"Analyzing Large Earth Data Sets: New Tools from the OptIPuter and LOOKING Projects"

Presentation to 3rd Annual GEON Meeting

Bahia Resort

San Diego, CA

May 5, 2005

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Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

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Abstract

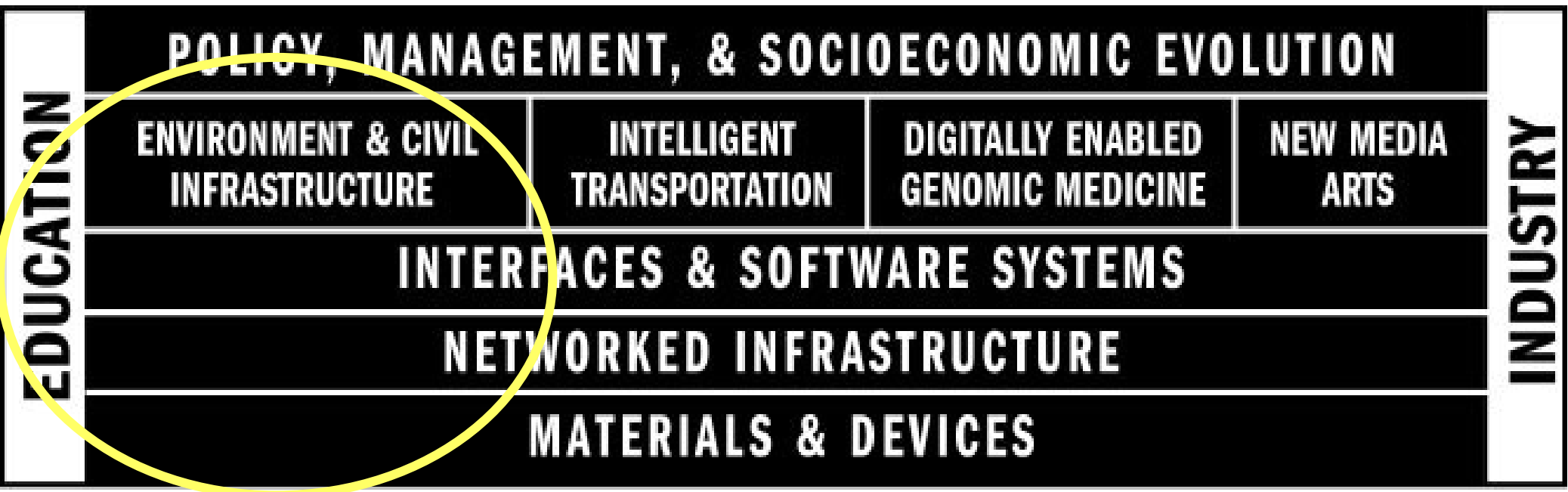
Earth and ocean sciences are powerful application drivers for extending the Grid to the LambdaGrid. In the NSF OptIPuter project, the Grid, which is defined on the best effort shared internet, is extended to dedicated 1 or 10 Gb/s optical circuits, thereby adding predictability to the network underpinning the Grid middleware. This project is driven by both medical and earth sciences, in particular, EarthScope, the Mars rovers, and large scale integration of a variety of earth sciences data. Much progress has been made in scalable visualization nodes for the end user, which have been distributed through the GeoWall Consortium. A newer NSF grant LOOKING is extending the OptIPuter to include an integration of Web and Grid Services for remote control of ocean observatory instruments. Ontology for the ocean sciences is a central part of the LOOKING project, with strong overlap with GEON. We look toward the future in which GEON will utlize some of these more advanced services, creating a unified ontology and middleware system for the earth and ocean sciences.

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Calit2 -- Research and Living Laboratories on the Future of the Internet

UC San Diego & UC Irvine Faculty
Working in Multidisciplinary Teams
With Students, Industry, and the Community



www.calit2.net

Two New Calit2 Buildings Will Provide a Persistent Collaboration "Living Laboratory"



- Over 1000 Researchers in Two Buildings
- International Conferences and Testbeds
- Will Create New Laboratory Facilities
  - SDSC/Calit2 Synthesis Center
  - SDSC Data Group



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California Provided $100M for Buildings
Industry Partners $85M, Federal Grants $250M

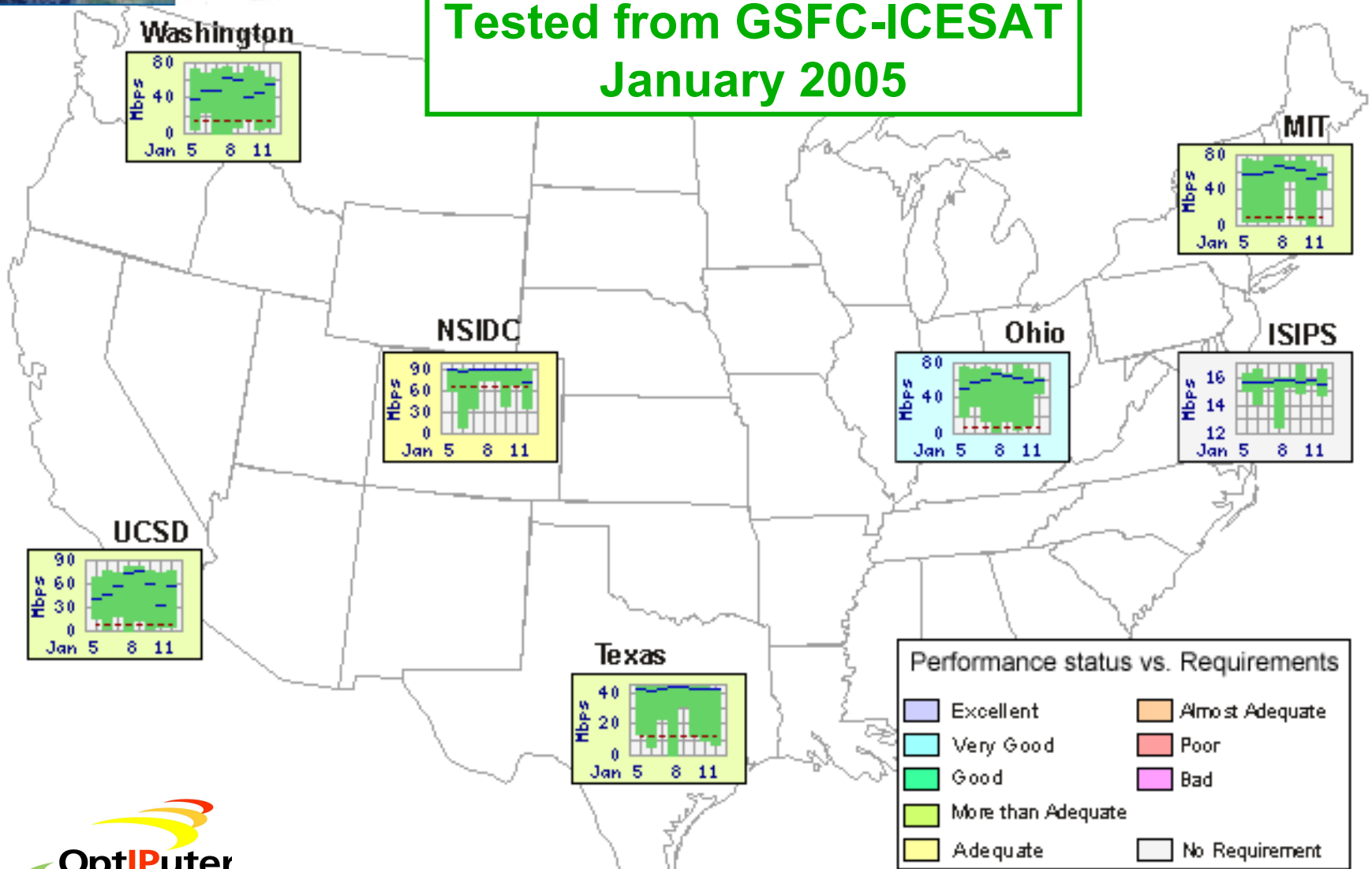
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Challenge: Average Throughput of NASA Data Products to End User is Only < 50 Megabits/s



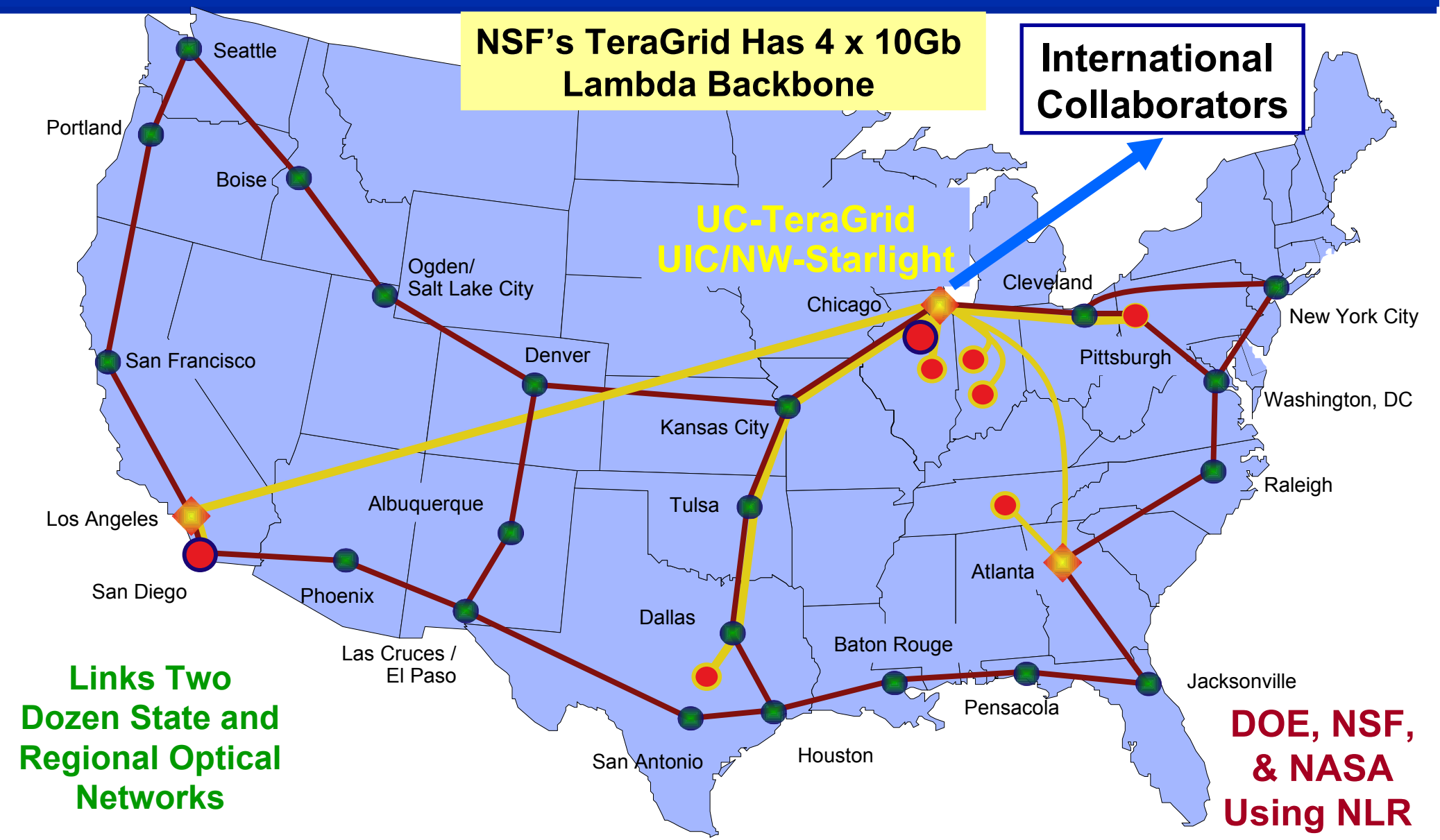
ENSIGHT Active Testing ICESat Destinations

Tested from GSFC-ICESAT January 2005



http://ensight.eos.nasa.gov/Missions/icesat/index.shtml

National Lambda Rail (NLR) and TeraGrid Provides Researchers a Cyberinfrastructure Backbone



Lambdas Provide Global Access to Large Data Objects and Remote Instruments

Global Lambda Integrated Facility (GLIF)
Integrated Research Lambda Network



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Visualization courtesy of
Bob Patterson, NCSA

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The Networking Double Header of the Century Will Be Driven by LambdaGrid Applications

Maxine Brown, Tom DeFanti, Co-Organizers



iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY



www.startap.net/igrid2005/

September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology



SC|05 Gateway to Discovery

Washington State Convention and Trade Center Seattle, WA
November 12-18 2005

http://sc05.supercomp.org

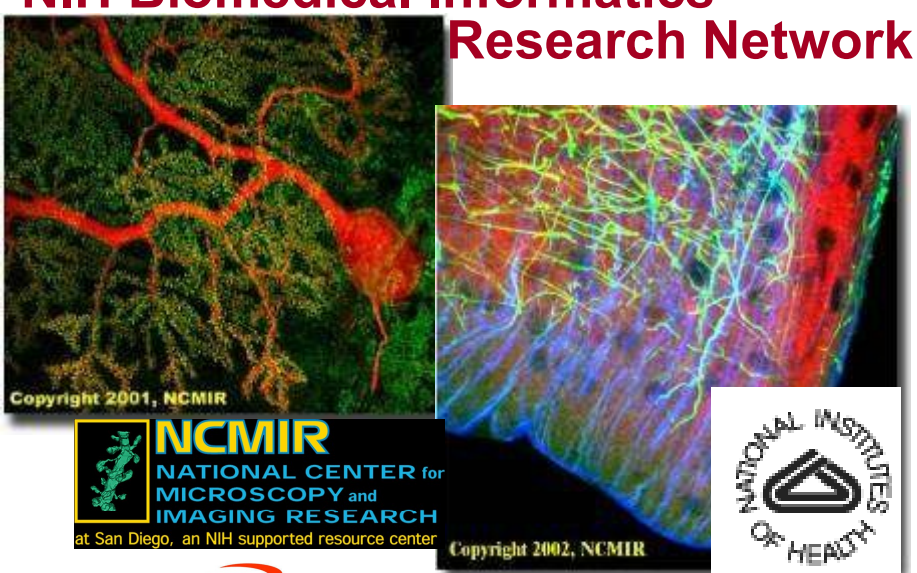
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The OptIPuter Project –
Creating a LambdaGrid "Web" for Gigabyte Data Objects

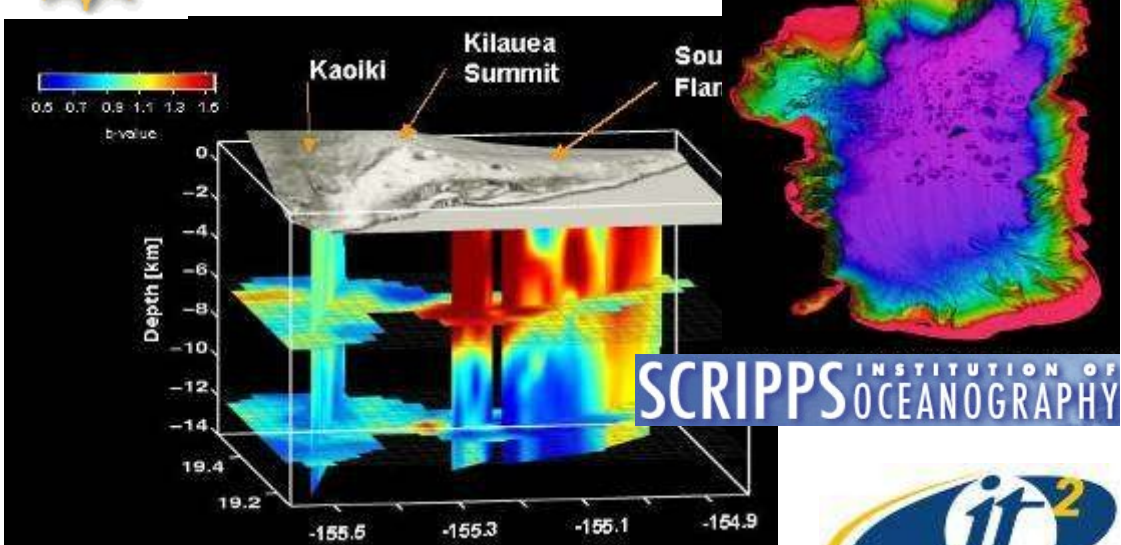
- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
  - Partnering Campuses: USC, SDSU, NW, TA&M, UvA, SARA, NASA
- **Industrial Partners**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- **$13.5 Million Over Five Years**
- **Linking User's Linux Clusters to Remote Science Resources**

NIH Biomedical Informatics Research Network



http://ncmir.ucsd.edu/gallery.html

NSF EarthScope and ORION



siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

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Optical Networking, Internet Protocol, Computer
Bringing the Power of Lambdas to Users

- **Complete the Grid Paradigm by Extending Grid Middleware to Control Jitter-Free, Fixed Latency, Predictable Optical Circuits**
  - One or Parallel Dedicated Light-Pipes
    - 1 or 10 Gbps WAN Lambdas
  - Uses Internet Protocol, But Does NOT Require TCP
  - Exploring Both Intelligent Routers and Passive Switches
- **Tightly Couple to End User Clusters Optimized for Storage, Visualization, or Computing**
  - Linux Clusters With 1 or 10 Gbps I/O per Node
  - Scalable Visualization Displays with OptIPuter Clusters
- **Applications Drivers:**
  - Earth and Ocean Sciences
  - Biomedical Imaging
  - Designed to Work with any Discipline Driver

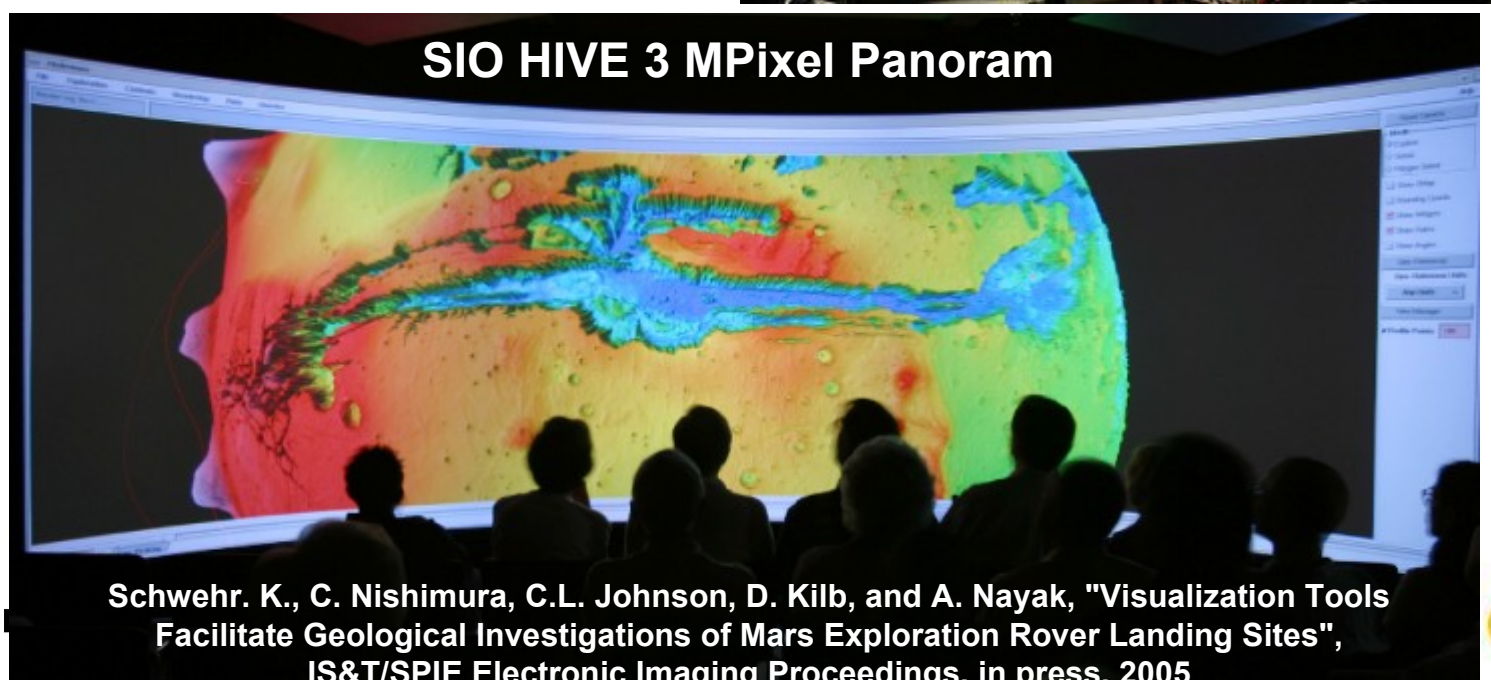
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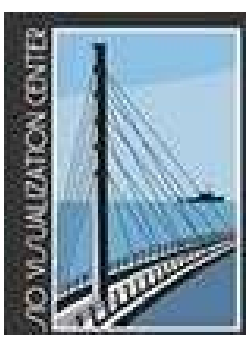
Earth and Planetary Sciences: High Resolution Portals to Global Earth Sciences Data





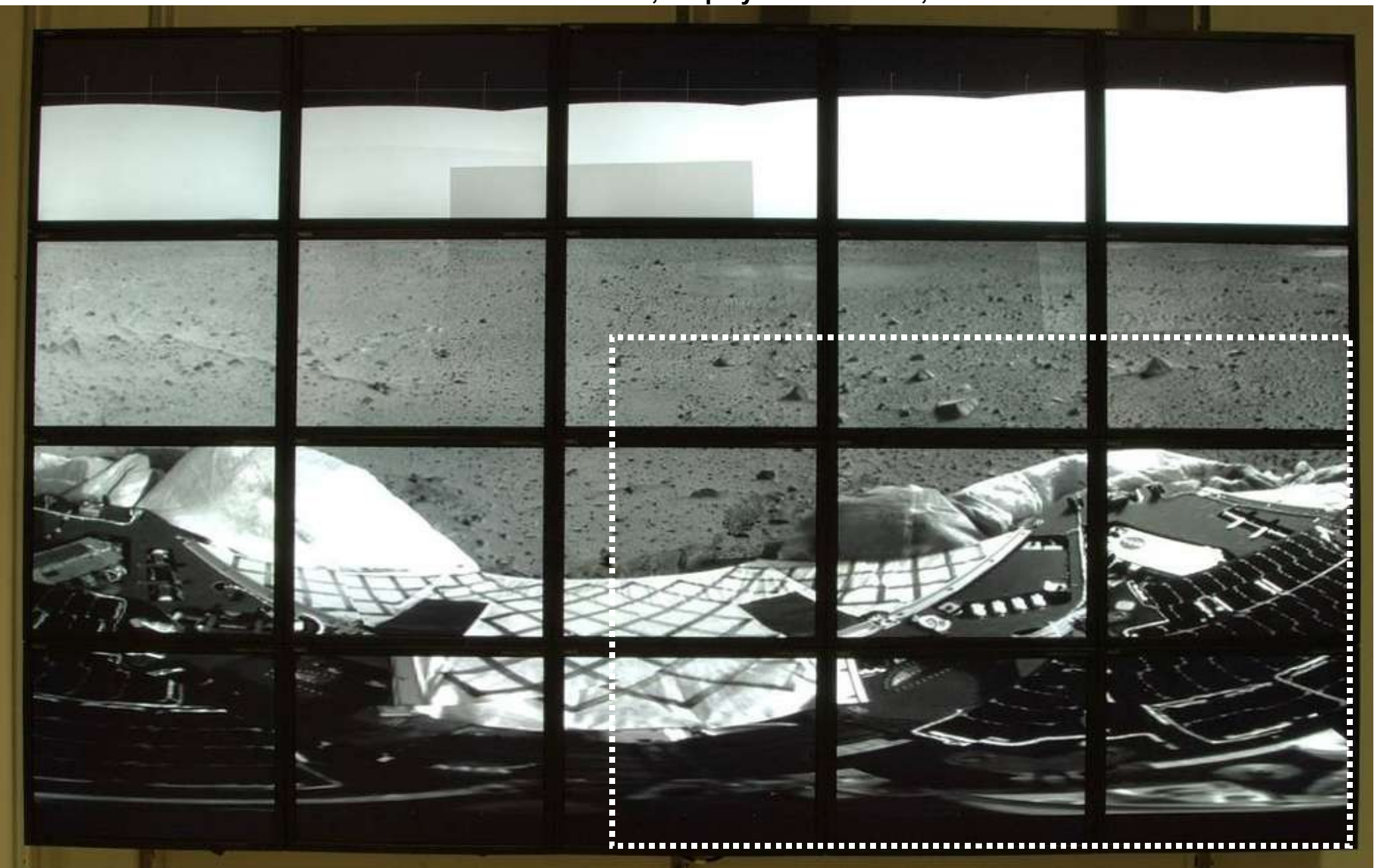


Schwehr. K., C. Nishimura, C.L. Johnson, D. Kilb, and A. Nayak, "Visualization Tools Facilitate Geological Investigations of Mars Exploration Rover Landing Sites", IS&T/SPIE Electronic Imaging Proceedings, in press, 2005



Tiled Displays Allow for Both Global Context and High Levels of Detail—150 MPixel Rover Image on 40 MPixel OptIPuter Visualization Node Display

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



Interactively Zooming In Using UIC's Electronic Visualization Lab's JuxtaView Software

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



Highest Resolution Zoom

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



High Resolution Aerial Photography Generates Images With 10,000 Times More Data than Landsat7

Landsat7 Imagery
100 Foot Resolution
Draped on elevation data





New USGS Aerial Imagery
At 1-Foot Resolution

~10x10 square miles of 350 US Cities
2.5 Billion Pixel Images Per City!

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Multi-Gigapixel Images are Available from Film Scanners Today

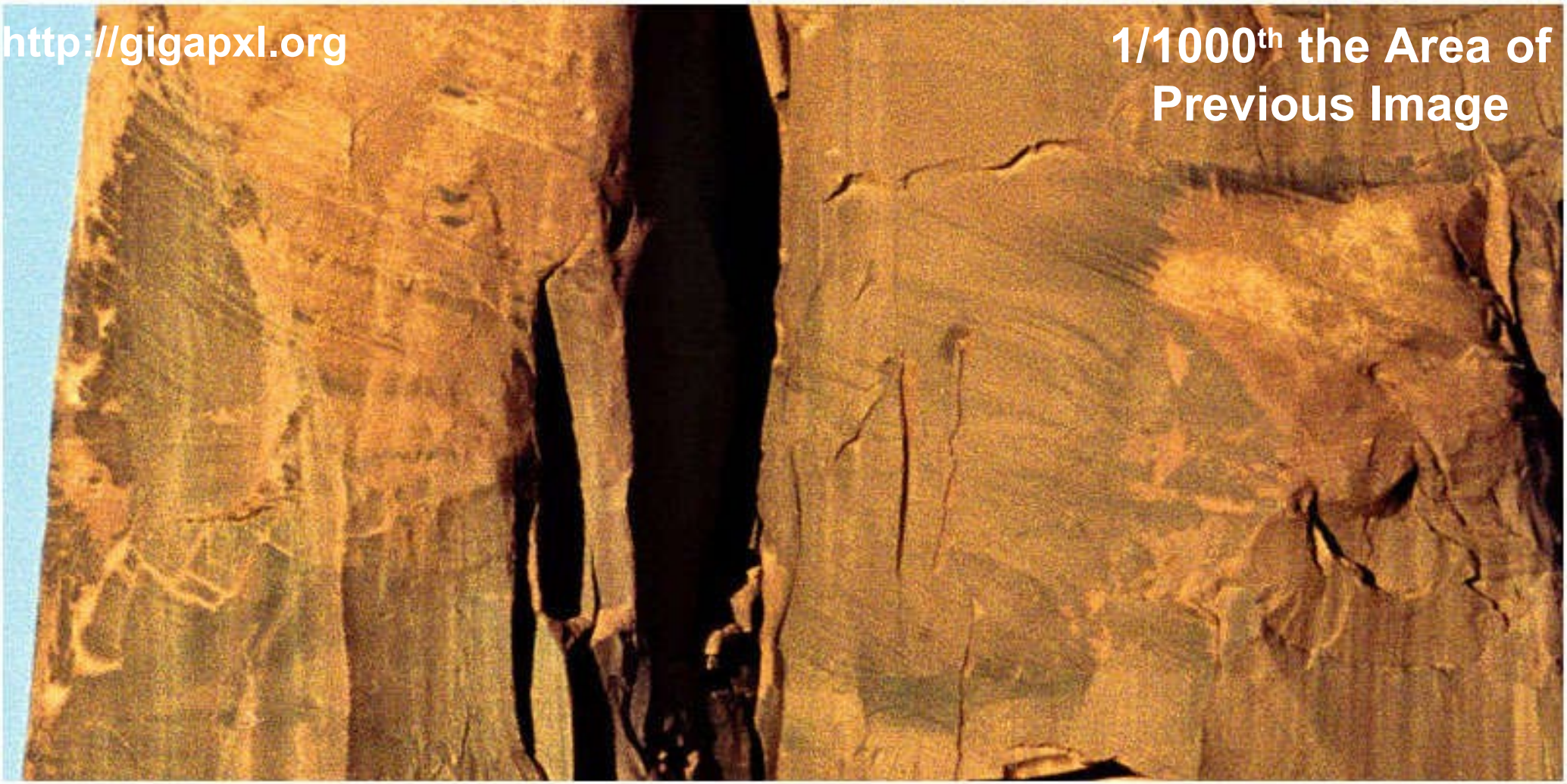


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The Gigapxl Project
http://gigapxl.org

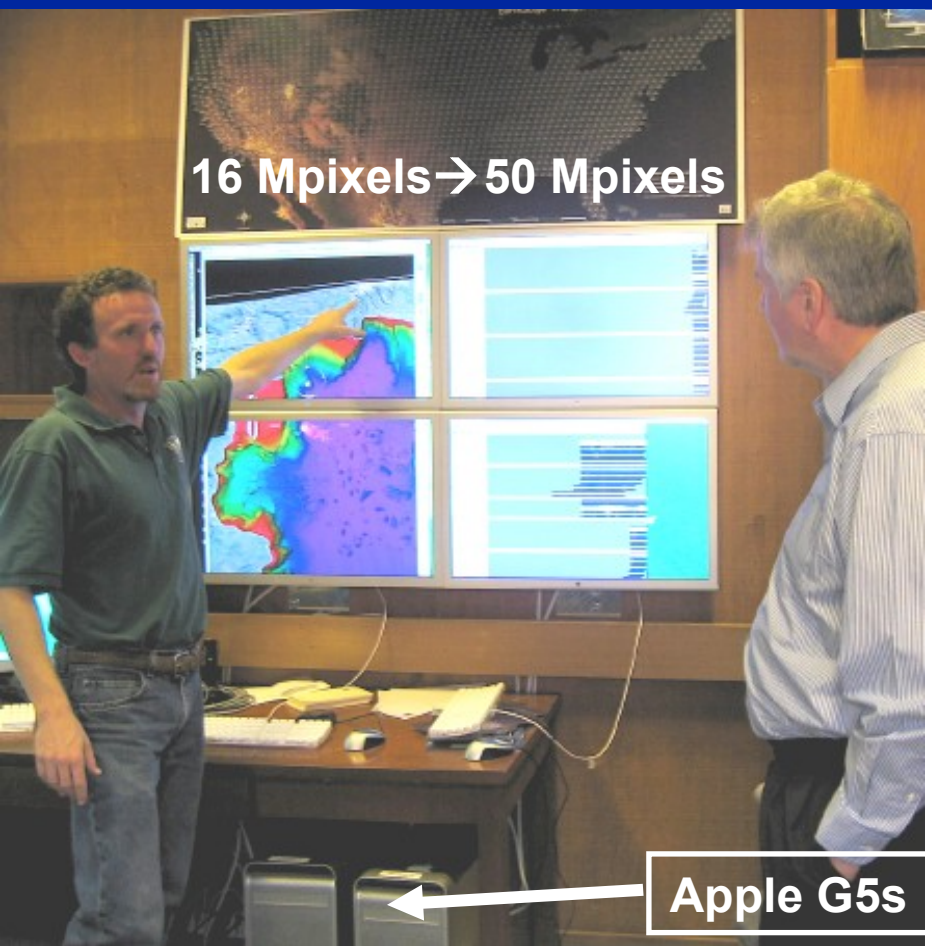
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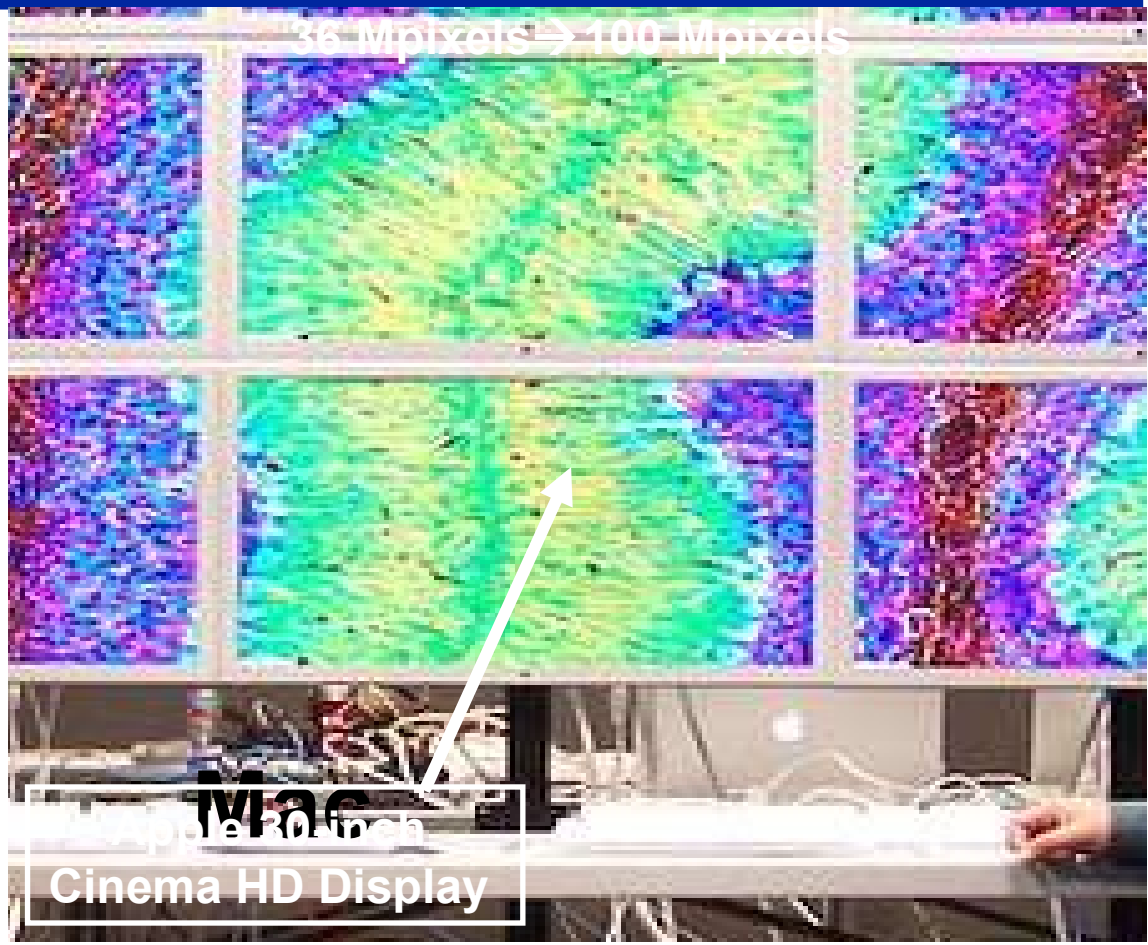
Large Image with Enormous Detail Require Interactive LambdaVision Systems



The OptIPuter Project is Pursuing Obtaining Some of these Images for LambdaVision 100M Pixel Walls

OptIPuter Scalable Displays Have Been Extended to Apple-Based Systems "iWall Driven by iCluster"





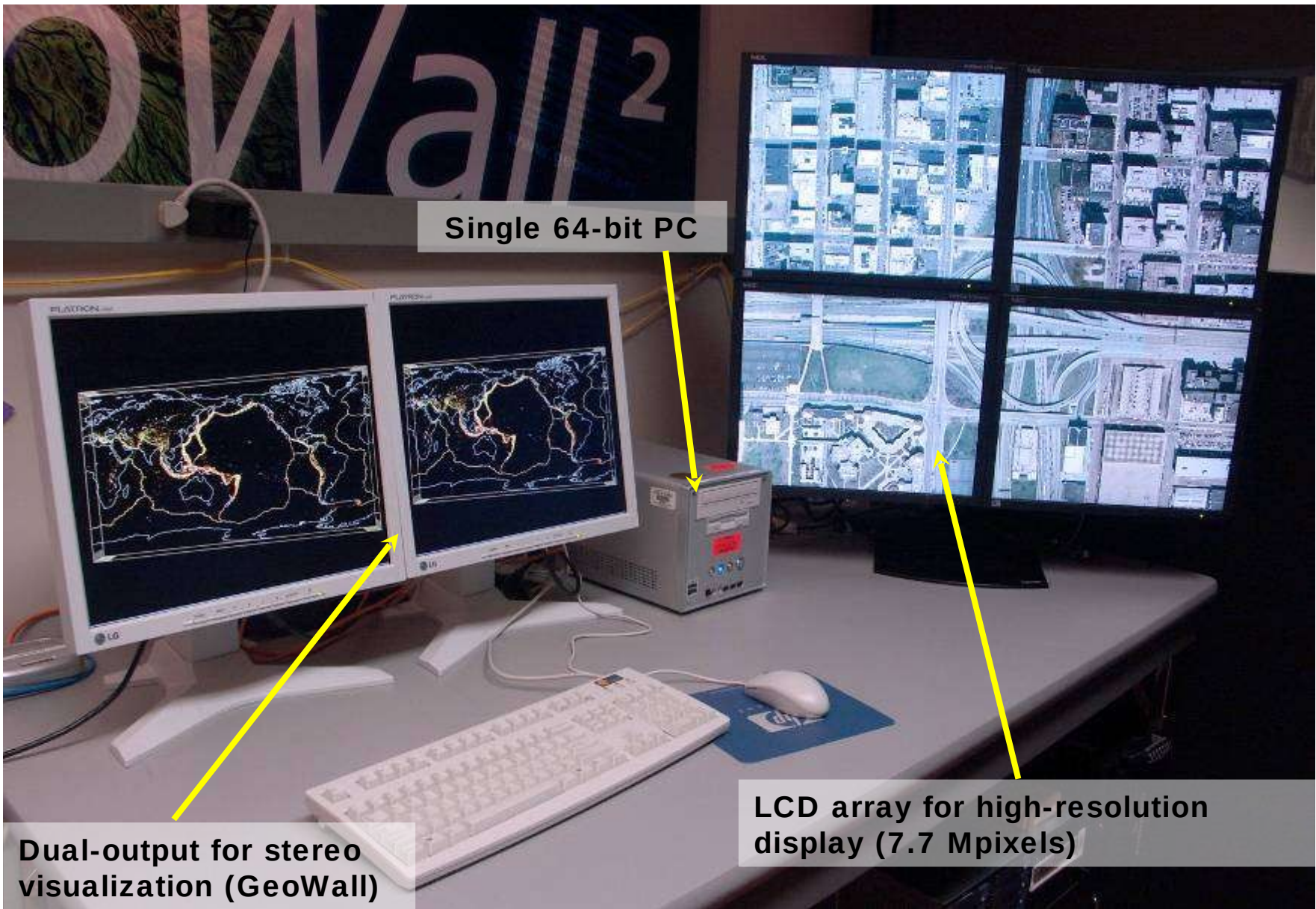
Source: Atul Nayak, SIO
Collaboration of
Calit2/SIO/OptIPuter/USArray

Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

See GEON Poster: iCluster : Visualizing USArray Data on a Scalable High Resolution Tiled Display Using the OptIPuter

Personal GeoWall 2 (PG2): Individual OptIPuter User Node

Demonstrated by EVL (UIC) at 4th GeoWall Consortium Meeting



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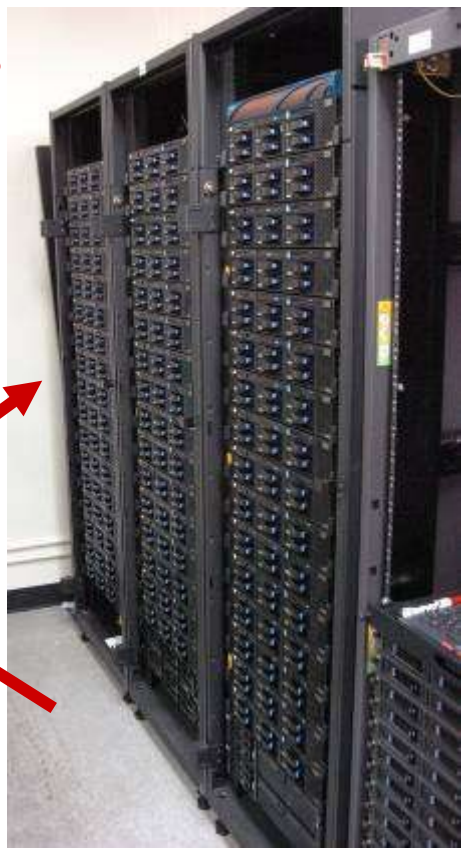
Campuses Must Provide Fiber Infrastructure to End-User Laboratories & Large Rotating Data Stores

SIO Ocean Supercomputer



UCSD Campus LambdaStore Architecture

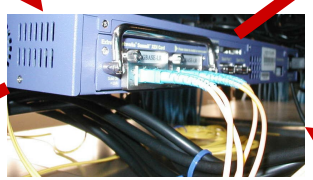
IBM Storage Cluster



Streaming Microscope







2 Ten Gbps Campus Lambda Raceway





Global LambdaGrid

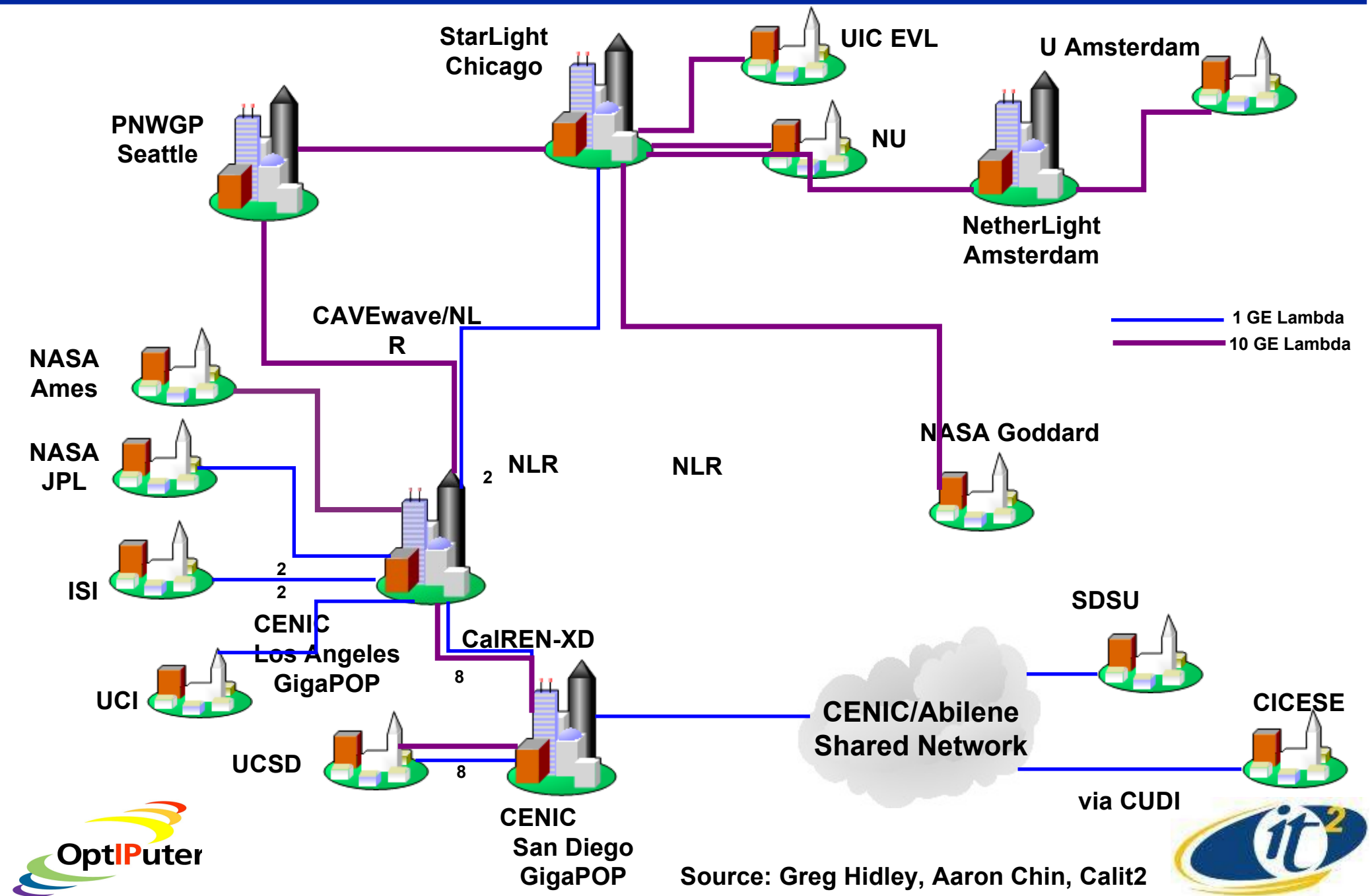


OptIPuter

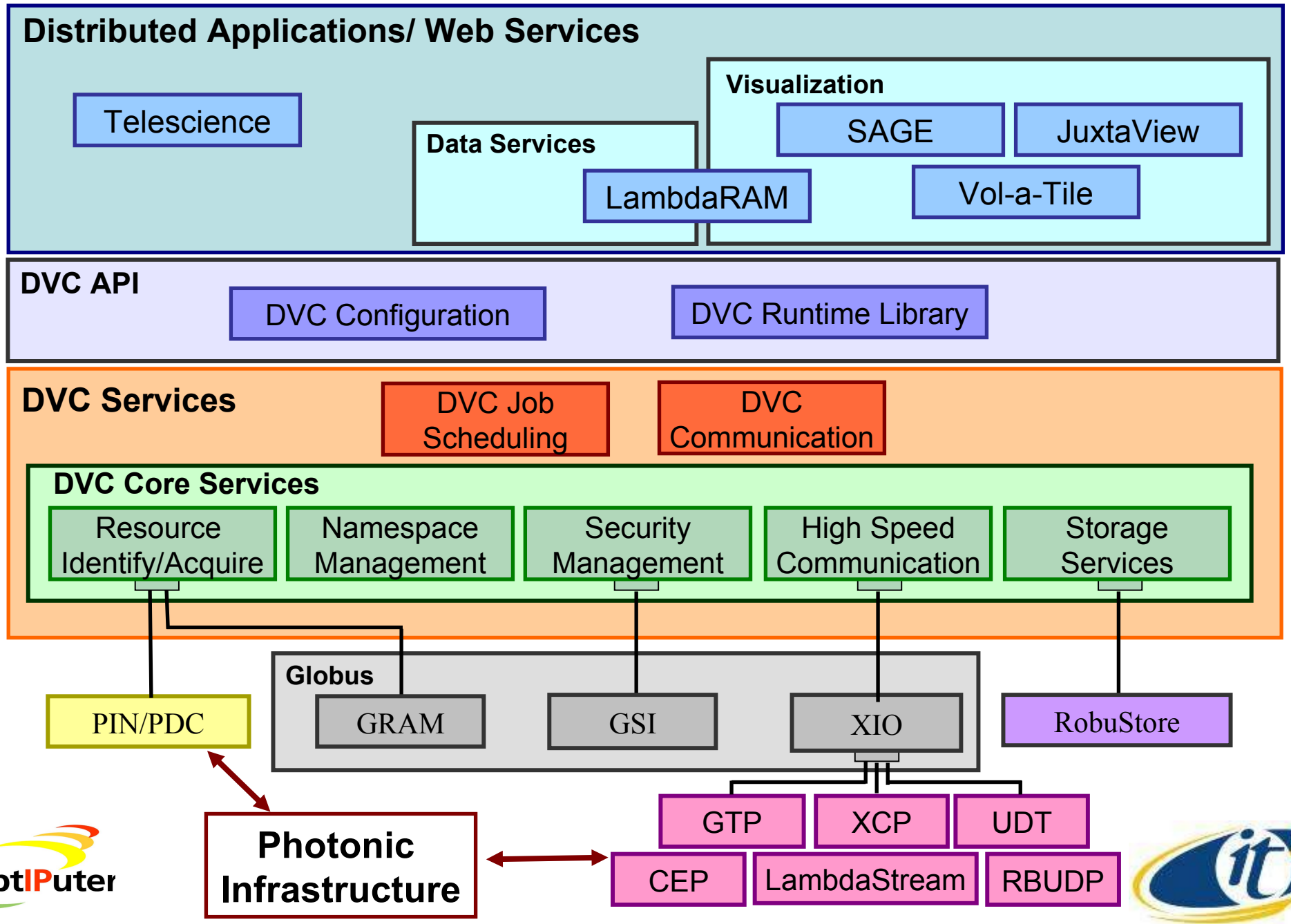
Source: Phil Papadopoulos, SDSC, Calit2

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The OptIPuter LambdaGrid is Rapidly Expanding



OptIPuter Middleware Architecture--
The Challenge of Transforming Grids into LambdaGrids



Interactive Retrieval and Hyperwall Display of Earth Sciences Images Using NLR

Enables Scientists To Perform Coordinated Studies Of Multiple Remote-Sensing Datasets

Source: Milt Halem & Randall Jones, NASA GSFC & Maxine Brown, UIC EVL





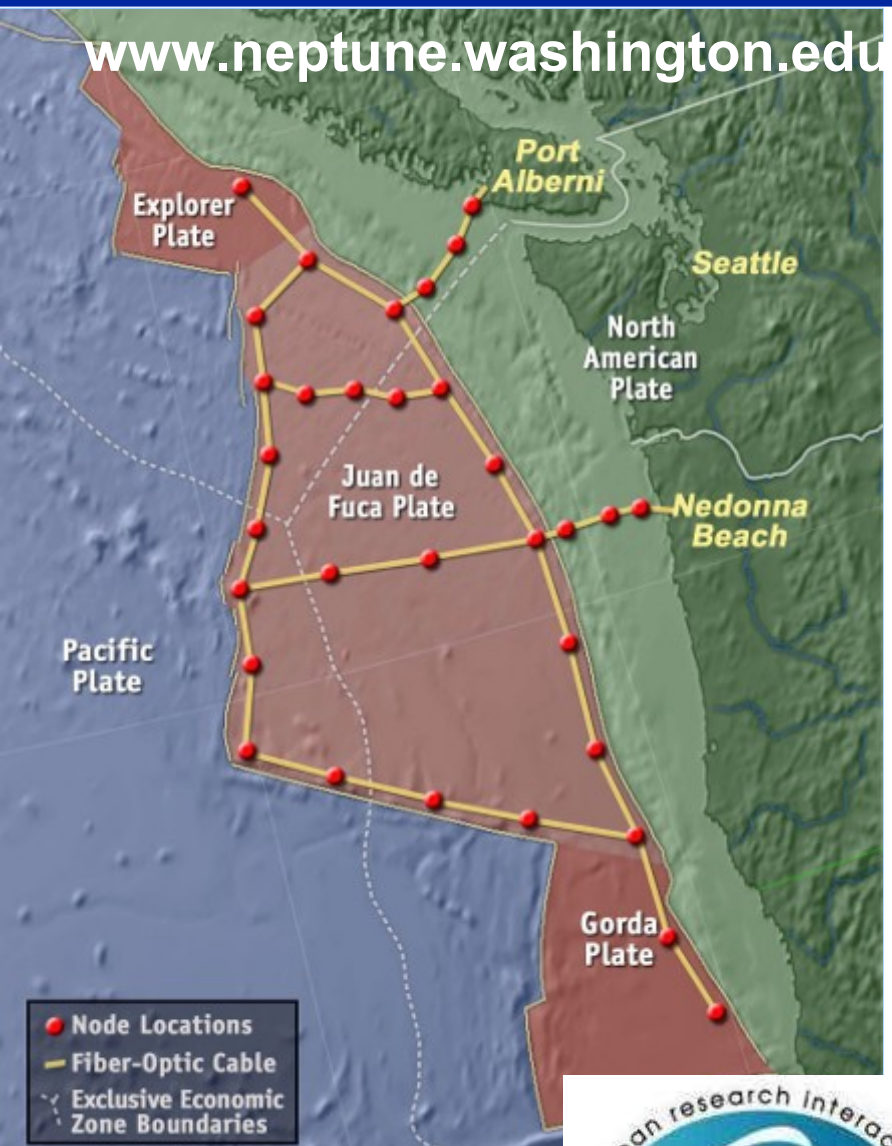
Earth Science Data Sets Created by GSFC's Scientific Visualization Studio were Retrieved Across the NLR in Real Time from OptIPuter servers in Chicago and San Diego and from GSFC Servers in McLean, VA, and Displayed at the SC2004 in Pittsburgh

OptIPuter

http://esdcd.gsfc.nasa.gov/LNetphoto3.html

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Adding Web and Grid Services to Lambdas to Provide Real Time Control of Ocean Observatories



LOOKING:
(Laboratory for the Ocean Observatory Knowledge Integration Grid)

http://lookingtosea.ucsd.edu/

- **Goal:**
  - Prototype Cyberinfrastructure for NSF's Ocean Research Interactive Observatory Networks (ORION)
- **LOOKING NSF ITR with PIs:**
  - John Orcutt & Larry Smarr - UCSD
  - John Delaney & Ed Lazowska –UW
  - Mark Abbott – OSU
- **Collaborators at:**
  - MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canarie

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NSF

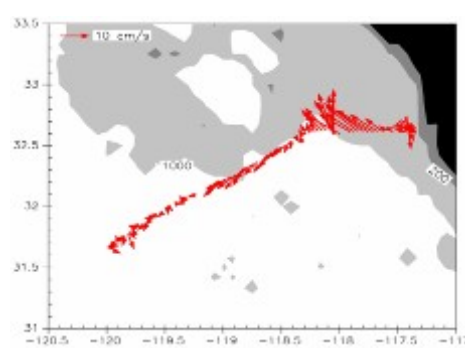
ORION ocean research interactive observatory networks

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LOOKING Builds on the Multi- Institutional SCCOOS Program, OptIPuter, and CENIC-XD

- **SCCOOS is Integrating:**
  - Moorings
  - Ships
  - Autonomous Vehicles
  - Satellite Remote Sensing
  - Drifters
  - Long Range HF Radar
  - Near-Shore Waves/Currents (CDIP)
  - COAMPS Wind Model
  - Nested ROMS Models
  - Data Assimilation and Modeling
  - Data Systems



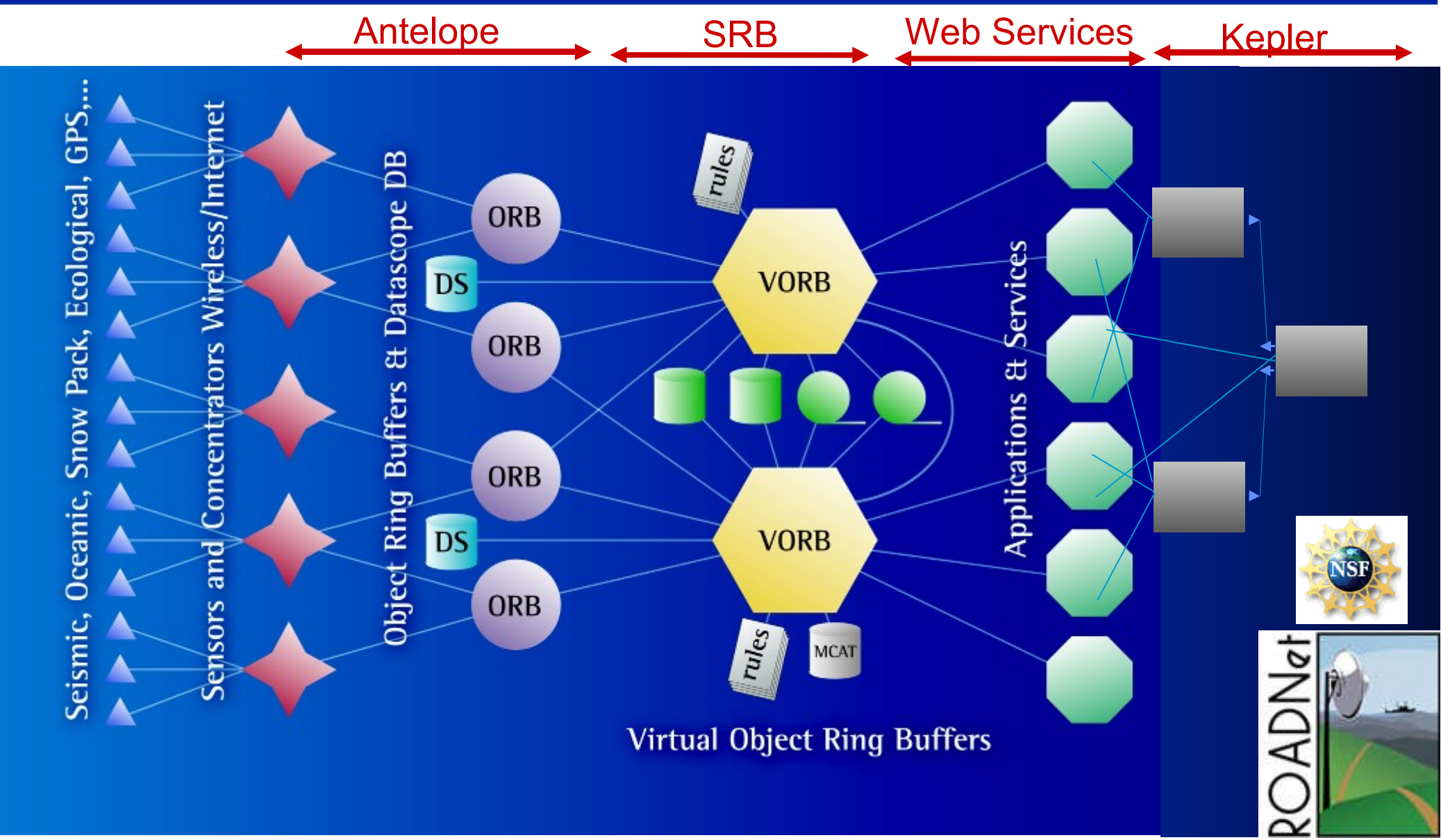




OptIPuter NSF ROADNet

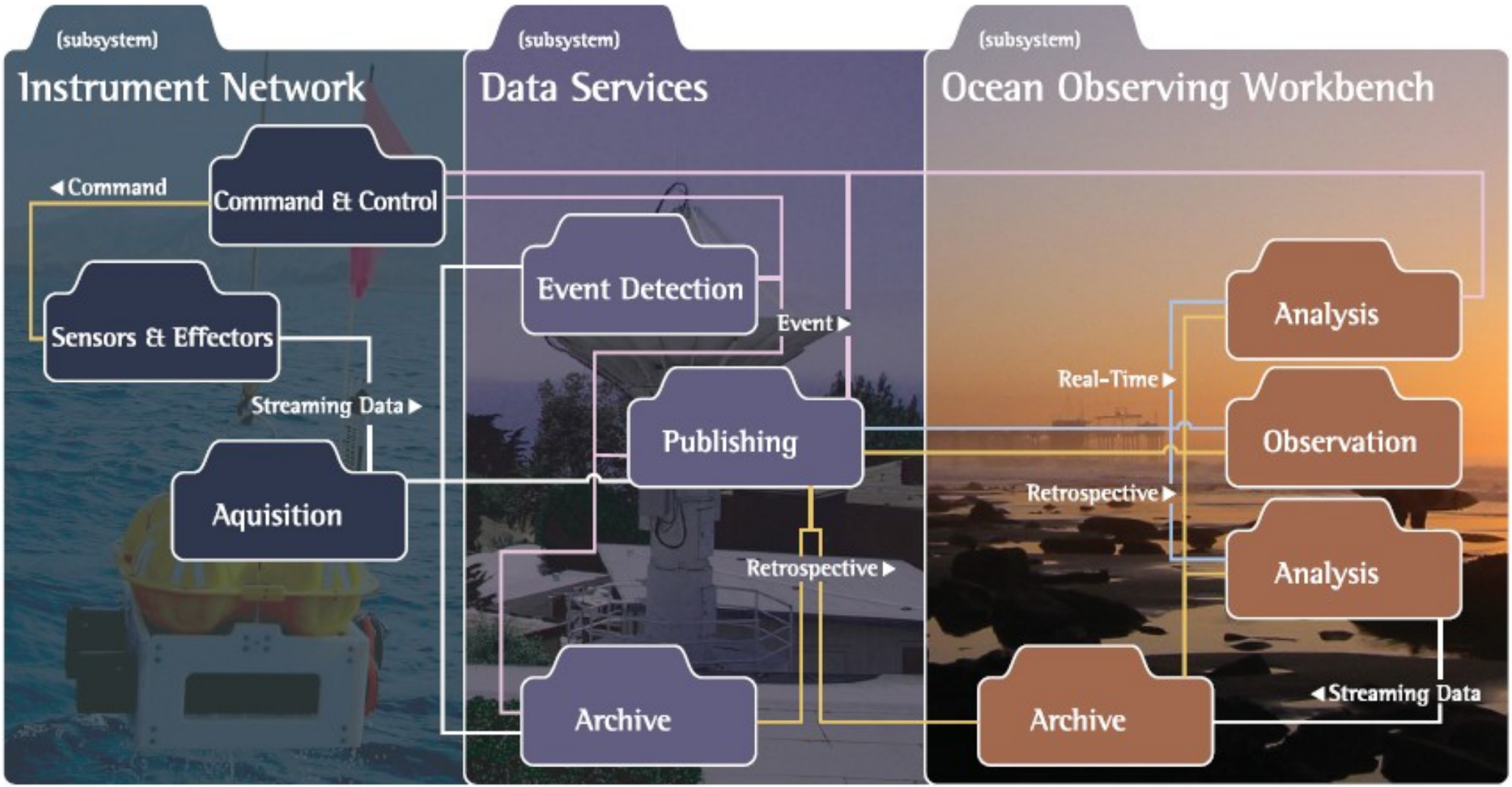
ROADNet Architecture:

SensorNets, Storage Research Broker, Web Services, Work Flow



Frank Vernon, SIO; Tony Fountain, Ilkay Altintas, SDSC

LOOKING Service-Oriented System Software Architecture



OptIPuter

http://lookingtosea.ucsd.edu/

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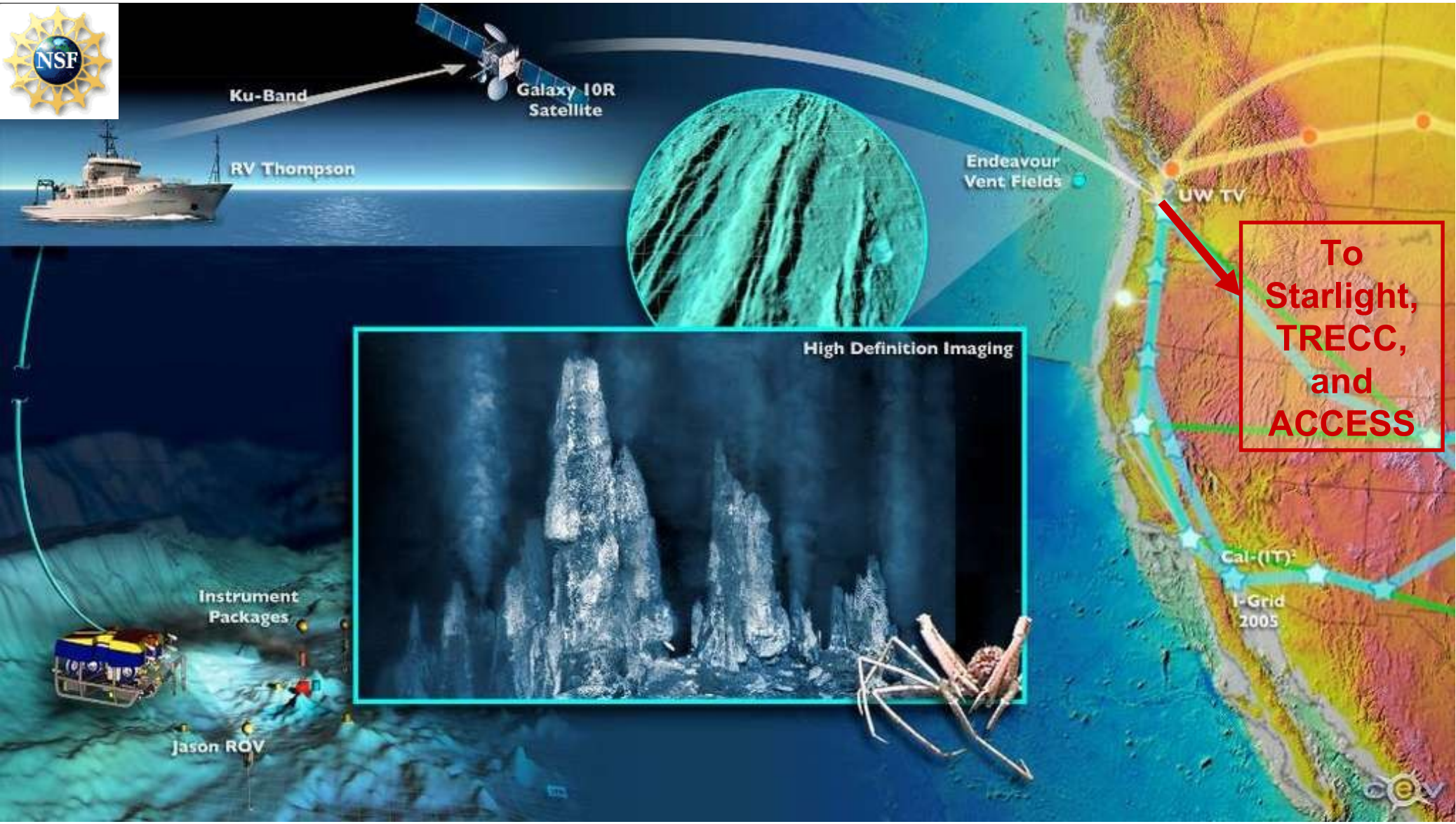
LOOKING High-Definition Interactive Instrument Cluster Goals

- **Multiple Instruments on Ocean Floor**
  - Operated Through Ocean Observing Workbench
- **Feature Identification and Analysis**
  - Exercising Metadata
  - Ontology Development
- **Command & Control of an Instrument Cluster**
  - Exercising Instrument Command Interface
  - Resource Management
  - Coordinated Control of Multiple Instruments
- **Utilization of High-Bandwidth Cabled-Network**
  - Linked to User's Over NLR with OptIPuter Middleware

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Proposed Experiment for iGrid 2005 – Remote Interactive HD Imaging of Deep Sea Vent



OptIPuter NEPTUNE

Source John Delaney & Deborah Kelley, UWash

it²