“How Fiber Optics are Transforming our World"

Invited Talk
Telluride Tech Festival
Telluride, CO
August 13, 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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We Are Living Through A Fundamental Global Change—How Can We Glimpse the Future?

[The Internet] has created a [global] platform where intellectual work, intellectual capital, could be delivered from anywhere.
It could be disaggregated, delivered, distributed, produced, and put back together again…

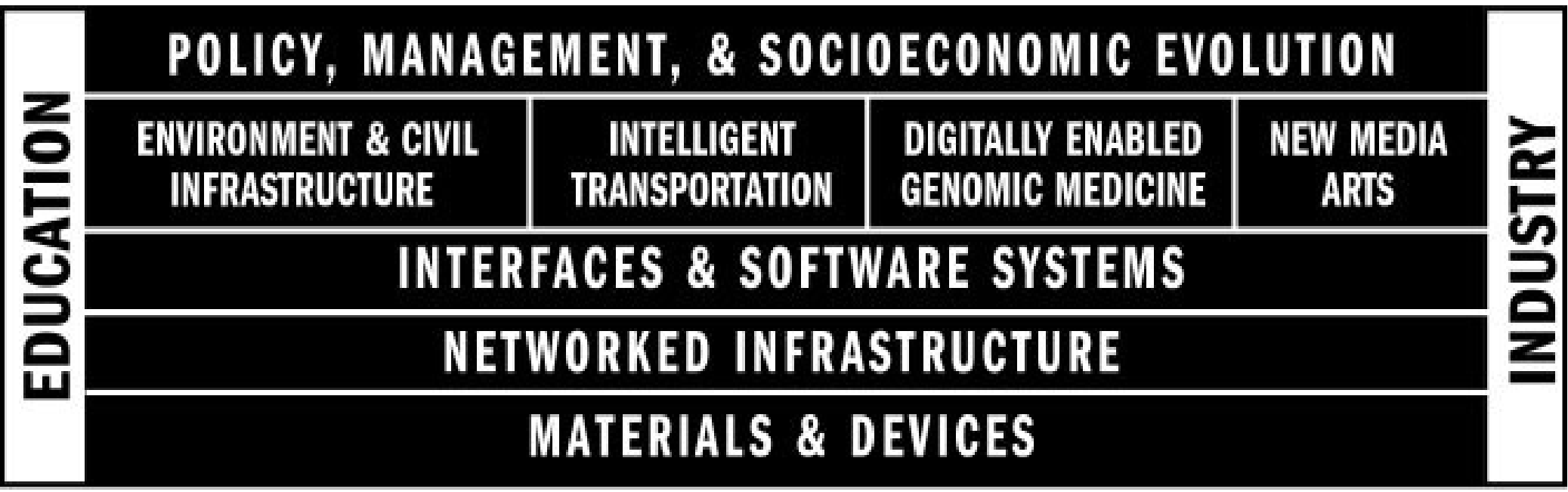
The playing field is being leveled."

Nandan Nilekani, CEO Infosys (Bangalore, India)

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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

California Institute for Telecommunications and Information Technology . Cal-(IT)^2



Extending the Internet Throughout the Physical World

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



- Over 1000 Researchers in Two Buildings
- Will Create New Laboratory Facilities
  - Nano, MEMS, RF, Optical, Visualization
- International Conferences and Testbeds
- 150 Optical Fibers into UCSD Building



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Preparing for an World in Which Distance Has Been Eliminated…

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The Calit2@UCSD Building is Designed for Extremely High Bandwidth

1.8 Million Feet of Cat6 Ethernet Cabling



Over 9,000 Individual 10/100/1000 Mbps Drops in the Building

150 Fiber Strands to Building
Experimental Roof Radio Antenna Farm
Building Radio Transparent Ubiquitous WiFi

Photo: Tim Beach, Calit2

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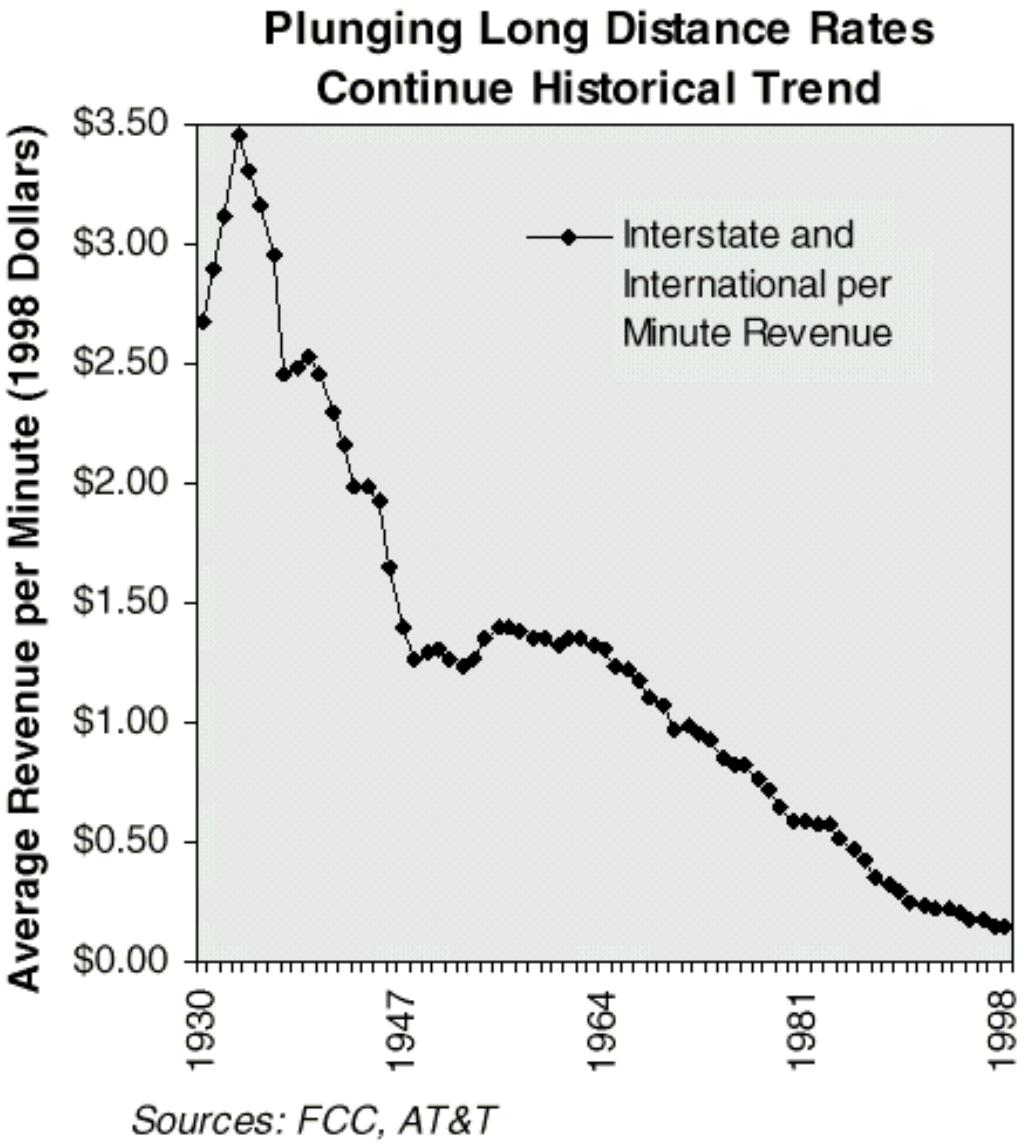
"This is What Happened with the Internet Stock Boom"

"It sparked a huge overinvestment in fiber-optic cable companies, which then laid massive amount of fiber-optic cable on land and under the oceans, which dramatically drove down the cost of making a phone call or transmitting data anywhere in the world."

--Thomas Friedman, The World is Flat (2005)

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Long Distance Phone Calls Have Almost Dropped to Zero Cost



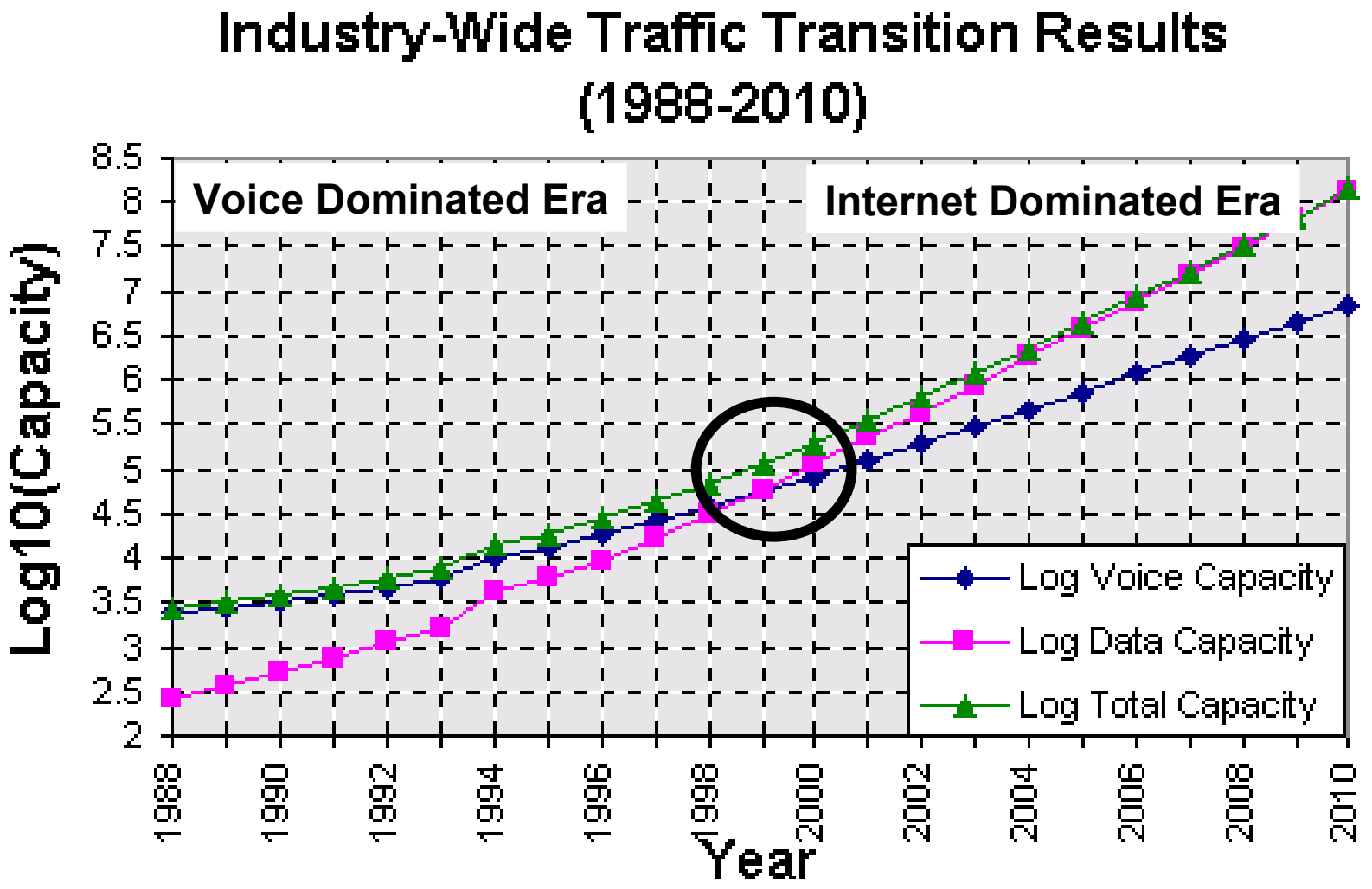
- **Implies Telecoms Will Need Alternate Revenue Streams**
  - **Cable TV**
  - **Broadband Internet Access**
  - **Wireless Telephone and Internet Access**

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From Smarr Talk (2000)

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Data Capacity Is Just Now Exceeding Voice Capacity on National Telephone Fibers



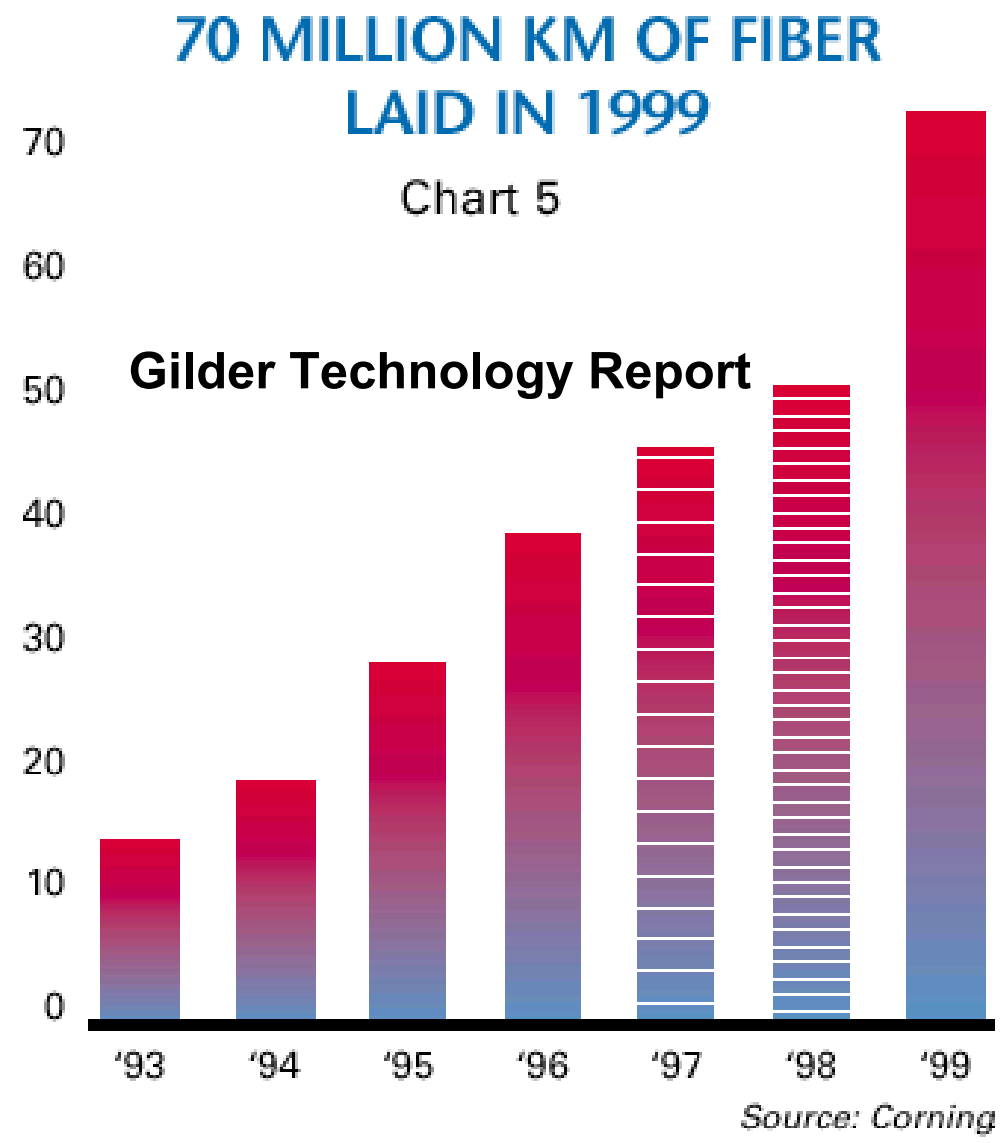
From Circuit-Switched to Packet-Switched Networks

www.ksg.harvard.edu/iip/iicompol/Papers/Mutooni.htm

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From Smarr Talk (2000)

Worldwide Deployment of Fiber Up 42% in 1999



That's Laying Fiber at the Rate of Nearly 10,000 km/hour!!

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From Smarr Talk (2000)

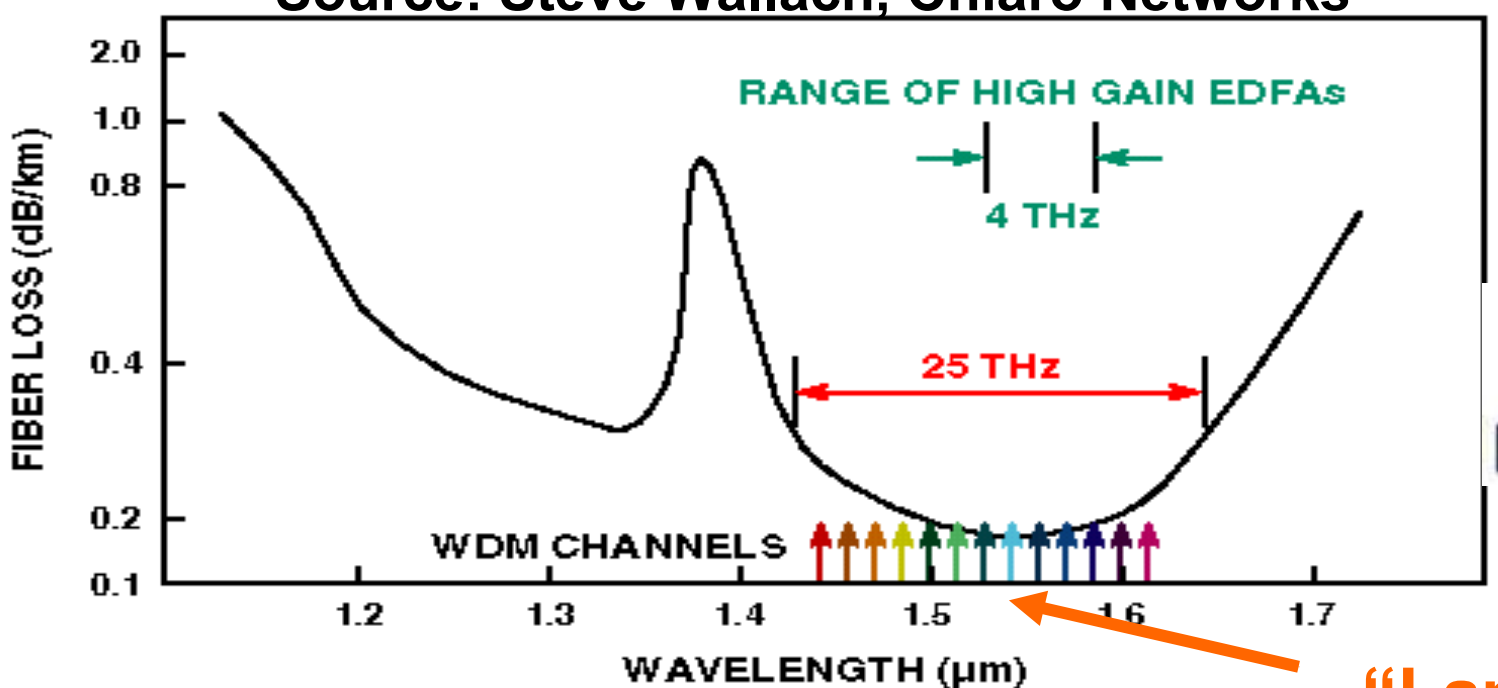
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Each Optical Fiber Can Now Carry Many Parallel Line Paths or "Lambdas"

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 Broad Overinvestment in Fiber Cable is a Gift That Keeps on Giving."

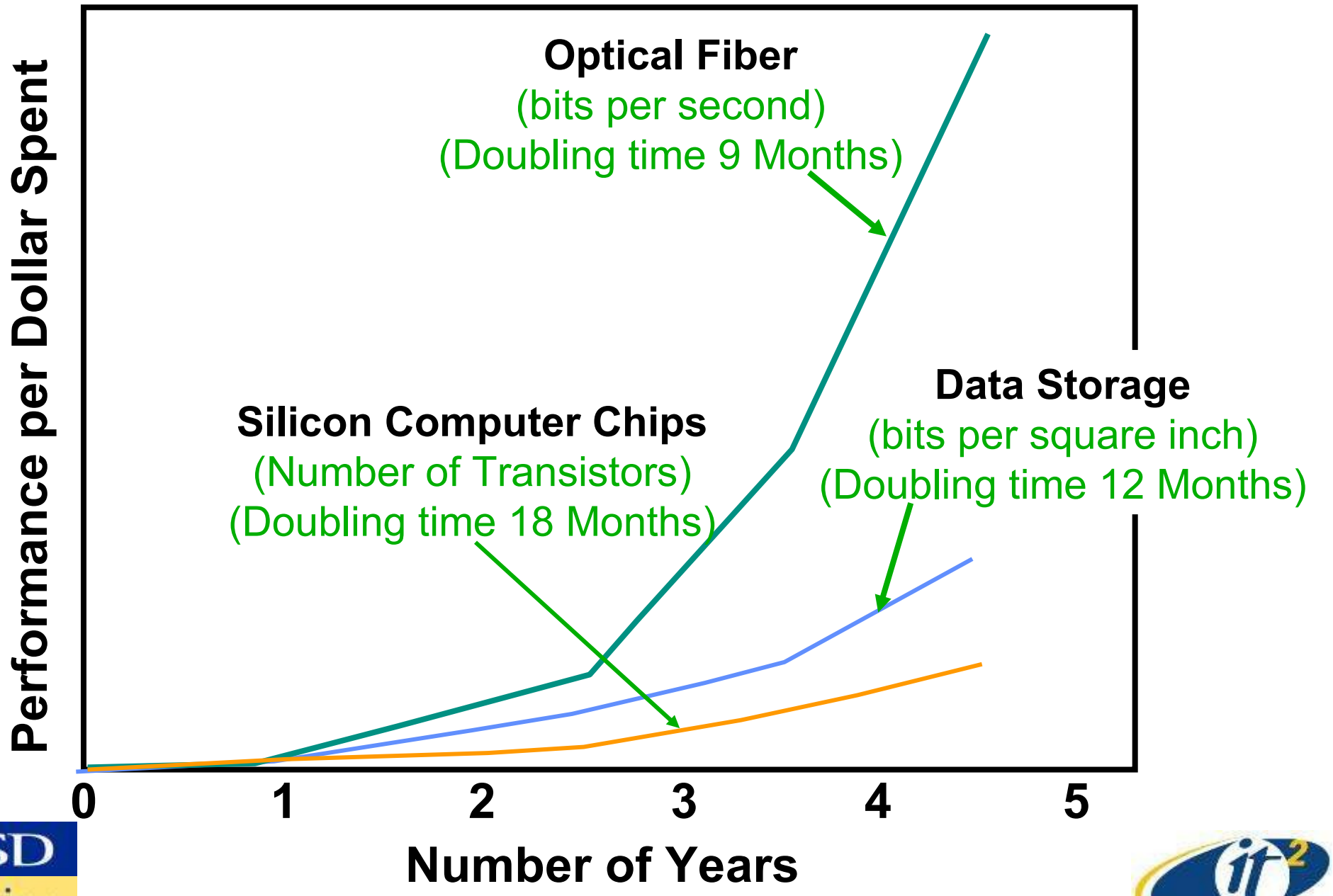
"When these fiber cables were originally laid, the optical switches could not take full advantage of the fiber's full capacity. But every year since then, the optical switches at the end of that fiber cable have gotten better and better, meaning that more and more voices and data can be transmitted down each fiber.

So, as the switches kept improving, the capacity of all the already installed fiber cables just kept on growing, making it cheaper and easier to transmit voices and data to any part of the world."

--Thomas Friedman, The World is Flat (2005)

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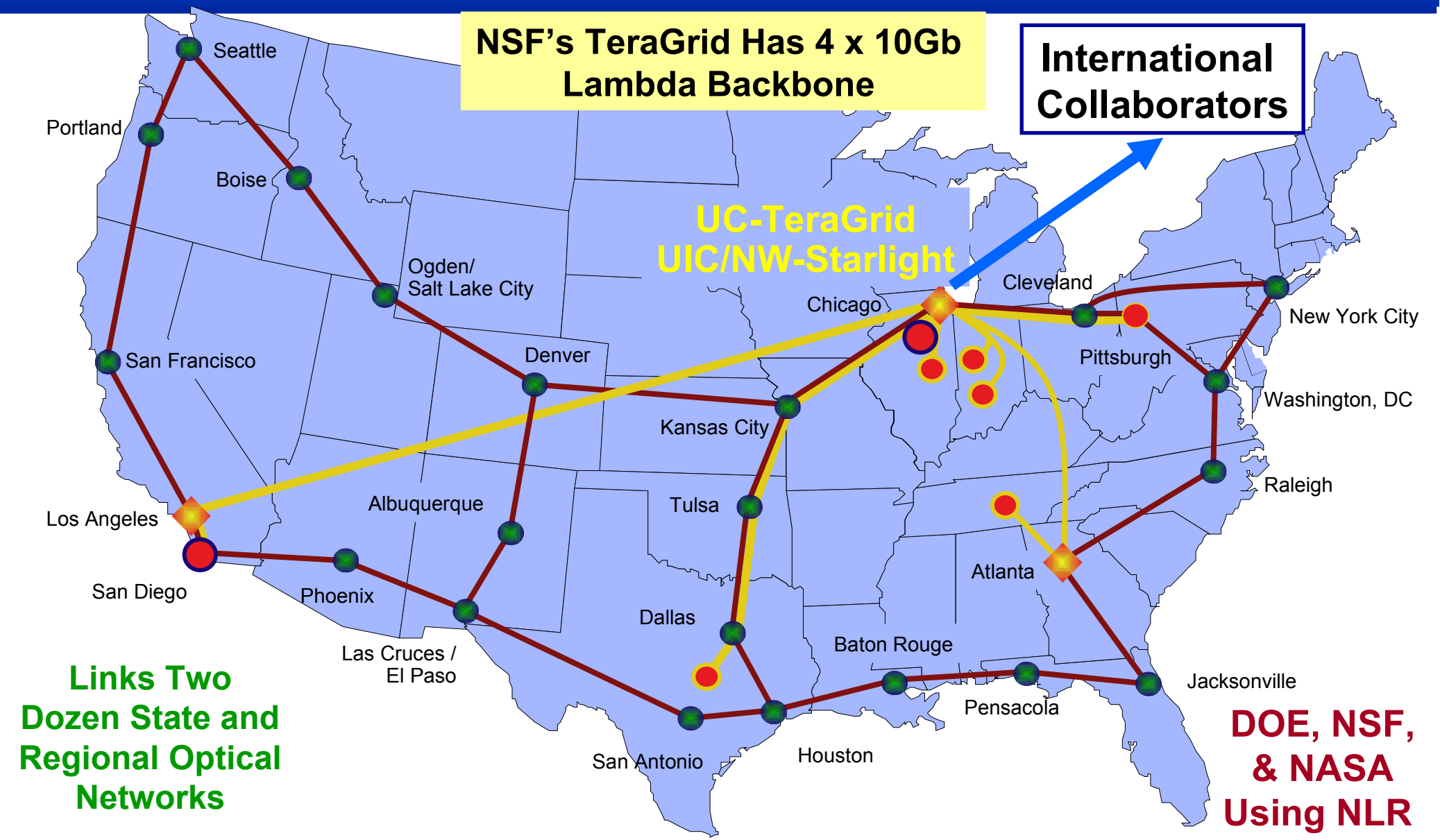
Why Optical Networks Will Become the 21st Century Driver



Scientific American, January 2001

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National LambdaRail (NLR) Provides the Cyberinfrastructure Backbone for U.S. University Researchers



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NLR 4 x 10Gb Lambdas Initially Capable of 40 x 10Gb wavelengths at Buildout

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Global Lambda Integrated Facility (GLIF)
Integrated Research Lambda Network

Many Countries are Interconnecting Optical Research Networks

to form a Global SuperNetwork



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Visualization courtesy of
Bob Patterson, NCSA

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

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





HDTV

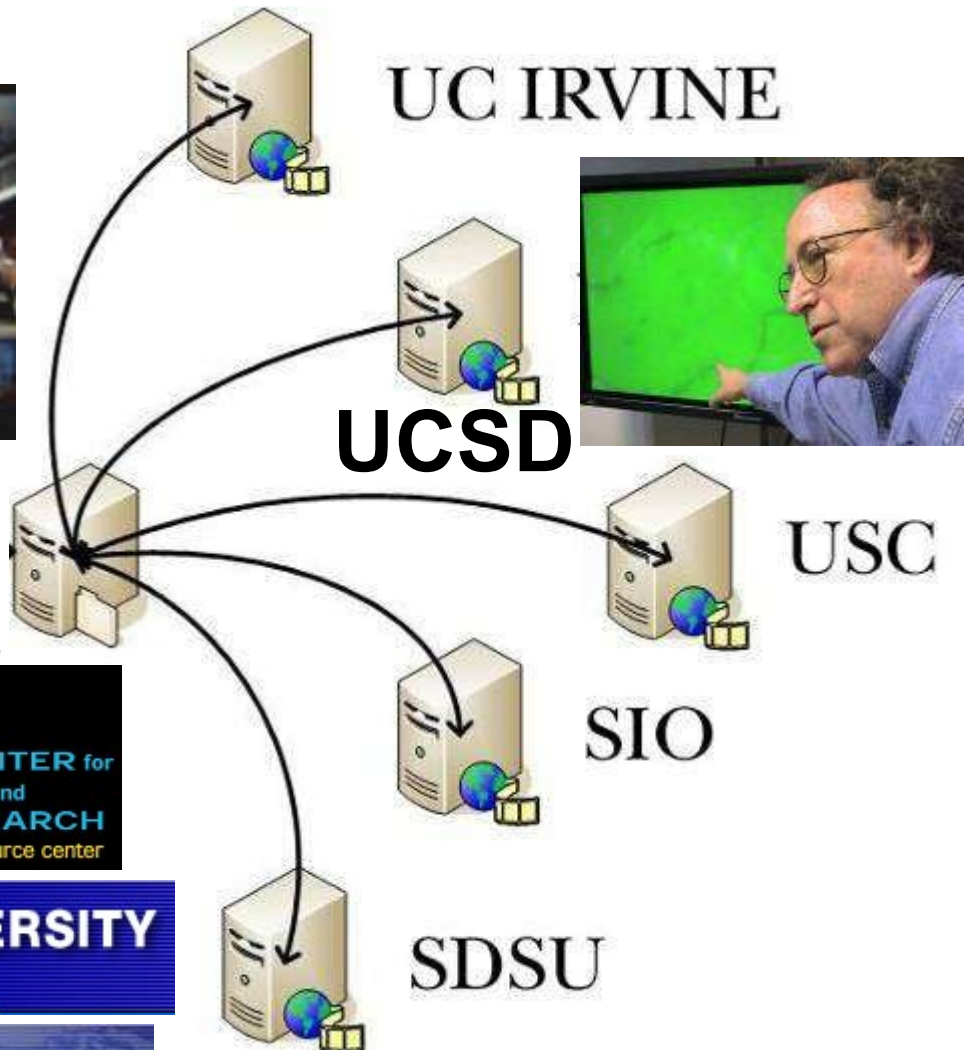
NBCR

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

OSAKA UNIVERSITY

KDDI GROUP KDDI Labs USA

Southern California OptIPuter



Source: Mark Ellisman, UCSD

The Upcoming World Jamboree of LambdaGrids

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

21 Countries Driving 100 Gbps to Calit2@UCSD Building Sept 2005-- A Number of Projects are SensorNets

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http://sc05.supercomp.org

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Goal – From Expedition to Cable Observatories with Streaming Stereo HDTV Robotic Cameras

http://disney.go.com/disneypictures/aliensofthedeep/alienseduguide.pdf

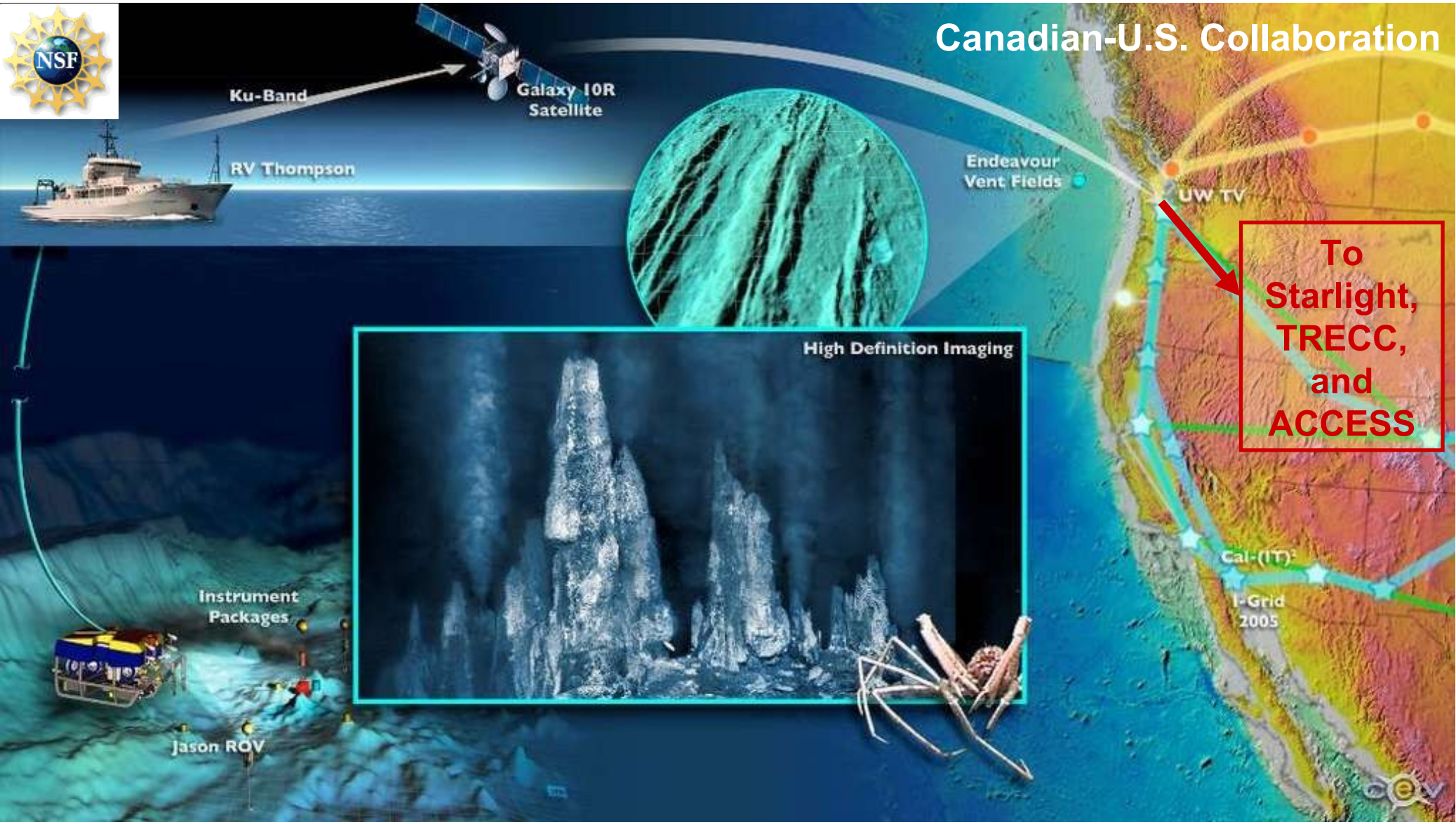




Scenes from The Aliens of the Deep, Directed by James Cameron & Steven Quale

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Proposed UW/Calit2 Experiment for iGrid 2005 – Remote Interactive HD Imaging of Deep Sea Vent

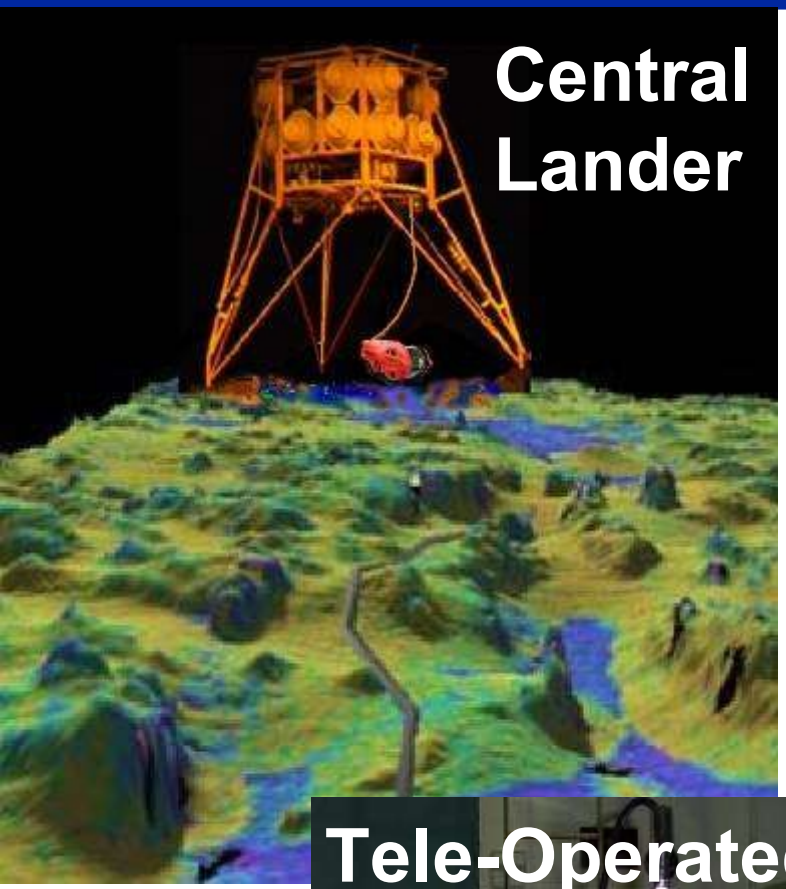


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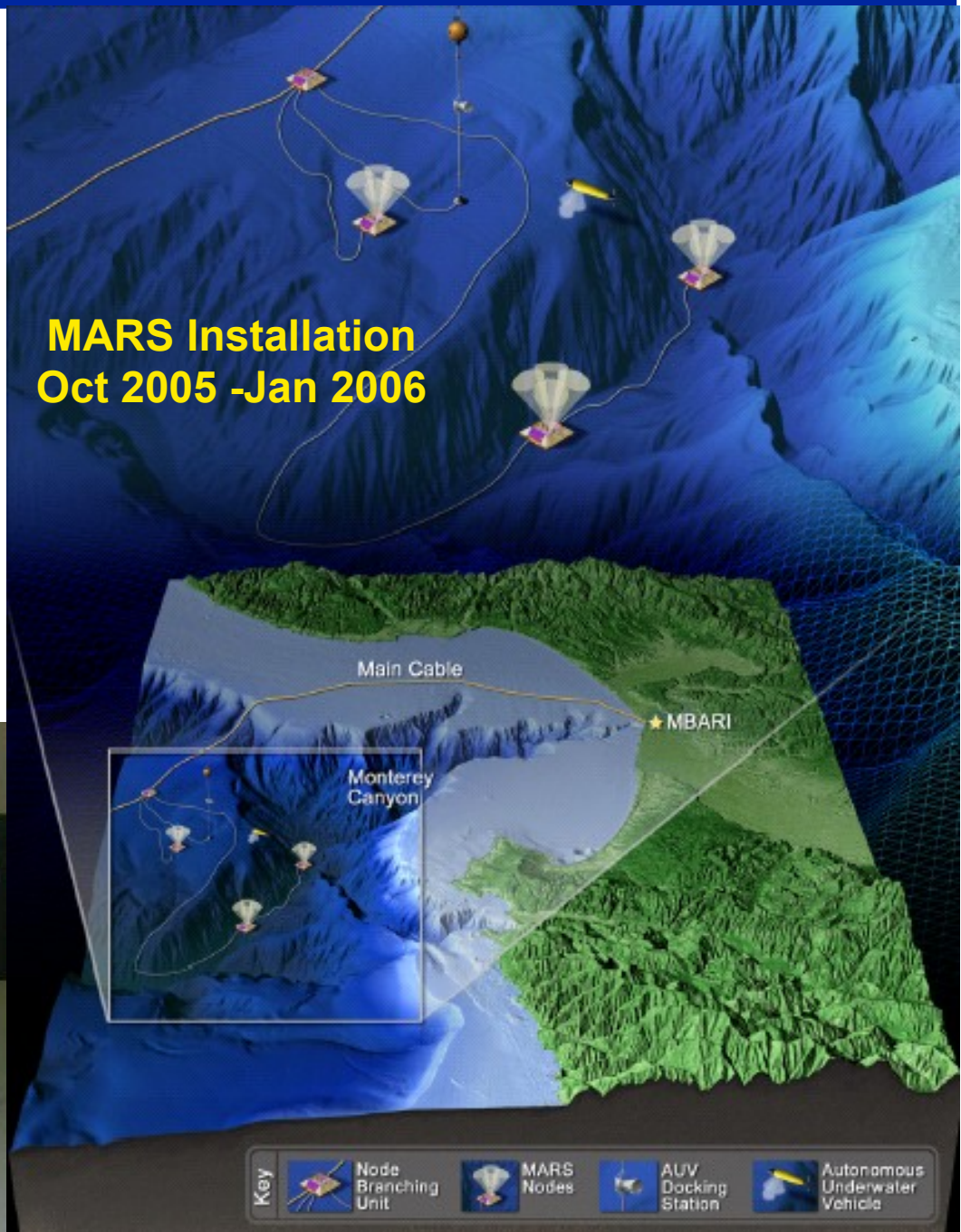
NEPTUNE

Source John Delaney & Deborah Kelley, UWash

Monterey Accelerated Research System (MARS) Cable Observatory Testbed







Source: Jim Bellingham, MBARI

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"Infosys's Global Conferencing Center Ground Zero for the Indian Outsourcing Industry."

**So this is our conference room,
probably the largest screen in Asia-
this is forty digital screens [put together].
We could be setting here [in Bangalore] with somebody from New York, London, Boston, San Francisco, all live.
…That's globalization."**

--Nandan Nilekani, CEO Infosys

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Early Vision of How Fiber-Optics Eliminates Distance



Linking Institute Control Rooms

Jason Leigh and Tom DeFanti, EVL; Rick Stevens, ANL

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From Smarr Talk (2000)

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Academics use the "Access Grid" for Global Conferencing



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

Creating CyberPorts on the NLR– Such as ACCESS DC and TRECC Chicago



TRECC



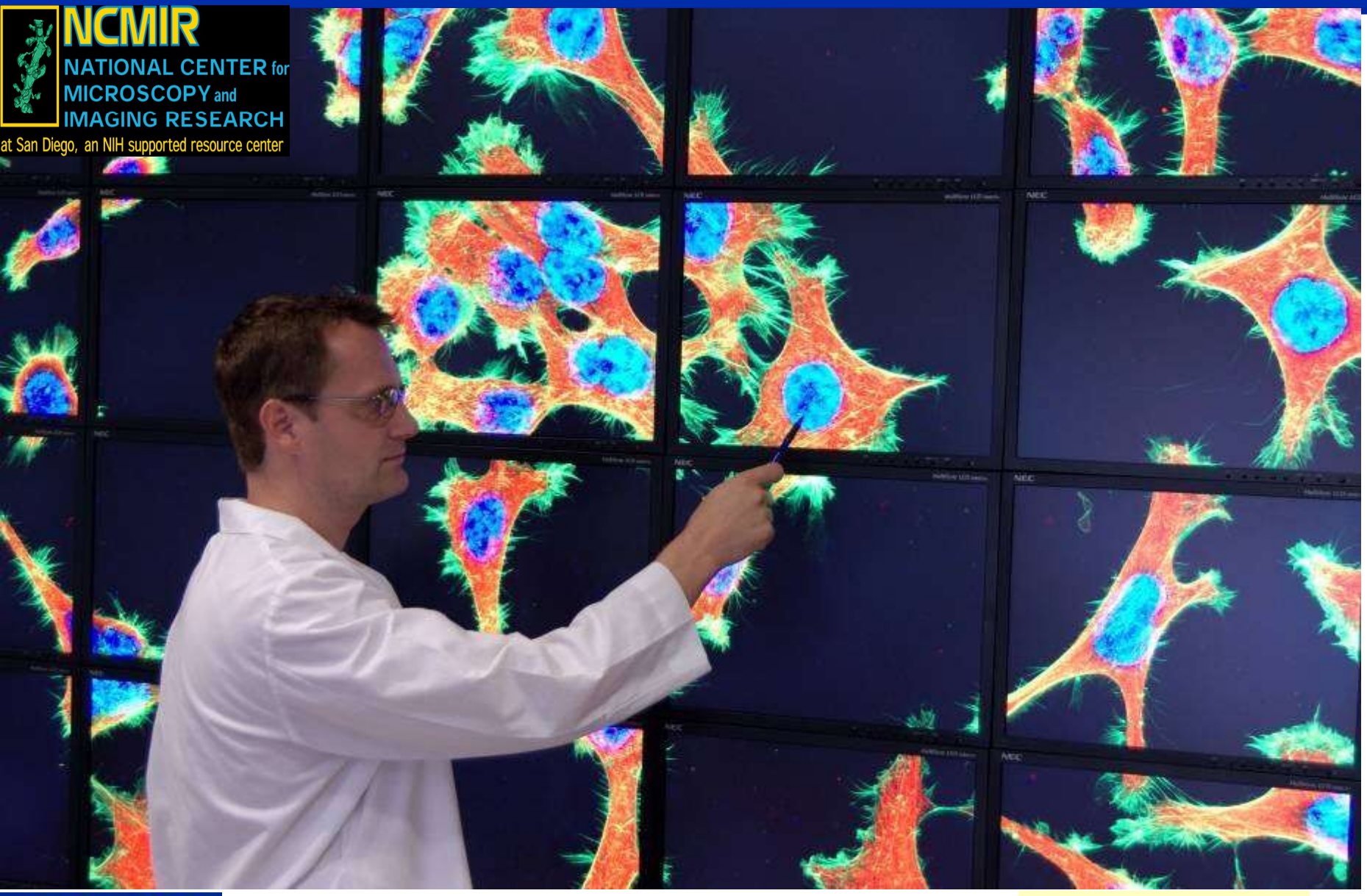






www.trecc.org

Realizing the Dream: High Resolution Portals to Global Science Data



Source: Mark Ellisman, David Lee, Jason Leigh, Tom Deerinck

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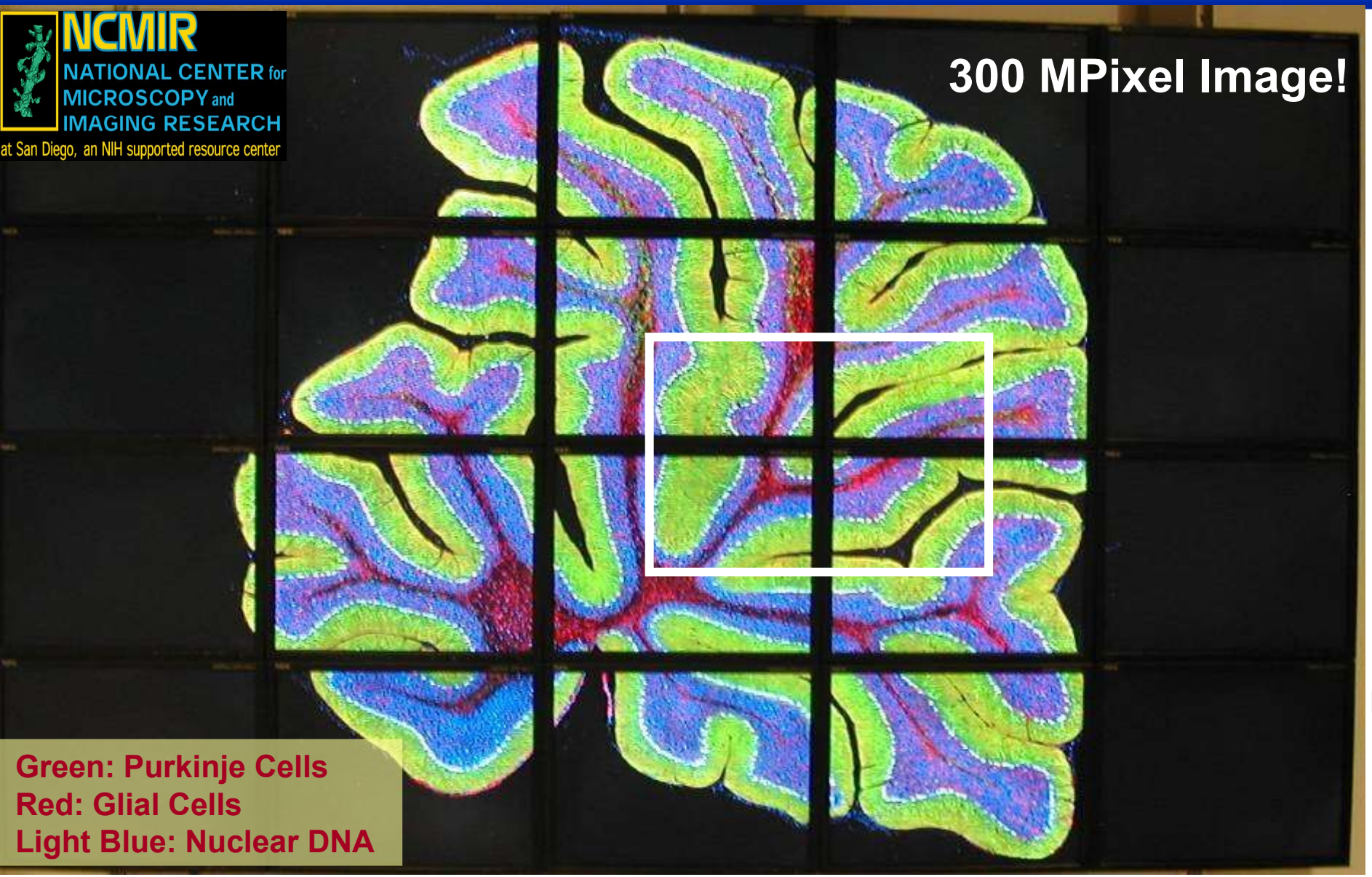
650 Mpixel 2-Photon Microscopy Montage of HeLa Cultured Cancer Cells

Green: Actin
Red: Microtubles
Light Blue: DNA

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Scalable Displays Being Developed for Multi-Scale Biomedical Imaging

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



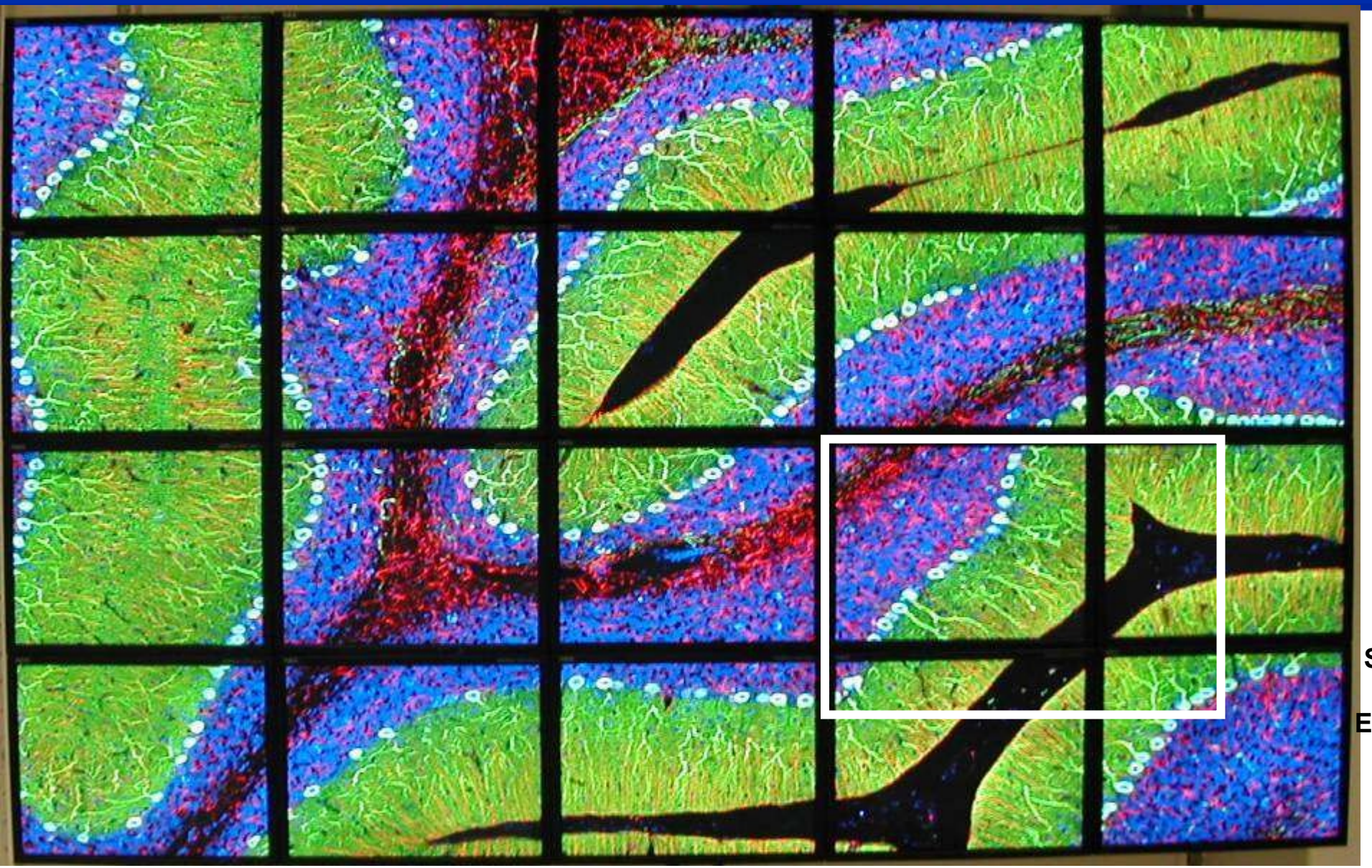
Source: Mark Ellisman, David Lee, Jason Leigh

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Two-Photon Laser Confocal Microscope Montage of 40x36=1440 Images in 3 Channels of a Mid-Sagittal Section of Rat Cerebellum Acquired Over an 8-hour Period

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Scalable Displays Allow Both Global Content and Fine Detail



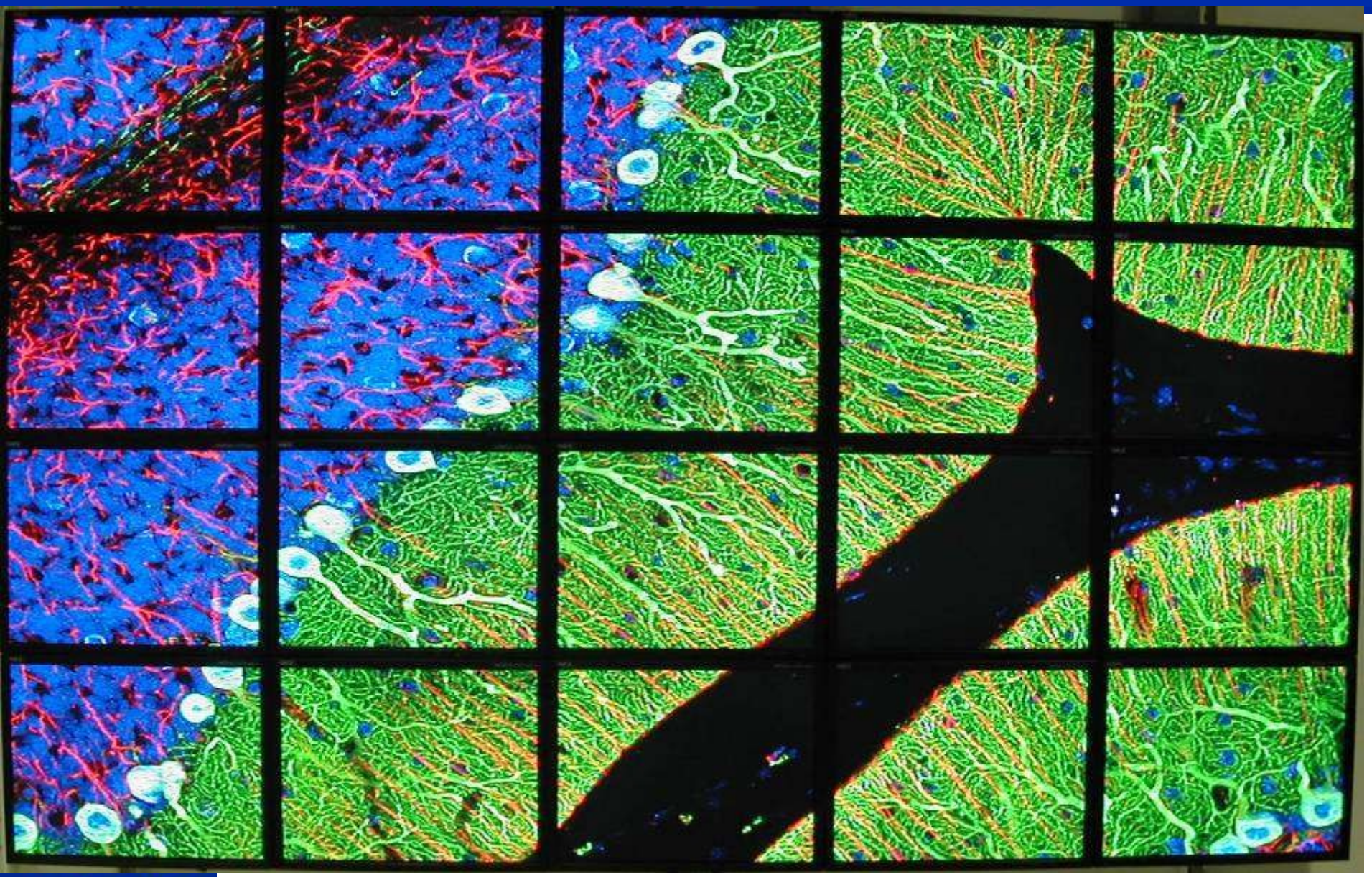
Source: Mark Ellisman, David Lee, Jason Leigh

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30 MPixel SunScreen Display Driven by a 20-node Sun Opteron Visualization Cluster

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Allows for Interactive Zooming from Cerebellum to Individual Neurons

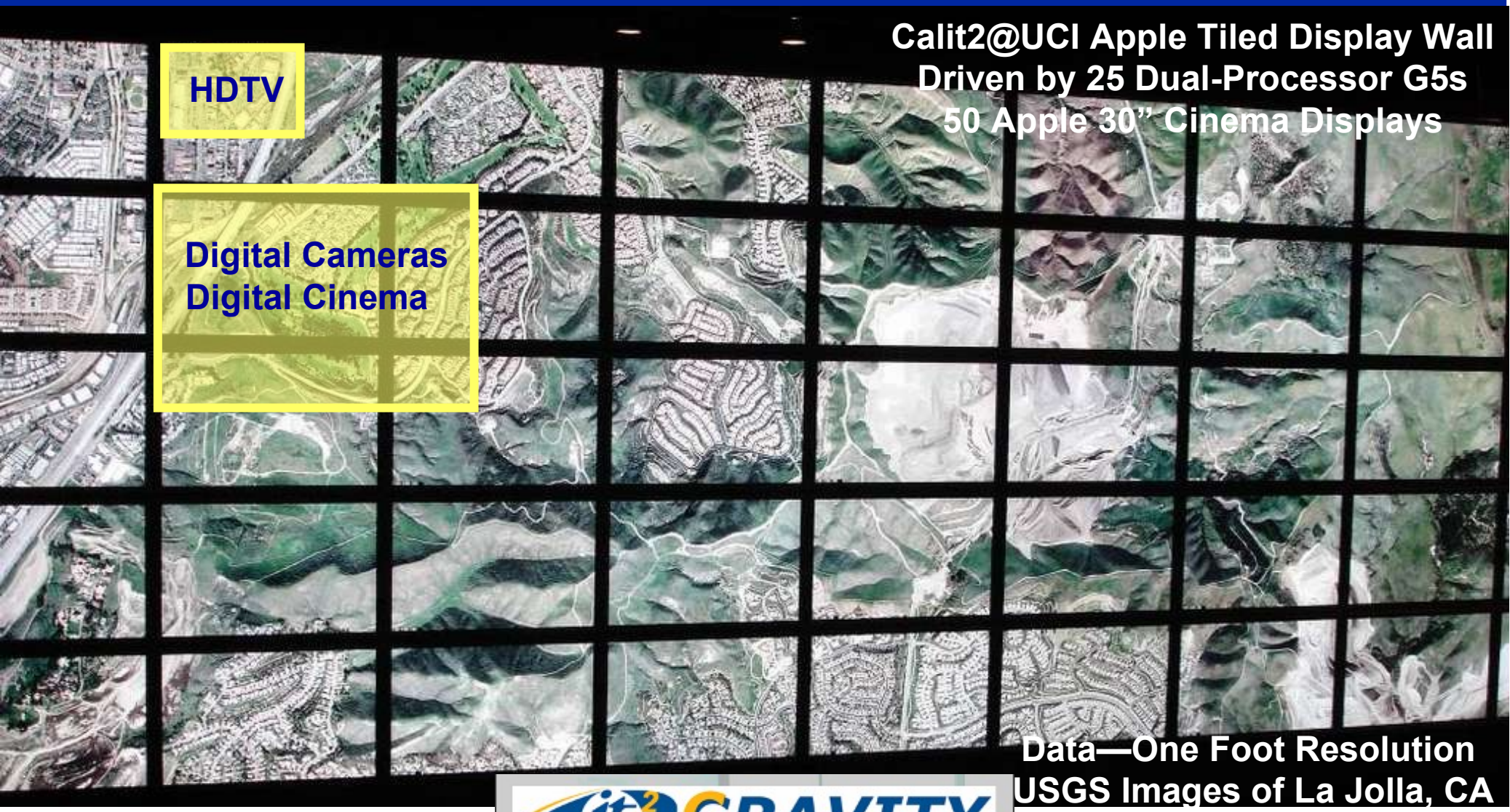


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Source: Mark Ellisman, David Lee, Jason Leigh

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200 Million Pixels of Viewing Real Estate!



it² Center of GRAVITY
Center of Graphics, Visualization and Imaging Technology

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Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

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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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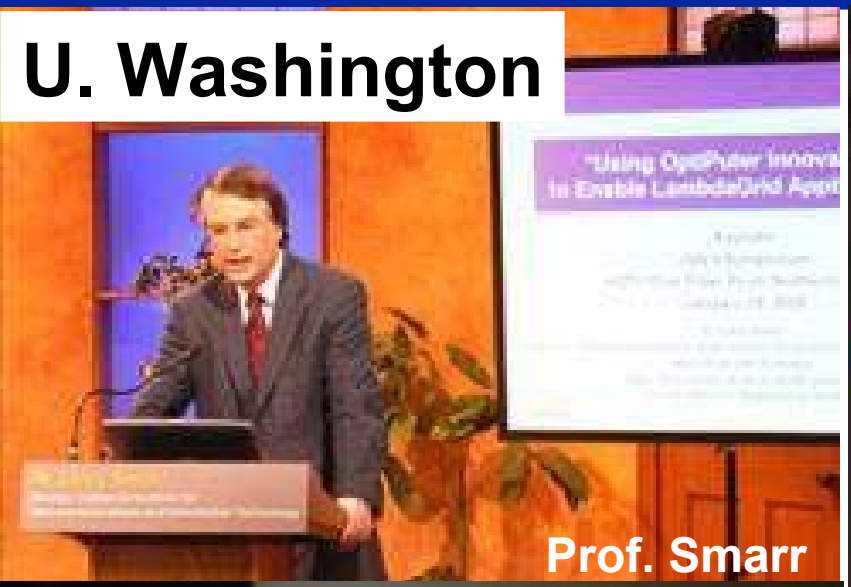
Large Image with Enormous Detail Require Interactive LambdaVision Systems



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

One Square Inch Shot From 100 Yards

Multiple HD Streams Over Lambdas Will Radically Transform Global Collaboration





Telepresence Using Uncompressed 1.5 Gbps HDTV Streaming Over IP on Fiber Optics--
75x Home Cable "HDTV" Bandwidth!

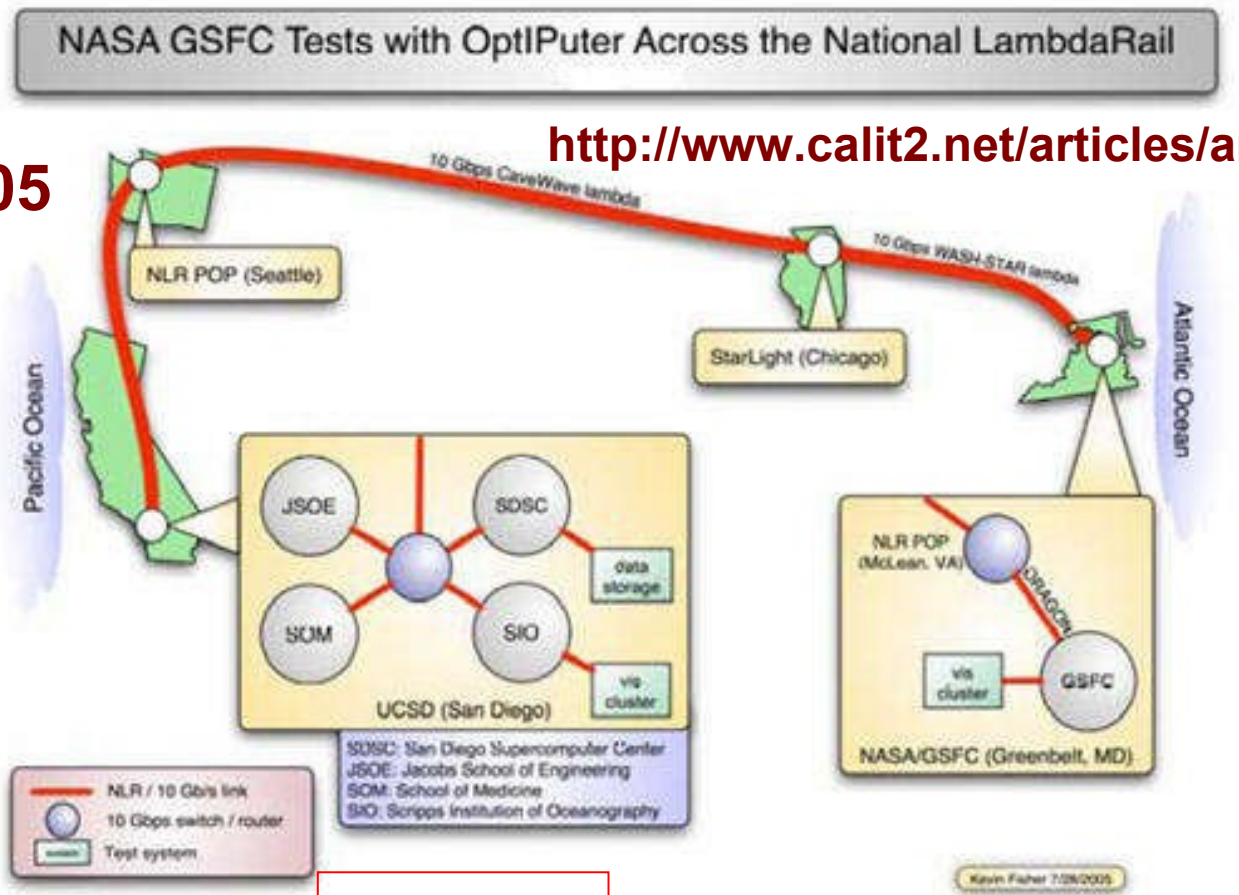


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Source: U Washington Research Channel

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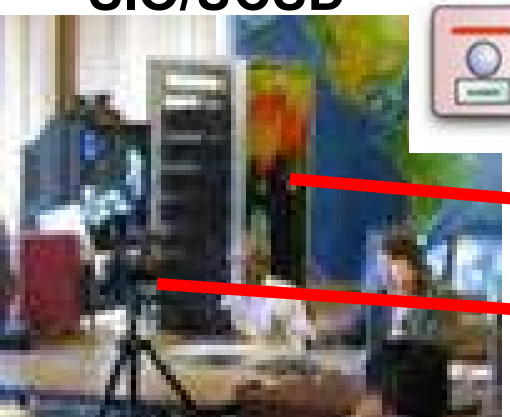
Combining Telepresence with Remote Interactive Analysis of Data Over NLR



August 8, 2005

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

SIO/UCSD



OptIPuter Visualized Data

HDTV Over Lambda

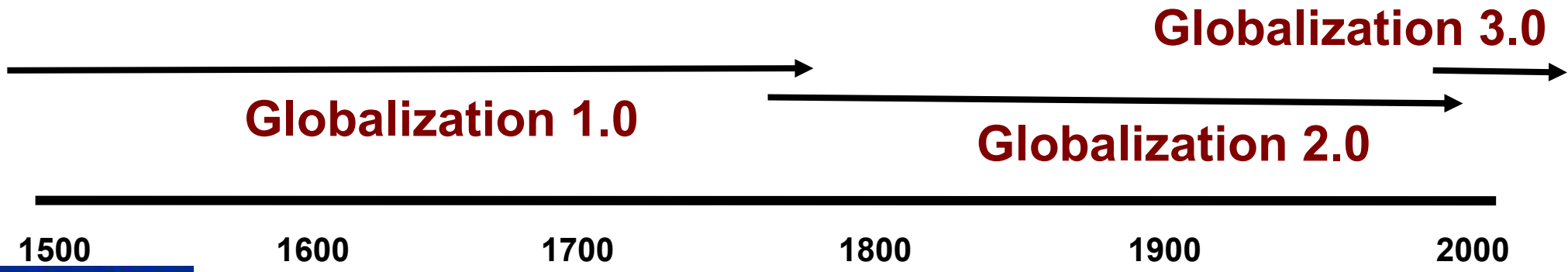


NASA Goddard

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We Stand at the Beginning of the Globalization 3.0 Era

Globalization 1.0 was about countries and muscles. In Globalization 2.0 the dynamic force driving global integration was multinational companies. The dynamic force in Globalization 3.0 is the newfound power for individuals to collaborate & compete globally. And the lever that is enabling individuals and groups to go global is software in conjunction with the creation of a global fiber-optic network that has made us all next-door neighbors."



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