"The Academic and R&D Sectors' Current and Future Broadband and Fiber Access Needs For US Global Competitiveness"

Invited Access Grid Talk

MSCMC FORUM Series

Examining the National Vision for Global Peace and Prosperity

Arlington, VA

February 23, 2005

Dr. Larry Smarr

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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A Once in Two-Decade Transition from Computer-Centric to Net-Centric Cyberinfrastructure

Bandwidth is getting cheaper faster than storage.
Storage is getting cheaper faster than computing.
Exponentials are crossing.

"A global economy designed
to waste transistors, power, and silicon area
-and conserve bandwidth above all-
is breaking apart and reorganizing itself
to waste bandwidth
and conserve power, silicon area, and transistors."
George Gilder Telecosm (2000)

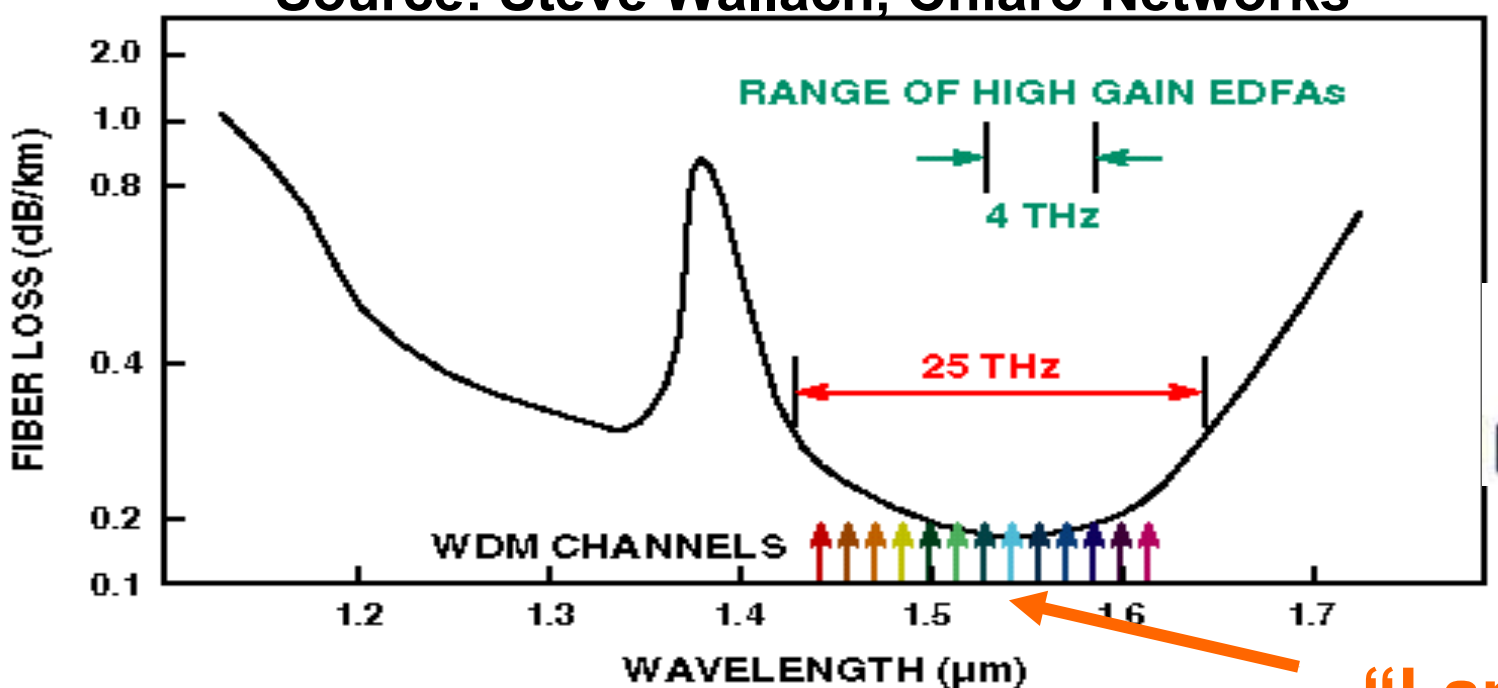
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Parallel Lambdas are Driving Optical Networking The Way Parallel Processors Drove 1990s Computing

WAVELENGTH DIVISION MULTIPLEXING (WDM)

- EXPLOITS
  - ENORMOUS BANDWIDTH OF SILICA FIBER
  - HIGH-GAIN WIDEBAND OPTICAL AMPLIFIERS

Source: Steve Wallach, Chiaro Networks



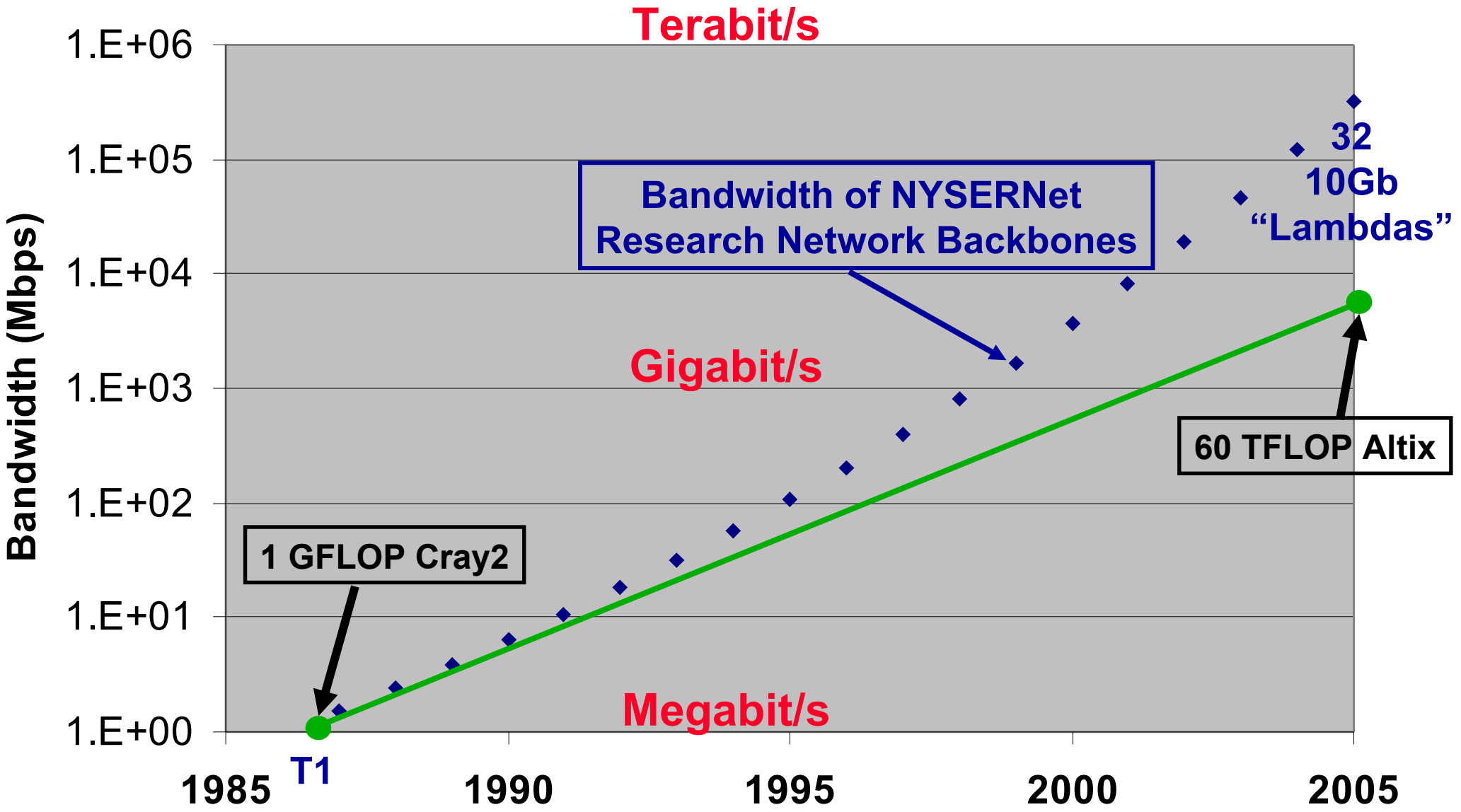
CHIARO

"Lambdas"

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The Evolution to a Net-Centric Architecture



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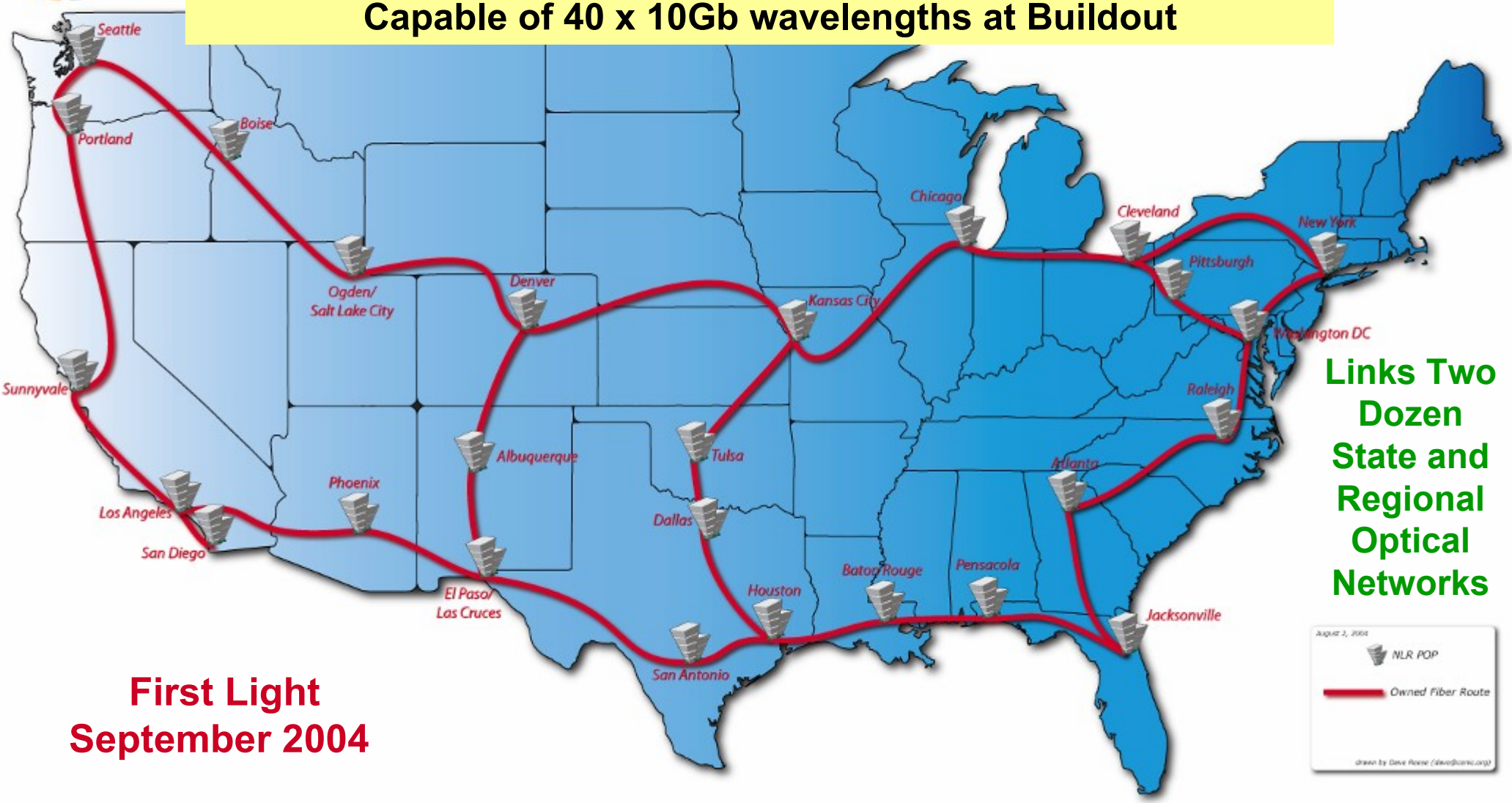
Source: Timothy Lance, President, NYSERNet

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NLR Will Provide an Experimental Network Infrastructure for U.S. Scientists & Researchers

"National LambdaRail" Partnership

Serves Very High-End Experimental and Research Applications
4 x 10Gb Wavelengths Initially
Capable of 40 x 10Gb wavelengths at Buildout



Links Two Dozen State and Regional Optical Networks

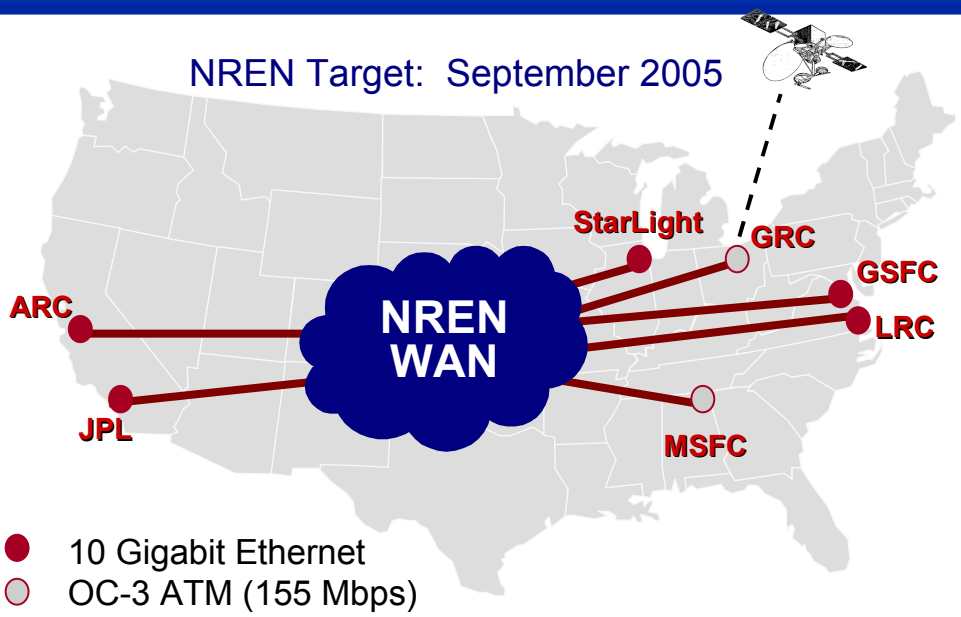
First Light September 2004

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

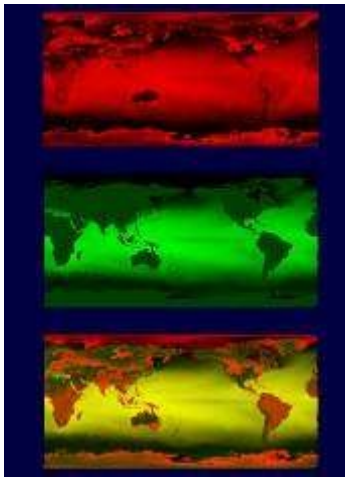
NASA Research and Engineering Network Lambda Backbone Will Run on CENIC and NLR

- NREN Goal
  - Provide a Wide Area, High-speed Network for Large Data Distribution and Real-time Interactive Applications
  - Provide Access to NASA Research & Engineering Communities - Primary Focus: Supporting Distributed Data Access to/ from Project Columbia





- Sample Application: Estimating the Circulation and Climate of the Ocean (ECCO)
  - ~78 Million Data Points
  - 1/6 Degree Latitude-Longitude Grid
  - Decadal Grids ~ 0.5 Terabytes / Day
  - Sites: NASA JPL, MIT, NASA Ames



- **Next Steps**
  - **1 Gbps (JPL to ARC) Across CENIC (February 2005)**
  - **10 Gbps ARC, JPL & GSFC Across NLR (May 2005)**
  - **StarLight Peering (May 2005)**
  - **10 Gbps LRC (Sep 2005)**



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Source: Kevin Jones, Walter Brooks, ARC

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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

Maxine Brown, Tom DeFanti, Co-Organizers

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.startap.net/igrid2005/

September 26-30, 2005

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

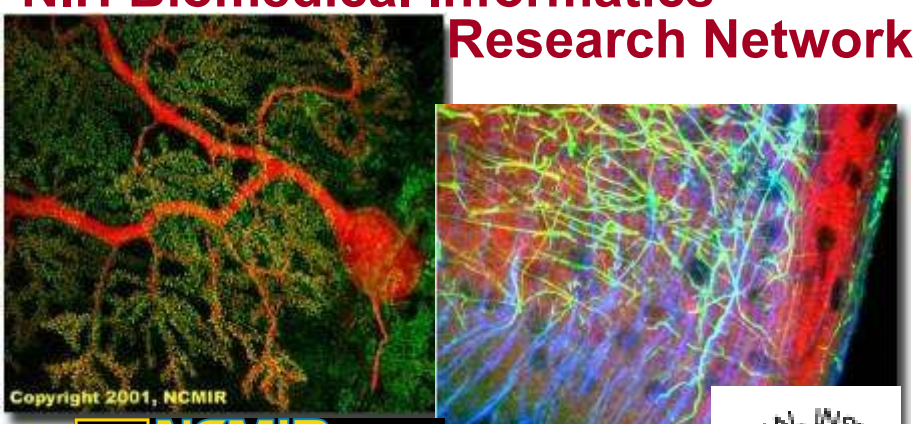
November 12-18 2005

http://sc05.supercomp.org

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**
- **Driven by Global Scale Science Projects**

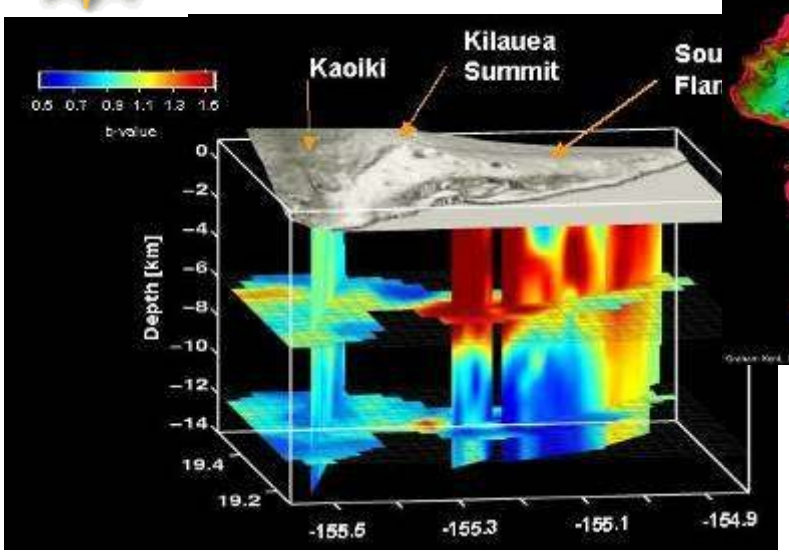
NIH Biomedical Informatics Research Network

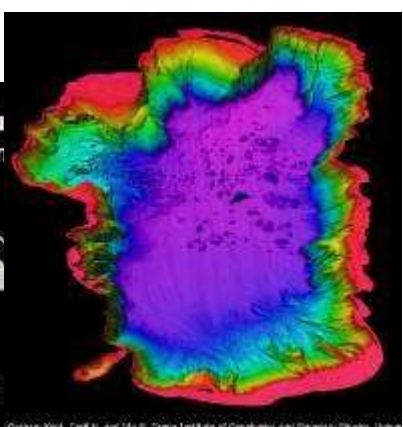


NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

NATIONAL INSTITUTES OF HEALTH

NSF EarthScope and ORION





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

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

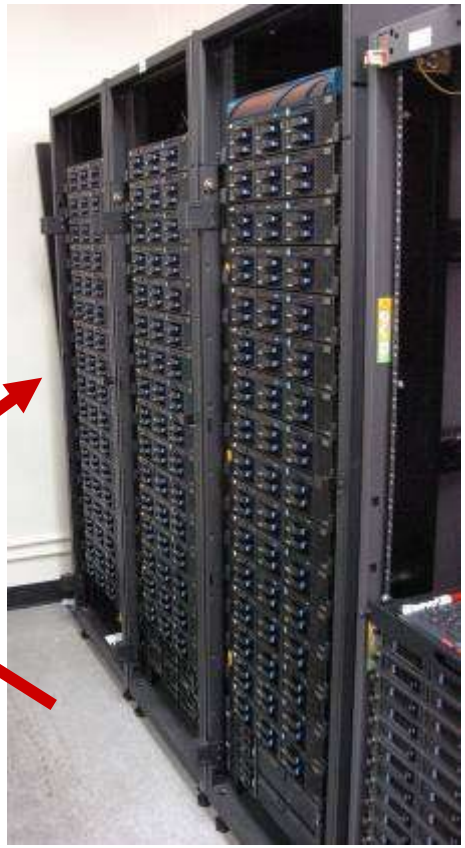
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UCSD Campus LambdaStore Architecture
Dedicated Lambdas to Labs Creates Campus LambdaGrid

SIO Ocean Supercomputer



IBM Storage Cluster

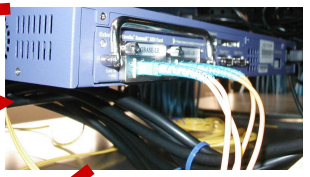


Streaming Microscope



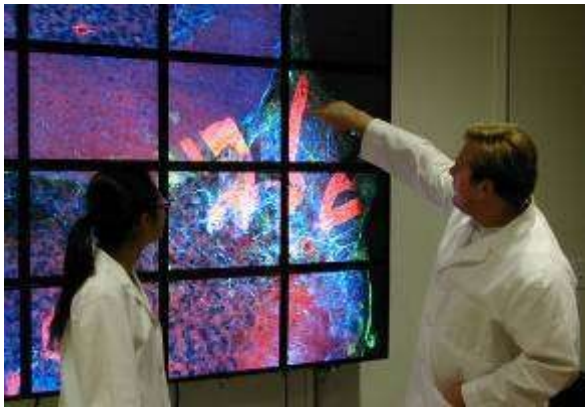


Extreme Switch with
2 Ten Gbps Uplinks







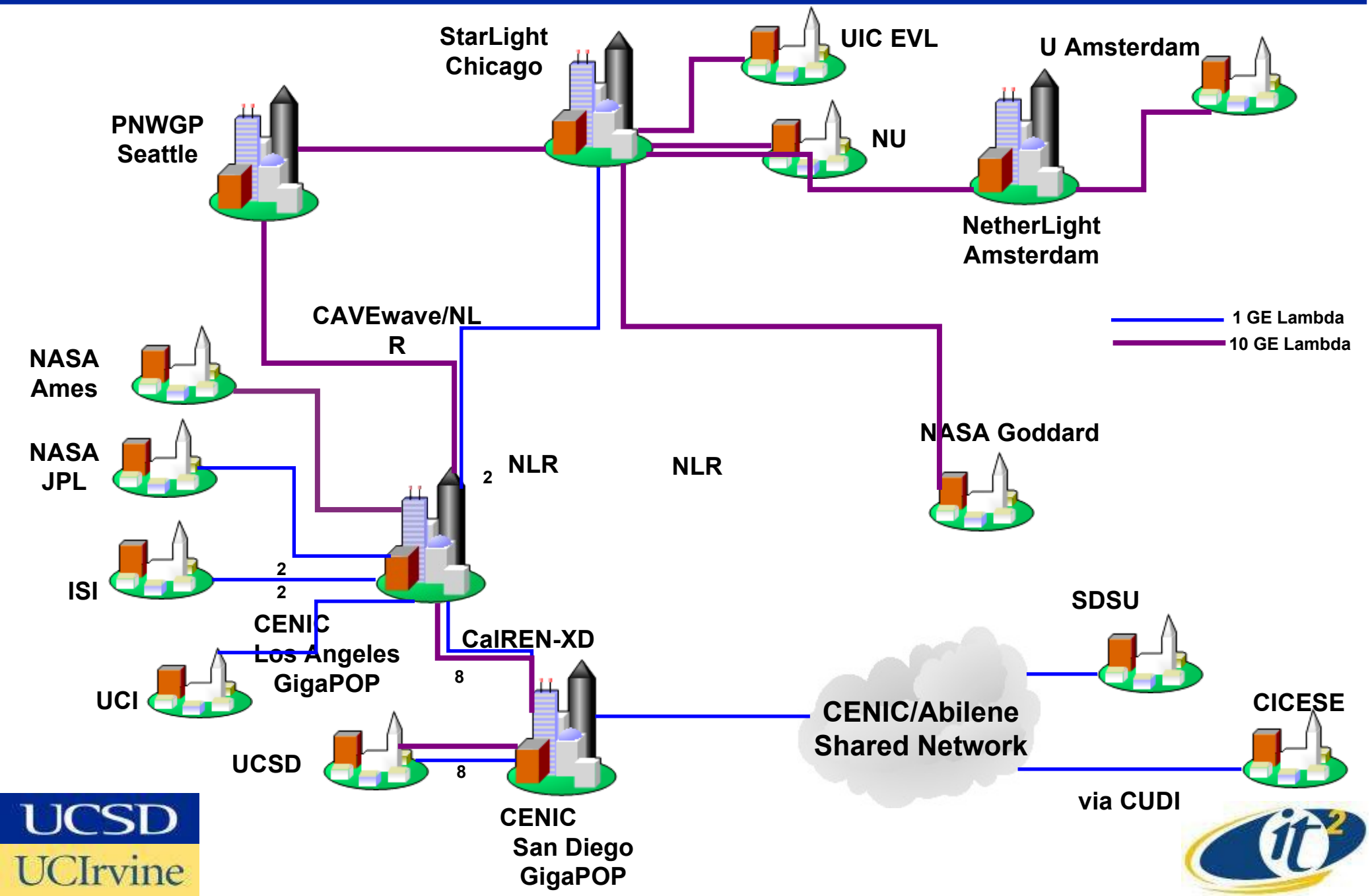


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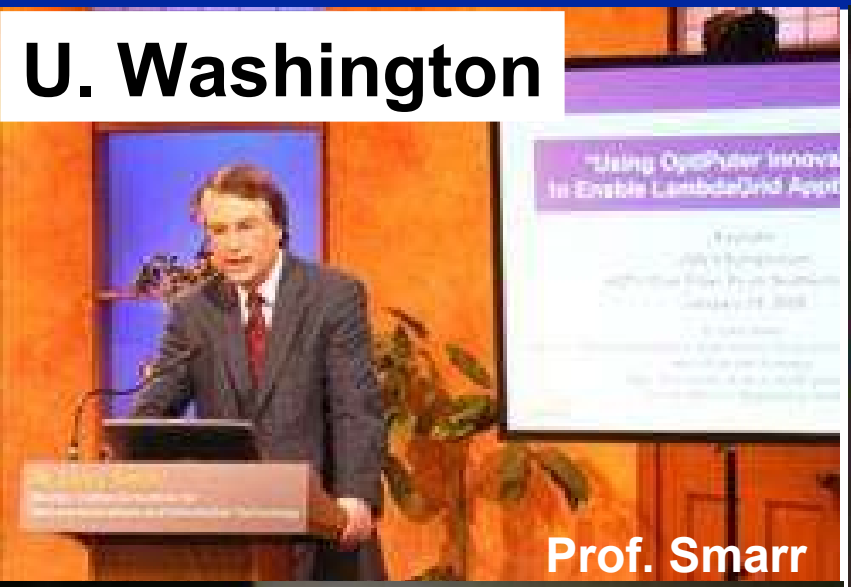
Source: Phil Papadopoulos,
SDSC, Calit2

it2

Expanding the OptIPuter LambdaGrid



Multiple HD Streams Over Lambdas Will Radically Transform Network Collaboration





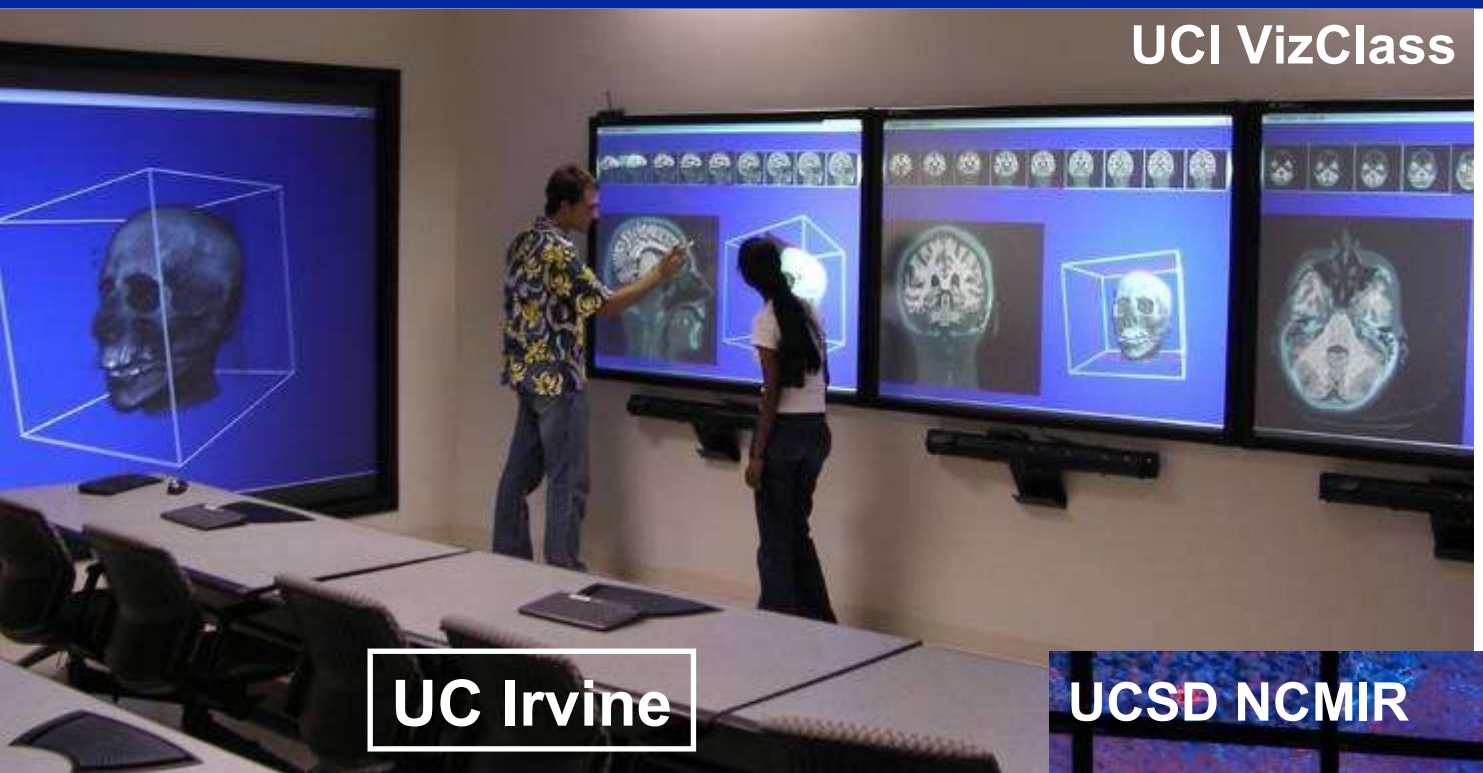


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Source: U Washington Research Channel

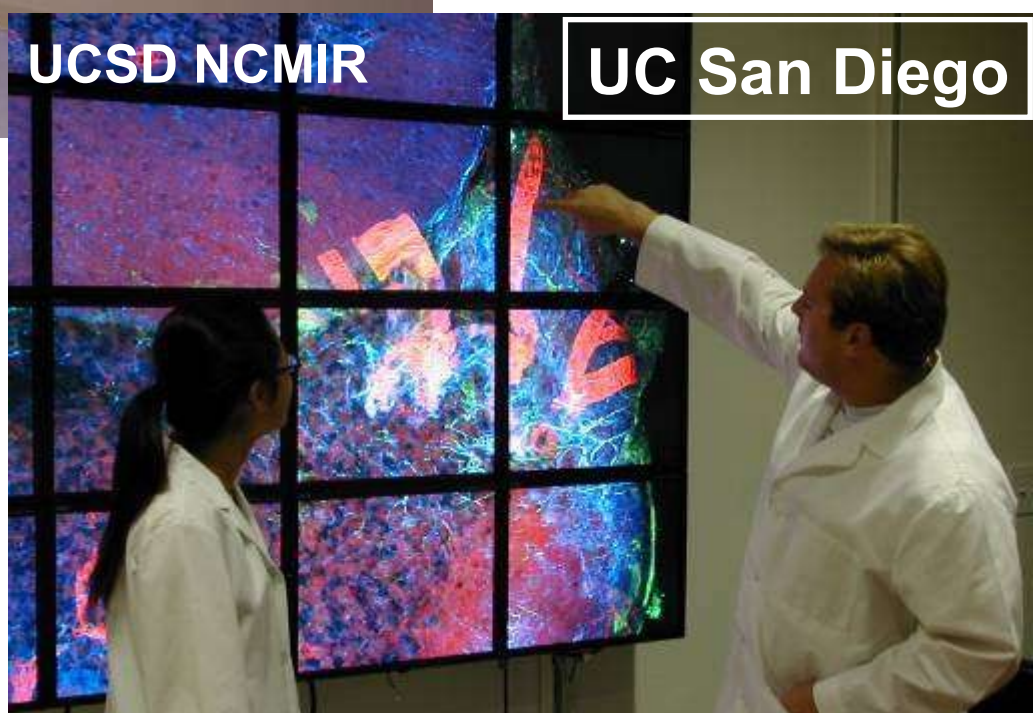
it²

Calit2 Collaboration Rooms Testbed
UCI to UCSD



Source: Falko Kuester, UCI & Mark Ellisman, UCSD

OptIPuter



In 2005 Calit2 will Link Its Two Buildings via CENIC-XD Dedicated Fiber over 75 Miles Using OptIPuter Architecture to Create a Distributed Collaboration Laboratory

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Goal—Upgrade Access Grid to HD Streams Over IP on Dedicated Lambdas



Access Grid Talk with 35 Locations on 5 Continents—SC Global Keynote Supercomputing 04

OptIPuter Is Establishing CyberPorts on the NLR-- Such as ACCESS DC and TRECC Chicago



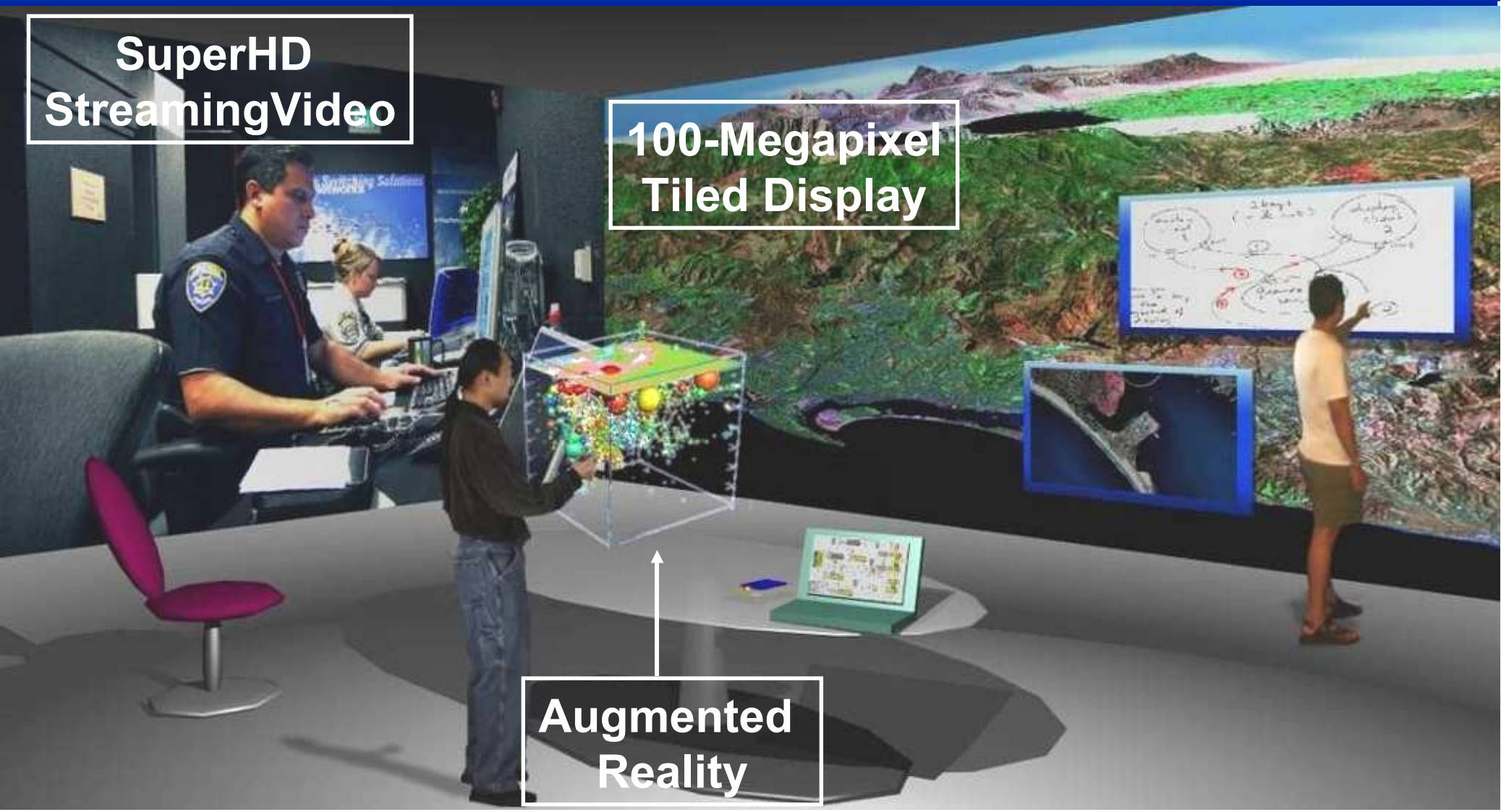








An OptIPuter LambdaVision Situation Room as Imagined In 2005



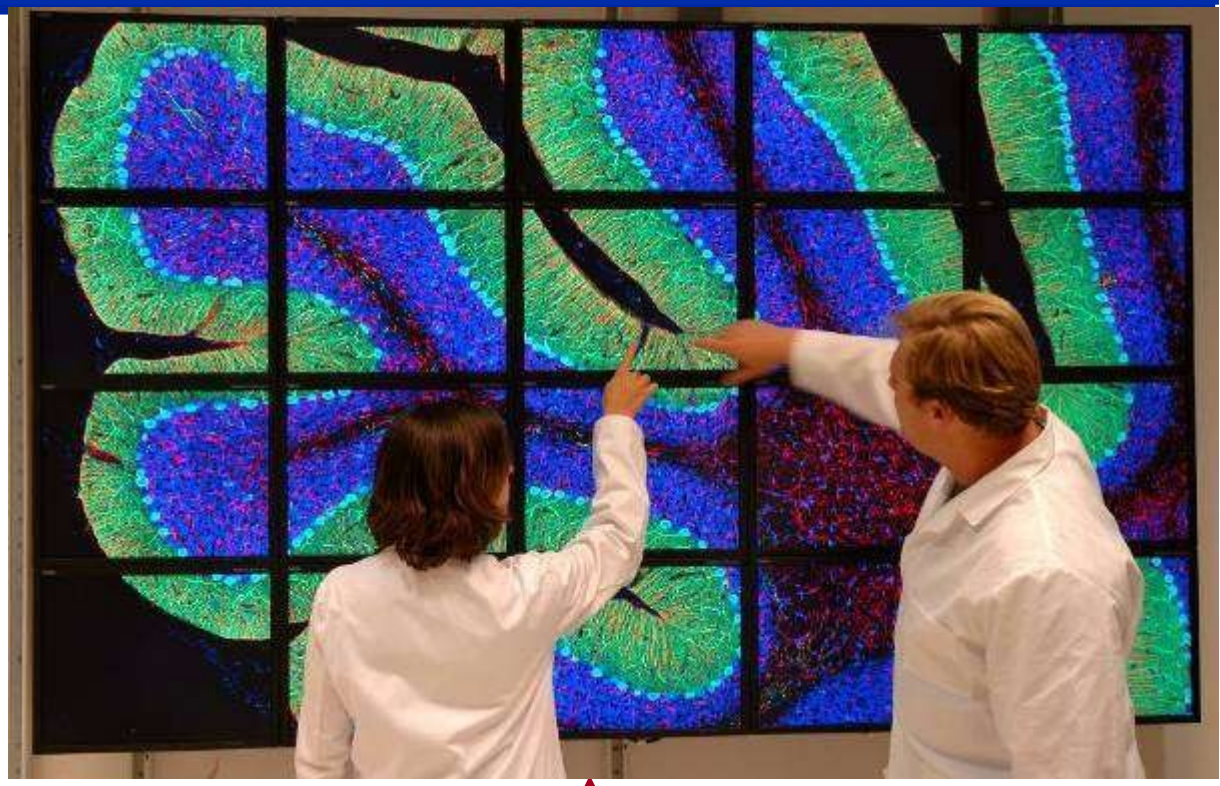
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Source: Jason Leigh, EVL, UIC

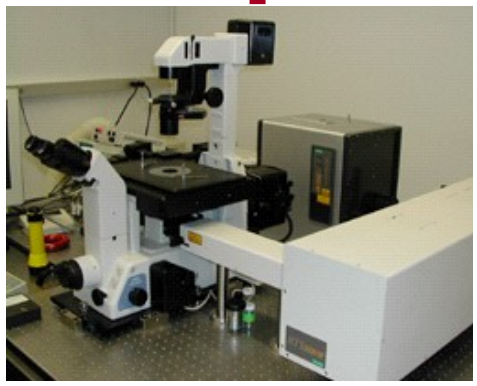
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On-Line Microscopes Creating Very Large Biological Montage Images

- 2-Photon Laser Confocal Microscope
  - GigE On-line Capability
- Montage Over 40,000 Images
  - ~150 Million Pixels!
- Use Graphics Cluster with Multiple GigEs to Drive Tiled Displays



1 Gigabit/sec!



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NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH at San Diego, an NIH supported resource center

Source: David Lee, NCMIR, UCSD

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Brain Imaging Collaboration -- UCSD & Osaka Univ. Using Real-Time Instrument Steering and HDTV

Most Powerful Electron Microscope in the World -- Osaka, Japan





HDTV



Southern California OptIPuter

NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

OSAKA UNIVERSITY

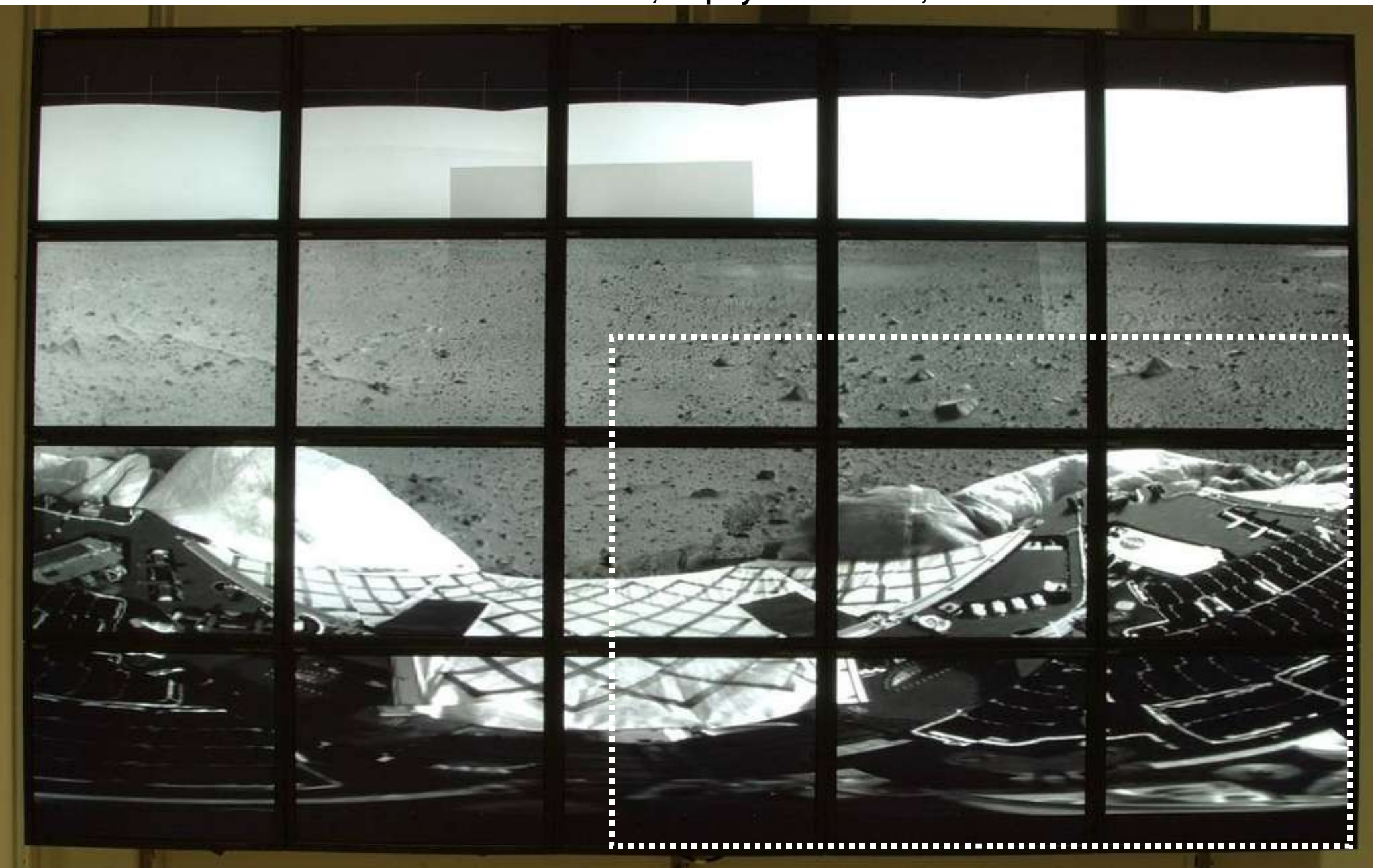
KDDI GROUP KDDI Labs USA

Source: Mark Ellisman, UCSD

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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 EVL's JuxtaView on NCMIR's Sun Microsystems Visualization Node

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

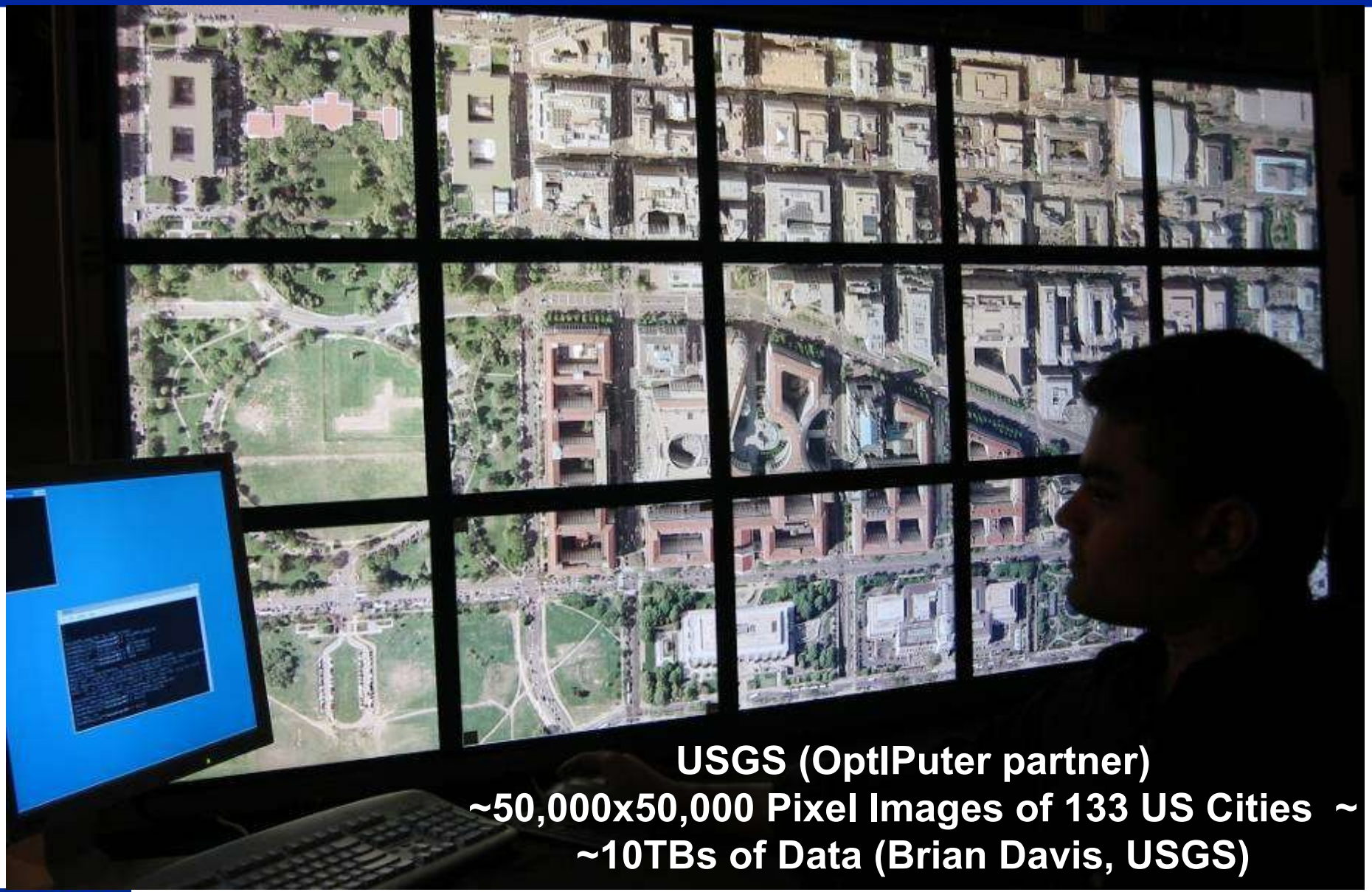


Highest Resolution Zoom on NCMIR 40 MPixel OptIPuter Display Node

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



OptIPuter Driver: Ultra Resolution Digital Aerial Photographs for Homeland Security



USGS (OptIPuter partner)
~50,000x50,000 Pixel Images of 133 US Cities ~
~10TBs of Data (Brian Davis, USGS)

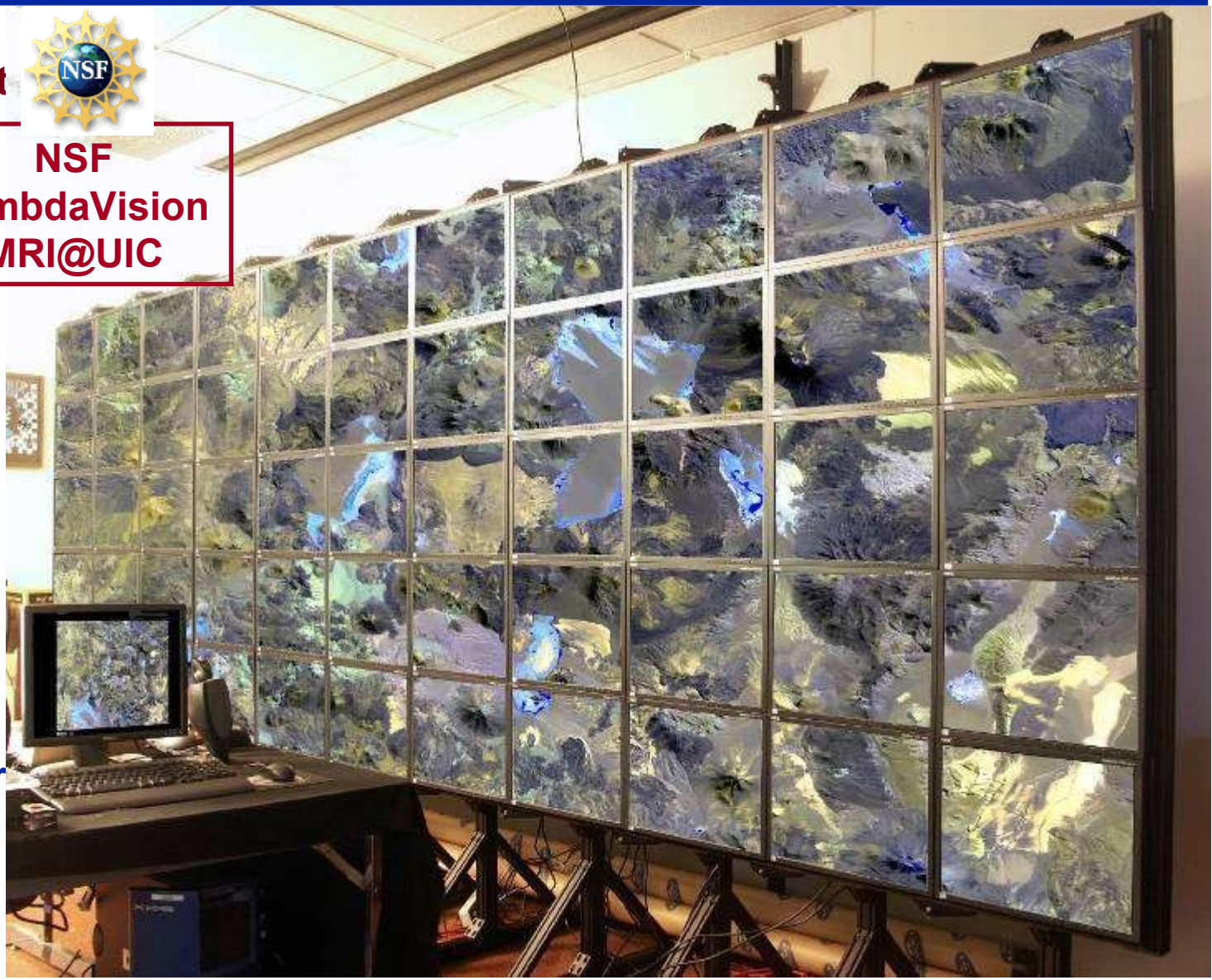
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Currently Developing OptIPuter Software to Coherently Drive 100 Mpixel Displays

- Scalable Adaptive Graphics Environment (SAGE) Controls:

NSF LambdaVision MRI@UIC

- 100 Megapixels Display
  - 55-Panel
- 1/4 TeraFLOP
  - Driven by 30 Node Cluster of 64 bit Dual Opterons
- 1/3 Terabit/sec I/O
  - 30 x 10GE interfaces
  - Linked to OptIPuter
- 1/8 TB RAM
- 60 TB Disk

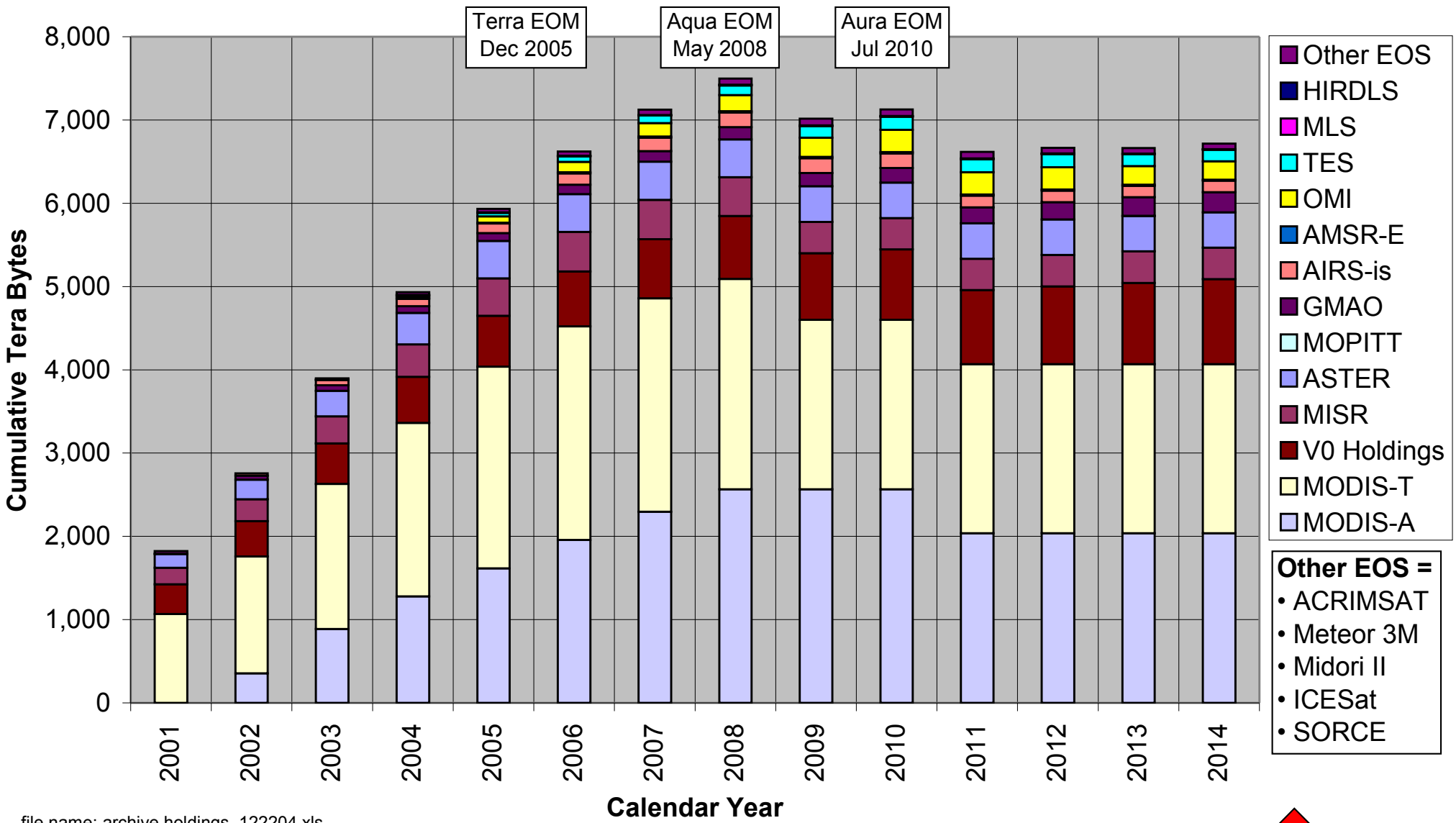


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Source: Jason Leigh, Tom DeFanti, EVL@UIC
OptIPuter Co-PIs

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Cumulative EOSDIS Archive Holdings--Adding Several TBs per Day



file name: archive holdings_122204.xls
tab: all instr bar

NOTE: Data remains in the archive pending transition to LTA

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Source: Glenn Iona, EOSDIS Element Evolution Technical Working Group January 6-7, 2005

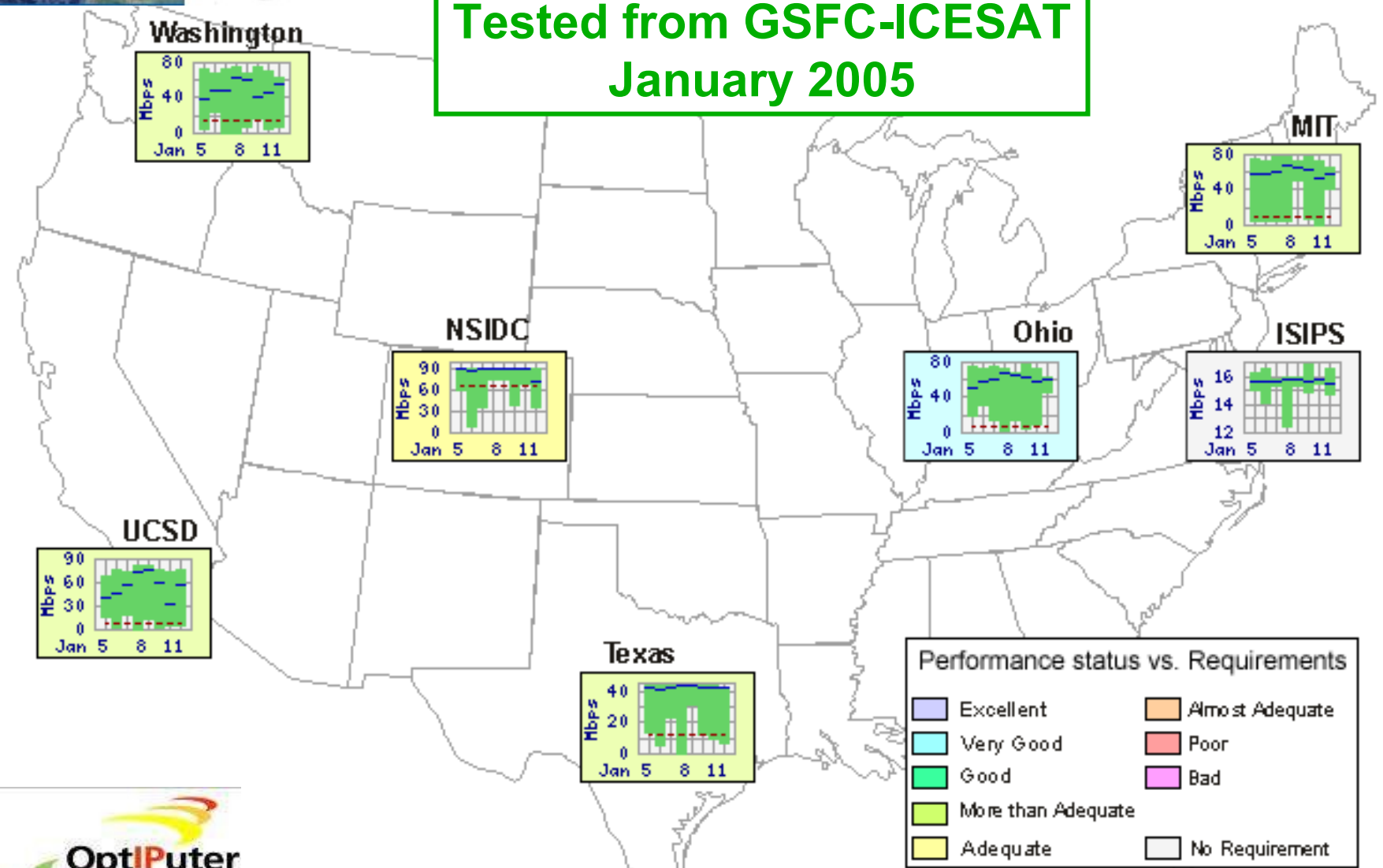
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Challenge: Average Throughput of NASA Data Products to End User is Only < 50 Megabits/s



ENSIGHT Active Testing ICESat Destinations

Tested from GSFC-ICESAT January 2005



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

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

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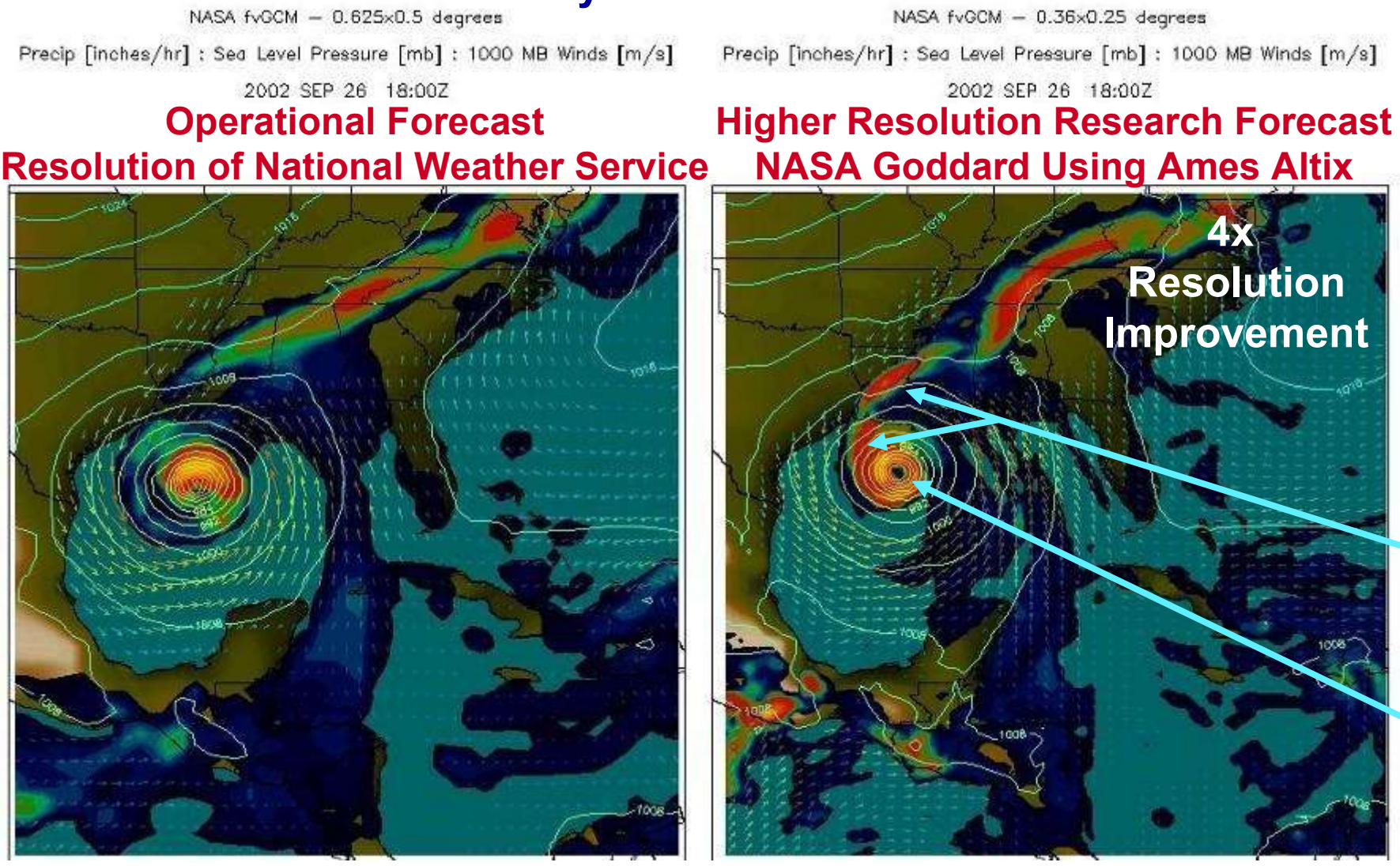
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http://esdcd.gsfc.nasa.gov/LNetphoto3.html

Increasing Accuracy in Hurricane Forecasts

Real Time Diagnostics in GSFC of Ensemble Runs on ARC Project Columbia

5.75 Day Forecast of Hurricane Isidore



Operational Forecast
Resolution of National Weather Service

Higher Resolution Research Forecast
NASA Goddard Using Ames Altix

NLR will Remove the InterCenter Networking Bottleneck

Intense Rain-Bands

Resolved Eye Wall

Source: Bill Putman, Bob Atlas, GFSC

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Project Contacts: Ricky Rood, Bob Atlas, Horace Mitchell, GSFC; Chris Henze, ARC

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Planning for Optically Linking Crisis Management Control Rooms in California

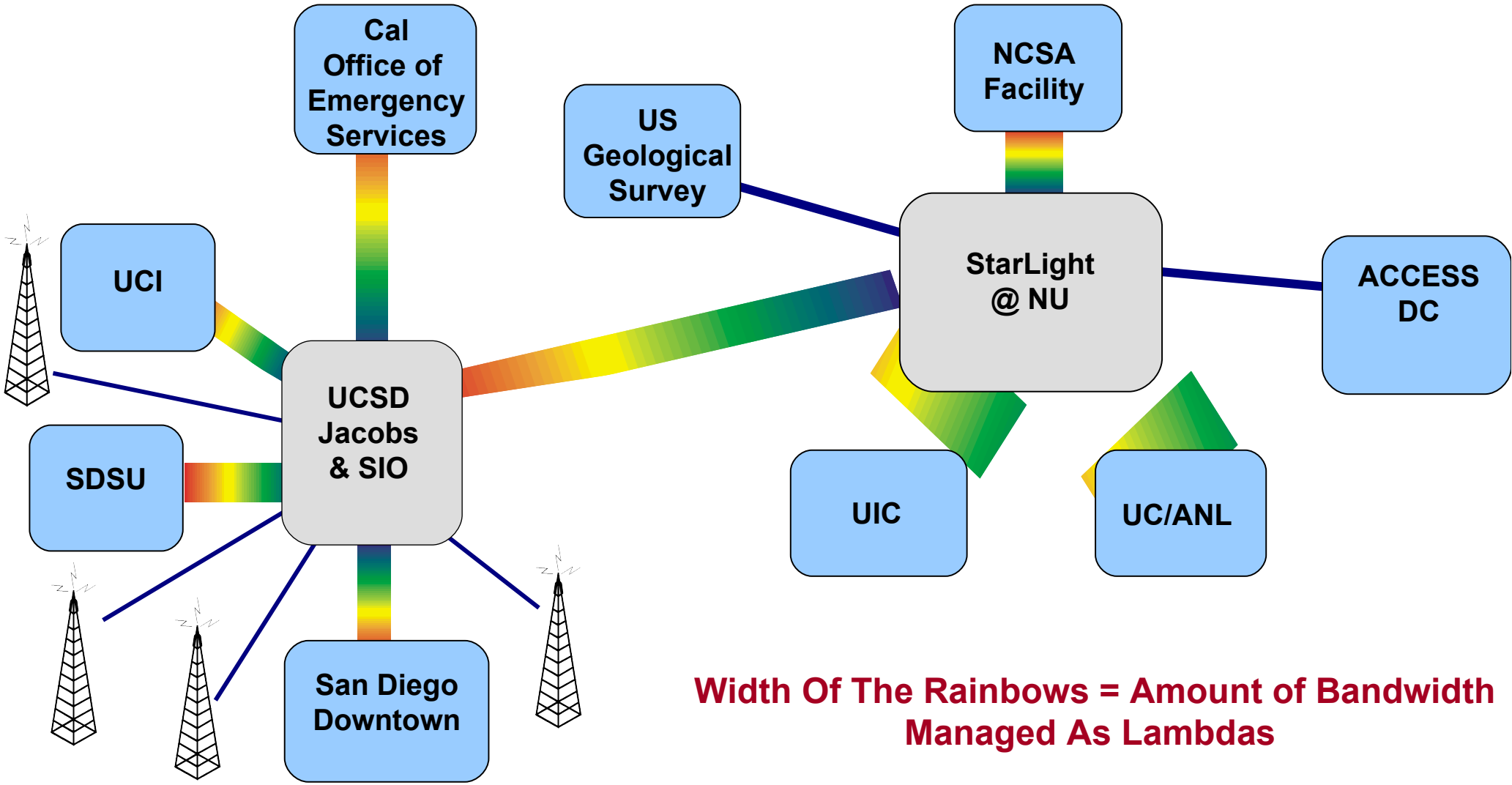


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California Office of Emergency Services, Sacramento, CA

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ENDfusion: End-to-End Networks for Data Fusion in a National-Scale Urban Emergency Collaboratory



Width Of The Rainbows = Amount of Bandwidth Managed As Lambdas

Blue Lines Are Conventional Networks

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Source: Maxine Brown, EVL, UIC

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