Inputs on Advanced R&E Networks -- Limited to Pat's Perspective --

Outline

- NASA Science Mission, esp. Earth Science
- Current GSFC Advanced R&E Networks
- On-Going and Future Applications

J. Patrick (Pat) Gary
Network Projects Leader
Networks and Information Technology Security Group/
Computational and Information Sciences and Technology Office
NASA Goddard Space Flight Center

October 18, 2006
For MPLS2006 Advanced Networks for Research & Education Panel

Pat's Limited Perspective

NASA

- **Science Mission Directorate (HQ)**
  - **Earth Science Division (HQ)**
    - **Goddard Space Flight Center (GSFC)**
      - **Science and Exploration Directorate**
        - » **Computational and Information Sciences and Technology Office**

Earth and Space Data Computing Division

Computing Capability Chart

March 1, 2004 Summary

Network Routers

GIG-E (1,000 Mb/s)
HIPPI (800 Mb/s)
ATM (622 Mb/s)
ATM (155 Mb/s) NREN, CNE
Ethernet (100 Mb/s)
T3 (45 Mb/s)
Ethernet (10 Mb/s)
T1 (1.5 Mb/s)

High-Speed Networks

696 Nodes
14,822 Mb/s Bandwidth

High Performance Computers

HP/Compaq SC45 Development "charney"	HP/Compaq SC45 Preproduction "milton"	HP/Compaq SC45 Production "halem"	SGI Origin 2000 "mintz"	SGI Origin 3800 "daley"	SGI Origin 3800 "courant"	SGI Origin 3800 "jimpf"	SGI Origin 3800 "chapman"
32 Proc 16 GB Mem 64 GFLOPS	16 Proc 8 GB Mem 32 GFLOPS	512 Proc @1.0 GHz / 880 Proc @1.25 GHz 696 GB Mem 3.2 TFLOPS	64 Proc 32 GB Mem 38.4 GFLOPS	384 Proc @400 MHz 192 GB Mem 307.2 GFLOPS	128 Proc @400 MHz 64 GB Mem 102.4 GFLOPS	96 Proc @500 MHz 48 GB Mem 96 GFLOPS	1,024 Proc 256 GB Mem 819.2 GFLOPS
.5 TB Disk Total	1 TB Disk Total	8.5 TB Disk Total	11.0 TB Disk Total	3.65 TB Disk Total	5.2 TB Disk Total	1.3 TB Disk Total	2.1 TB Disk Total

1056 GB Memory**
3,840 GigaFLOPS**

High-Speed Disks

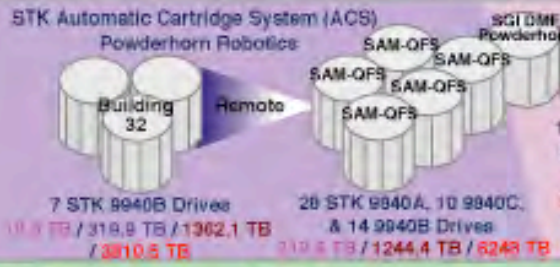
34.05 TB Disk Total**

Mass Data Storage and Delivery System

339.5 TB
2.54 PB+
9.82 PB+

Sun E10000
legacy UniTree
(12) 336 MHz Proc
8 GB Memory
8.5 TB Disk Total

SunFire 15000
"dirac" - SAM-QFS
(20) 1050 MHz Proc
40 GB Memory
8.5 TB Disk Total



7 STK 9940B Drives
19.9 TB / 319.9 TB / 1362.1 TB / 3810.5 TB

28 STK 9840A, 10 9840C, & 14 9940B Drives
319.4 TB / 1244.4 TB / 6243 TB

10 STK 9940 Drives
6 STK 9840 Drives
328 TB / 160 TB / 807.2 TB / 1250 TB

Mass-Storage Systems

1145.4 TB Total Data Stored
665.5 TB Unique Data Stored
>11 Million Unique Files
479.9 TB Duplicate Data Stored
3,413.7 TB Media Capacity/ 11.04 PB+ Potential Capacity

Commodity Clusters

http://ct.gsfc.nasa.gov/gsfc-supercomputers.html

381 GB RAM

Medusa	Thunderhead	Dell	Gateway	IBM	SGI	VA Linux
128 1.2-Ghz Athlon MP 64 GB RAM	512 2.4-Ghz P4 Xeon 256 GB RAM	40 500-Mhz PIII Xeon 5 GB RAM	32 500-Mhz PIII Xeon 8 GB RAM	32 650-Mhz PIII 16 GB RAM	32 700-Mhz PIII 16 GB RAM	32 700-Mhz PIII 16 GB RAM

Scientific Visualization Studio

http://svs.gsfc.nasa.gov

Visualization Animation Infrastructure:
(4) Linux file servers
(13) Linux workstations (Maya)
(7) Linux render servers (RenderMan)
(10) Apple OSX graphics workstations
5.9 TB online disk storage capability

Immersive Display System:
Fakespace Immersive Workbench
Polhemus Fastrak Tracker
(1) 8 Proc, 16GB SGI Onyx2 IR2
(1) 8 node hyperwall visualization cluster

Video Infrastructure:
Apple OSX video and DVD editing
(2) HDTV plasma displays
(1) HD MPEG-2 hardware player
(1) ACCOM Digital Disk Recorder

Video Decks and Cameras
(3) BETACAM, (1) DV, (1) DVD
(2) VHS, (1) Canon XL1-S

NASA Center for Computational Sciences (NCCS) High Performance Computing
NCCS Sun/UniTree Mass Storage System
Earth Science Technology Office (ESTO) Computational Technologies
Scientific Visualization Studio (SVS)

** Totals do not include "chapman"
* PB = 1024 TB

Located at GISS
Located at NASA/ARC; % Allocated to NASA/GSFC

Other Servers & Workstations
- (1) GSFC Earth Science Directorate Web Server (webserv)
- (136) Macintosh
- (53) SGI
- (52) Sun
- (203) PC

JLLC/GRR

http://nccs.gsfc.nasa.gov/PRIVATE/NCCS/images/NCCS.config.pdf

NASA'S VISION

To improve life here,

To extend life to there,

To find life beyond.

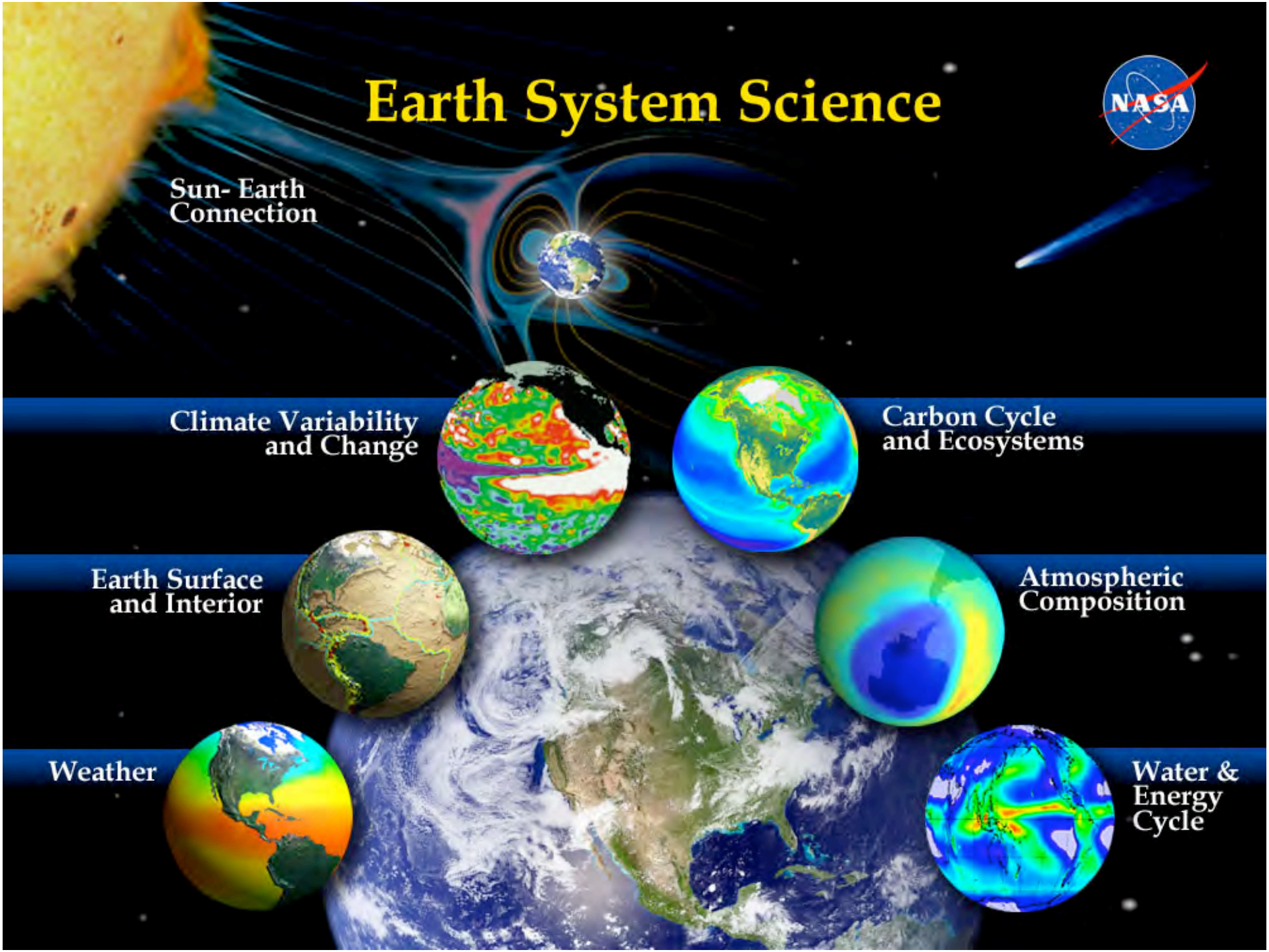
NASA'S MISSION

To understand and protect our home planet

To explore the Universe and search for life

To inspire the next generation of explorers

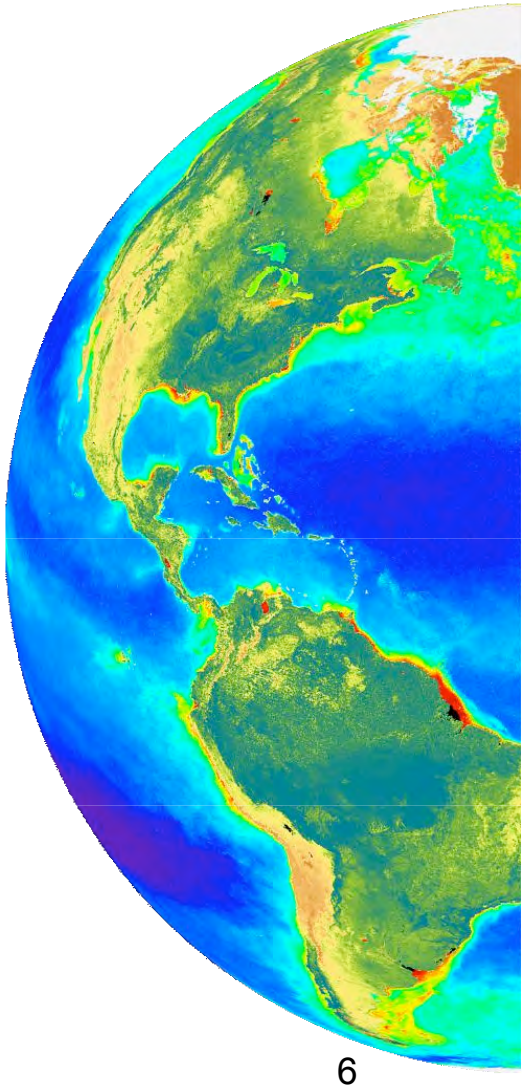
… as only NASA can.


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

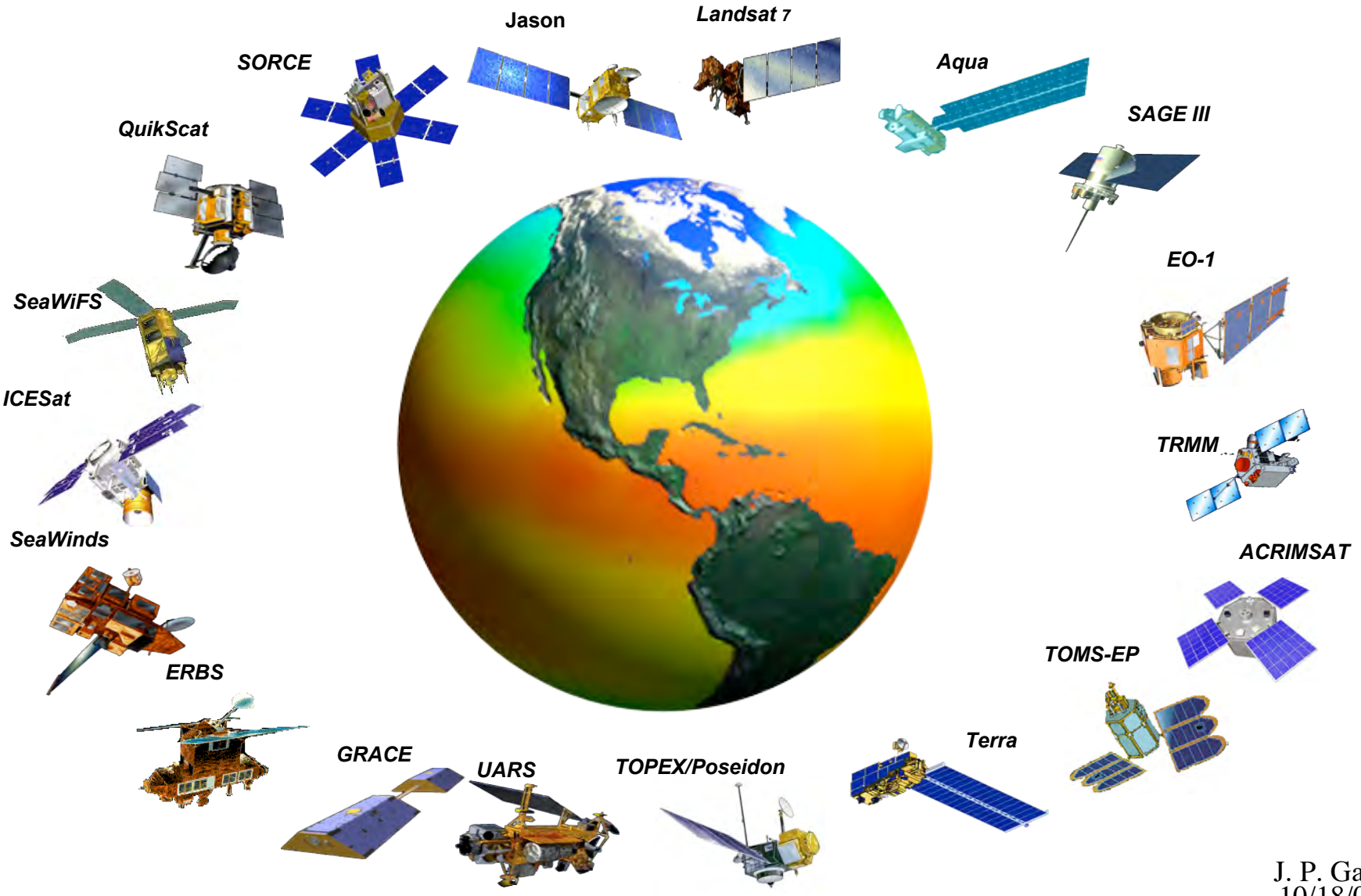
ESE Fundamental Science Questions

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?



NASA Earth Science Research Satellites



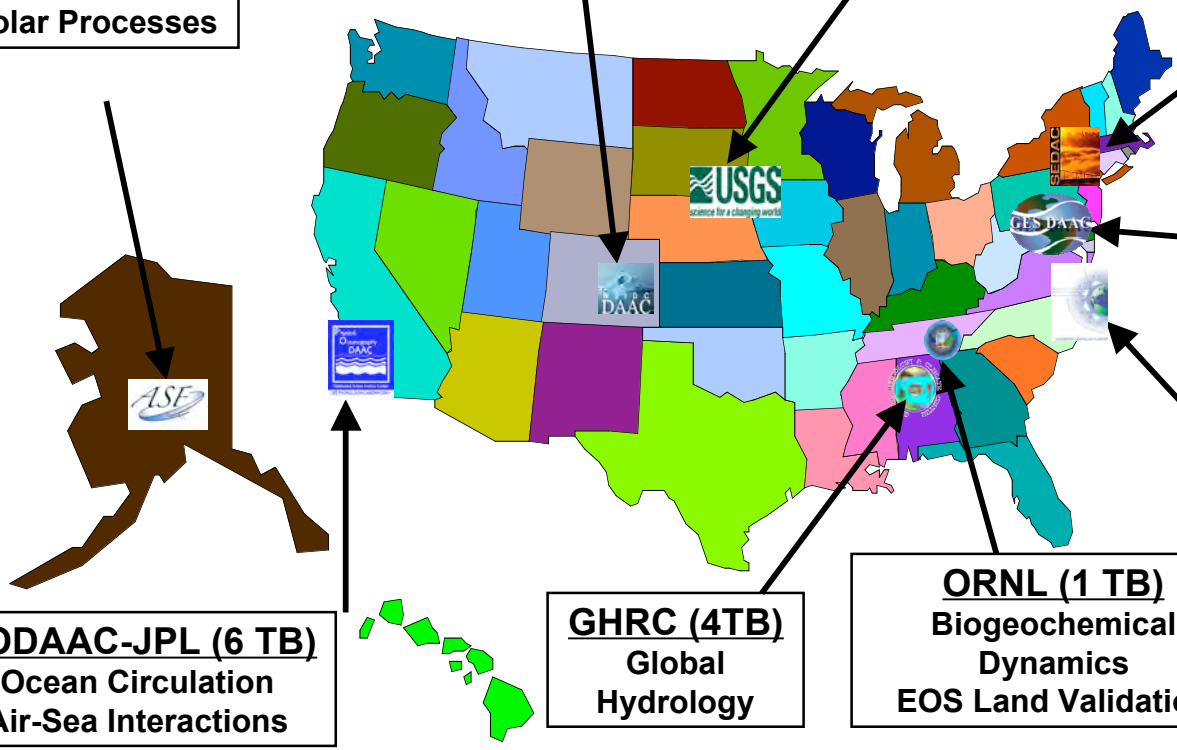
Earth System Enterprise-Data Lives in Distributed Active Archive Centers (DAAC)

NSIDC (67 TB)
Cryosphere
Polar Processes

LPDAAC-EDC (1143 TB)
Land Processes
& Features

ASF (256 TB)
SAR Products
Sea Ice
Polar Processes

SEDAC (0.1 TB)
Human Interactions in
Global Change



GES DAAC-GSFC (1334 TB)
Upper Atmosphere
Atmospheric Dynamics, Ocean Color, Global Biosphere, Hydrology, Radiance Data

ASDC-LaRC (340 TB)
Radiation Budget,Clouds
Aerosols, Tropospheric
Chemistry

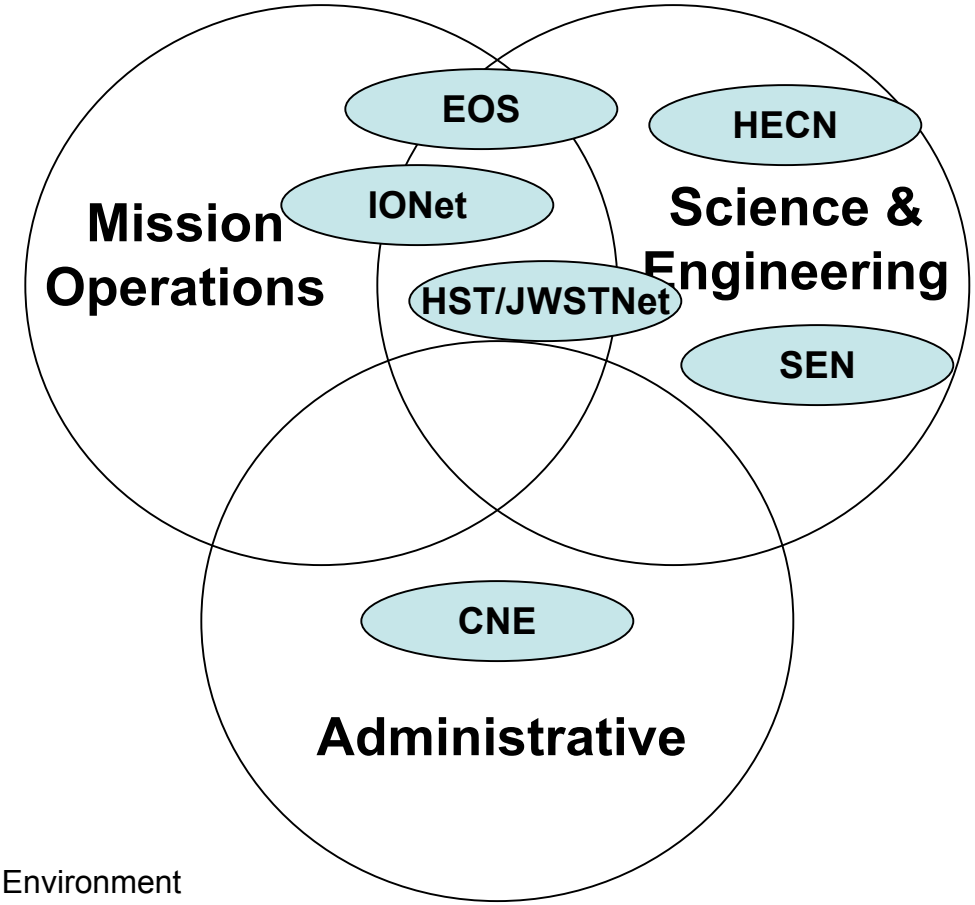
ORNL (1 TB)
Biogeochemical
Dynamics
EOS Land Validation

GHRC (4TB)
Global
Hydrology

PODAAC-JPL (6 TB)
Ocean Circulation
Air-Sea Interactions

EOS Aura Satellite Will Be Launched Soon
Challenge is How to Evolve to New Technologies

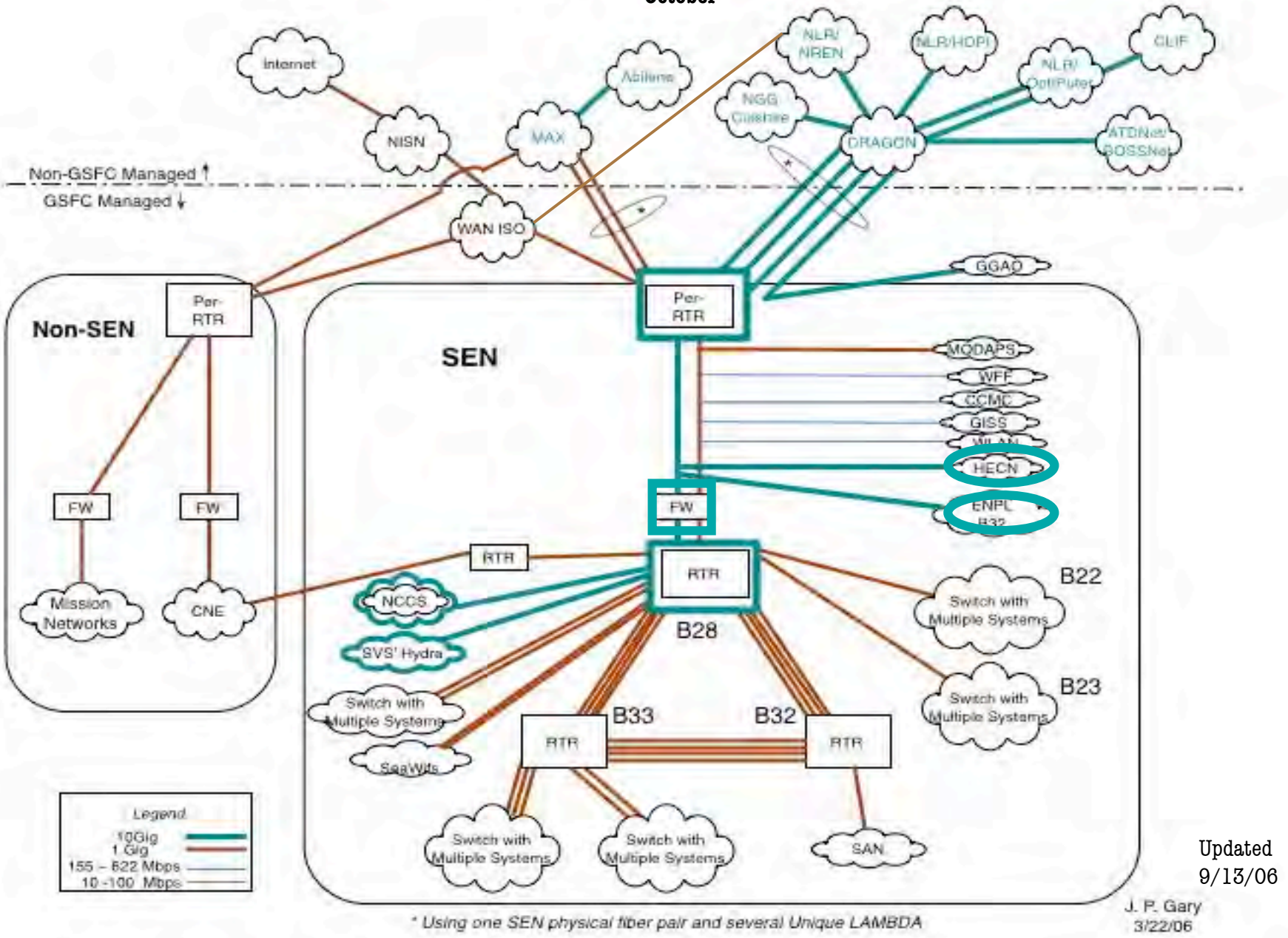
GSFC Managed Networks



CNE: Center Network Environment
EOS: Earth Observing System
HECN: High End Computing Network
HST/JWSTNet:: Hubble Space Telescope/James Webb Space Telescope Network
IONet: IP Operational Network
SEN: Science & Engineering Network

GSFC Scientific and Engineering Network (SEN) Major Links

Circa 1 ~~March~~ October 2006



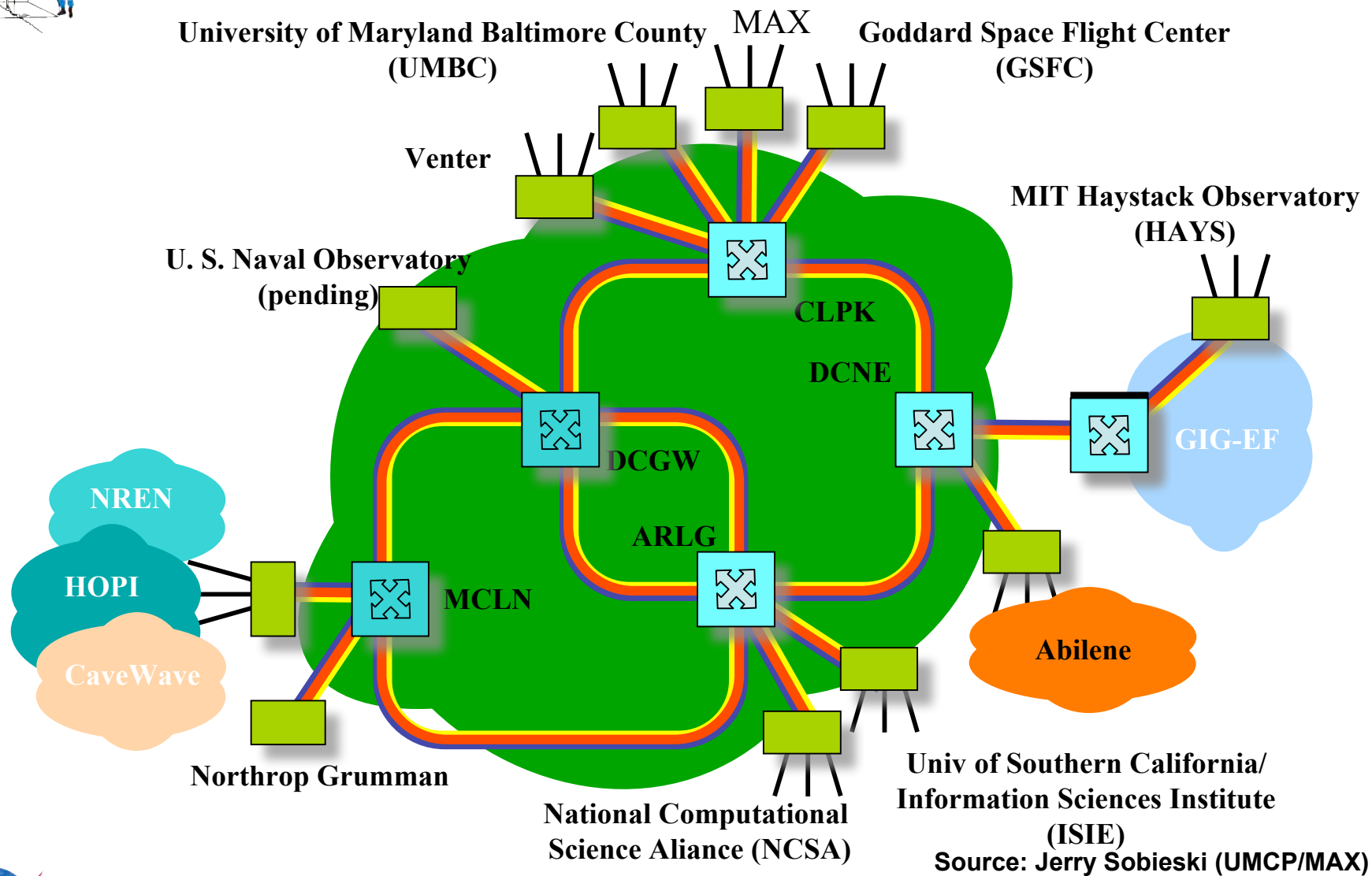
* Using one SEN physical fiber pair and several Unique LAMBDA

J. P. Gary
3/22/06

Updated
9/13/06

The DRAGON Testbed

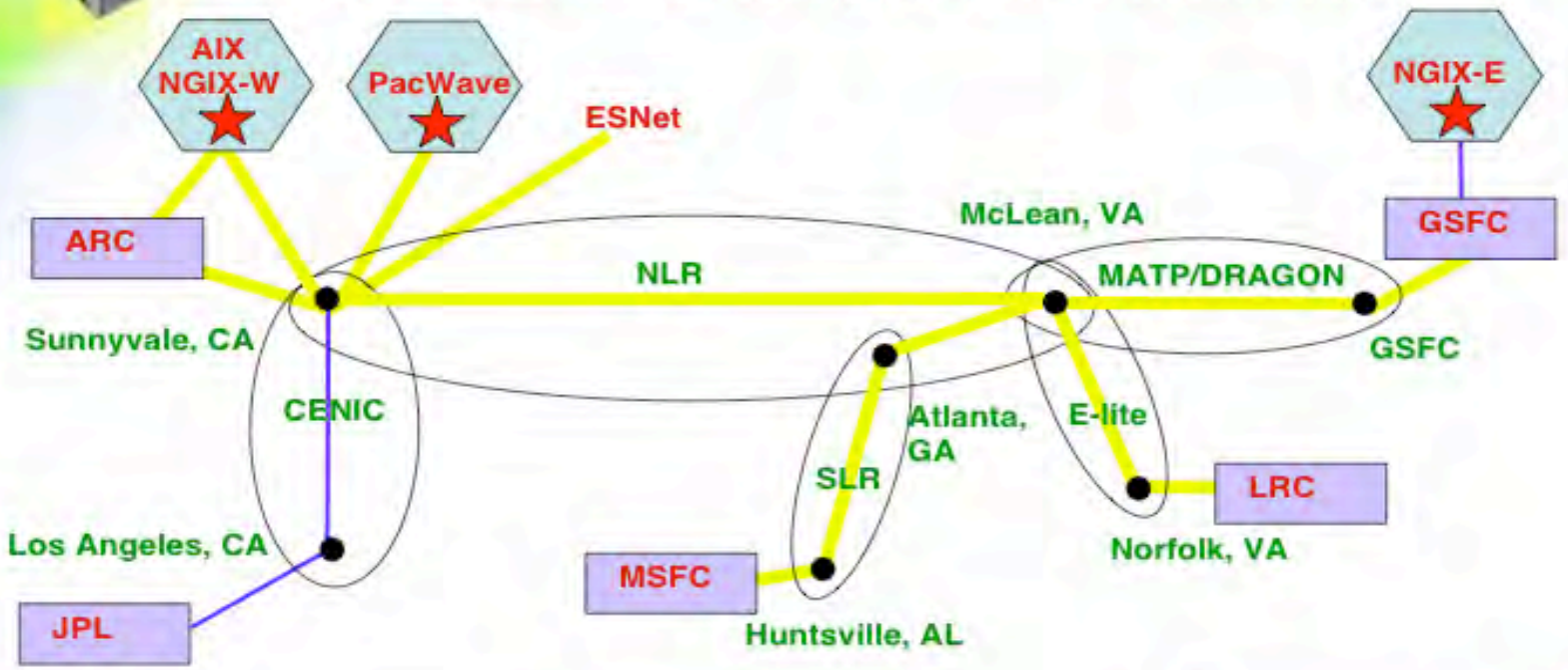
Washington, DC metro region



Source: Jerry Sobieski (UMCP/MAX)

NREN Target FY06

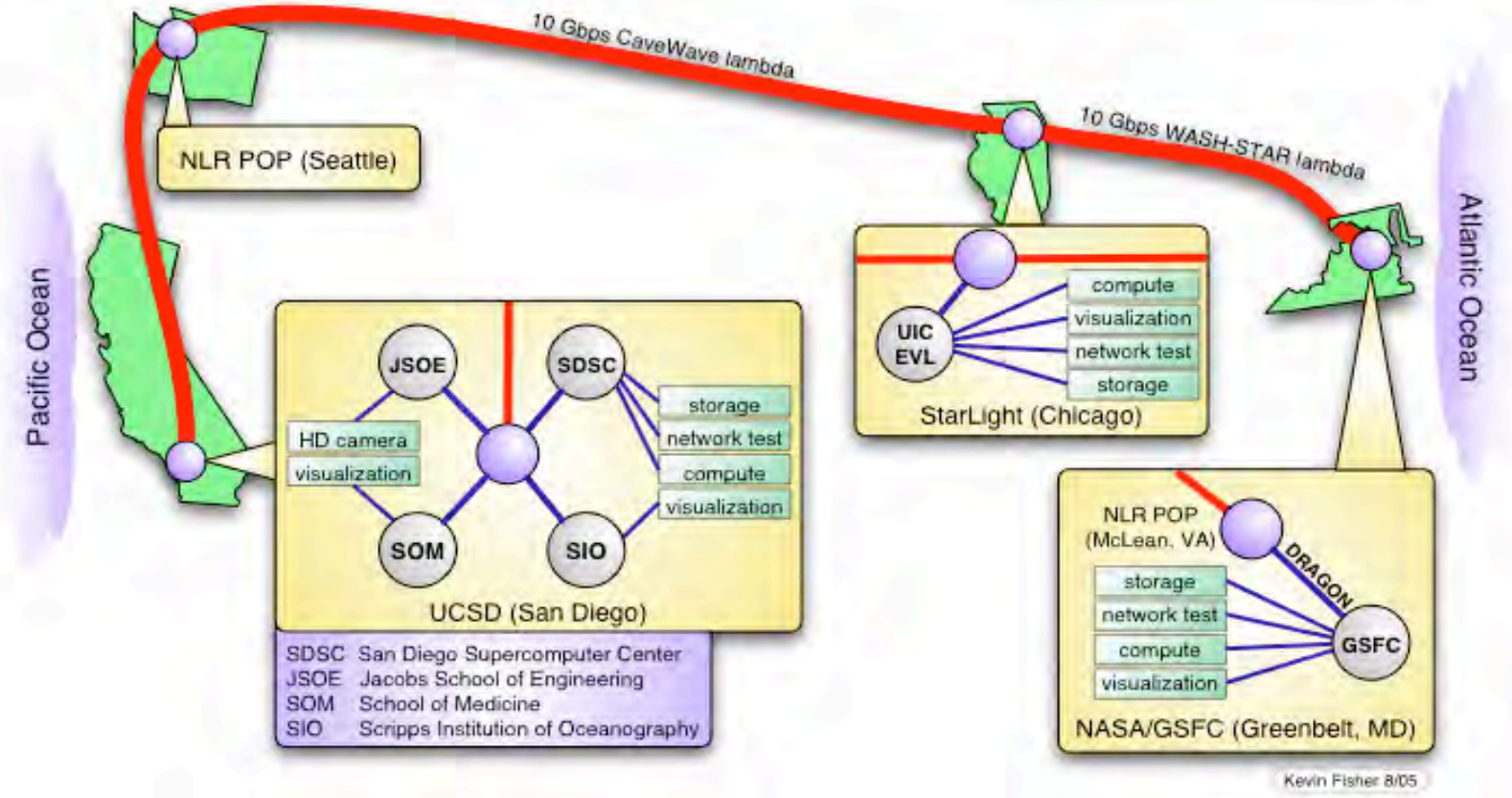
10G waves at the core, dark fiber to end sites



- National and Regional optical networks provide links over which 10 Gbps and 1 Gbps waves can be established.
- Distributed exchange points provide interconnect in metro and regional areas to other networks and research facilities

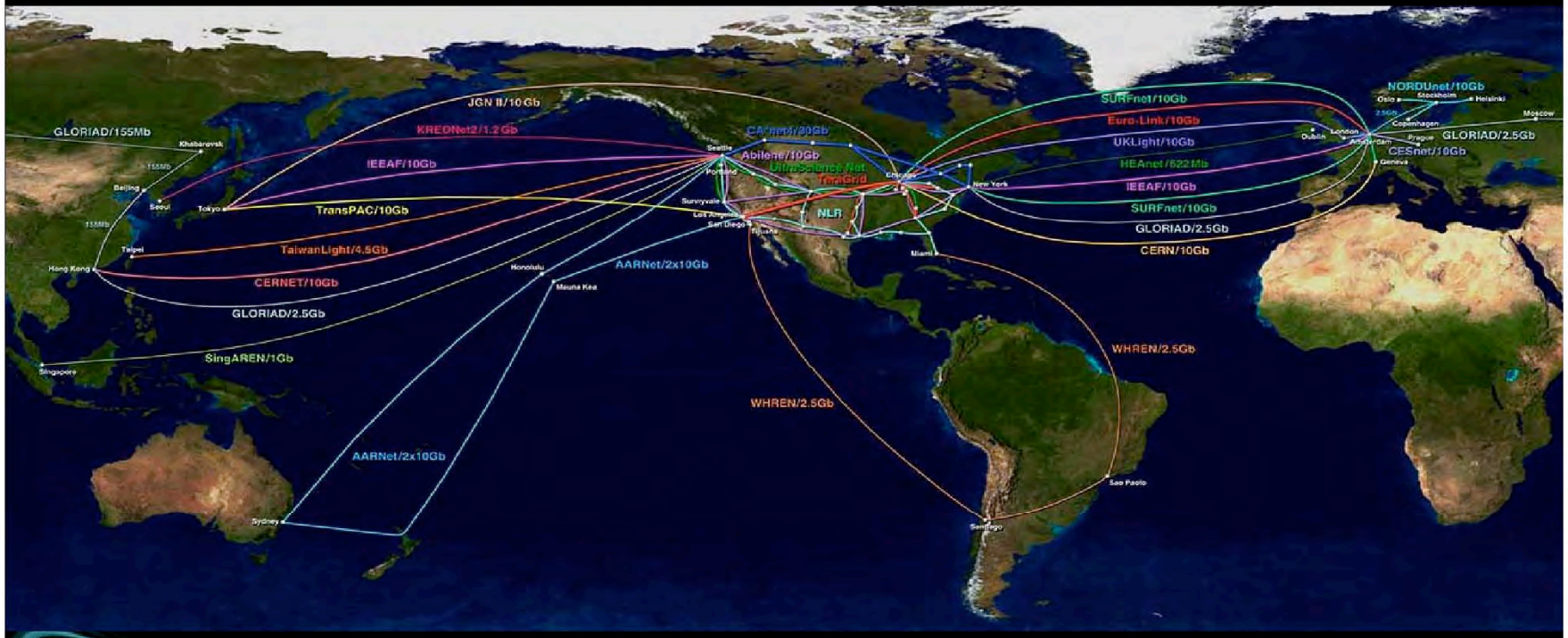
Source: Mark Foster (ARC)

NASA GSFC Tests with OptIPuter Across the National LambdaRail



Global Lambda Integrated Facility
World Map – December 2004

Predicted international Research & Education Network bandwidth, to be made available for scheduled application and middleware research experiments by December 2004.



www.glif.is

Visualization courtesy of
Bob Patterson, NCSA.

STARLIGHT℠

Inputs on Advanced R&E Networks
-- Limited to Pat's Perspective --

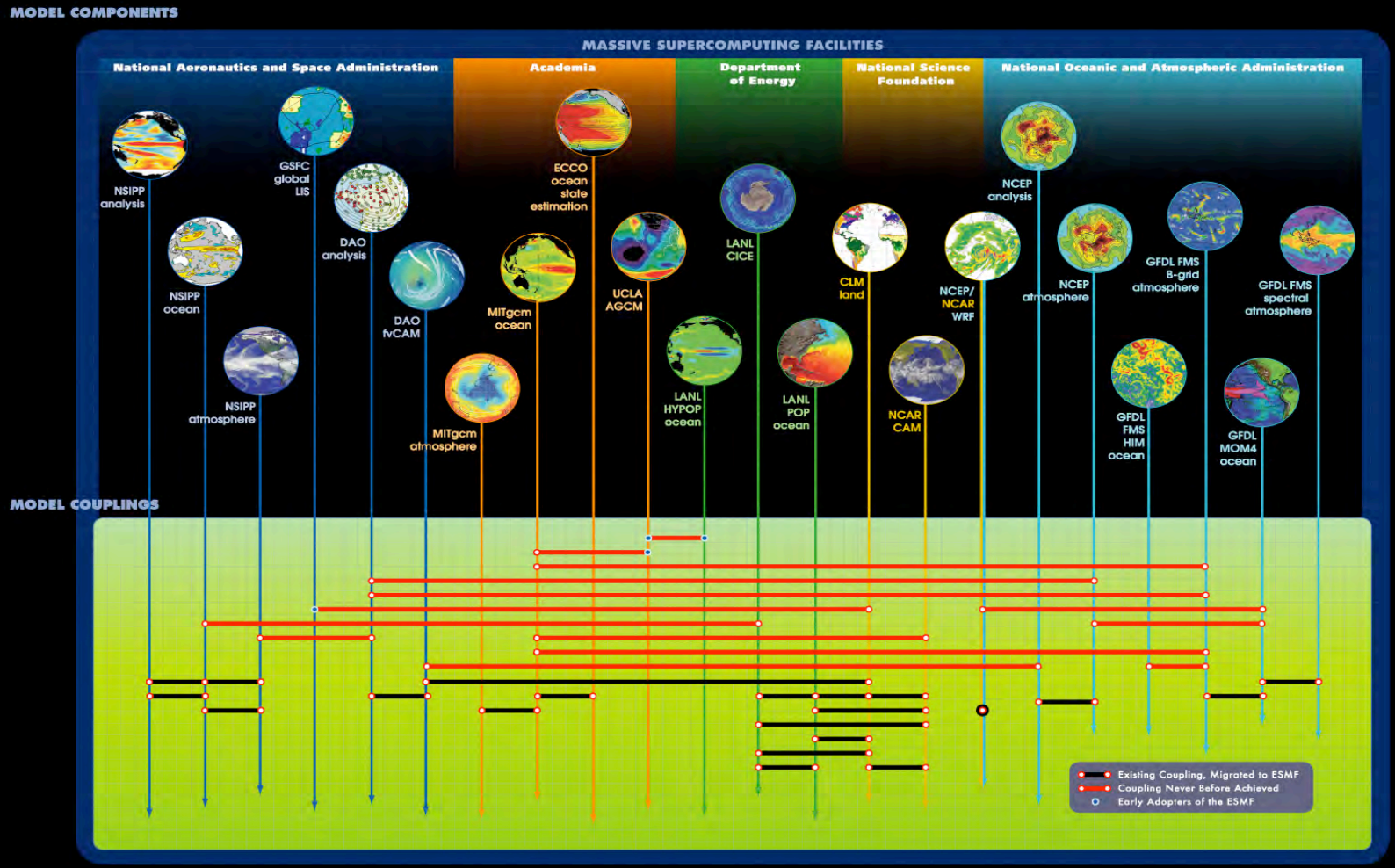
Previous and/or On-Going Applications

- Using ARC/NAS/Columbia Supercomputer (w/NREN)
- Distributed ESMF R&D
- eVLBI (w/MIT-Haystack, …)
- OptIPuter & Multi-channel Collaboration/Video Streaming Technologies(w/UCSD & UIC)
- 3D HDTV-over-IP R&D (w/Physical Optics Corporation)
- SAN-over-IP (w/UMIACS & NGC)

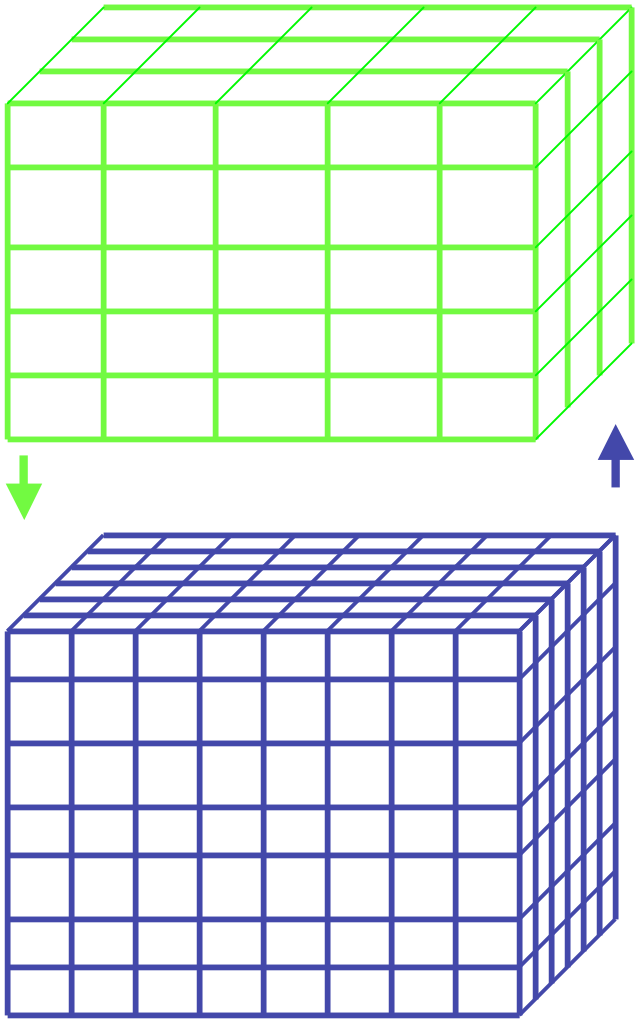
Columbia Supercomputer

- 10,240 1.6 GHz CPUs
- Configured as twenty 512 CPU single-system image nodes via NUMA
- SGI Altix 3700 Architecture, runs Linux
- 1 Terabyte shared memory per node
- Over 500 terabytes of online disk space

EARTH SYSTEM MODELING FRAMEWORK



Coupled Atmosphere-Ocean Models



Atmosphere

Ocean

Different grid type, resolution

Cross-Organization Coupling of Climate Models through ESMF

(A Prototype Over High-Speed Networks)

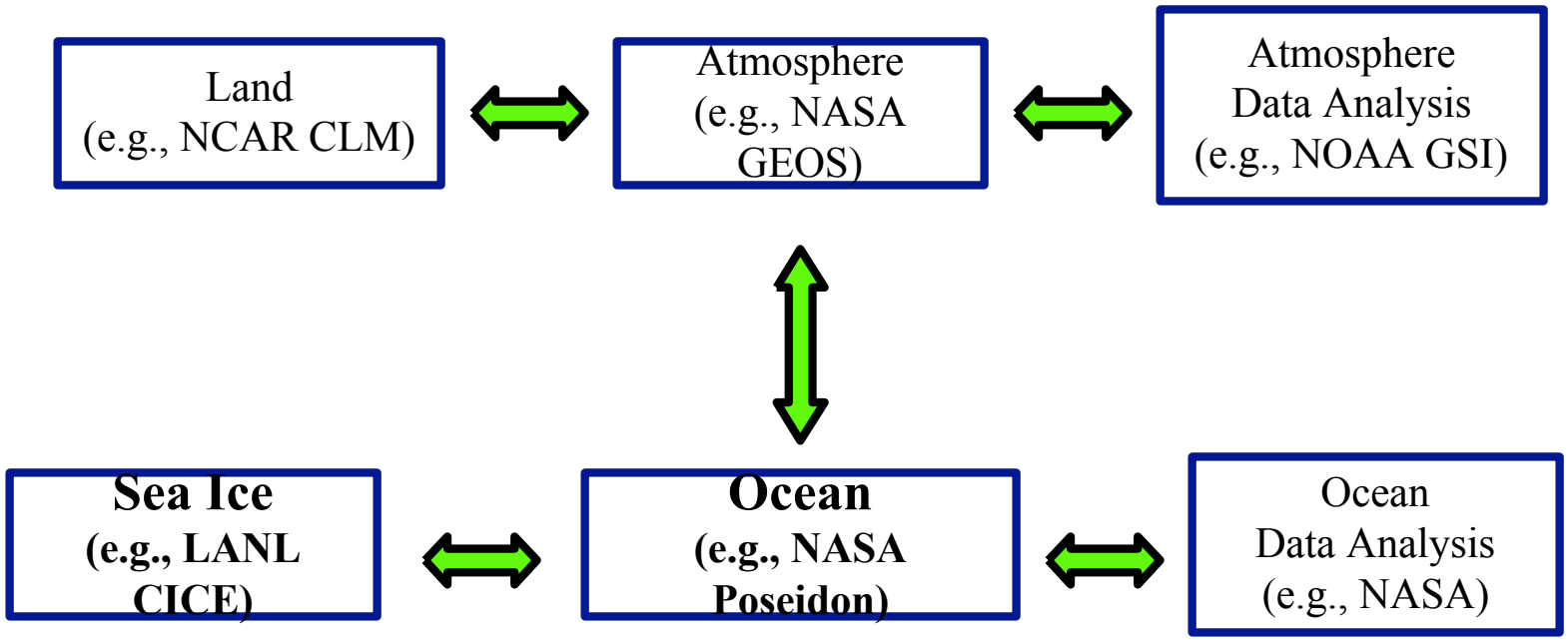
Shujia Zhou (Lead), C. Cruz, R. Burns, B. Womack, G. Higgins NASA SIVO/Northrop Grumman TASC

Collaborators:

- **High-speed network: P. Gary, B. Fink, P. Lang (NASA GSFC/ADNET)**
- **Cluster system admin: K. Fisher (NASA GSFC)**
- **XCAT/Proteus: M. Govindaraju, K. Chiu, M. Head (SUNY, Binghampton)**
- **Models: J. Spahr, C. Mechoso (UCLA), C. Hill (MIT), P. Jones (LANL)**

Presented at NASA Exhibit (booth 1810) at SC|05, November 14-18, 2005

ESMF-Enabled Coupled Models



2006 Hurricane Season - Global Modeling

NCEP
Inputs (1 GB)

INTEL Corp
Portland, Oregon

NASA Ames
Mt. View, California

Northrop Grumman
McLean, Virginia

NASA Goddard
Greenbelt, Maryland

DISTRIBUTED COMPUTING NODES

NEXT-GEN NETWORKS

Conventional Network
(600 Mb/s)

National Lambda Rail (10 - 40 Gb/s)

All model Outputs (500 GB per execution, ~15TB for entire season

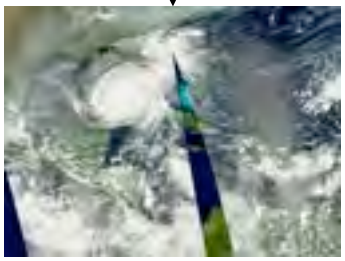
Tape Backup

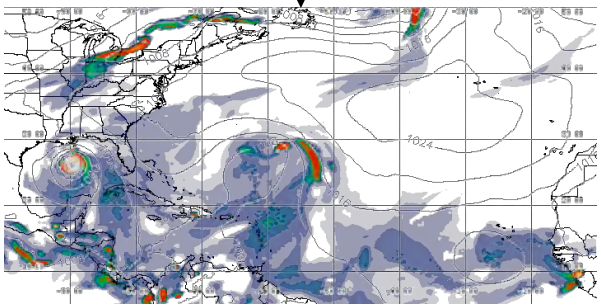
NASA Goddard
Greenbelt, Maryland

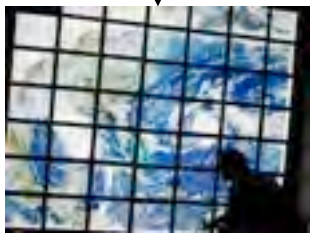
Main Server

NASA Goddard
Greenbelt, Maryland

DATA SERVERS / LONG TERM STORAGE



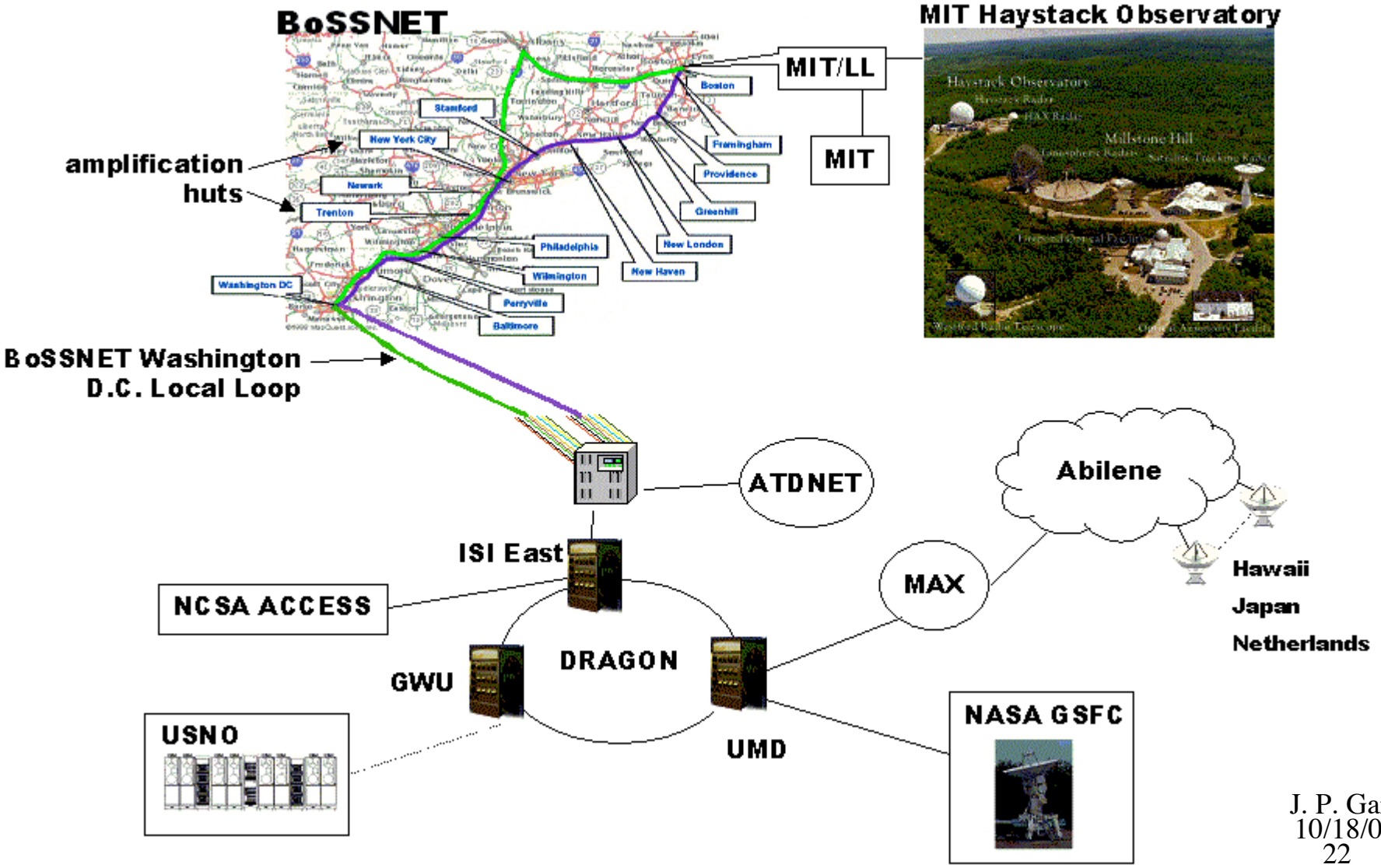




WEB SERVICES / ADVANCED VISUALIZATIONS

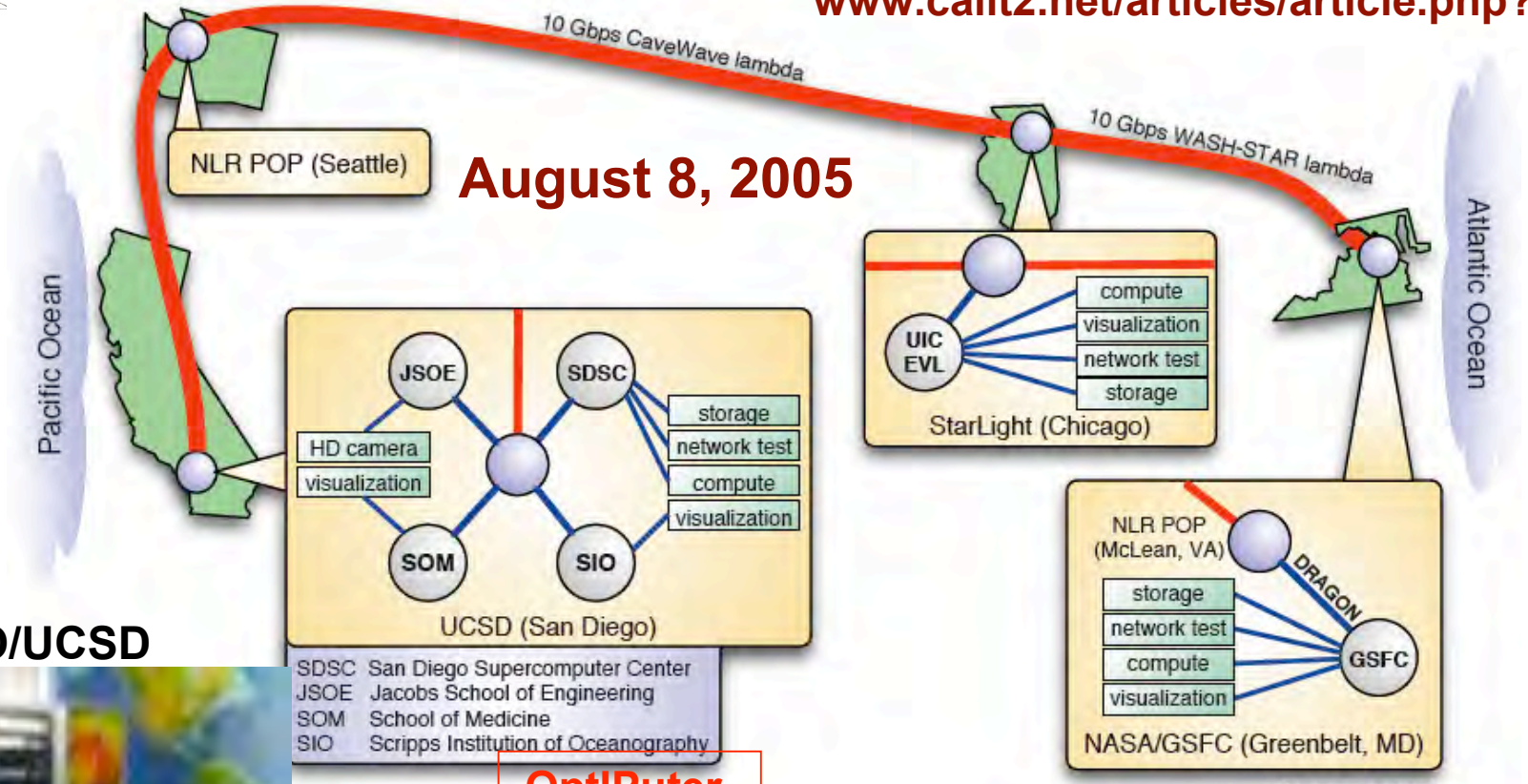
Source: Mike Seablom (GSFC/610.3)

DRAGON eVLBI Experiment Configuration



Combining Telepresence with Remote Interactive Analysis of Data Over NLR

www.calit2.net/articles/article.php?id=660



SIO/UCSD

OptIPuter Visualized Data

HDTV Over Lambda

NASA Goddard

iGrid 2005 Workshop, 26-29Sep05, UCSD/CalIT2

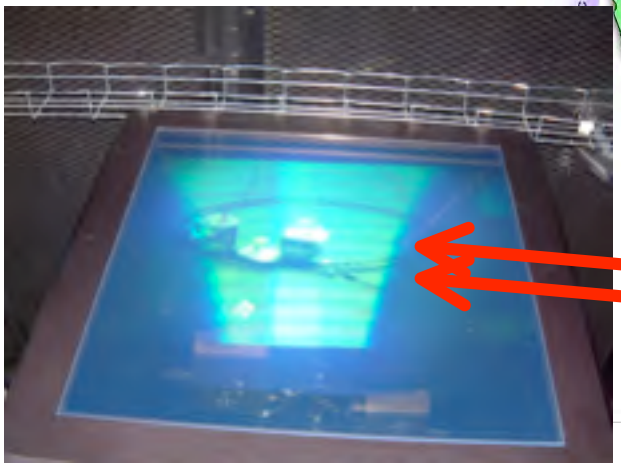
Accelerating the Use of Multi-10Gigabit per Second International and National Networks: www.igrid2005.org

GSFC's Ben Kobler (left) and POC's Sookwang Ro and Kirill Kolesnikov (right) work to set up POC's 35" x 35" holographic 3D HDTV video display system (center) prior to the start of iGrid 2005.

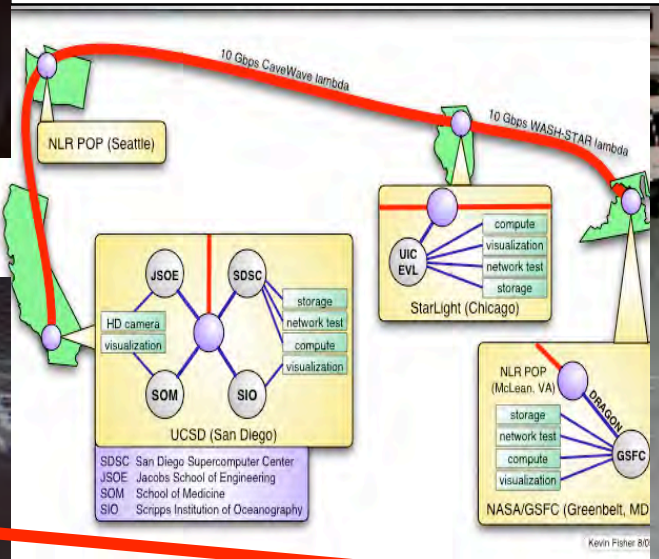
US130: Real-Time True-3D/HDTV (No Goggles) Visualization Over the National LambdaRail

NASA and Physical Optics Corporation demonstrate a holographic 3D HDTV video display system that does not require goggles or other special head gear, using a live cross-country video feed from NASA Goddard Space Flight Center to the iGrid 2005 site in San Diego. POC is a NASA SBIR Phase 1 awardee, and worked with NASA GSFC on this project.

www.poc.com/emerging_products/3d_display/default.asp



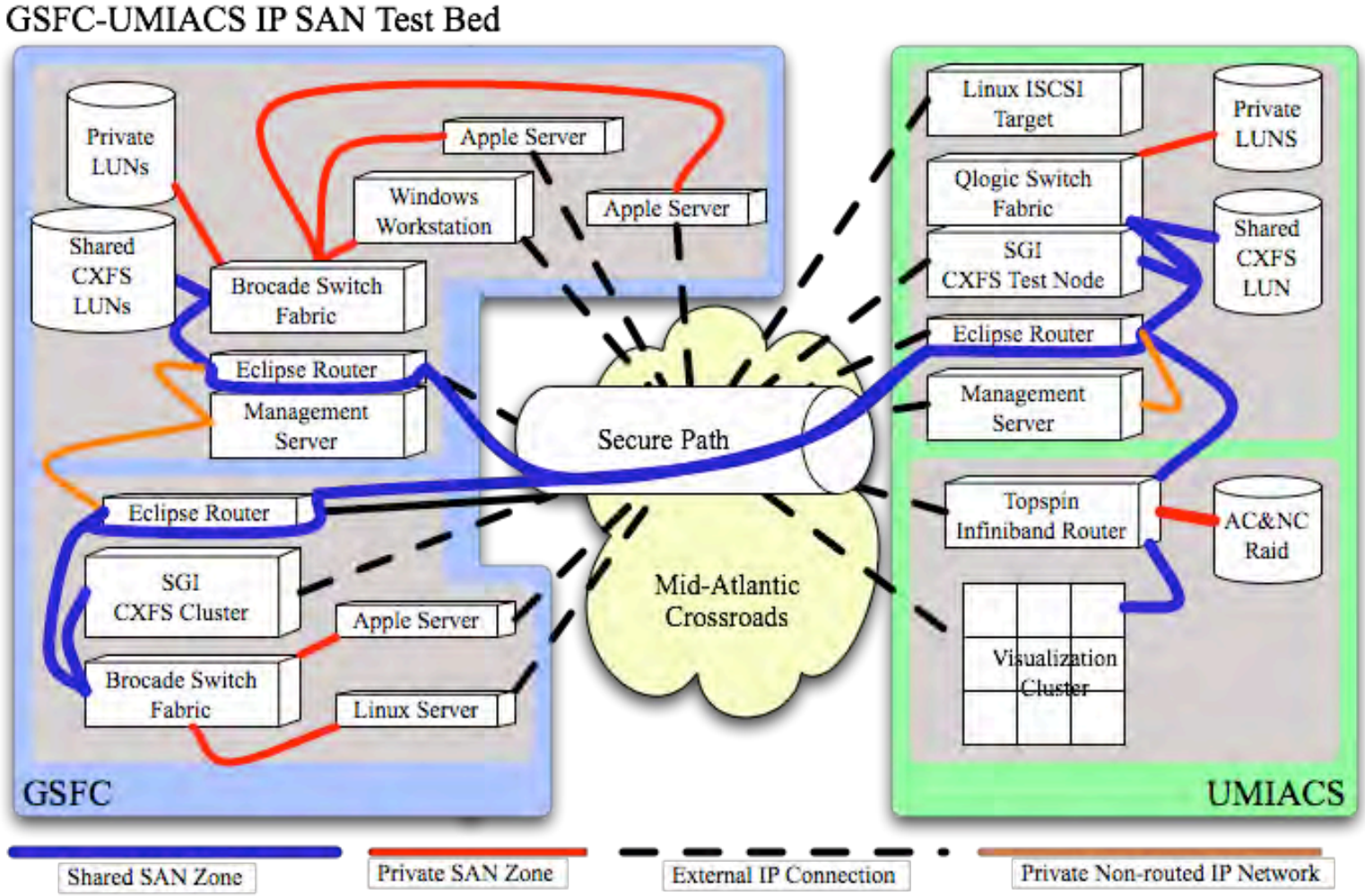
Only a non-stereo image of the True-3D display is captured in this photo of the real-time stereo-HDTV images transmitted from GSFC.



3D HDTV Over Lambda

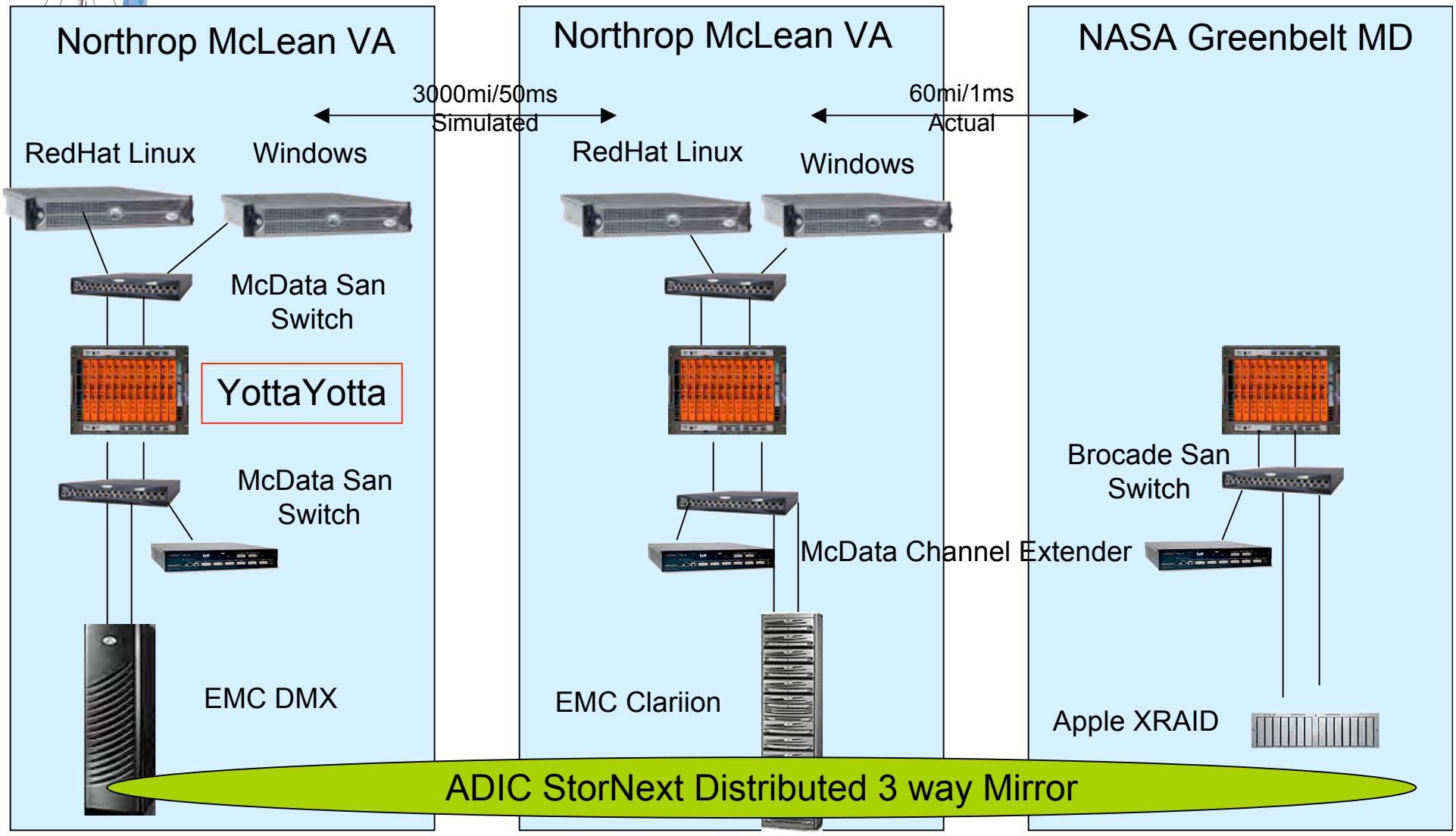
Stereoscoptically-aligned Sony HDV 1080i HDR-FX1HDTV cameras and the viewed targets at GSFC.

Current SAN-over-IP Test-bed



Source: Fritz McCall (UMIACS)

Wide Area Storage Configuration



Source: Bob Bramow (YottaYotta)

Inputs on Advanced R&E Networks
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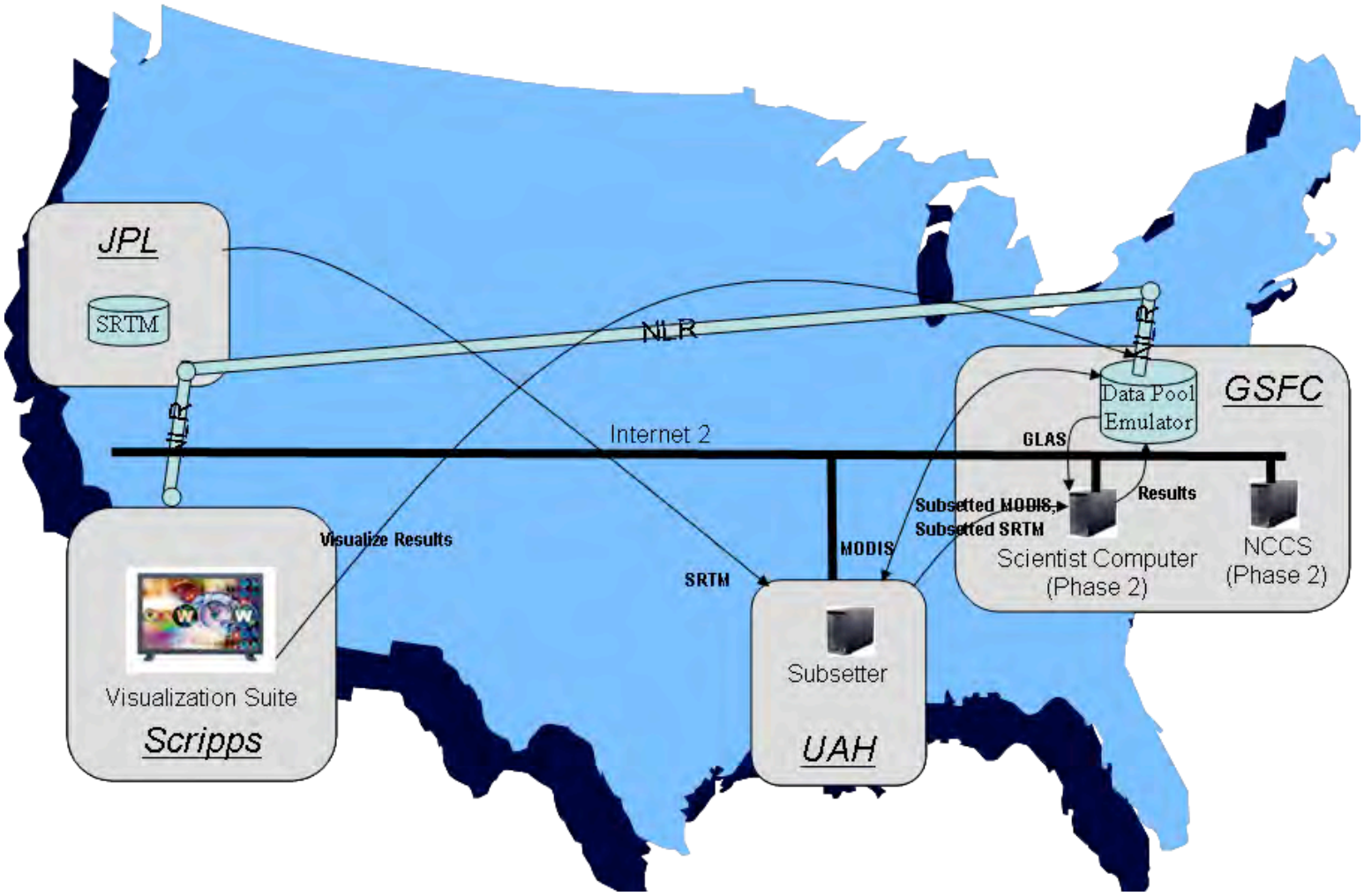
Upcoming and/or Future Applications

- SOA+Brokering for ECHO (w/SIO, JPL & UAH)
- Dynamic Linking (w/ORNL, CUNY)
- Grid Computing (w/TBD: SURAGrid, UMBC, …)
- InterPlaNetary Internet

"Brokering and Chaining Distributed Services and Data Using OptIPuter and the National Lambda Rail" by Ramapriyan (GSFC) et al to NASA's ROSES NRA



"Enabling NASA Applications Across Heterogeneous High Performance Networks" by Habib (CUNY) et al to NASA NNH05ZDA001N-Applied Information Systems Research (a.k.a. ROSES:D3)

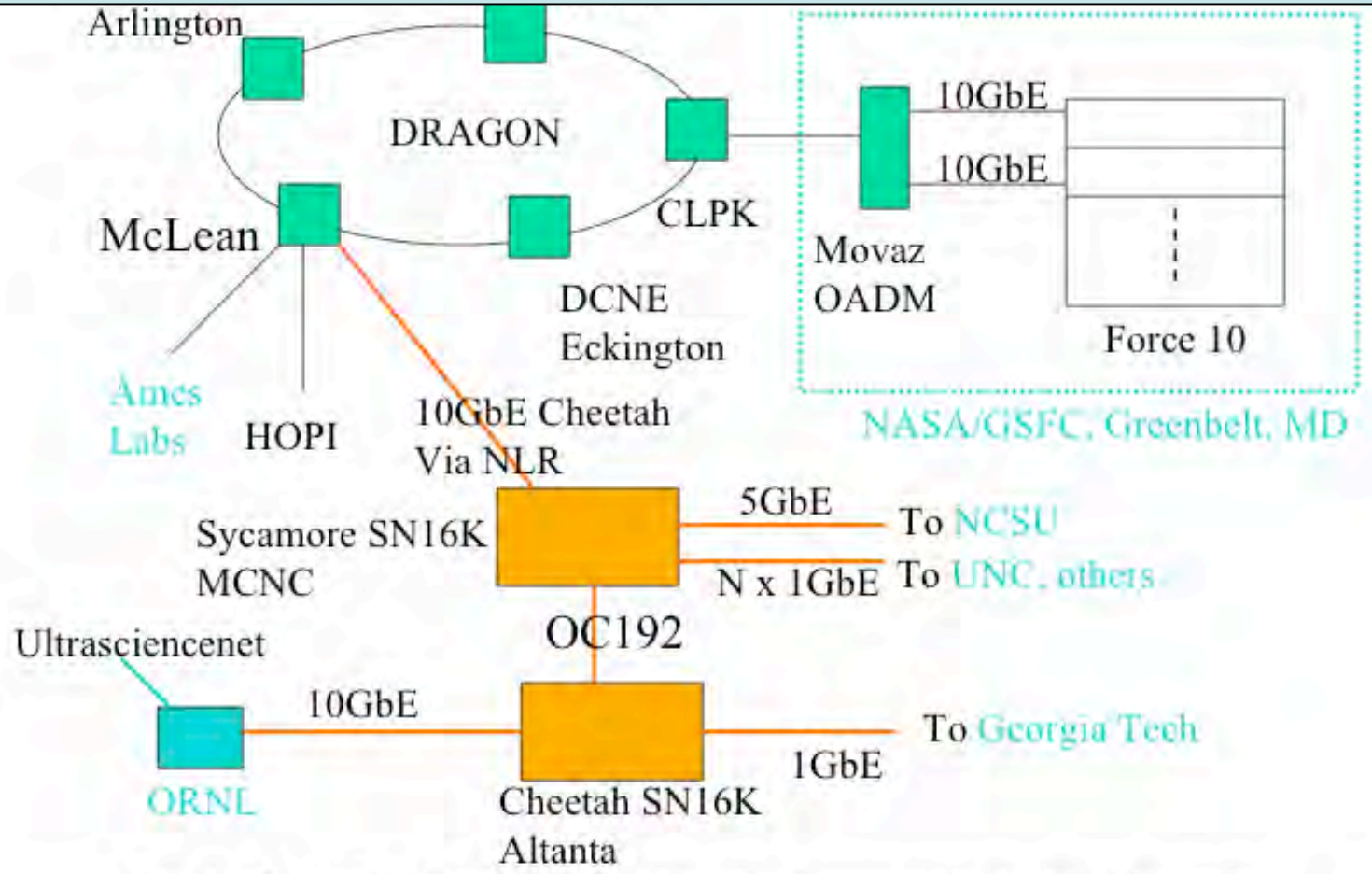
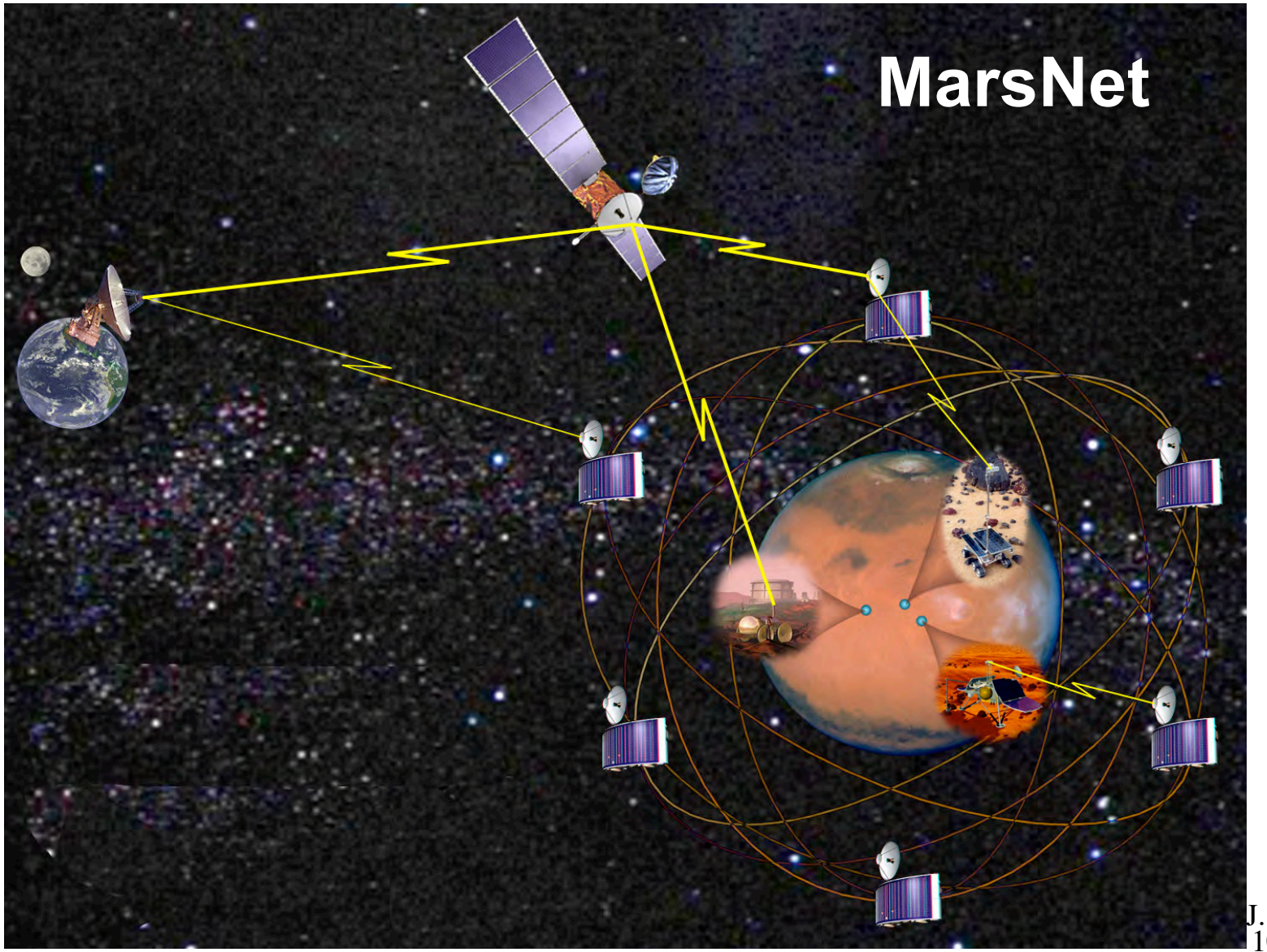


Fig. 1: Overall Proposed Network Connectivity to Cheetah

InterPlaNetary Internet
Defining a New NASA Space Communications Architecture



Source: JPL, Vint Cerf, MCI


NETWORK
BOTTLENECKS

Inputs on Advanced R&E Networks
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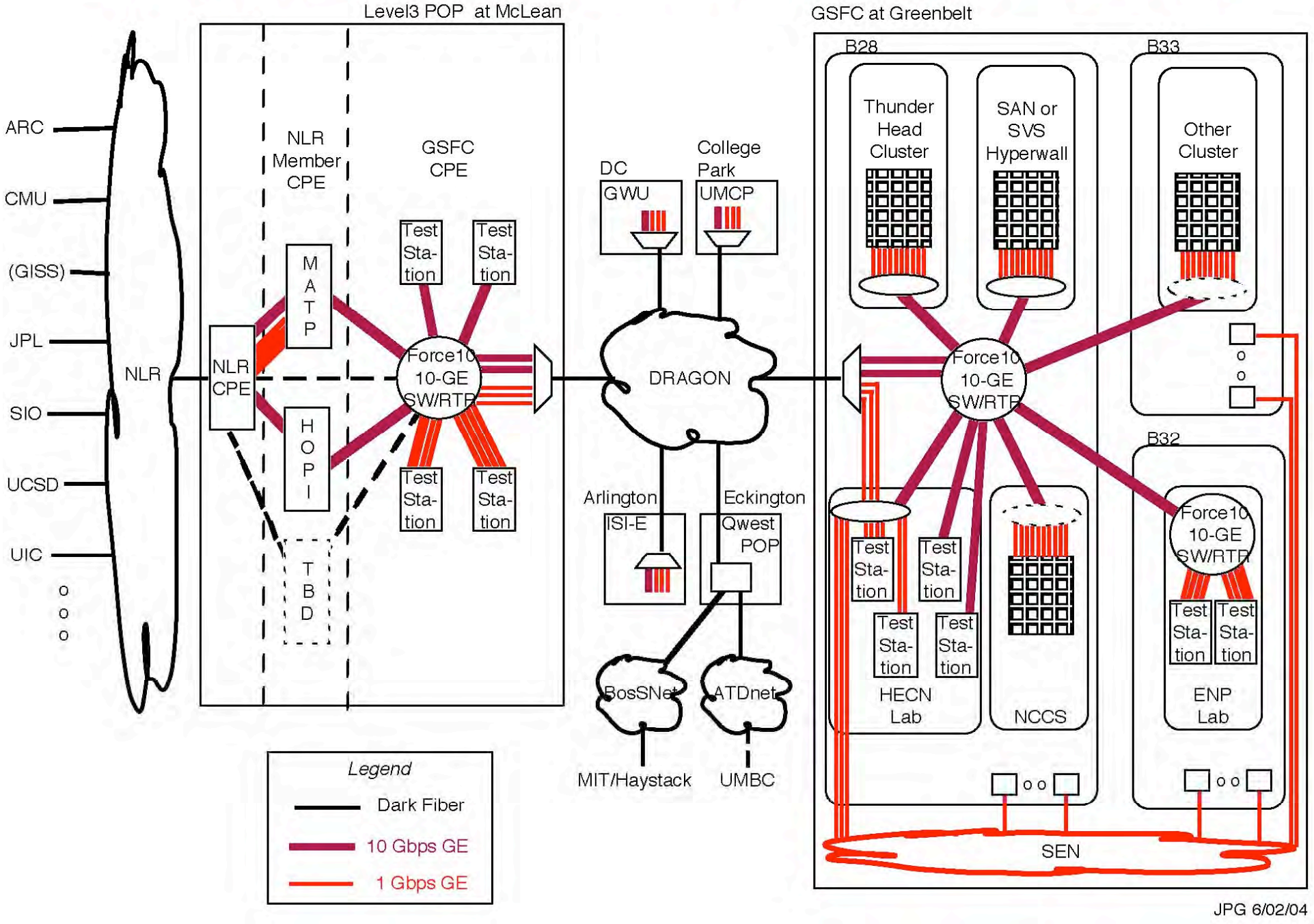
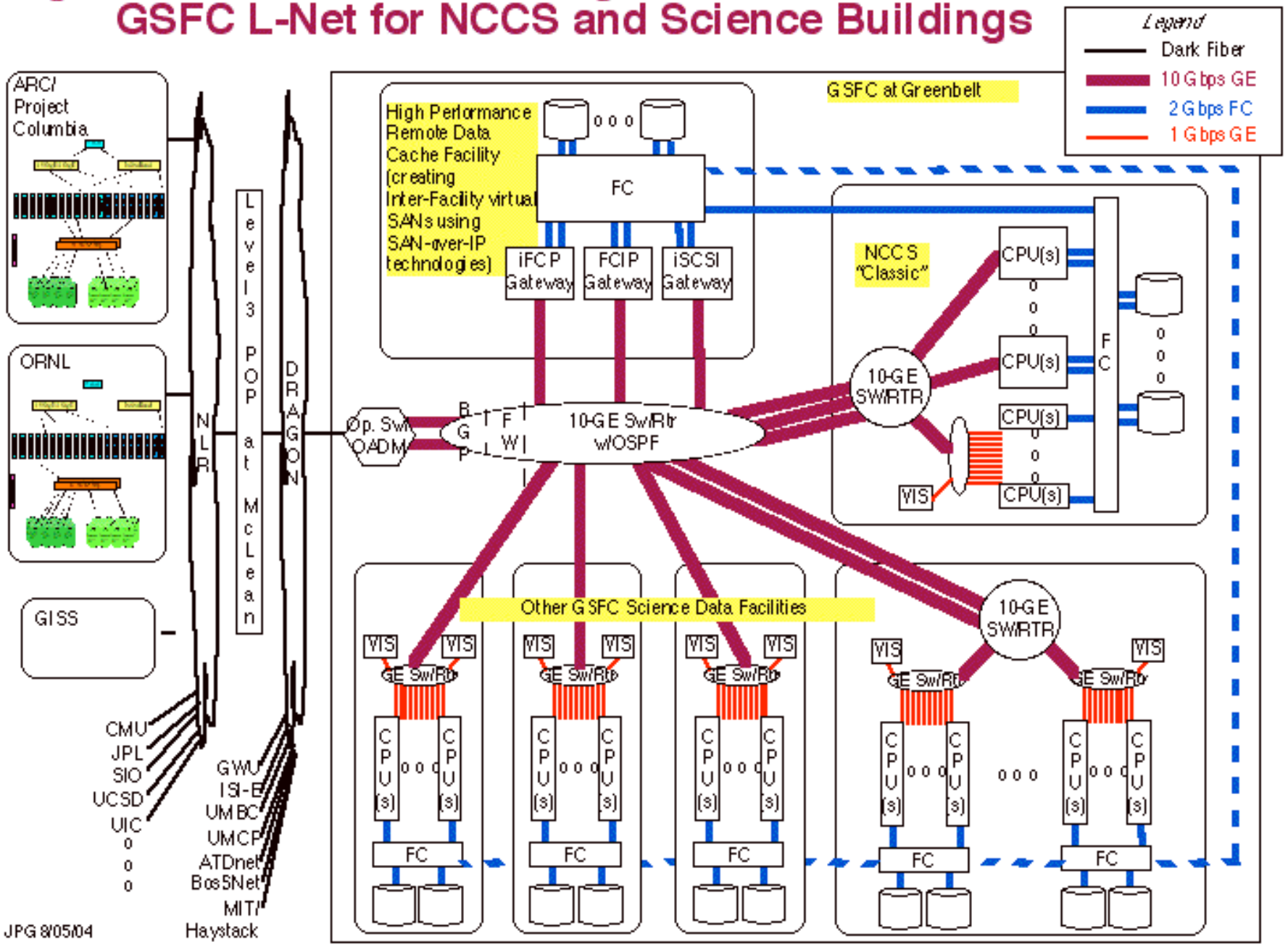
Backup Slides

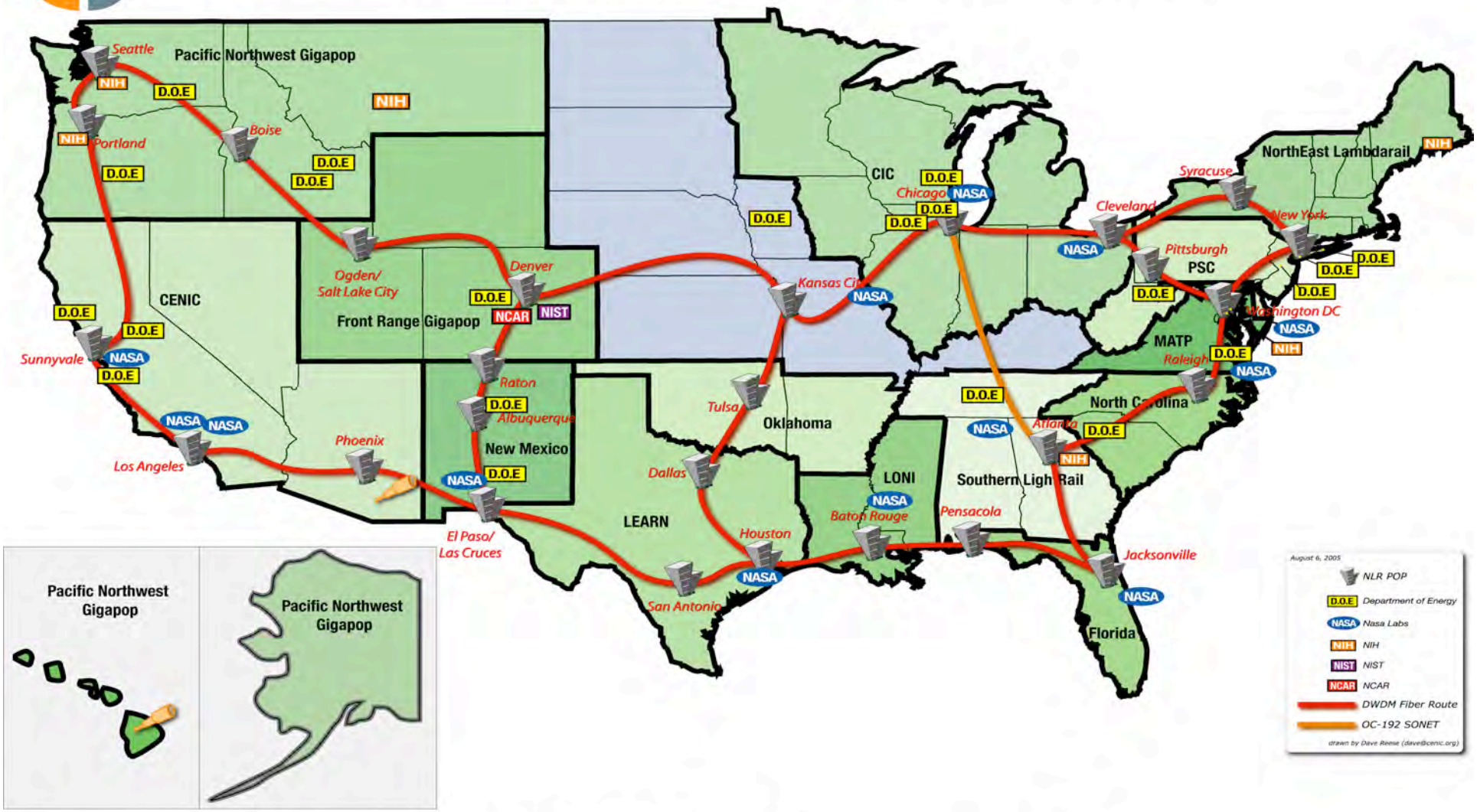
GSFC L-Net Configurations at McLean and Greenbelt



High Performance Networking and Remote Data Access
GSFC L-Net for NCCS and Science Buildings



National LambdaRail Architecture



For more information regarding NLR see http://www.nlr.net or contact info@nlr.net

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Previous and/or On-Going Applications

- Multi-channel Collaboration/Video Streaming Technologies
  - Scalable Adaptive Graphics Environment (SAGE) (http://www.evl.uic.edu/cavern/sage)
  - HDTV-over-IP
  - Demonstrations of 21st Century National-Scale Team Science (http://www.calit2.net/newsroom/release.php?id=660)
- 3D HDTV-over-IP
  - 3D Multichannel Networked System via NASA SBIR FY06 Phase2 awardee Physical Optics Corporation
  - Live 3D HDTV multi-Gbps real-time data streaming from GSFC to holographic display at iGrid2005 as the US130/Real-Time_True-3D_Visualization exhibitor (http://www.igrid2005.org/program/applications/vizservices_3dviz.html)

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Previous and/or On-Going Applications

- Enabling e-VLBI real-time data flows from GGAO to MIT/Haystack (http://web.haystack.mit.edu/e-vlbi/evlbi.html)
- Prototyping of Earth System Modeling Framework (ESMF)-based cross-organization coupling of climate models over a high speed network (http://cisto.gsfc.nasa.gov/L-Netpdfs/sc05_esmf_demo_v5.pdf)
- Evaluating SAN-over-IP and distributed shared file system applicability to enhancing science data flows
  - NCCS' participation in the Data Intensive Computing Environment (DICE) Project (http://www.avetec.org/dice)
  - NCCS data portal environment
  - McCall et al, "A framework for Managing Inter-site Storage Area Networks using Grid Technologies" (http://romulus.gsfc.nasa.gov/msst/conf2006/Papers/2006-025-McCall.pdf)

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Future Plans (partial list)

- New NGC(Colshire) and UMBC DWDM connections to DRAGON
- Leverage existing DRAGON-provided 10-Gbps connection with Internet2's NLR/HOPI lambda
- Support plans identified in NASA NRA Proposals
  - "MAP Core Integration LambdaGrid Infrastructure" by Smarr (UCSD) et al to NASA's MAP NRA
  - "Brokering and Chaining Distributed Services and Data Using OptIPuter and the National Lambda Rail" by Ramapriyan (GSFC) et al to NASA's ROSES NRA
  - "Enabling NASA Applications Across Heterogeneous High Performance Networks" by Habib (CUNY) et al to NASA NNH05ZDA001N-Applied Information Systems Research (a.k.a. ROSES:D3)
- Extend GSFC's existing10 Gbps L-Net to additional GSFC buildings, computers, and users; increase the number and type of GSFC science/exploration research projects that benefit from the increased throughput performance that multi-wavelength optical networking can provide
- Expand SAN-over-IP testing: intra-GSFC, between GSFC-UMCP & GSFC-ARC & …

NLR/GSFC Applications: Hurricane Prediction

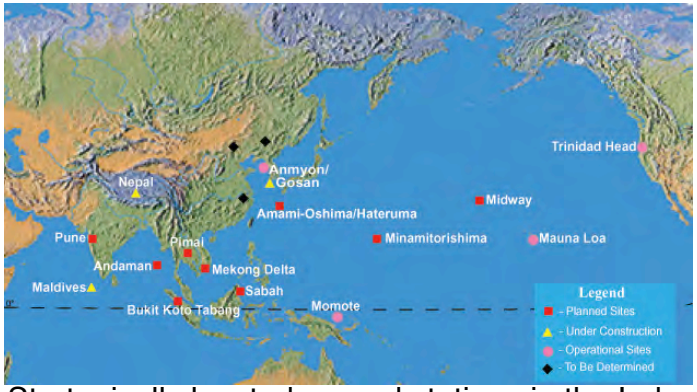
- The NASA Finite-Volume General Circulation Model (fvGCM) has been producing real-time, high-resolution (~25 km) weather forecasts focused on improving hurricane track and intensity forecasts.
- During the active 2004 Atlantic hurricane season, the fvGCM provided landfall forecasts with an accuracy of ~100 km up to 5 days in advance.
- The 50–100 Mbps throughput available between fvGCM users at GSFC and the Columbia supercomputer at ARC greatly hindered carrying out time-critical simulations of the hurricanes that devastated Florida.
- The 10 Gbps NLR access will enable remote, 3D visualization analysis as soon as forecast variables become available.
- Key Contacts: Ricky Rood, Bob Atlas, Horace Mitchell, GSFC; Chris Henze, ARC.

In an fvGCM forecast, Hurricane Frances makes landfall on the Gulf Coast of Florida while Hurricane Ivan intensifies in the tropical Atlantic. Visualization by J. Williams, GST.

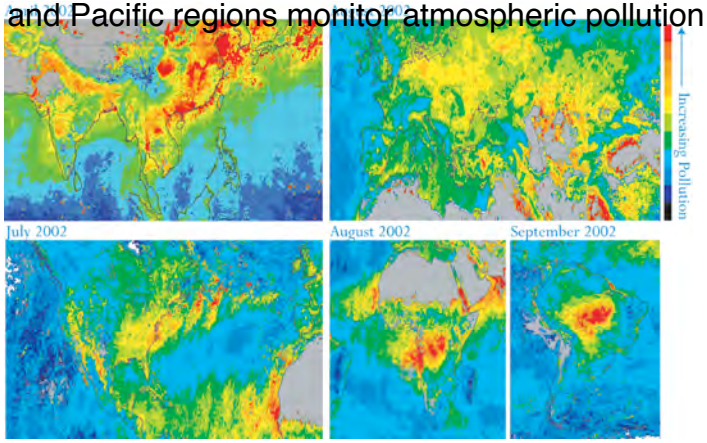
http://fvnwp.gsfc.nasa.gov

NLR/GSFC Applications: Global Aerosols

- Project Atmospheric Brown Clouds (ABC) is an international effort to discover and analyze areas of brown colored atmosphere to learn how dust and pollution particles are transported and what impacts they have on the environment, climate, agricultural cycles, and quality of life.
- GSFC and the Scripps Institution of Oceanography (SIO) are planning a collaboration to predict the flow of aerosols from Asia across the Pacific to the U.S. on timescales of days to a week.
- GSFC will provide an aerosol chemical tracer model (GOCAR) embedded in a high-resolution regional model (MM5) that can assimilate data from Indo-Asian and Pacific ground stations, satellites, and aircraft.
- Remote computing and analysis tools running over the NLR will enable acquisition and assimilation of the Project ABC data.
- Key Contacts: Yoram Kaufman, William Lau, GSFC; V. Ramanathan, Chul Chung, SIO.



Strategically located ground stations in the Indo-Asian and Pacific regions monitor atmospheric pollution.

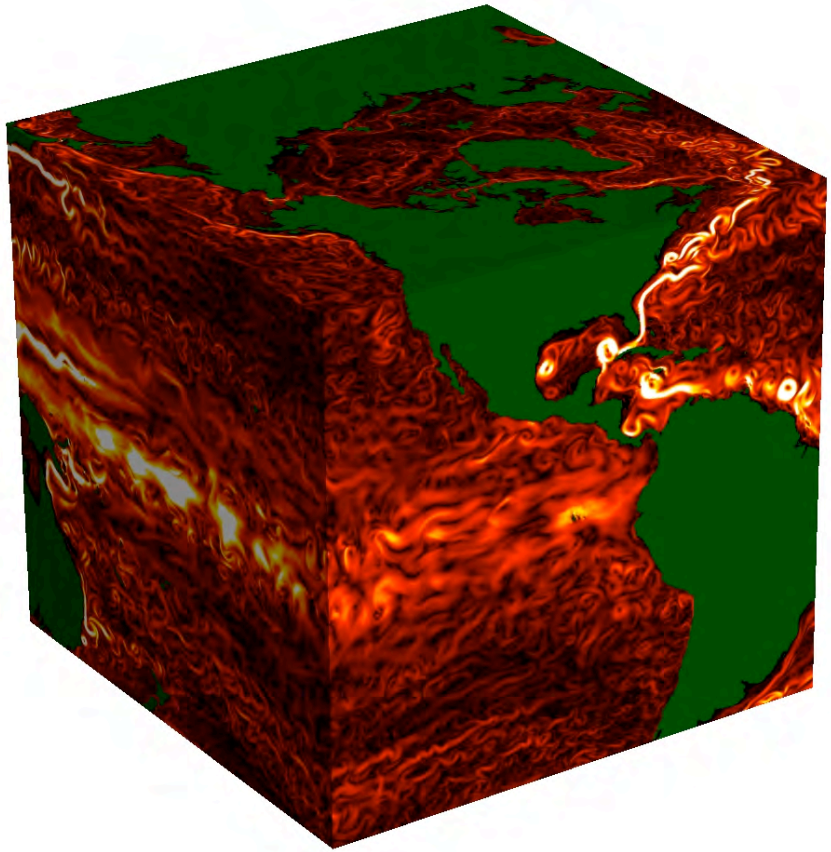


The global nature of brown clouds is apparent in analysis of NASA MODIS Data. Research by V. Ramanathan, C. Corrigan, and M. Ramana, SIO.

http://www-abc-asia.ucsd.edu

NLR/GSFC Applications: Remote Viewing and Manipulation of Large Earth Science Data Sets

- Remote viewing and manipulation of data sets at GSFC and JPL is needed to support EOSDIS and Earth system modeling.
- GSFC's EOSDIS Clearing House (ECHO) and JPL's GENESIS prototype science analysis system (iEarth) will become connected over the NLR. The link will enable comparison of hundreds of terabytes of data, generating large, multi-year climate records.
- Initial work will focus on the Estimating the Circulation and Climate of the Ocean (ECCO) modeling team. Besides ready access to the NLR, the team will need versatile subsetting and other data manipulation functions to reduce compute and bandwidth requirements as well as a set of Grid-accessible statistical analysis and modeling operators to refine and validate the ECCO models.
- Key Contacts: ECHO metadata gateway team, GSFC; GENESIS team, led by Tom Yunck, JPL.

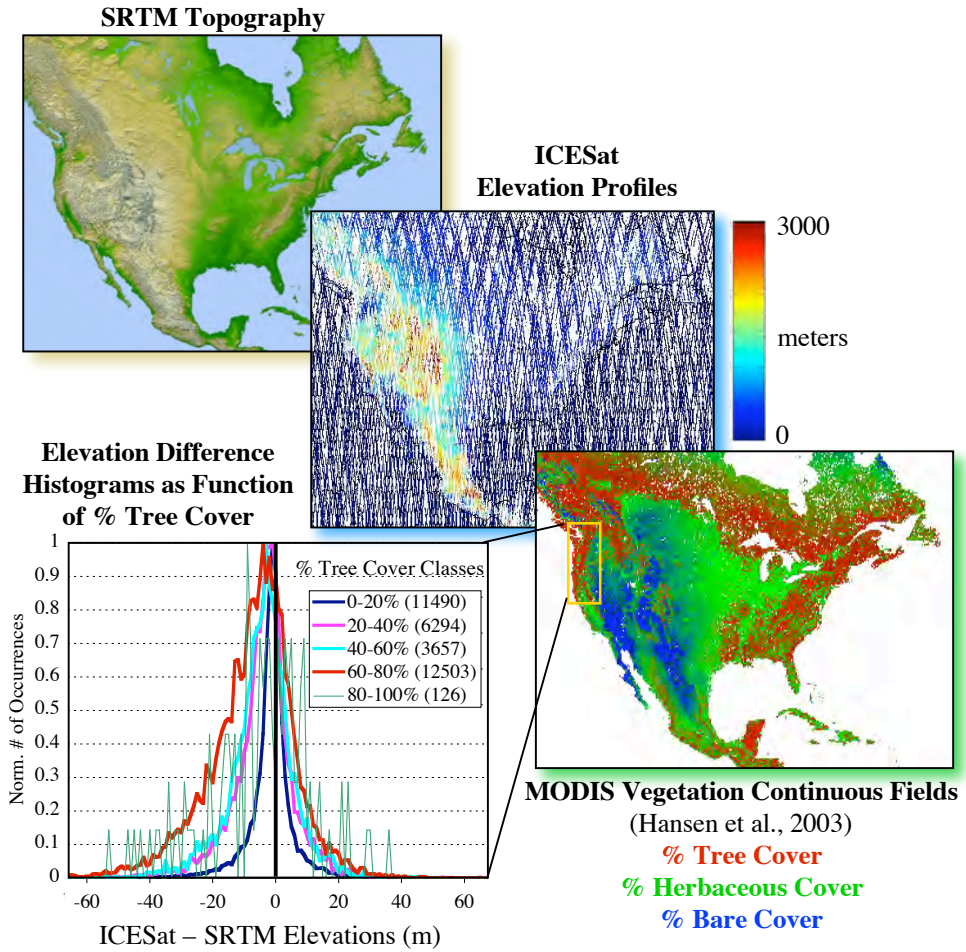


Near-surface (15-m) ocean current speed from an eddy-permitting integration of the cubed-sphere ECCO ocean circulation model. Research by JPL and MIT. Visualization by C. Henze, Ames.

http://www.ecco-group.org

NLR/GSFC Applications: Integration of Laser and Radar Topographic Data with Land Cover Data

- NASA has executed two advanced missions to create an accurate high-resolution topographic model of the Earth: the Shuttle Radar Topography Mission (SRTM) and ICESat, with its Geoscience Laser Altimeter System (GLAS).
- The agency now has the opportunity to merge the two data sets, using SRTM to achieve good coverage and GLAS to generate calibrated profiles. Proper interpretation requires extracting land cover information from Landsat, MODIS, ASTER, and other data archived in multiple DAACs.
- Use of the NLR and local data mining and subsetting tools will permit systematic fusion of global data sets, which are not possible with current bandwidth.
- Key Contacts: Bernard Minster, SIO; Tom Yunck, JPL; Dave Harding, Claudia Carabajal, GSFC.



http://icesat.gsfc.nasa.gov
http://www2.jpl.nasa.gov/srtm
http://glcf.umiacs.umd.edu/data/modis/vcf

High speed networking and Grid computing for large-scale simulation in geodynamics

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[1] NASA Goddard Space Flight Center, [2] JCET, UMBC, [3] Northrop Grumman IT/TASC, [4] Bowie State University, [5] Raytheon ITSS, [6] INDUSCORP

Introduction

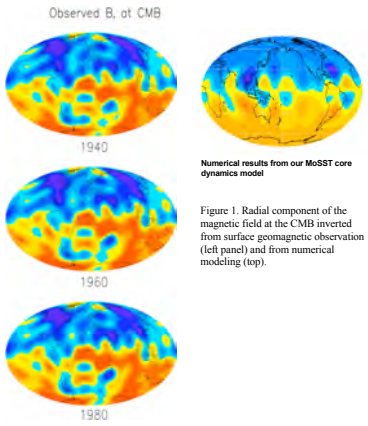
Now large-scale simulation has been wide-spread in many disciplines of solid Earth science research. A typical numerical test in the simulation can easily reach 10^{13} flops and beyond.

One such research problem that we are working on now is to establish a framework on predicting geomagnetic secular variation on decadal and longer time scales, utilizing surface geomagnetic/paleomagnetic records and our MoSST core dynamics model (Figure 1). In this approach, model forecast results and observations are weighted to provide initial state for assimilation (Figure 2). Typically 30 independent numerical tests are necessary for a reasonable ensemble size. This could easily require a computing cycle on orders of petaflops and larger.

A single super-computing facility for such studies is not an optimal choice, due to many limitations, in particular those on user management and administration. But it is relatively easy for users (researchers) to manage because of a unified system environment.

Grid computing can be a much better choice so that independent numerical tests can be carried out independently on different systems. However, researchers (users) have to deal with heterogeneous systems and other problems, such as those on network communication.

In this poster, we discuss our activities in GSFC on application of grid computation to geodynamics modeling.



Numerical results from our MoSST core dynamics model

Figure 1. Radial component of the magnetic field at the CMB inverted from surface geomagnetic observation (left panel) and from numerical modeling (top).

Geomagnetic data assimilation

$$\mathbf{x}^a = \mathbf{x}^f + \mathbf{K}\left(\mathbf{x}^o - \mathbf{H}\mathbf{x}^f\right)$$

$\mathbf{X}^a$: Assimilation solution
$\mathbf{X}^f$: Forecast solution
$\mathbf{X}^o$: Observation data

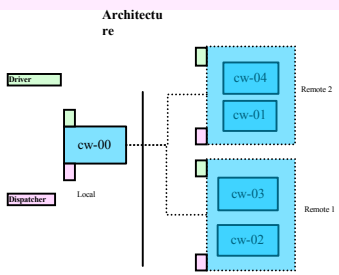
Figure 2. Mathematical foundation of data assimilation. The common gain **K** depends on knowledge of error statistics of observations and of models. If ensemble Kalman-filter approach is applied. An ensemble size of at least 30 (i.e. independent tests) is required.

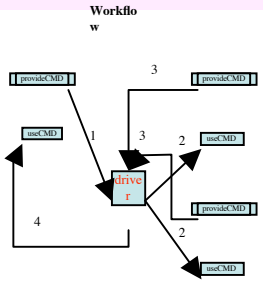
Prototype on MoSST simulation with independent systems

The objective of this prototype work is to test operability of executing our MoSST core dynamics model on independent computing systems. Individual computing units are slated out from selected components of our beowulf system to mimic independent computing environment. The prototype program for grid computing is built upon xcat3 framework (based on java/python). See Figure 3 for conceptual layout of our prototype experiment.

The sample script and the execution process are shown in Figure 4.

Our prototype experiment is very successful. With this experiment, we can proceed further our test on real remote systems. Also with this experiment, we can identify the needs from the user's considerations on supporting environment and other middleware that makes grid computing "friendly" .





System configuration

OS: Fedora core 2; MPICH-1.2.5.2; Intel Fortran Compiler; Java 2
PE: Dual Intel Xeon, 2.4 Ghz, 1 GB, 1 GigEthernet

Figure 3. Prototype layout

```
import sys
import cca

from jarray import zeros

from java.lang import System
from java.lang import String, Object
# get the absolute location for XCAT

# create the TypeMap for the user component
# create component wrappers
geo1Provides = cca.createComponentWrapper("geo1Provider",
geo1ProviderMap)
geo2Provides = cca.createComponentWrapper("geo2Provider",
geo2ProviderMap)
#uses = cca.createComponentWrapper("user", userMap)
# assign a machine name
cca.setMachineName(uses, "cw-00")
cca.setMachineName(provides, "cw-00")
cca.setMachineName(geo1Provides, "cw-03")
cca.setMachineName(geo2Provides, "cw-04")

# set a creation mechanism to in-process
cca.setCreationMechanism(uses, "local")
cca.setCreationMechanism(provides, "local")
cca.setCreationMechanism(geo1Provides, "ssh")
cca.setCreationMechanism(geo2Provides, "ssh")

# connect their ports
cca.connectPorts(uses, "dispatchUsesPort", provides,
"dispatchProvidesPort")
cca.connectPorts(uses, "geo1UsesPort", geo1Provides,
"geo1ProvidesPort")
cca.connectPorts(uses, "geo2UsesPort", geo2Provides,
"geo2ProvidesPort")
# invoke the method
cca.invokeMethodOnComponent(uses,

                            portClassName,
                            portType,
                            methodName,
                            methodParams)
```

Figure 4. Prototype Operation Script (left) and Screen Caption (right)

Discussions

1. Our research on geomagnetic data assimilation can greatly benefit from grid computing.
2. Our prototype experiment is successful and can be readily expanded to systems with identical settings and SSH communication protocol.
3. Our prototype experiment is limited in many areas, such as handling network communication between independent systems (e.g. instant feedback of remote systems to host systems), heterogeneous environment (e.g. prior knowledge on participating systems is necessary), authentication (e.g. prototype cannot handle high level access security requirement). Therefore, further experiment is needed to improve our work, such as integrating our work with other (developed and developing) middleware handling the problems.

Related work at GSFC

There are parallel, but related research going on in GSFC on networking and software development. These research activities are updated in http://esdcd.gsfc.nasa.gov/LNetImplement.html. Recent overview of GSFC research activities is given by Dr. M. Halem and can be found in http://esdcd.gsfc.nasa.gov/L-Netpdfs/ESSAAC_MHpres9904.pdf. Some of the activities listed in the report are shown in Figures, 5 and 6. These activities work towards establishing 21st century cyber infrastructure for large-scale scientific teamwork based on fast network.

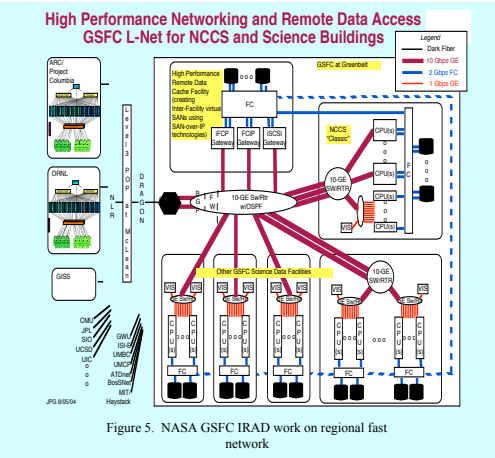


Figure 5. NASA GSFC IRAD work on regional fast network

An Example of Application Requiring L-NET

Drs. Paul Houser and Mike Bosilovich of Code 970 are collaborating with Dr. John Roads of SIO on the **Coordinated Earth Observing Program (CEOP)** accessing 300TB's of Observational Data in Tokyo and 100TB's of Model Assimilation Data in MPI in Hamburg Germany and analyzing remote data using GRaD-DODS at these sites over the NLR and Starlight.

Figure 6.

GSFC High End Computer Network (HECN) Project's Research Partners and Collaborators

- *DRAGON Project: http://dragon.maxgigapop.net/twiki/bin/view/DRAGON/WebHome*
  - *PI: Jerry Sobieski (UMCP)*
  - *GSFC L-Net on DRAGON network diagram: http://dragon.maxgigapop.net/twiki/bin/view/DRAGON/Network*
- *e-VLBI Project: http://web.haystack.mit.edu/e-vlbi/evlbi.html*
  - *PI: Alan Whitney (MIT/Haystack)*
  - *GSFC L-Net on e-VLBI network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/SC04_eVLBI_network.pdf*
- *GLIF: http://www.glif.is/*
  - *Chair: Kees Neggers (SURFnet)*
  - *GLIF network diagrams: http://www.glif.is/publications/#maps*
- *NGC IT Sector: http://www.it.northropgrumman.com/index.html*
  - *PI: Brice Womack (NGC)*
  - *GSFC L-Net on NGC IT Sector Colshire network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/DRAGON_NGC_030606.pdf*
- *NLR: http://www.nlr.net/*
  - *CEO: Tom West (NLR)*
  - *NLR network diagram: http://www.nlr.net/infrastructure/*
- *NREN Project: http://www.nren.nasa.gov/*
  - *PM: Ken Freeman (ARC)*
  - *GSFC L-Net/SEN on NREN network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/CENIC2006_13_mfoster_excerpts.pdf*
- *OptIPuter Project: http://www.optiputer.net/*
  - *PI: Larry Smarr (UCSD)*
  - *GSFC L-Net on OptIPuter network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/SMARR-OptIPuter-AHM-gold.pdf*
- *TeraFlow Testbed Project: http://www.teraflowtestbed.net/*
  - *PI: Robert Grossman (UIC)*
  - *GSFC L-Net on TeraFlow Testbed network diagram: http://www.ncdm.uic.edu/maps/index.jpeg*

Inputs on Advanced R&E Networks
-- Limited to Pat's Perspective --

Special Acknowledgements

GSFC Internal

- **High End Computer Network Team**
  - **Bill Fink/606.1**
  - **Kevin Kranacs/585**
  - **Paul Lang/ADNET/606.1**
  - **Aruna Muppalla/ADNET/606.1**
  - **Jeff Martz/CSC/606.2**
  - **Mike Steffenelli/CSC/606.2**
  - **Kevin Fisher/586/UMBC coop**
- **ESDIS Network Prototyping Lab**
  - **George Uhl/SWALES/423**
- **ESTC Computing Technology Project**
  - **PM: Jim Fischer/606**
- **IT Pathfinder Working Group**
  - **Chair: Dr. Milton Halem/Emeritus & UMBC**
- **Thunderhead Cluster**
  - **John Dorband/696**

GSFC External

- **National LambdaRail**
  - **CEO: Tom West**
  - **Net Eng Lead: Debbie Montano**
- **OptIPuter Project (NSF-funded)**
  - **PI: Dr. Larry Smarr/UCSD**
  - **Co-PI: Dr. Tom DeFanti/UIC**
  - **PM: Maxine Brown/UIC**
  - **UCSD Net Eng: Greg Hidley, Arron Chin, Phil Papodopolos**
  - **UIC Net Eng: Alan Verlo, Linda Winkler**
- **DRAGON Project (NSF-funded)**
  - **PI: Jerry Sobieski/UMCP**
  - **Co-I: Tom Lehman/USC-ISI/E**
  - **Net Eng: Chris Tracy/UMCP**
- **NASA Research and Education Network**
  - **DPM: Kevin Jones/ARC**

Inputs on Advanced R&E Networks
-- Limited to Pat's Perspective --

GSFC Lambda Network Project Website

- http://cisto.gsfc.nasa.gov/IRAD_Lambda.html
  - **Designs**
    - GSFC Local Network Part (i.e., within GSFC)
    - Regional Network Part (i.e., between GSFC in Greenbelt, MD, & Level3 POP in McLean, VA, typically involving the DRAGON optical network)
    - Transcontinental Network Part (i.e., use of NLR, GSFC 10-GE switch & workstations in the Level3 POP in McLean, VA, & remote end users/sites)
  - **Implementation Status**
    - GSFC Local Network Part
    - Regional Network Part
    - Transcontinental Network Part
  - **Presentations/Events in the News**
    - Eg: P. Gary's 18Feb05 presentation at GSFC's FY04 IRAD Colloquium <http://cisto.gsfc.nasa.gov/L-Netpdfs/FY04IRADGARY.pdf>
    - Live Demonstration of 21st Century National-Scale Team Science <http://www.calit2.net/articles/article.php?id=660>
  - **Related Links (e.g., DRAGON, HOPI, NLR, OptIPuter, …)**