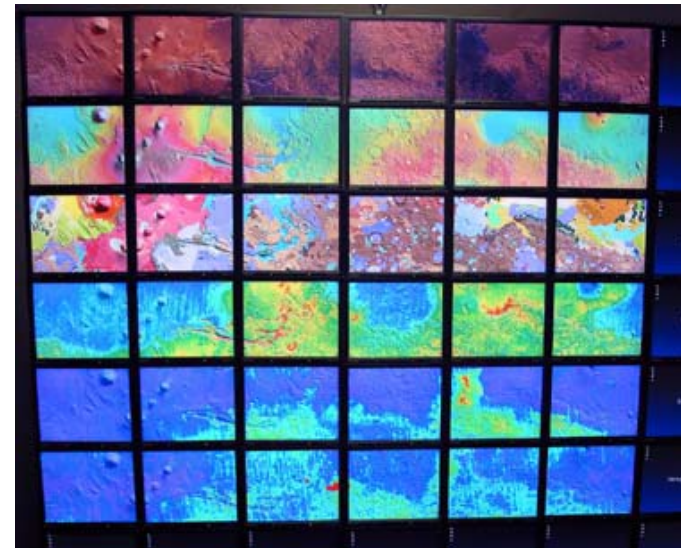
# Hyperwall

- Technology Description

- The hyperwall can display multiple independent, but related, images, and provides useful means for composing and controlling these image sets. In place of elaborate software or hardware crossbar switches, scientists rely on the human visual system for integration, synthesis, and pattern discrimination in complex and high-dimensional data spaces.

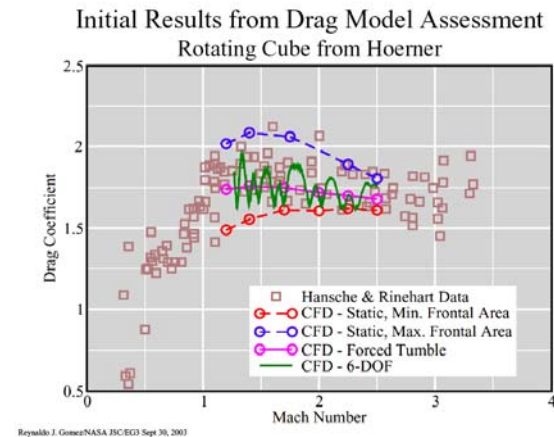
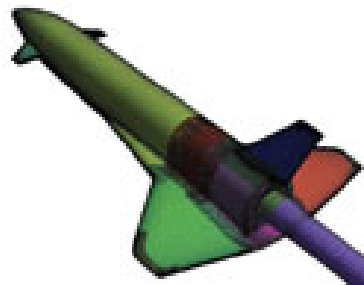
- Locations

- NASA Ames, NASA Goddard, University of Montana



# Return to Flight

- Application: Cart3D and AeroDB
  - Cart3D is a high-fidelity inviscid analysis package for conceptual and preliminary aerodynamic design. It allows users to perform automated computational fluid dynamics (CFD) analysis on complex geometry.
  - Cart3D is being used to develop a high fidelity package for Shuttle tumbling debris.
  - AeroDB, a framework that enables applications to be run on supercomputers, is being tested on Space Shuttle launch vehicle CFD simulations. These simulations are by far the largest CFD jobs run by AeroDB so far, with over 25 million grid points.
- Locations
  - NASA Ames, NASA JSC



<http://people.nas.nasa.gov/~aftosmis/cart3d/>

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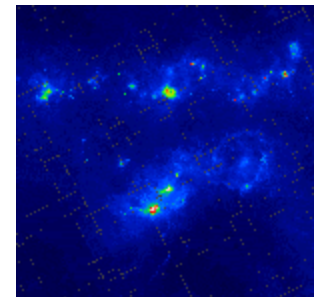
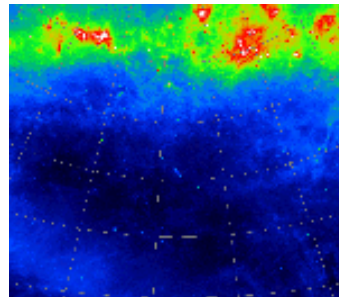
# Montage

- Technology Description

- Montage: A portable, compute-intensive service that will deliver science grade mosaics on-demand, with requests made through existing astronomical portals
- Application interface for National Virtual Observatory

- Locations

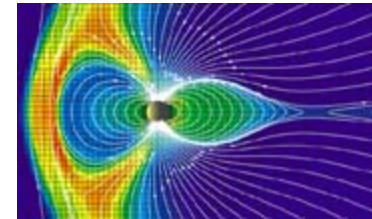
- Jet Propulsion Laboratory, CalTech, NCSA, Argonne National Lab via the TeraGrid



# Space Weather Modeling

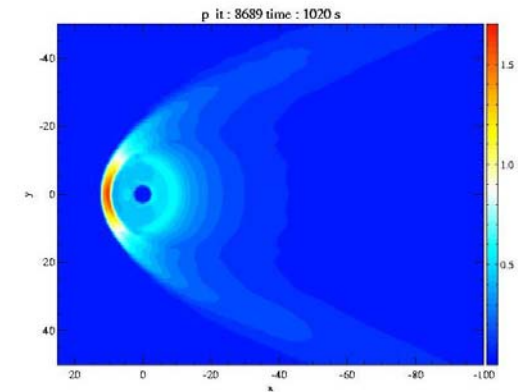
## ■ Concept

- ❑ Real-time space weather prediction capability using coupled models driven by solar and interplanetary observations.



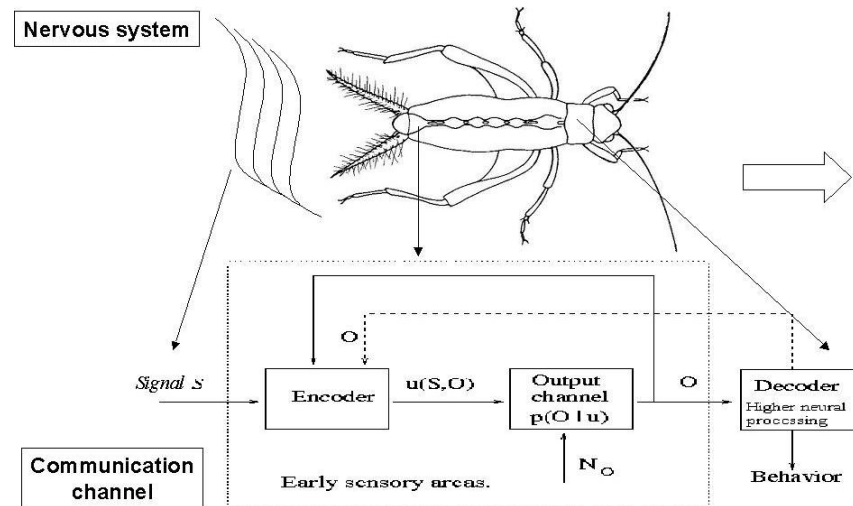
## ■ Locations

- ❑ NASA Goddard, University of Michigan



# Lariat / Neural Coding

- Concept
  - Study of cricket nervous system for use in biotechnology applications
- Locations
  - NASA Ames, University of Montana



# Application Matrix

| Application             | Low Latency | Low Jitter | High Bandwidth |
|-------------------------|-------------|------------|----------------|
| ECCO                    |             |            | ◆              |
| AeroDB                  |             |            | ◆              |
| Cart3D                  |             |            | ◆              |
| Montage                 | ◆           |            | ◆              |
| Space Weather Modeling  |             |            | ◆              |
| High Definition TV      | ◆           | ◆          |                |
| MPEG-2 Digital Video    | ◆           | ◆          |                |
| Laurent - Neural Coding |             |            | ◆              |

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# Application Matrix

| <b>Application</b>      | <b>Latency</b> | <b>Jitter</b> | <b>High Bandwidth</b> | <b>Network Tech</b> |
|-------------------------|----------------|---------------|-----------------------|---------------------|
| ECCO                    |                |               | 600 Mbps              | QoS                 |
| AeroDB                  | < 200 ms       |               | 100 Mbps              |                     |
| Cart3D                  |                |               | 200 Mbps              |                     |
| Montage                 | < 100 ms       |               | 200 Mbps              | QoS                 |
| Space Weather Modeling  |                |               | 100 Mbps              |                     |
| High Definition TV      | < 100 ms       | 250-300 ms    | 30 Mbps               | QoS                 |
| MPEG-2 Digital Video    | < 100 ms       | 200 ms        |                       | QoS                 |
| Laurent - Neural Coding |                |               | 200 Mbps              | QoS                 |

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