The Future Applications of Australia's National Broadband Network

Digital Futures Keynote Address
Plenary Hall, Wrest Point Hotel
Hobart, Tasmania, Australia
August 10, 2009

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

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Tasmania Has Taken the Lead for Australia in Fiber to the Premise (FTTP)

- **Tasmanian Collaborative Optical Leading Testbed**
  - Five Years of Experience Since the Proposal
  - South Hobart & New Town in the South, Devonport in the NorthWest Connected 2006-08 – 1200 Premises
  - First of Its Kind and Scale in Australia
- **Wide Range of Applications:**
  - High Speed Internet
  - Multiple Voice Lines Using Voice Over IP (VOIP)
  - Digital Broadcast TV
  - Video on Demand (VOD)
  - High Speed Data Networks/Virtual Private Networks (VPN)
  - Video Conferencing
  - Video Security

tecc.com.au
Tasmanian Electronic Commerce Centre Pty Ltd

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

tasCOLT
Tasmanian Collaborative Optical Leading Testbed

it²

Digital Future of Tasmania--A Five Year Vision
2011 – 2012 Focus

- **Transition of Government Services to Digital Delivery**
  - **Lifestyle and Economic Parity**
    - **Between Rural, Regional and Urban Tasmania**
  - **Increase Efficiency in Energy and Natural Resources Management and Consumption**
- **Implement State-Wide In Tasmania:**
  - **Virtual Home Care System**
  - **Virtual Class Rooms**
  - **Smart Utilities Grid**
  - **Virtual Management of All Irrigation/Water Systems**
  - **Next Generation Municipal Management**
  - **Services Tasmania In The Home**

Tasmania
Explore the possibilities

Source: Jim Wyatt, Department of Economic Development, Tasmania

Premier Bartlett
On 21st Century Infrastructure

- **For most of the 20th century, Tasmania's economic development was underpinned and driven by a far-sighted investment in hydro electricity.**

- **Tasmania's future will be closely tied to our ability as a State to stay connected to a fast-paced world.**

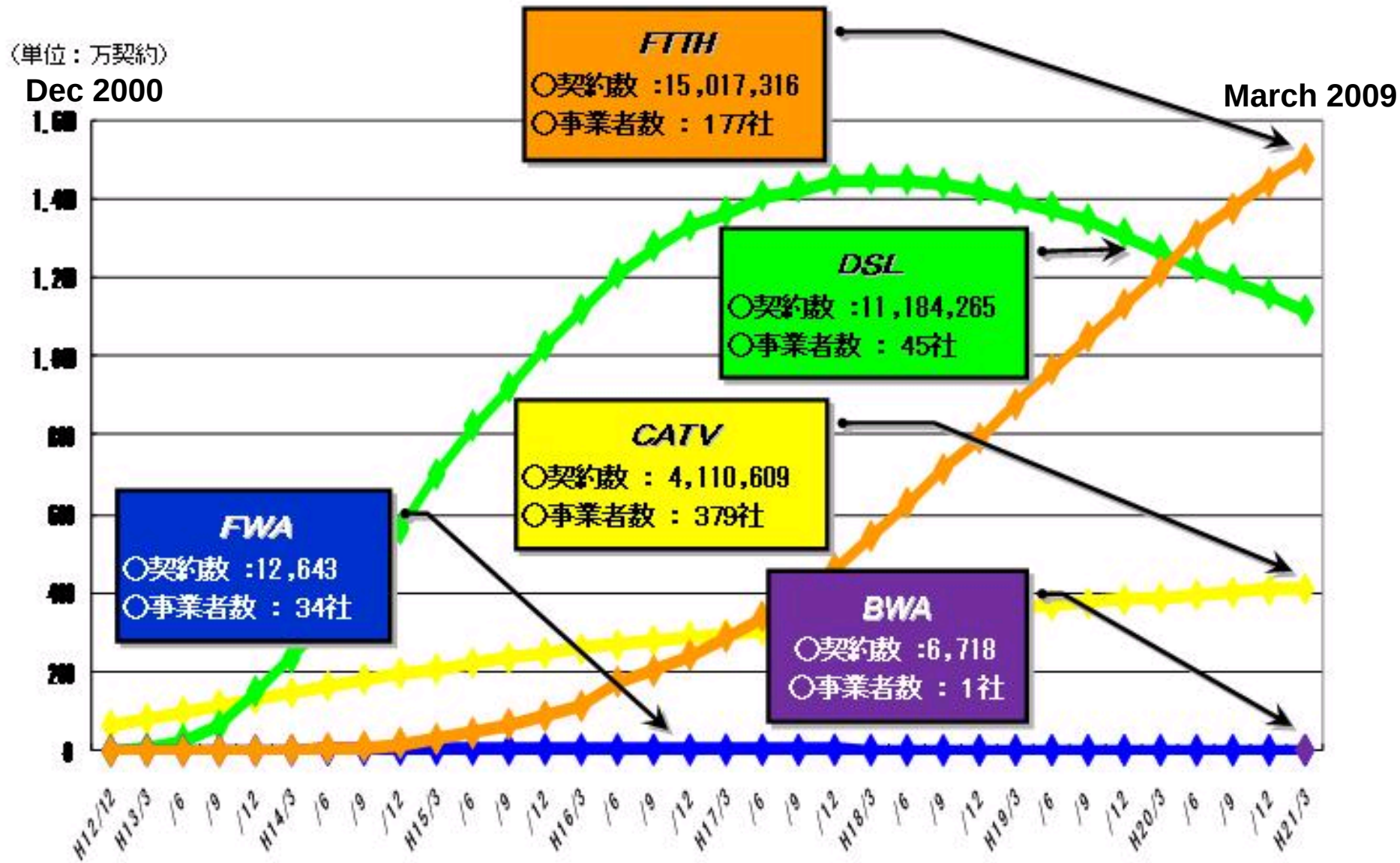
- **Telecommunications infrastructure will be to the 21st Century what the dams, poles and wires of the Hydro were to the 20th.**

3 March, 2009

State of the State Address 2009

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

In Japan, FTTH Has Become the Dominant Broadband--Subscribers to "Slow" 40 Mbps ADSL Are Decreasing!

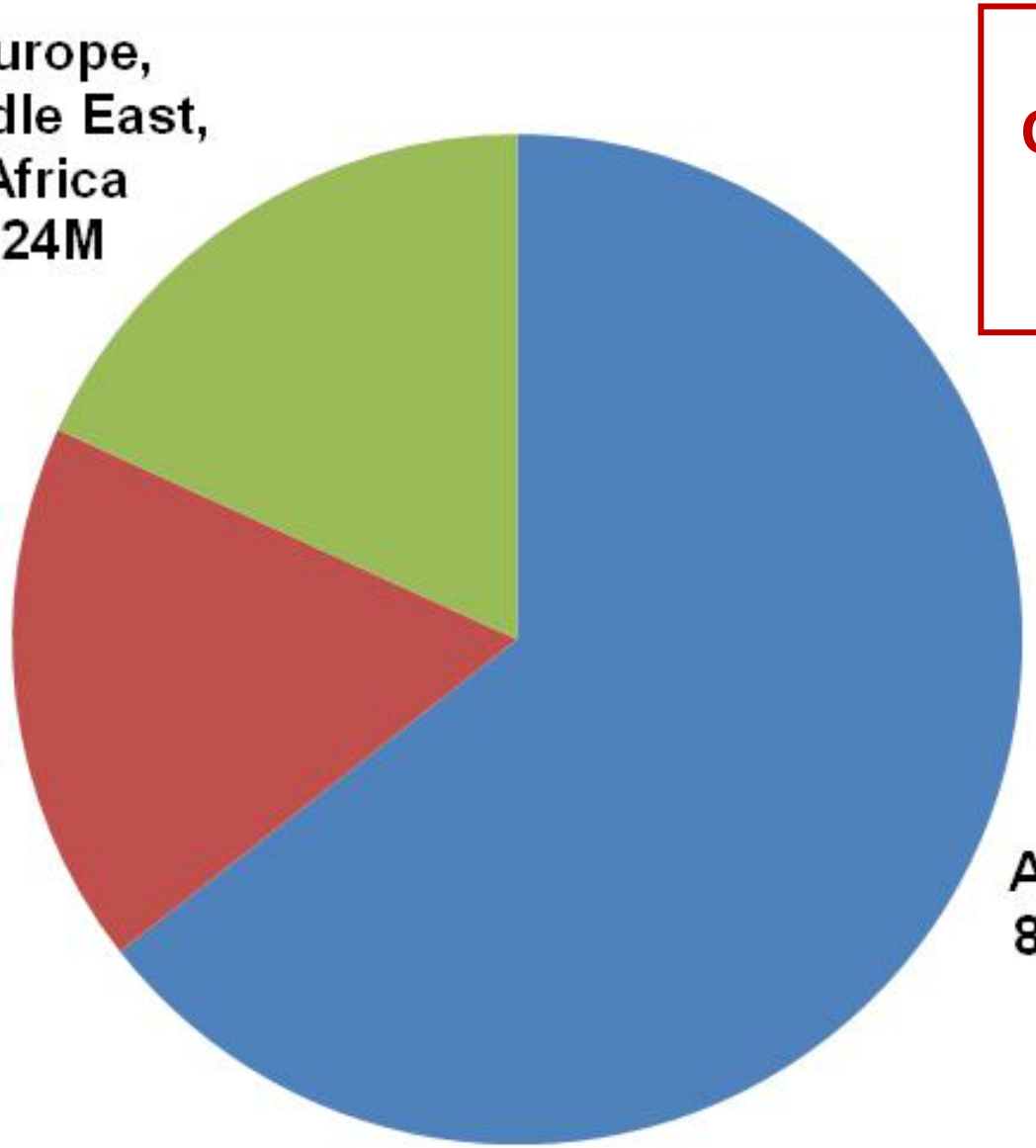


Source: Japan's Ministry of Internal Affairs and Communications
Add url

Globally Fiber to the Premise is Growing Rapidly, Mostly in Asia

47 Million Households with FTTH End of 2009

130 Million Households with FTTH in 2013



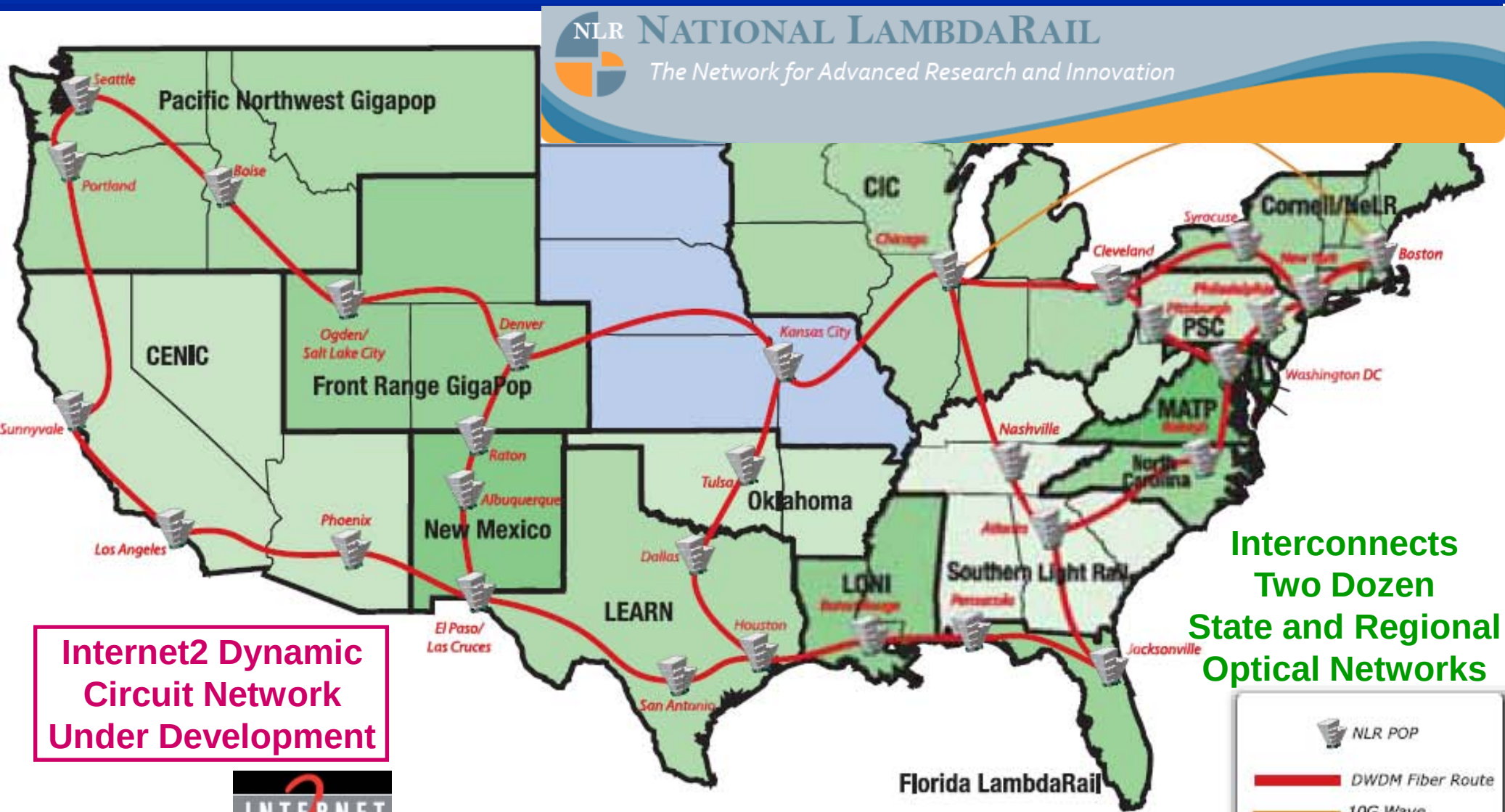
FTTP Connections Growing at ~30%/year

China Will Have Most by 2012

Source: Heavy Reading (www.heavyreading.com), the market research division of Light Reading (www.lightreading.com).

Australian American Leadership Dialogue

A View Into the Future of NBN Applications: University Research Using Dedicated 10Gbps Lightpaths



NSF's OptIPuter Project: Using Supernetworks to Meet the Needs of Data-Intensive Researchers



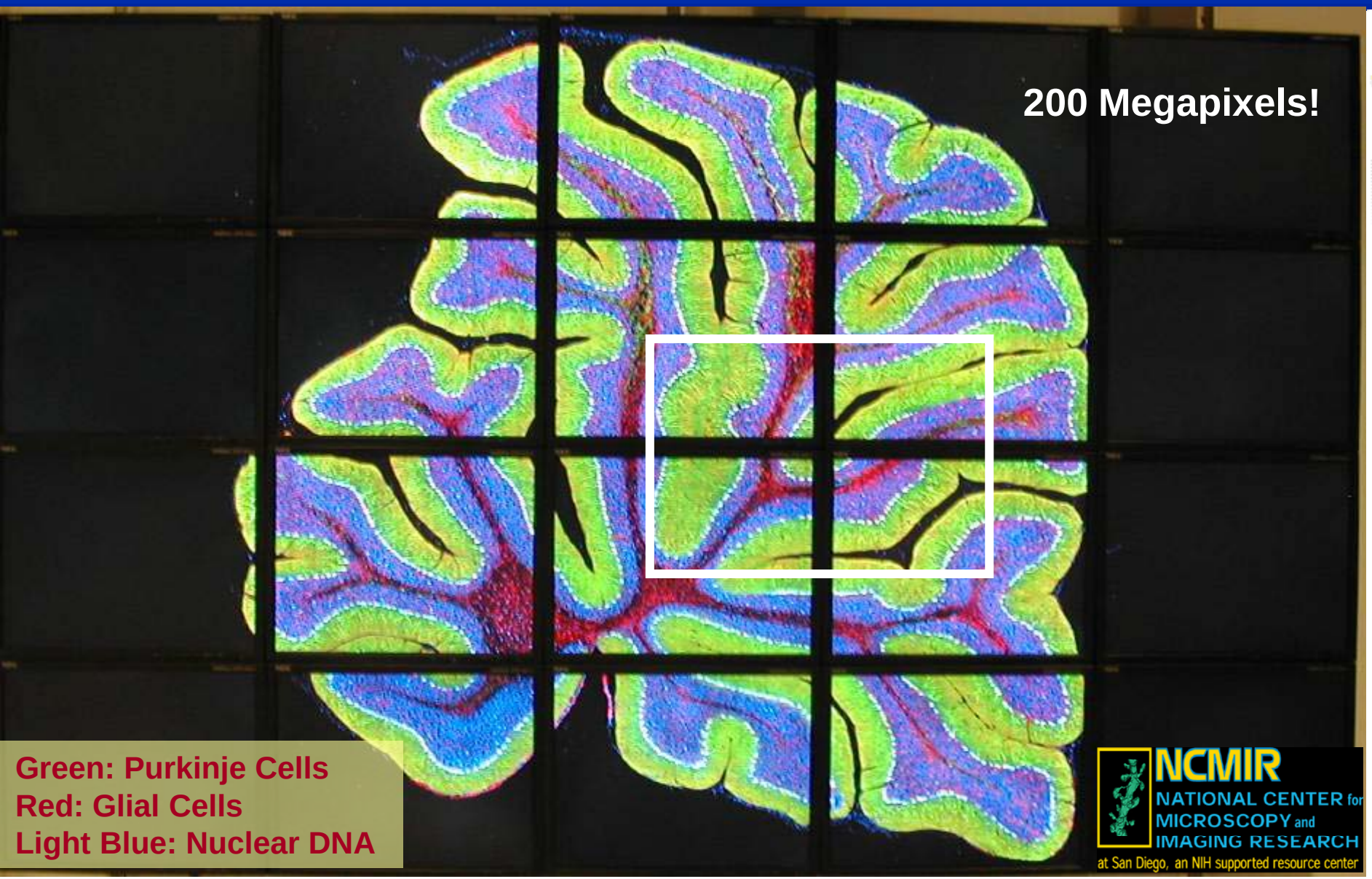
OptIPortal– Termination Device for the OptIPuter Global Backplane

Powered by Rocks

Australian American Leadership Dialogue

Calit2 (UCSD, UCI), SDSC, and UIC Leads—Larry Smarr PI
Univ. Partners: NCSA, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST
Industry: IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

Use of OptIPortal to Interactively View Multi-Scale Biomedical Imaging

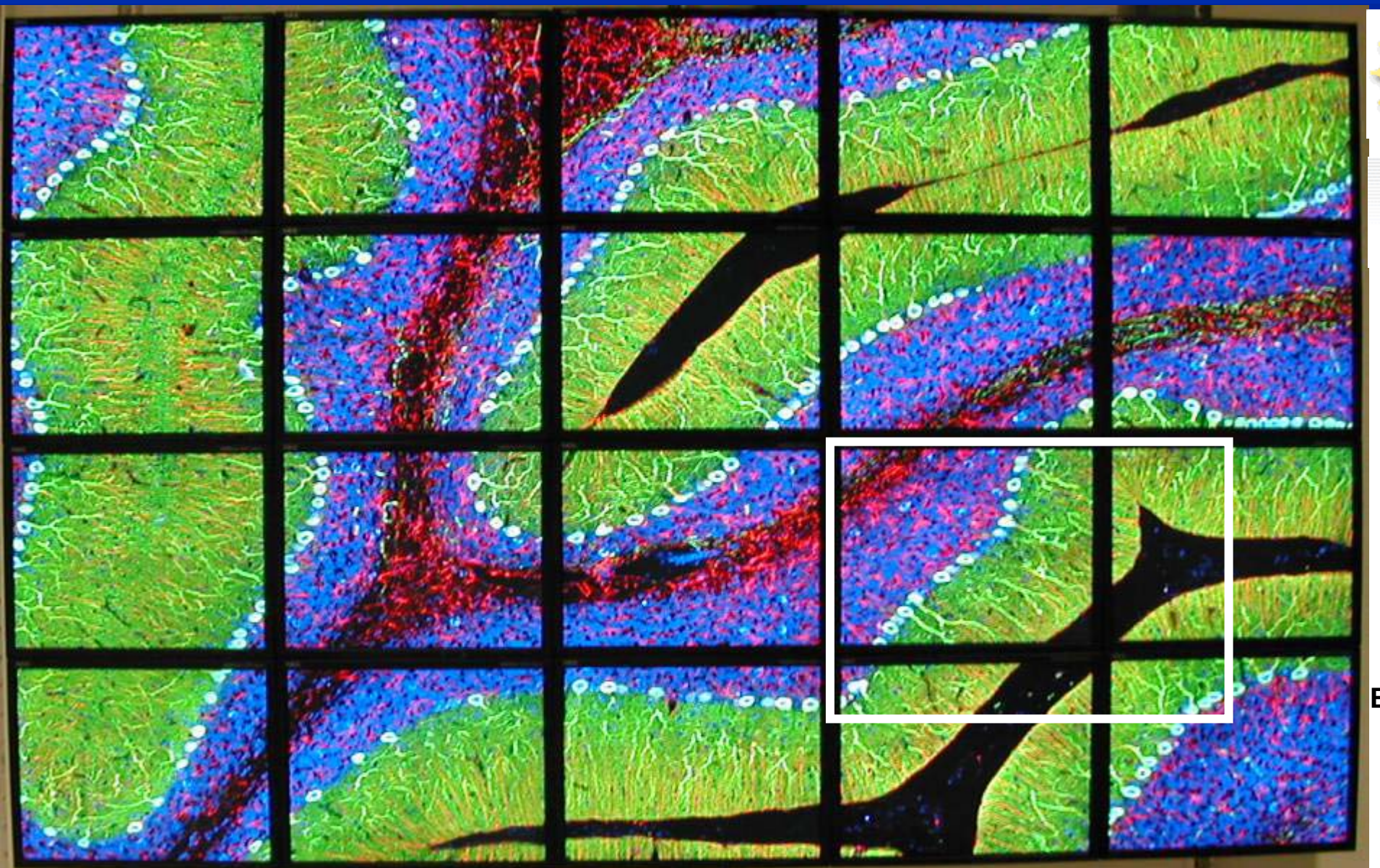


Source: Mark Ellisman, David Lee, Jason Leigh

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

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Scalable Displays Allow Both Global Content and Fine Detail



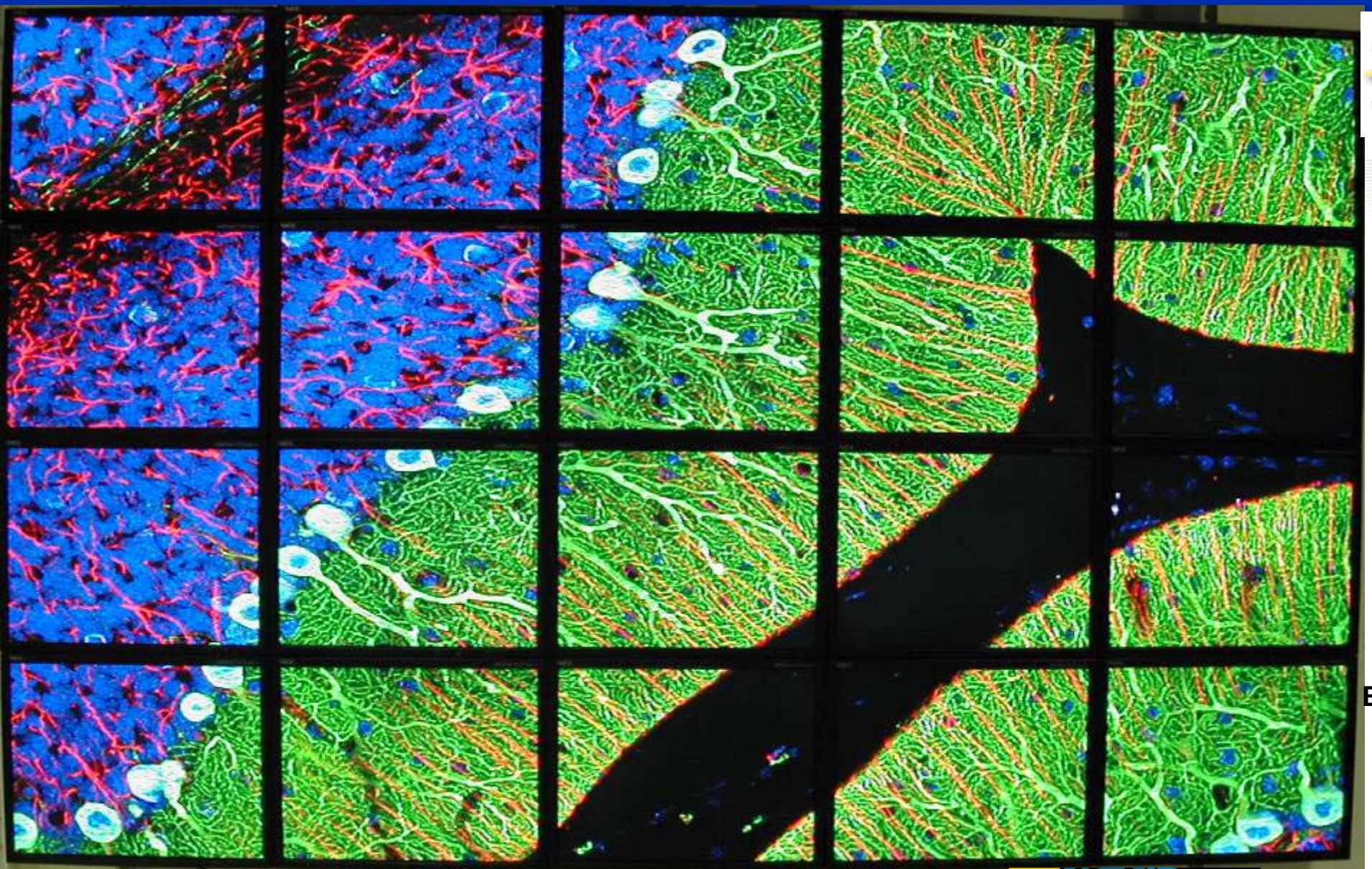
Source: Mark Ellisman, David Lee, Jason Leigh

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

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

it²

Allows for Interactive Zooming from Cerebellum to Individual Neurons



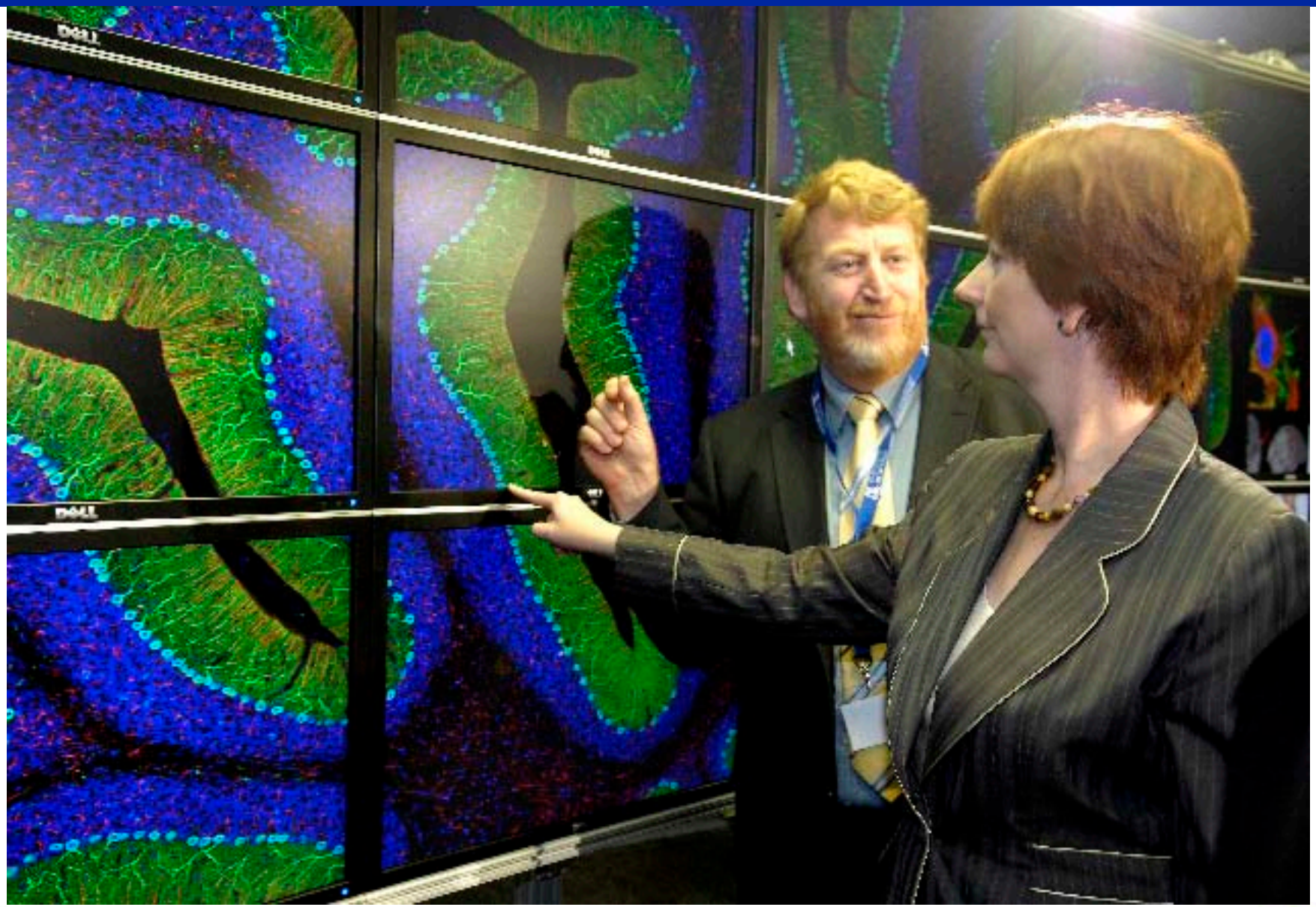
Source: Mark Ellisman, David Lee, Jason Leigh

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

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

it²

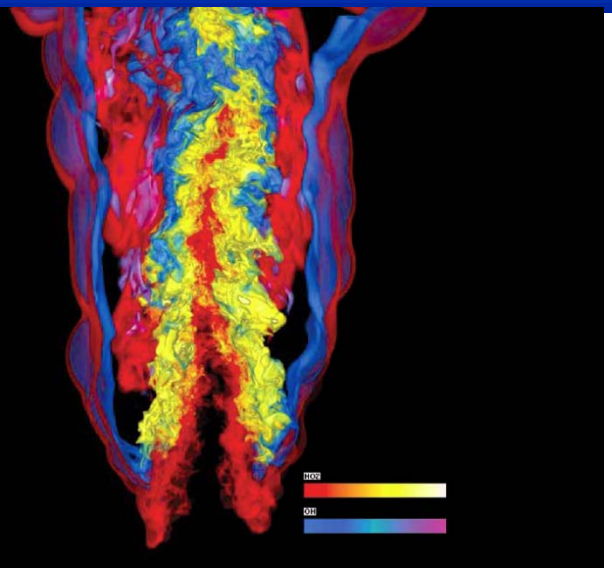
Empowering the "Digital Education Revolution"



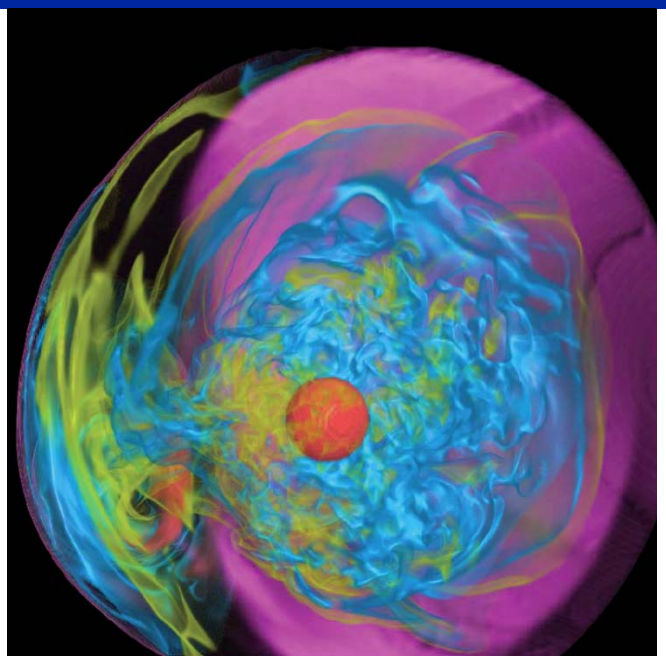
AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

© 2009, AARNet Pty Ltd

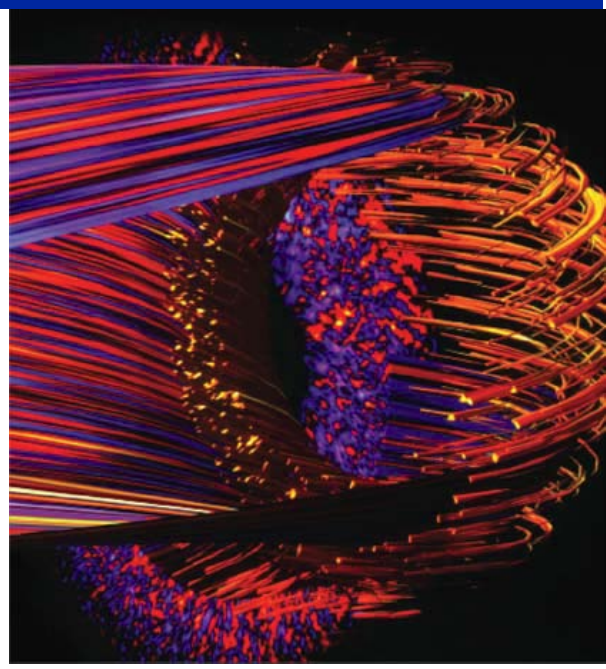
Department of Energy Office of Science
Leading Edge Applications of Petascale Computers



Flames

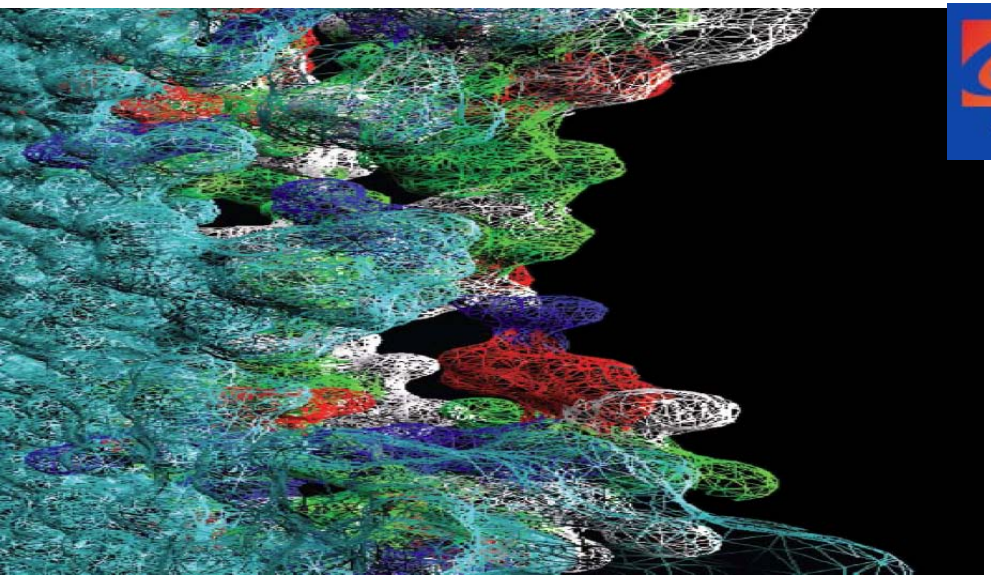


Supernova

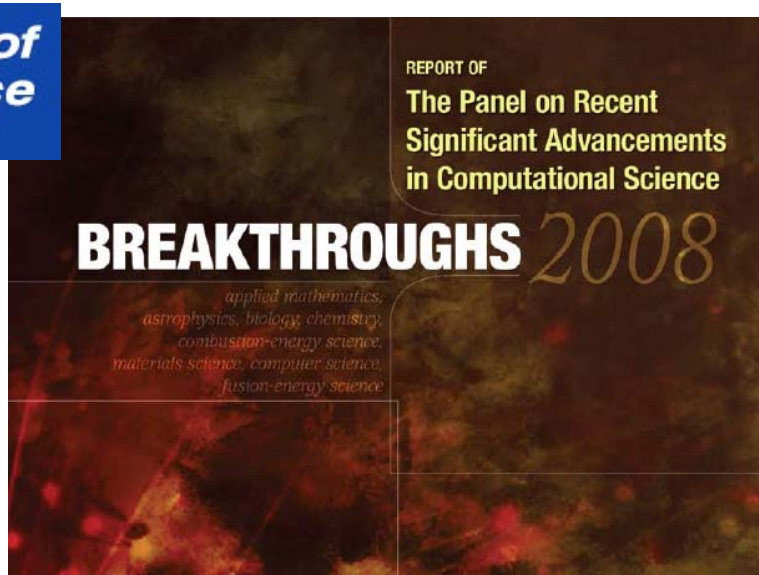


Fusion

Parkinson's



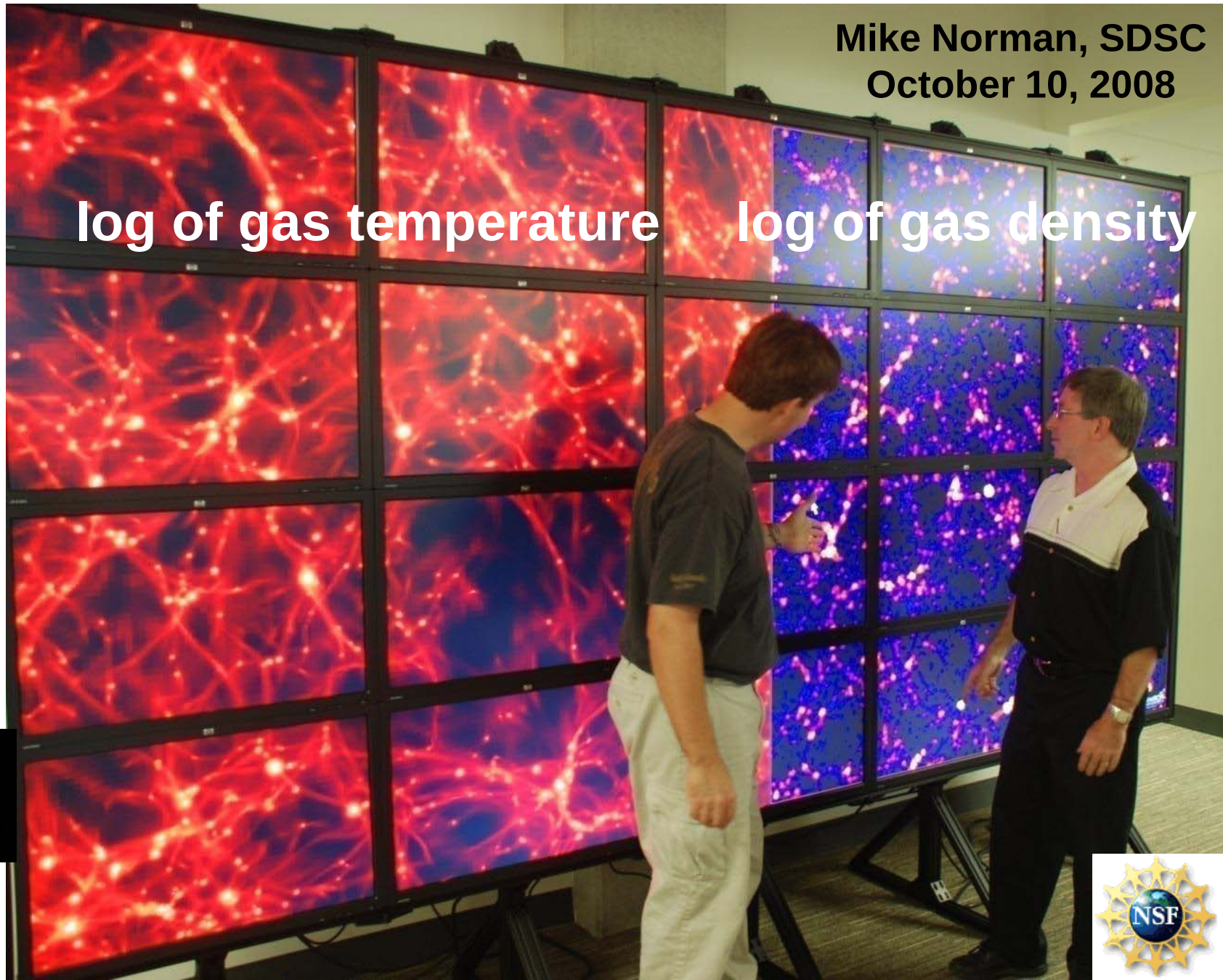
Office of Science
U.S. DEPARTMENT OF ENERGY



OptIPortals: Scaling up the Personal Computer For Supernetwork Connected Data-Intensive Users

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

Two 64K Images From a Cosmological Simulation of Galaxy Cluster Formation



ROCKS
www.rocksclusters.org

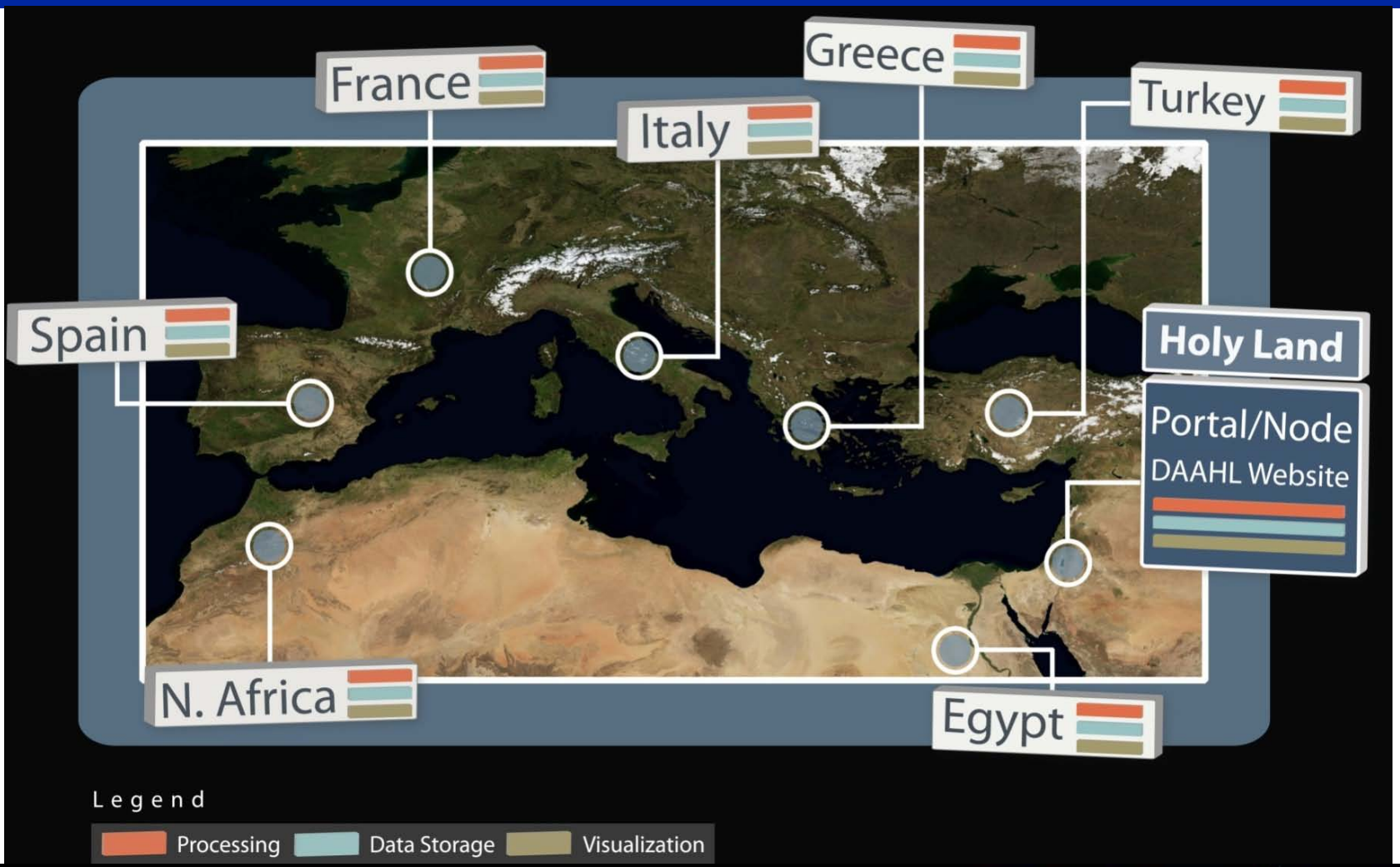
CGLX

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

NSF

Mediterranean Archaeological Network (MedArchNet)

Online Atlas, Cyberinfrastructure and Portal-Based Science Environments



CISA3

Center of Interdisciplinary Science for Art, Architecture, and Archaeology

UC San Diego Division, California Institute for Telecommunications and Information Technology

DAH UCSD Jacobs Calit2



Interactive VR Streamed Live from Tokyo to Calit2 Over Dedicated GigE and Projected at 4k Resolution







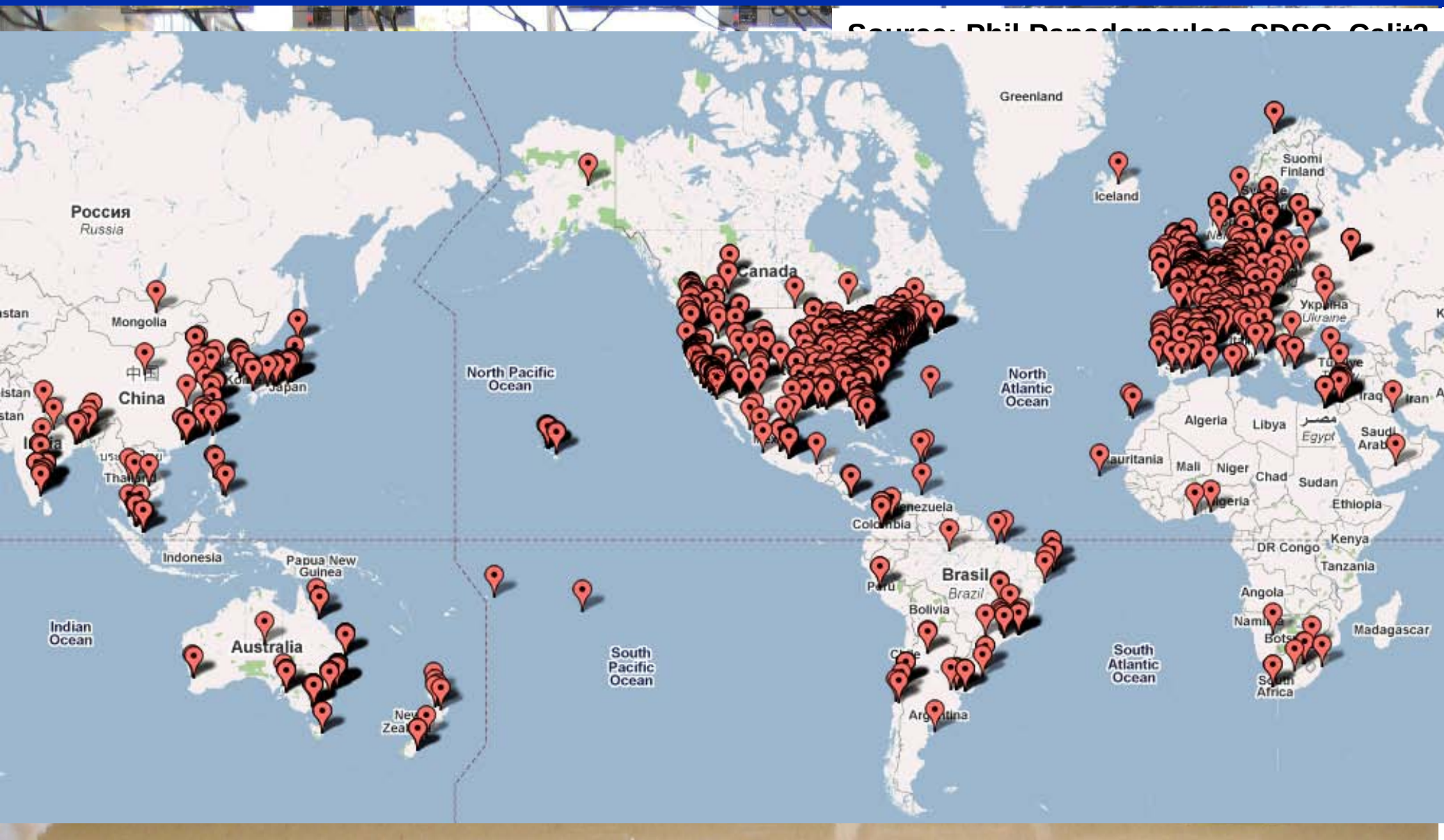
Source: Toppan Printing



iGrid 2005 Kyoto Nijo Castle

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Calit2 Microbial Metagenomics Cluster-
Next Generation Optically Linked Science Data Server



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

SDSC

ROCKS

camera
Marine Microbial Ecology

J. Craig Venter
INSTITUTE

it²

Remote Interactive High Definition Video of Deep Sea Hydrothermal Vents



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Source John Delaney & Deborah Kelley, UWash

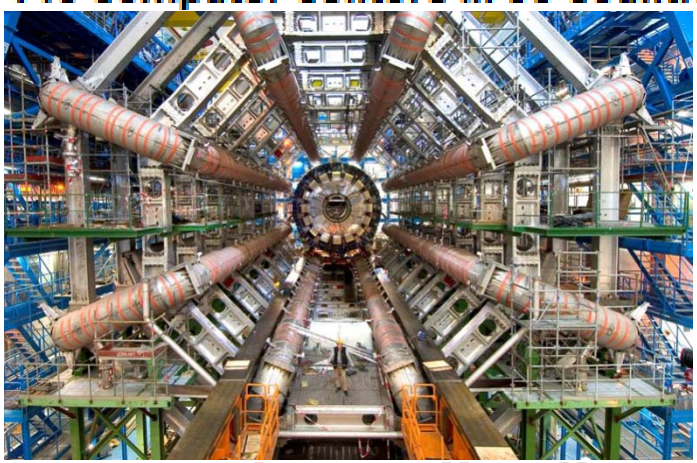
it²

The Large Hadron Collider Uses a Global Fiber Infrastructure To Connect Its Users

CERN Unveils Global Grid For Particle Physics Research

The network can pull in the IT power of more than 140 computer centers in 33 countries to crunch an expected 15 million GB of data every year.

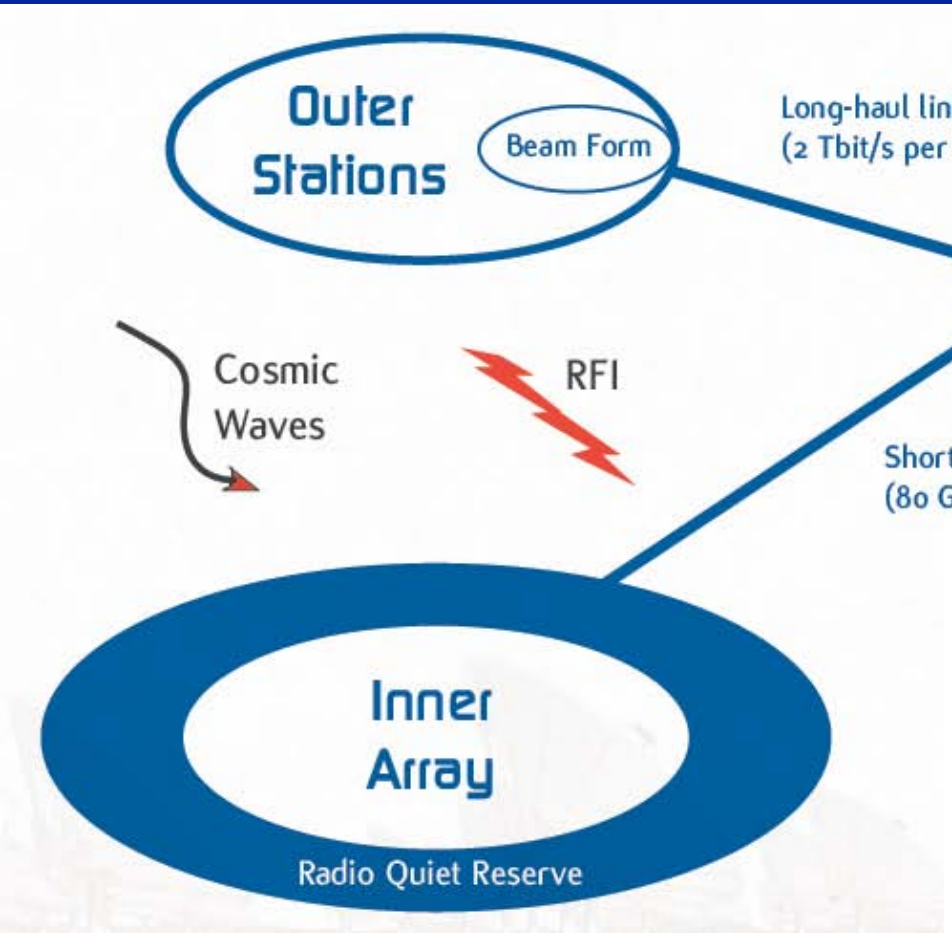
By Antone Gonsalves
InformationWeek
October 3, 2008 04:57 PM



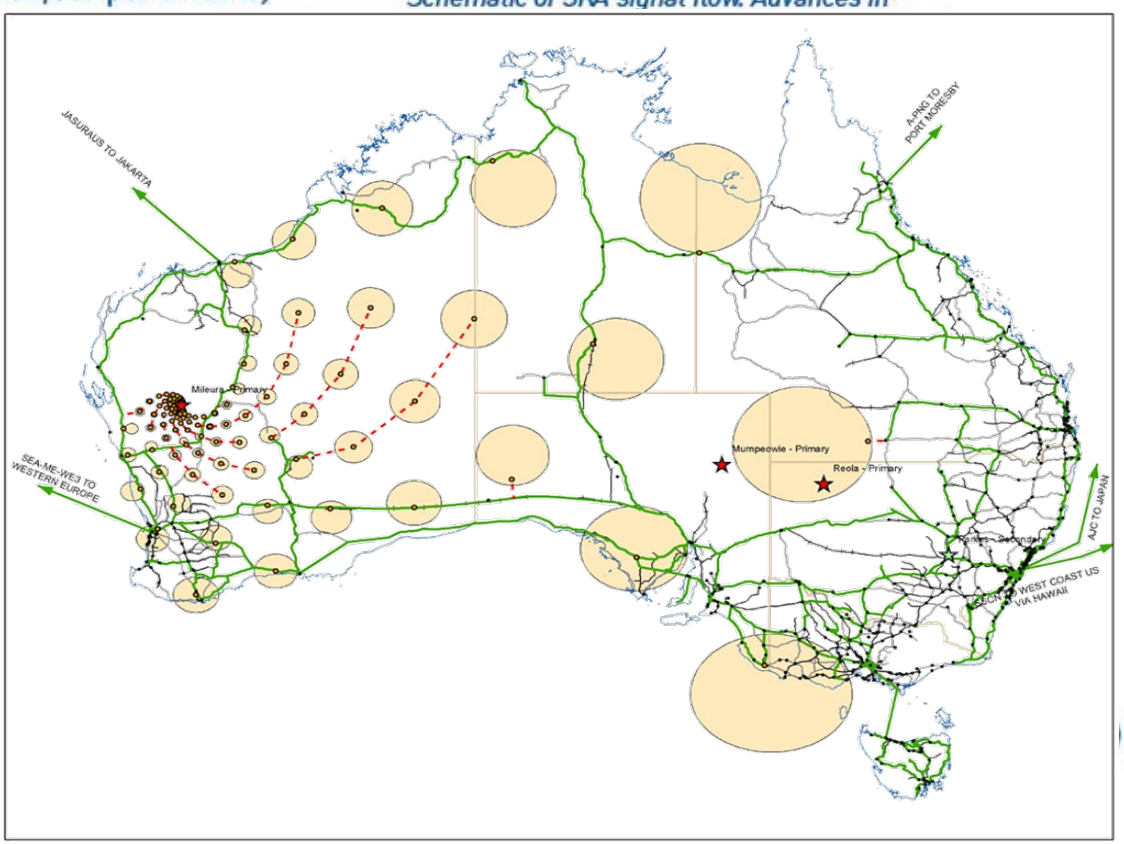
- **The grid relies on optical fiber networks to distribute data from CERN to 11 major computer centers in Europe, North America, and Asia**
- **The grid is capable of routinely processing 250,000 jobs a day**
- **The data flow will be ~6 Gigabits/sec or 15 million gigabytes a year for 10 to 15 years**

Next Great Planetary Instrument:
The Square Kilometer Array Requires Dedicated Fiber

www.skatelescope.org



Schematic of SKA signal flow. Advances in



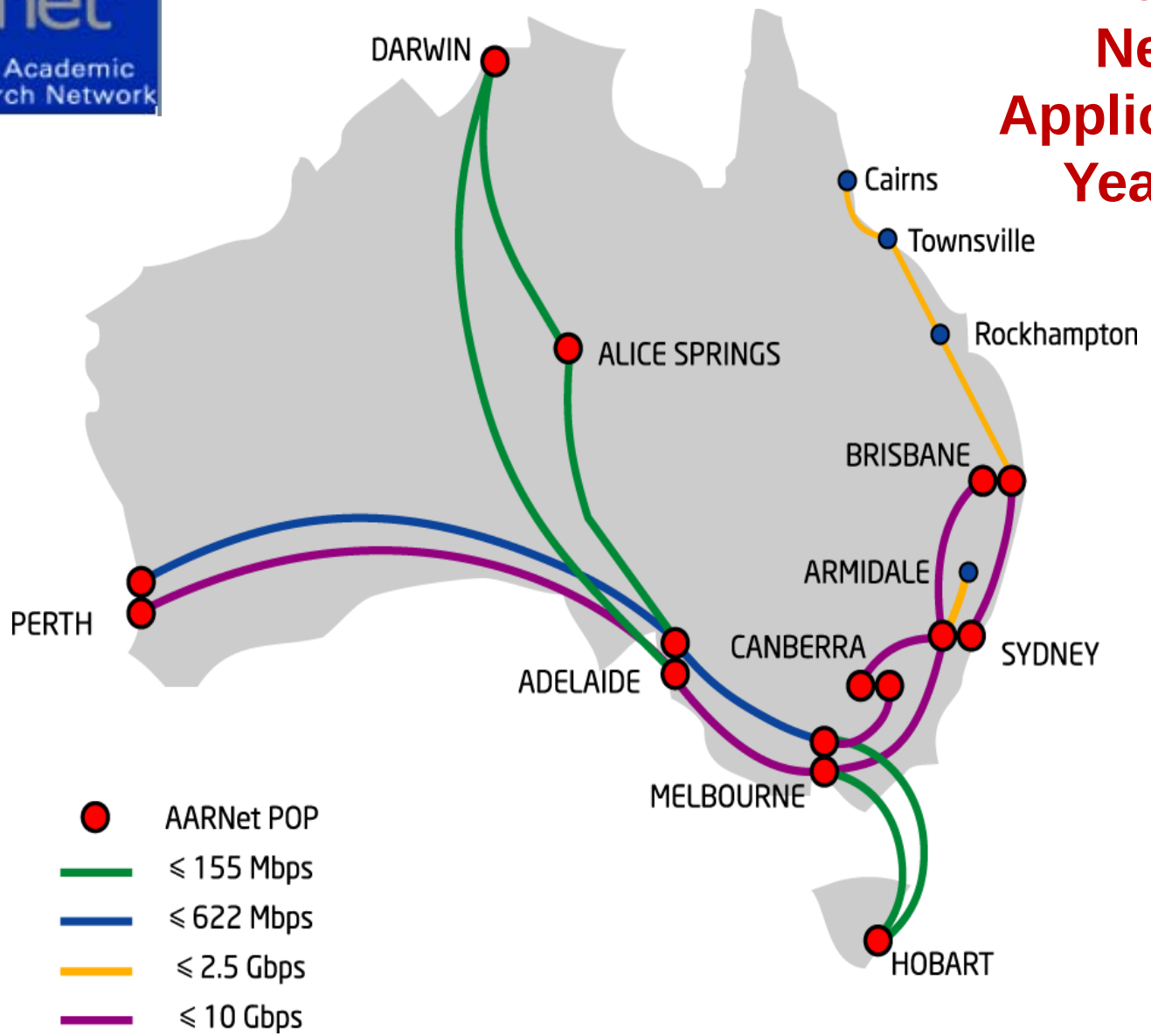
Transfers Of 1 TByte Images World-wide Will Be Needed Every Minute!

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

It is Essential to Couple University Innovations to NBN Buildout

aarnet
Australia's Academic and Research Network

Accelerate New FTTP Applications 5-10 Years Ahead



Source: Chris Hancock, AARNet CEO

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

it²

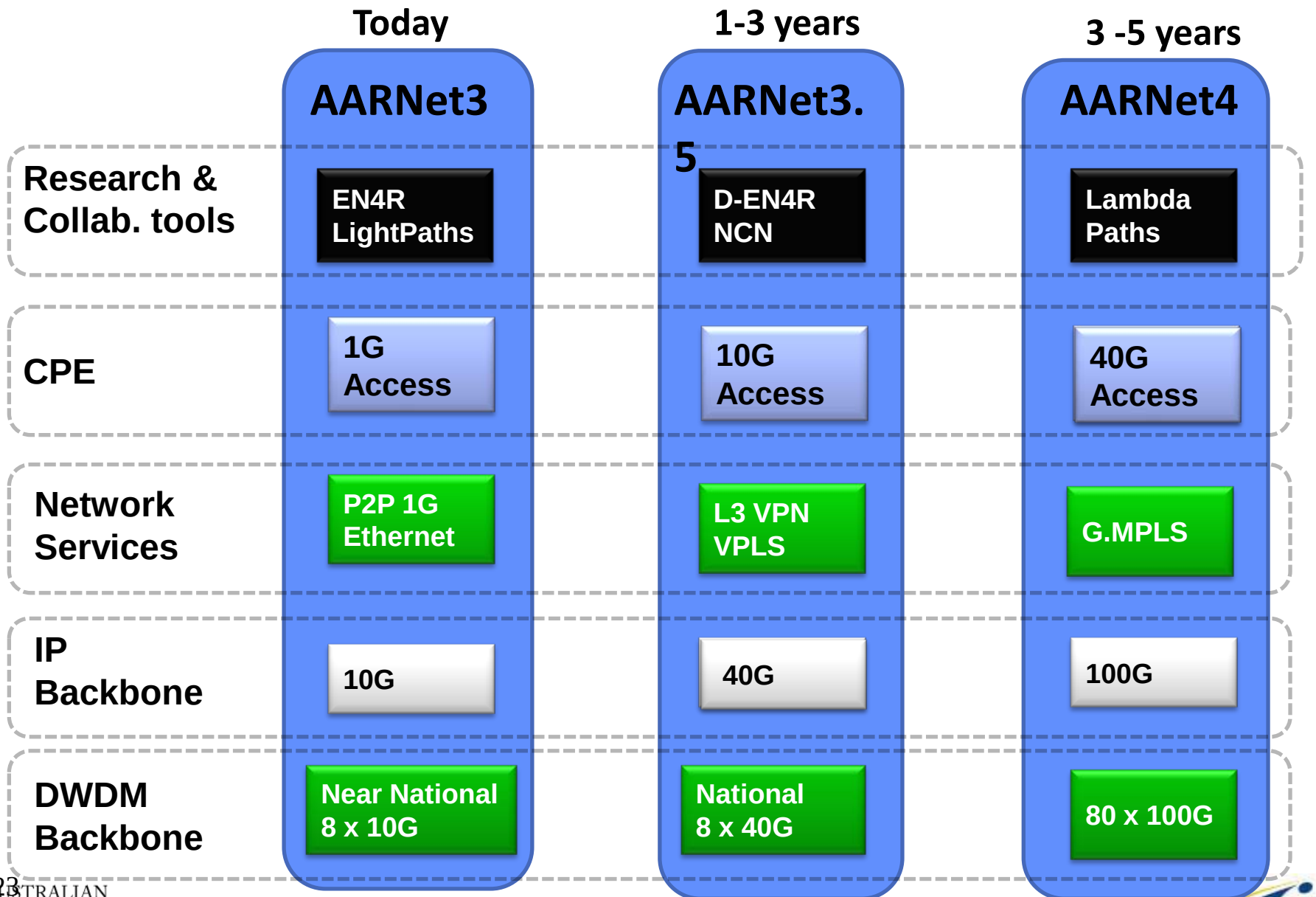
AARNet & the NBN

aarnet
Australia's Academic and Research Network

	2001	2009	2017
Most homes:	40-800 Kbps	1-20 Mbps	25-500 Mbps
Leading-edge homes	4-8 Mbps	100-200 Mbps	2.5-5.0 Gbps
Businesses	4-8 Mbps	100-200 Mbps	2.5-5.0 Gbps
Research centres	40-400 Mbps	1-10 Gbps	25-250 Gbps

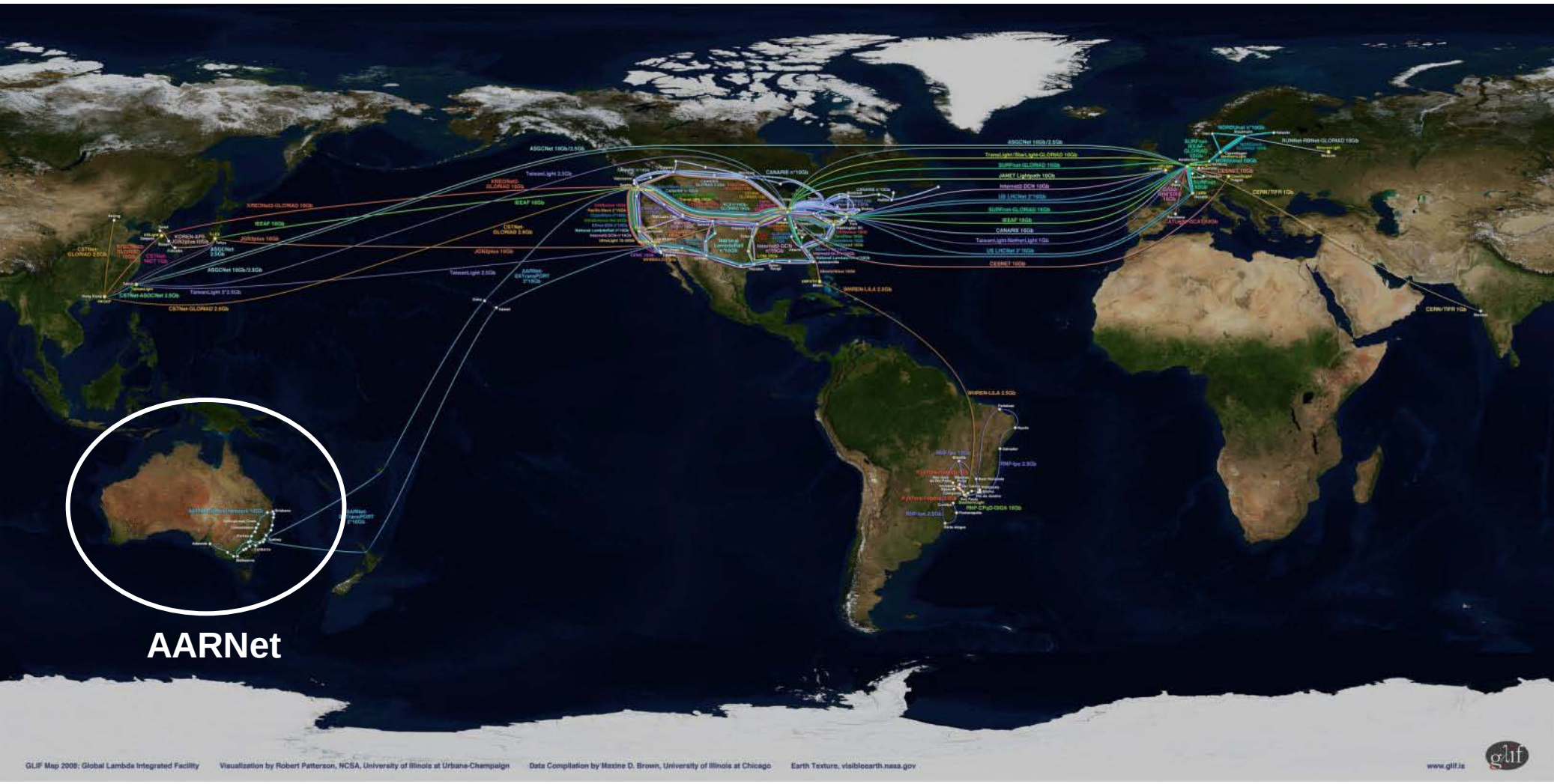
Source: Chris Hancock, AARNet CEO

AARNet Roadmap
Aggressively Growing to Meet Research Needs



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Global Innovation Centers are Being Connected with 10,000 Megabits/sec Clear Channel Lightpaths



Interconnects OptIPortals at Public Research Innovation Centers

Source: Maxine Brown, UIC and Robert Patterson, NCSA

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Use University Campuses as Green IT Testbeds

- **Campuses are Small Cities**
  - **Consolidated Clusters over Dedicated Optical Channels**
  - **Low Energy Mobile Infrastructure**
  - **Sensors and Actuators in Intelligent Buildings**
  - **Low Carbon Transportation System**
  - **Smart Electricity Grid**
  - **Ubiquitous Teleconferencing**
  - **Research on How to Change End User Behavior**
- **Calit2 is Partnering with UCSD and UCI**
  - **“Green Living Laboratories of the Future”**

Using High Definition to Link the Calit2 Buildings: Living Greener



June 2, 2008

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Cisco on Cisco TelePresence Deployment Overview

Changing the way we Work, Live, Play and Learn

- **533** Cisco TelePresence major cities globally
- US/Canada: **108** CTS 3000, **109** CTS 1000, **6** CTS 3200, 90 CTS 500, 3 CTS1300
- APAC: **29** CTS 3000, **34** CTS 1000, 14 CTS 500, 3 CTS 3200, 1 CTS1300
- Japan: **7** CTS 3000, **2** CTS 1000, 1 CTS 500, 1 CTS 3200, 1 CTS1300
- Europe: **31** CTS 3000, **35** CTS 1000, 5 CTS3200, 27CTS500, 2 CTS1300
- Emerging: **14** CTS 3000, 3 CTS1000, 1 CTS3200, 7 CTS 500

163 Major Cities in 45 countries

- **355K** TelePresence meetings scheduled to date. (**Weekly** average utilization in the past 30 days is **21,522** meetings)
- **473K** hours (average meeting is 1.25 hrs)
- **27K+** meetings with customers to discuss Cisco Technology over TelePresence

- **68K+** meetings avoided travel
- Conservative estimate of cost savings and productivity improvement

~~~$296M to date~~

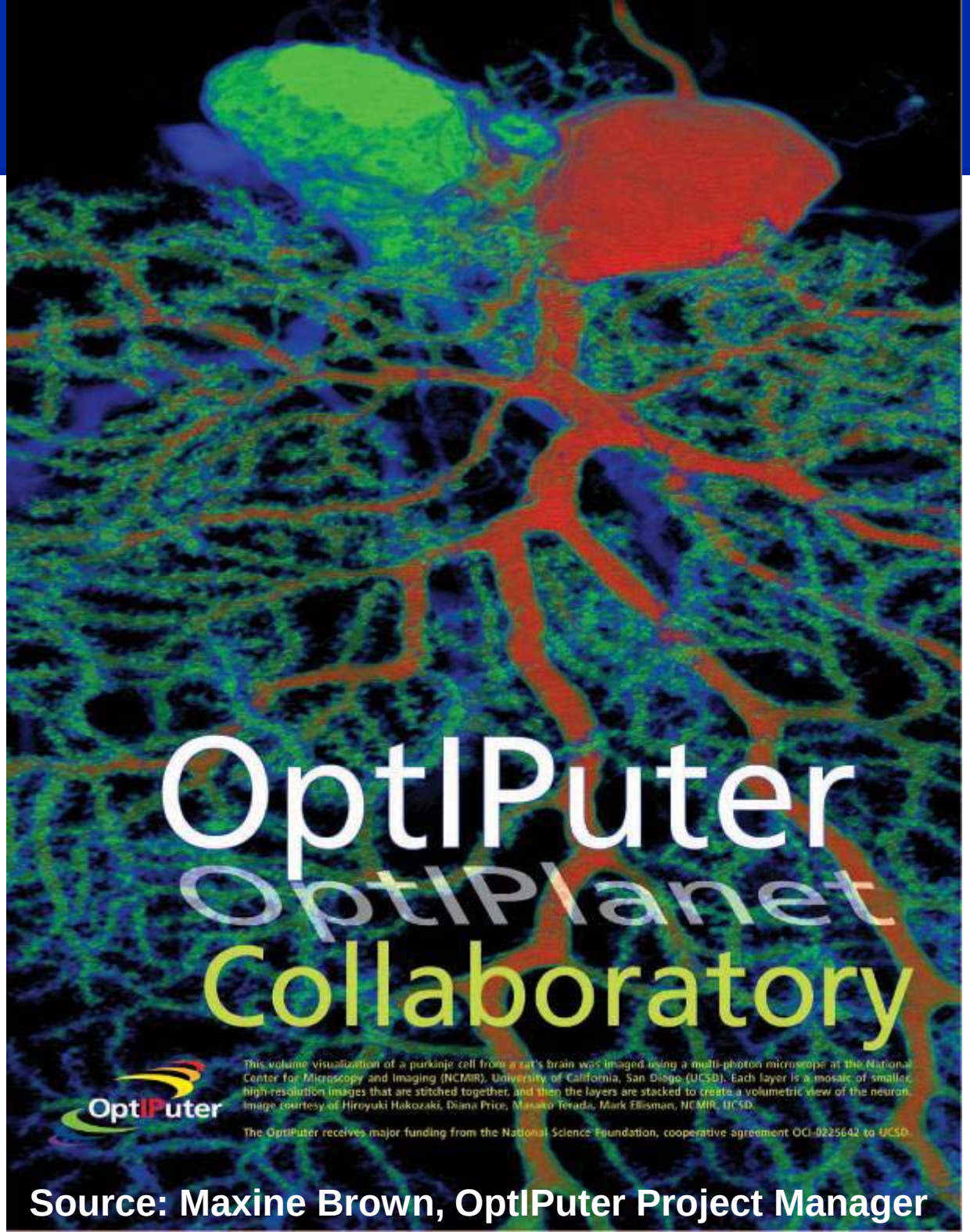
- Metric tons of emissions saved:: **149,018**
- Equal to **>25,000+ cars** off the road



•Overall average utilization **49%**

•30K Multipoint mtgs
•Average 3,919 in past 30 days

Updated Aug 2,2009….145 weeks after launch
~~~



Source: Maxine Brown, OptIPuter Project Manager

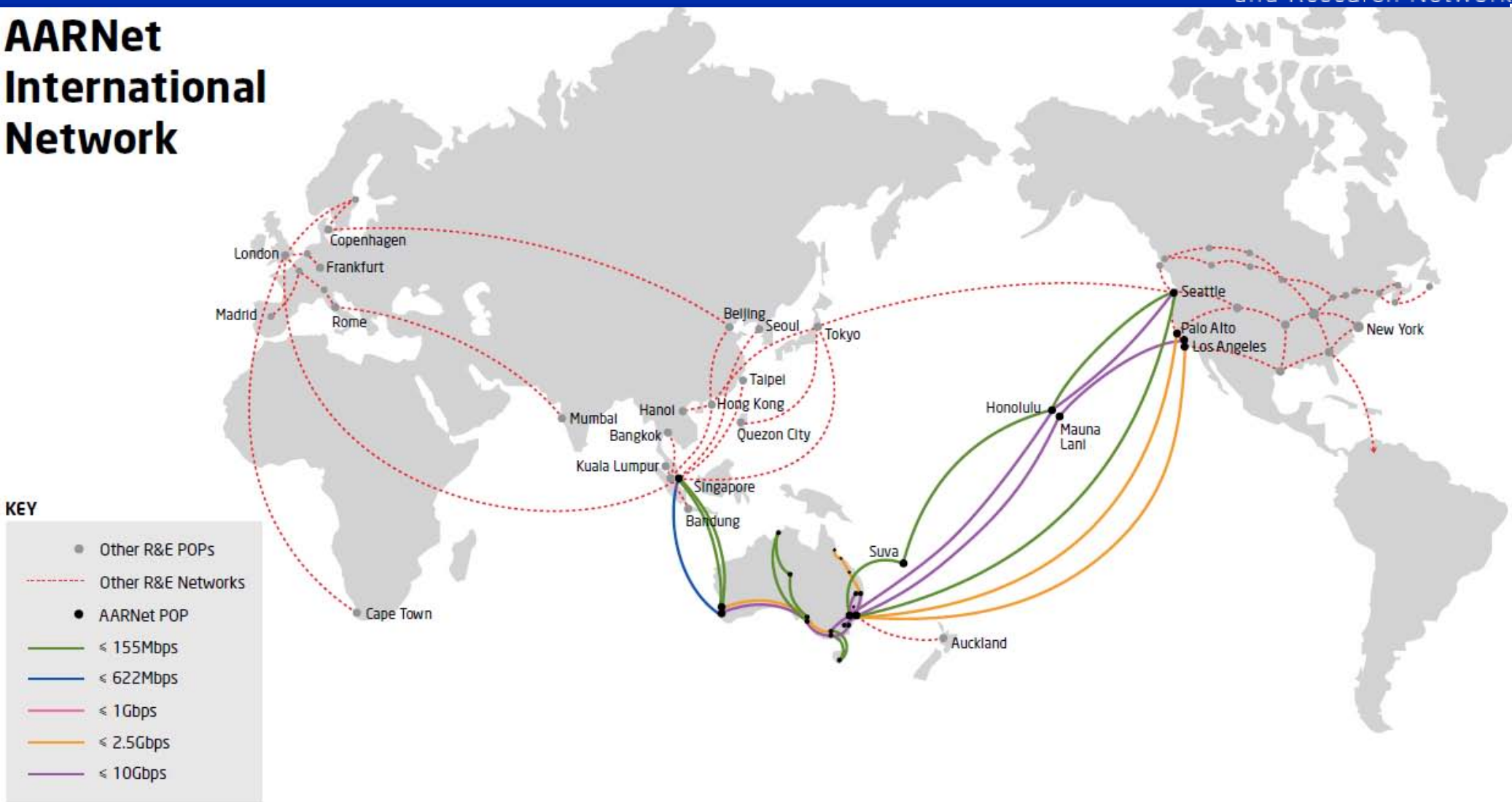
Green Initiative:

Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

AARNet International Network

aarnet
Australia's Academic and Research Network



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

it²

Beyond VTCs--Optical Fiber Telepresence Will Accelerate Rate of Global Discovery



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Qvidium Compressed High Definition Video
Over 1 Gbps AARNet/Pacific Wave/CENIC Lightpath

Australian American Leadership Dialogue Project Link "Sewing Together Rooms" at U Melbourne and UCSD



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

No Calit2 Person Physically Flew to Australia to Bring This Up!

www.calit2.net/newsroom/release.php?id=1219

Victoria Premier, Senator Conroy, and Australian Deputy Prime Minister Asking Questions



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

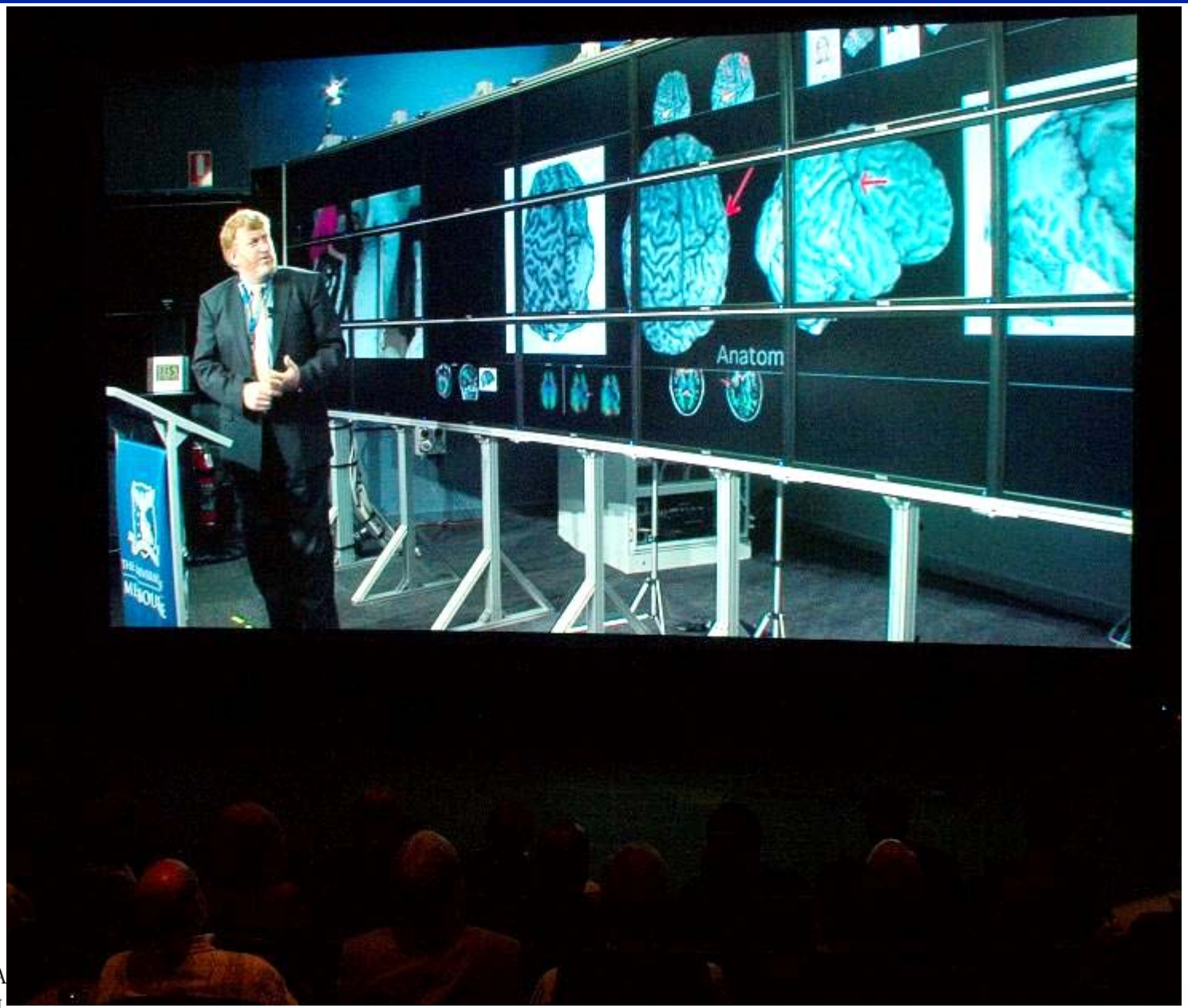
www.calit2.net/newsroom/release.php?id=1219

University of Melbourne Vice Chancellor Glyn Davis in Calit2 Replies to Question from Australia



AUSTRALIAN
AMERICAN
LEADERSHIP
DIALOGUE

UM Professor Graeme Jackson Planning Brain Surgery for Severe Epilepsy



AUSTRALIA AMERICAN LEADERSHIP DIALOGUE

www.calit2.net/newsroom/release.php?id=1219

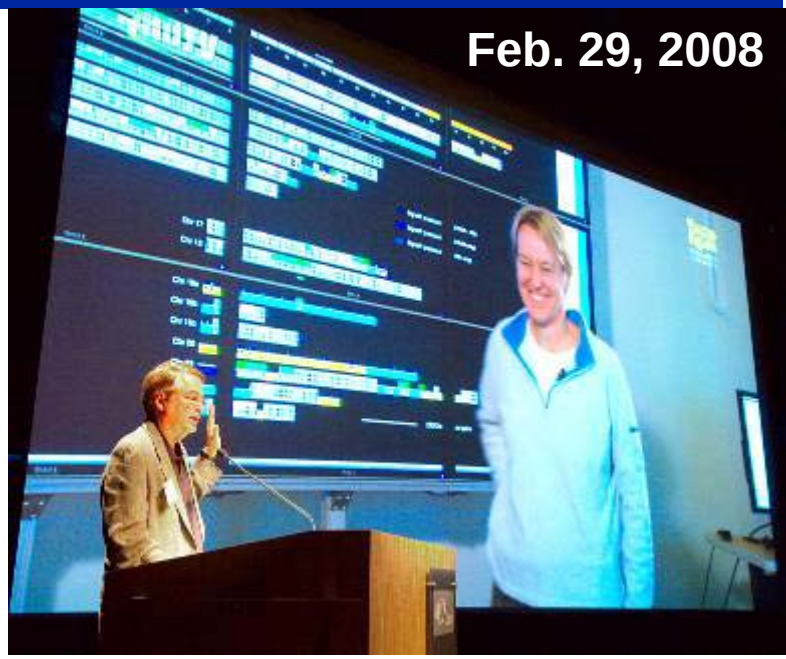
OptIPlanet Collaboratory Persistent Infrastructure Between Calit2 and U Washington



OptIPuter

Ginger Armbrust's Diatoms: Micrographs, Chromosomes, Genetic Assembly

ROCKS







UW's Research Channel
Michael Wellings

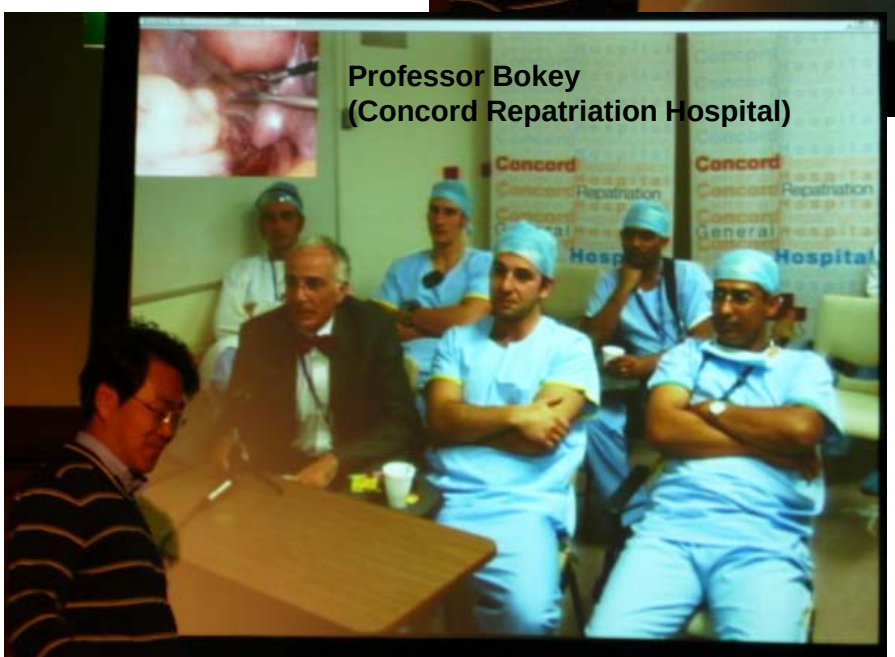
it²

Medical Videoconference

aarnet
Australia's Academic and Research Network

Live surgical demonstration performed at Kyushu University (Japan) Aug-08







AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

it2

1/3 Billion Pixel OptIPortal Linked to NASA Goddard Earth Satellite Images of October 2007 Wildfires



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Powered by Rocks ROCKS

Source: Falko Kuester, Calit2@UCSD

CGLX

it²

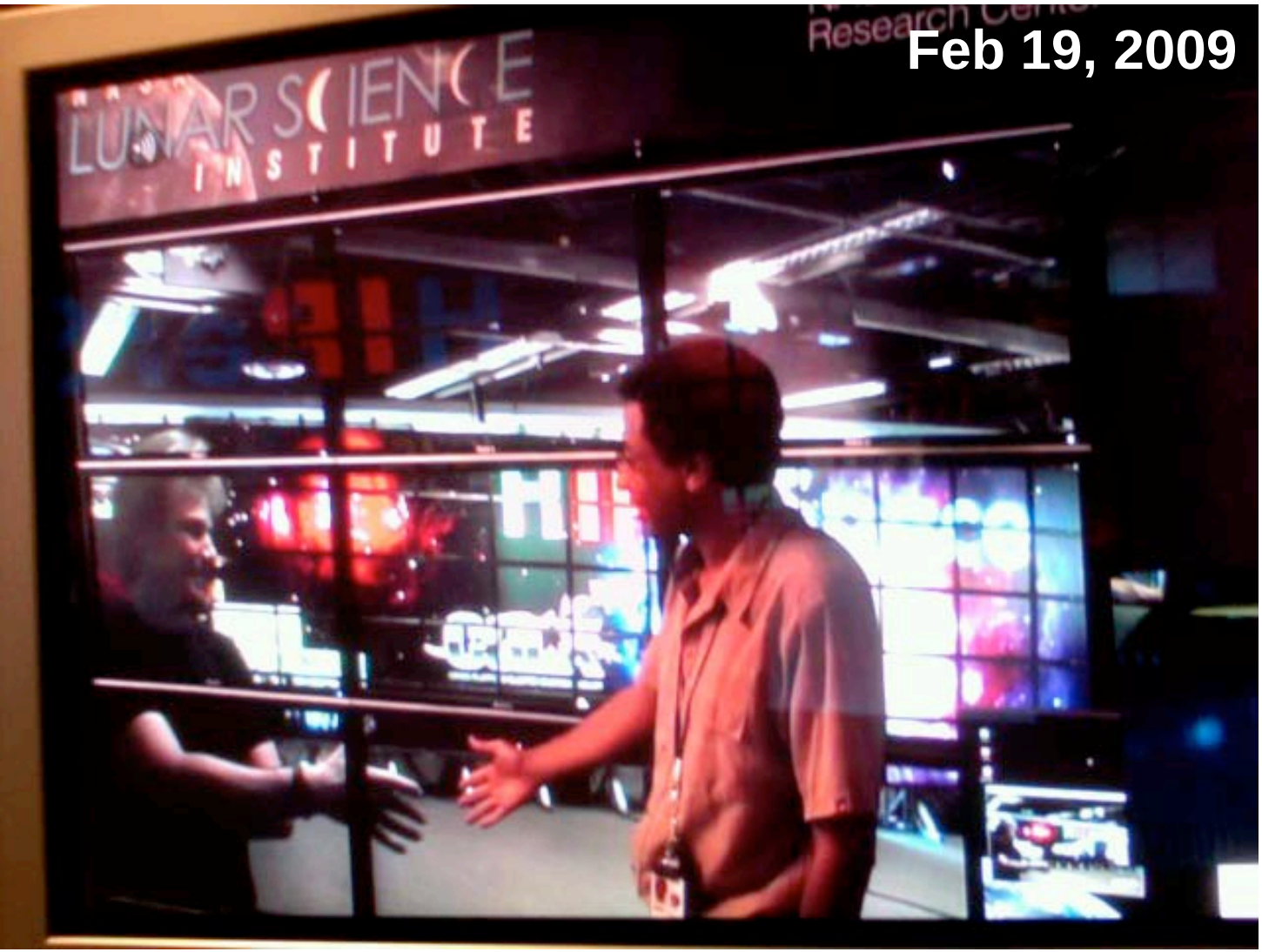
Remote Control of Scientific Instruments: Live Session with JPL and Mars Rover from Calit2



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Source: Falko Kuester, Calit2; Michael Sims, NASA

Just in Time OptIPlanet Collaboratory: Live Session Between NASA Ames and Calit2@UCSD



From Start to This Image in Less Than 2 Weeks!

View from NASA Ames Lunar Science Institute Mountain View, CA

Virtual Handshake

HD compressed 6:1

NASA Interest in Supporting Virtual Institutes

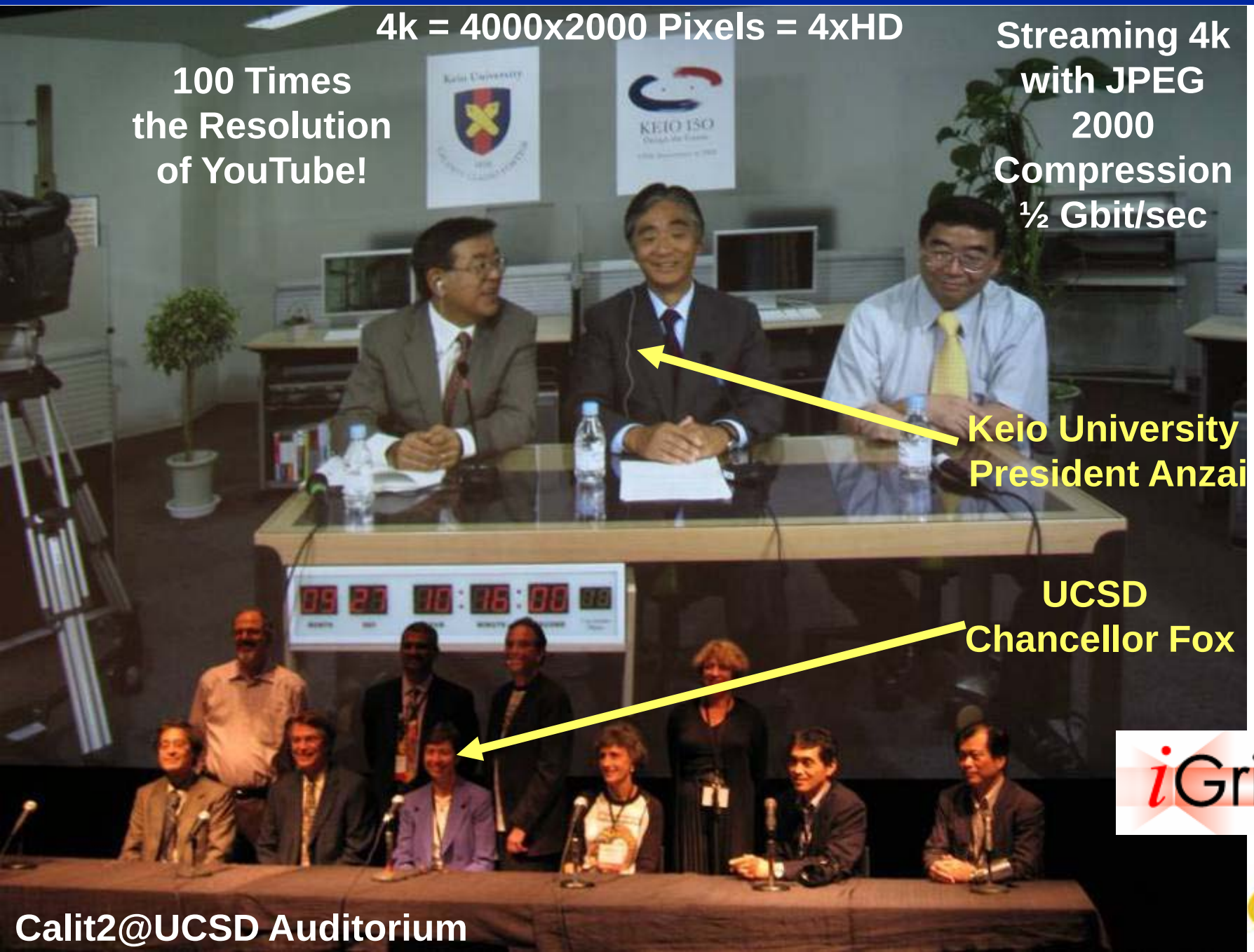
AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

CGLX

Source: Falko Kuester, Calit2; Michael Sims, NASA

it²

Telepresence Meeting
Using Digital Cinema 4k Streams



CineGrid

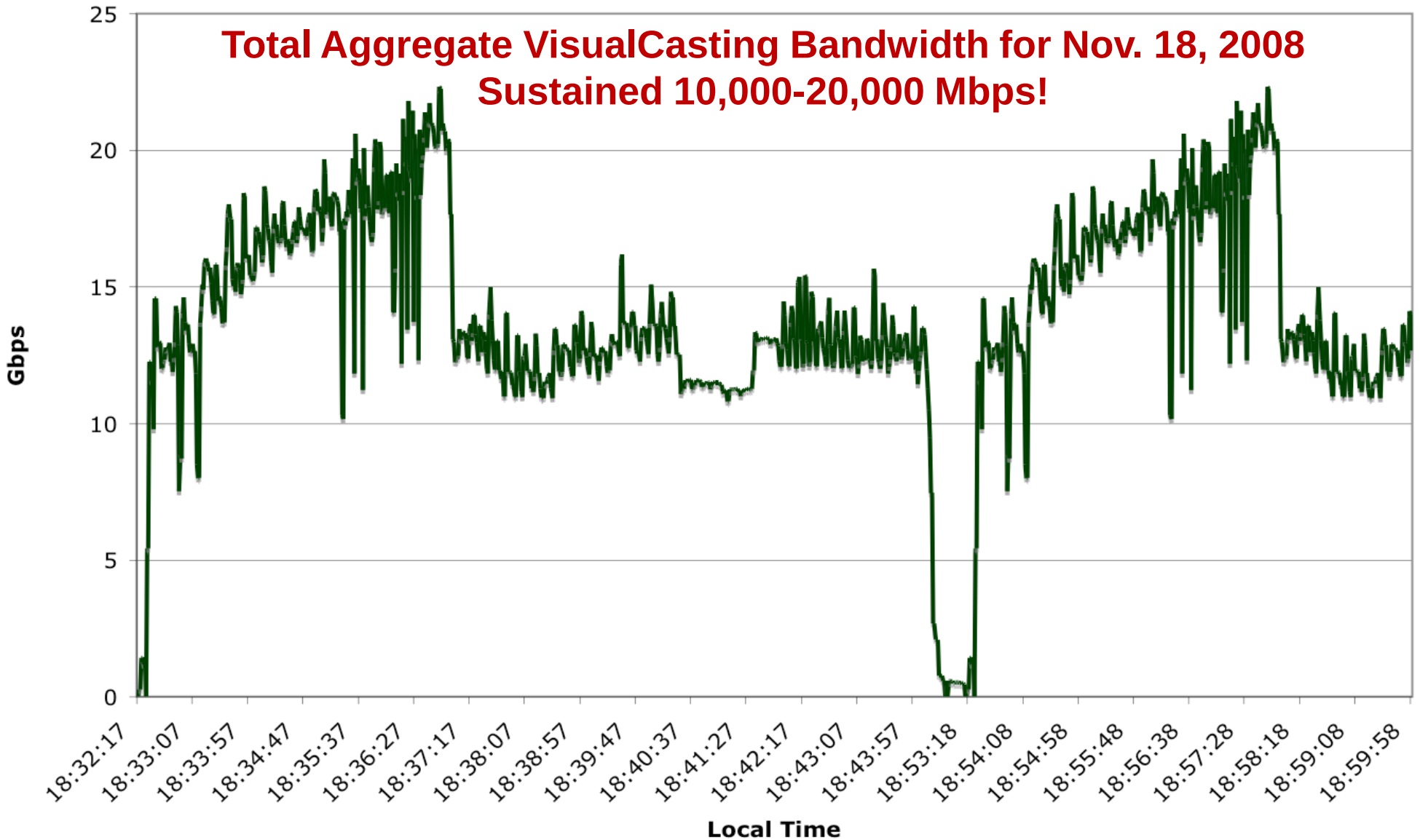
Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

it²

EVL's SAGE OptIPortal VisualCasting Multi-Site OptIPuter Collaboratory



Source: Jason Leigh, Luc Renambot, EVL, UI Chicago

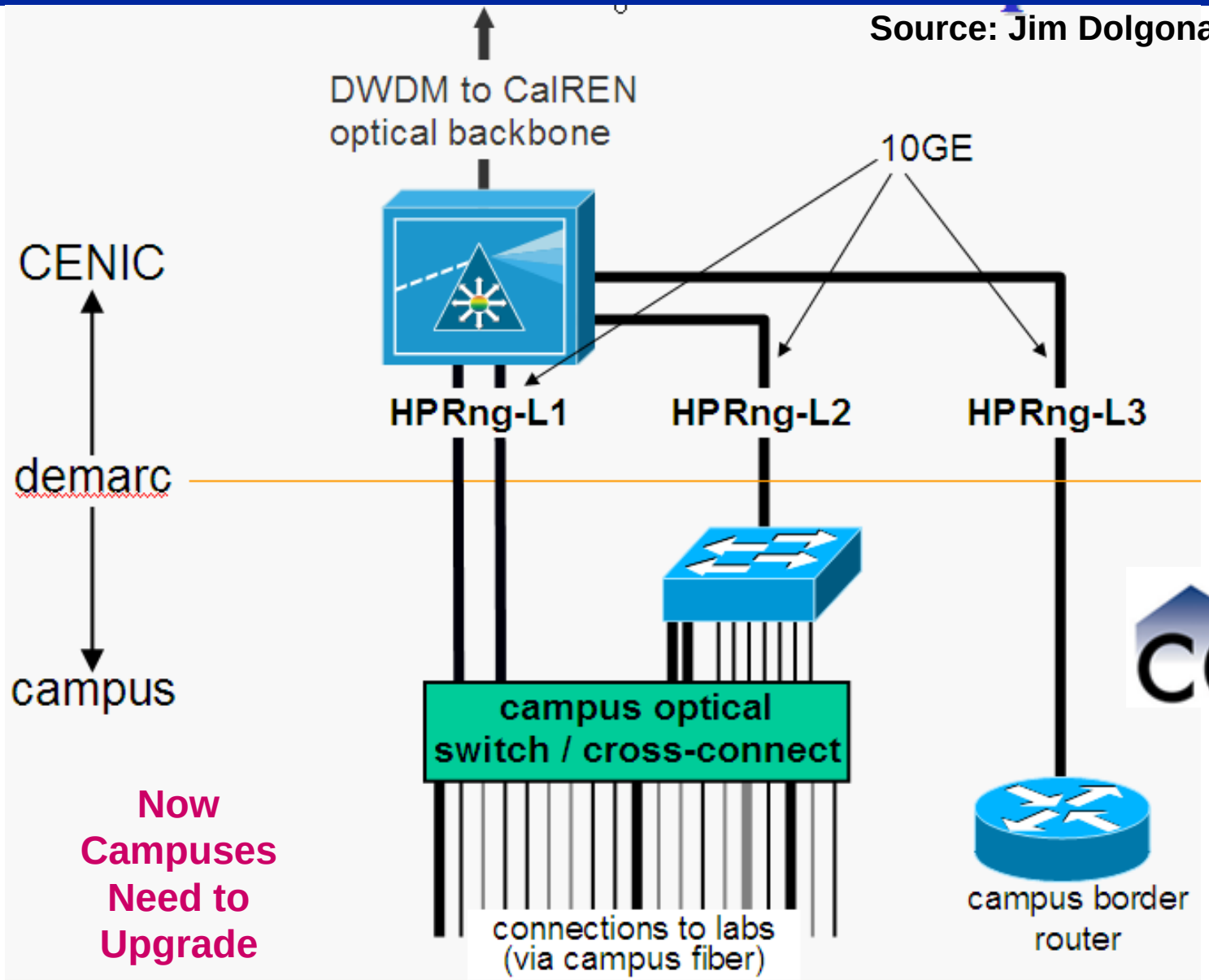
AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

CENIC's New "Hybrid Network" - Traditional Routed IP and the New Switched Ethernet and Optical Services

Source: Jim Dolgonas, CENIC

CENIC has Invested ~ $14M in Upgrade

CENIC is Preparing $10M 14 Campus NSF-ARI Proposal



Now Campuses Need to Upgrade

cenic

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

The "Golden Spike" UCSD Experimental Optical Core: Ready to Couple Users to CENIC L1, L2, L3 Services



End State 2008:

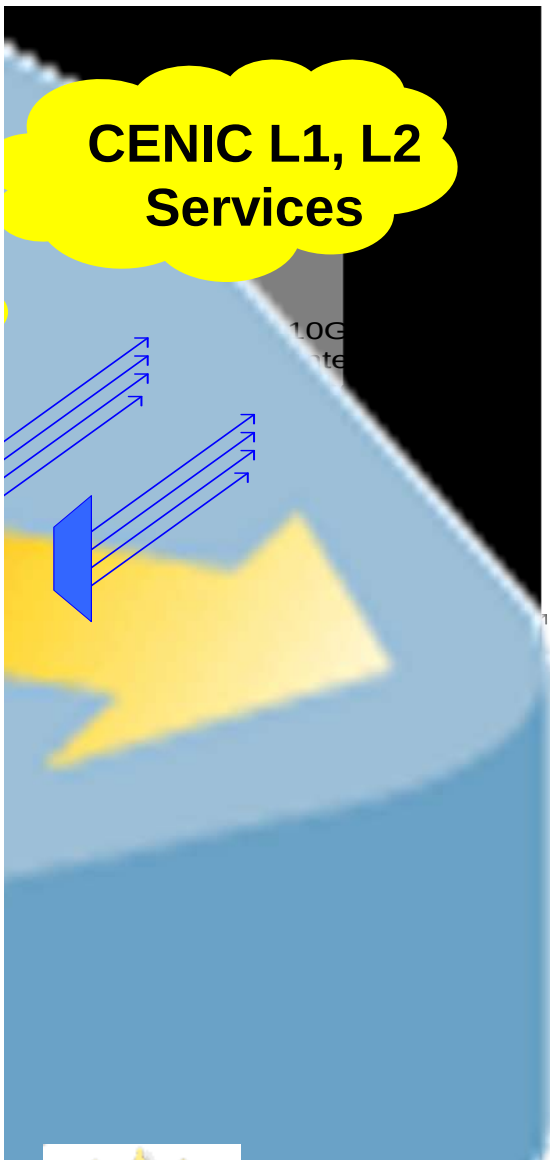
>= 60 endpoints at 10 GigE

>= 30 Packet switched

>= 30 Switched wavelengths

>= 400 Connected endpoints

Approximately 0.5 Tbps Arrive at the "Optical" Center of Hybrid Campus Switch



Source: Phil Papadopoulos, SDSC/Calit2 (Quartzite MRI PI, OptIPuter co-PI)

Funded by NSF MRI Grant

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

The GreenLight Project: Instrumenting the Energy Cost of Computational Science

- **Focus on 5 Communities with At-Scale Computing Needs:**
  - **Metagenomics**
  - **Ocean Observing**
  - **Microscopy**
  - **Bioinformatics**
  - **Digital Media**





- **Measure, Monitor, & Web Publish Real-Time Sensor Outputs**
  - **Via Service-oriented Architectures**
  - **Allow Researchers Anywhere To Study Computing Energy Cost**
  - **Enable Scientists To Explore Tactics For Maximizing Work/Watt**
- **Develop Middleware that Automates Optimal Choice of Compute/RAM Power Strategies for Desired Greenness**
- **Partnering With Minority-Serving Institutions Cyberinfrastructure Empowerment Coalition**

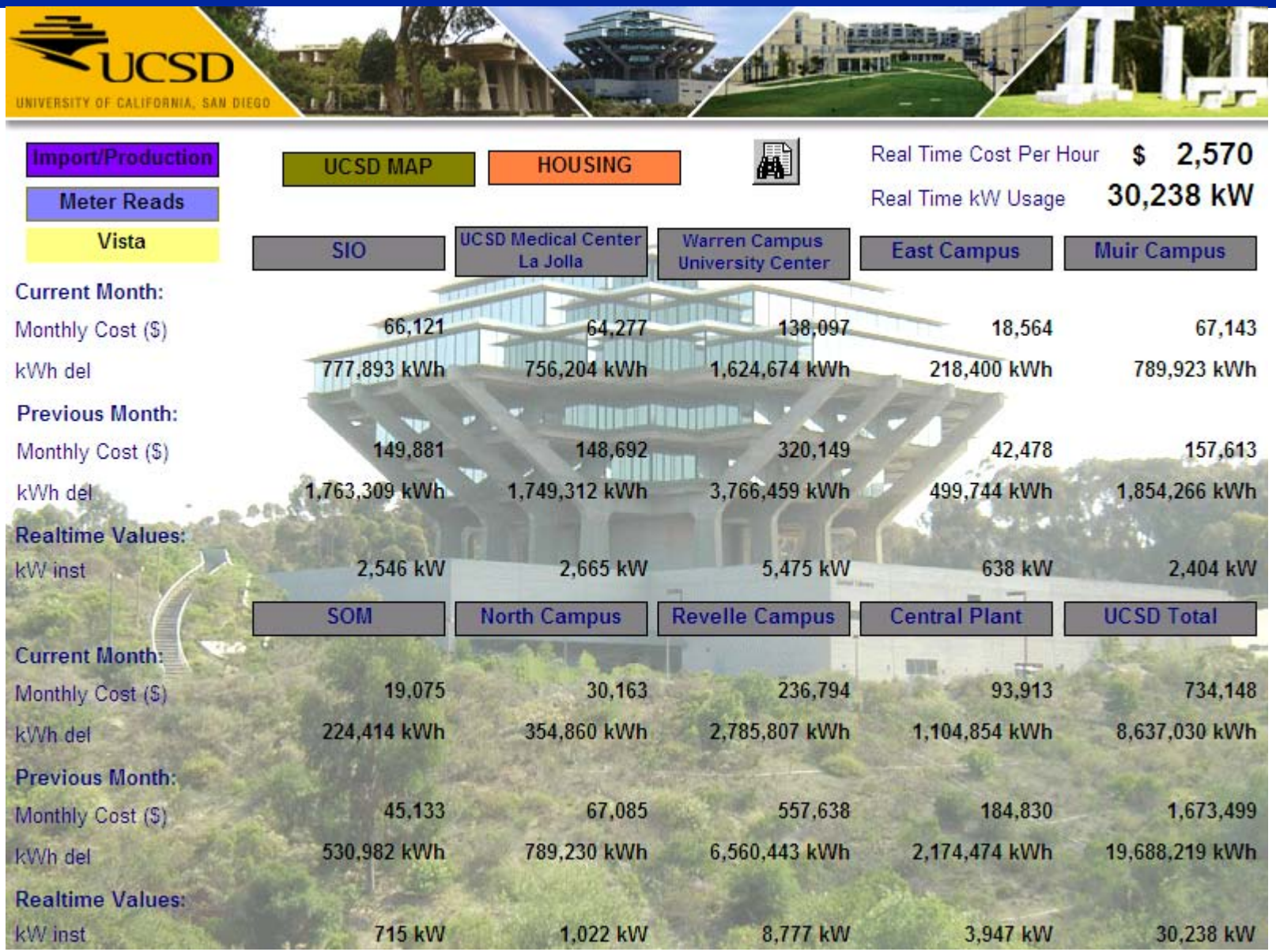
NSF

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Source: Tom DeFanti, Calit2; GreenLight PI

it²

Real-Time Monitoring of Building Energy Usage: UCSD Has 34 Buildings On-Line



	SIO	UCSD Medical Center La Jolla	Warren Campus University Center	East Campus	Muir Campus
Current Month:					
Monthly Cost ($)	66,121	64,277	138,097	18,564	67,143
kWh del	777,893 kWh	756,204 kWh	1,624,674 kWh	218,400 kWh	789,923 kWh
Previous Month:					
Monthly Cost ($)	149,881	148,692	320,149	42,478	157,613
kWh del	1,763,309 kWh	1,749,312 kWh	3,766,459 kWh	499,744 kWh	1,854,266 kWh
Realtime Values:					
kW inst	2,546 kW	2,665 kW	5,475 kW	638 kW	2,404 kW

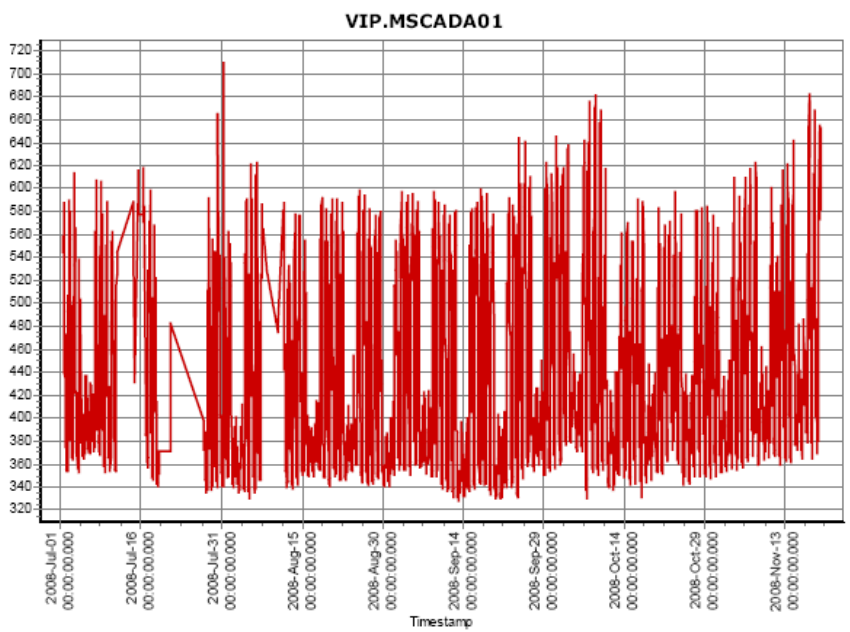
	SOM	North Campus	Revelle Campus	Central Plant	UCSD Total
Current Month:					
Monthly Cost ($)	19,075	30,163	236,794	93,913	734,148
kWh del	224,414 kWh	354,860 kWh	2,785,807 kWh	1,104,854 kWh	8,637,030 kWh
Previous Month:					
Monthly Cost ($)	45,133	67,085	557,638	184,830	1,673,499
kWh del	530,982 kWh	789,230 kWh	6,560,443 kWh	2,174,474 kWh	19,688,219 kWh
Realtime Values:					
kW inst	715 kW	1,022 kW	8,777 kW	3,947 kW	30,238 kW

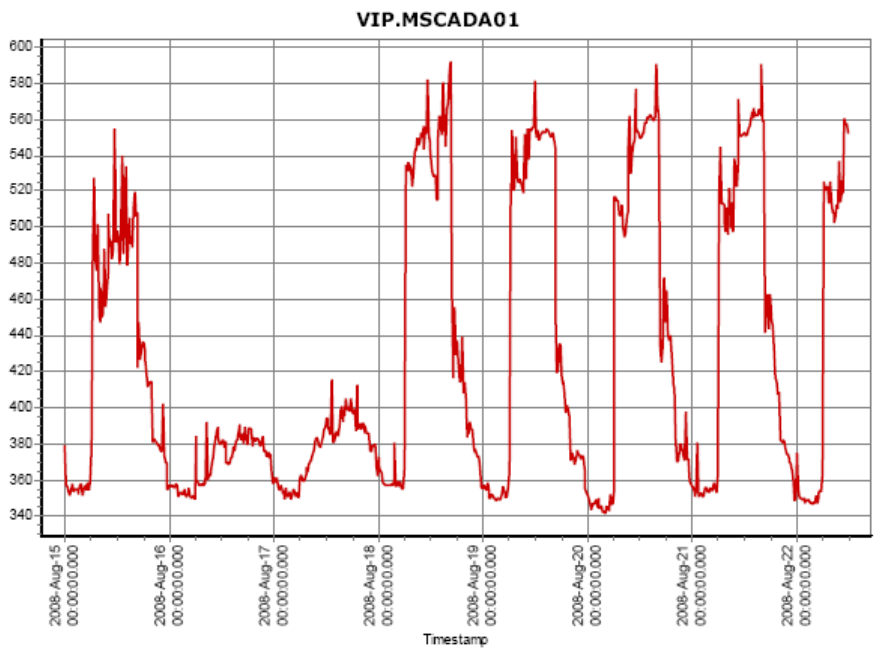
http://mscada01.ucsd.edu/ion/

Power Management in Mixed Use Buildings: The UCSD CSE Building is Energy Instrumented

- **500 Occupants, 750 Computers**
- **Detailed Instrumentation to Measure Macro and Micro-Scale Power Use**
  - **39 Sensor Pods, 156 Radios, 70 Circuits**
  - **Subsystems: Air Conditioning & Lighting**



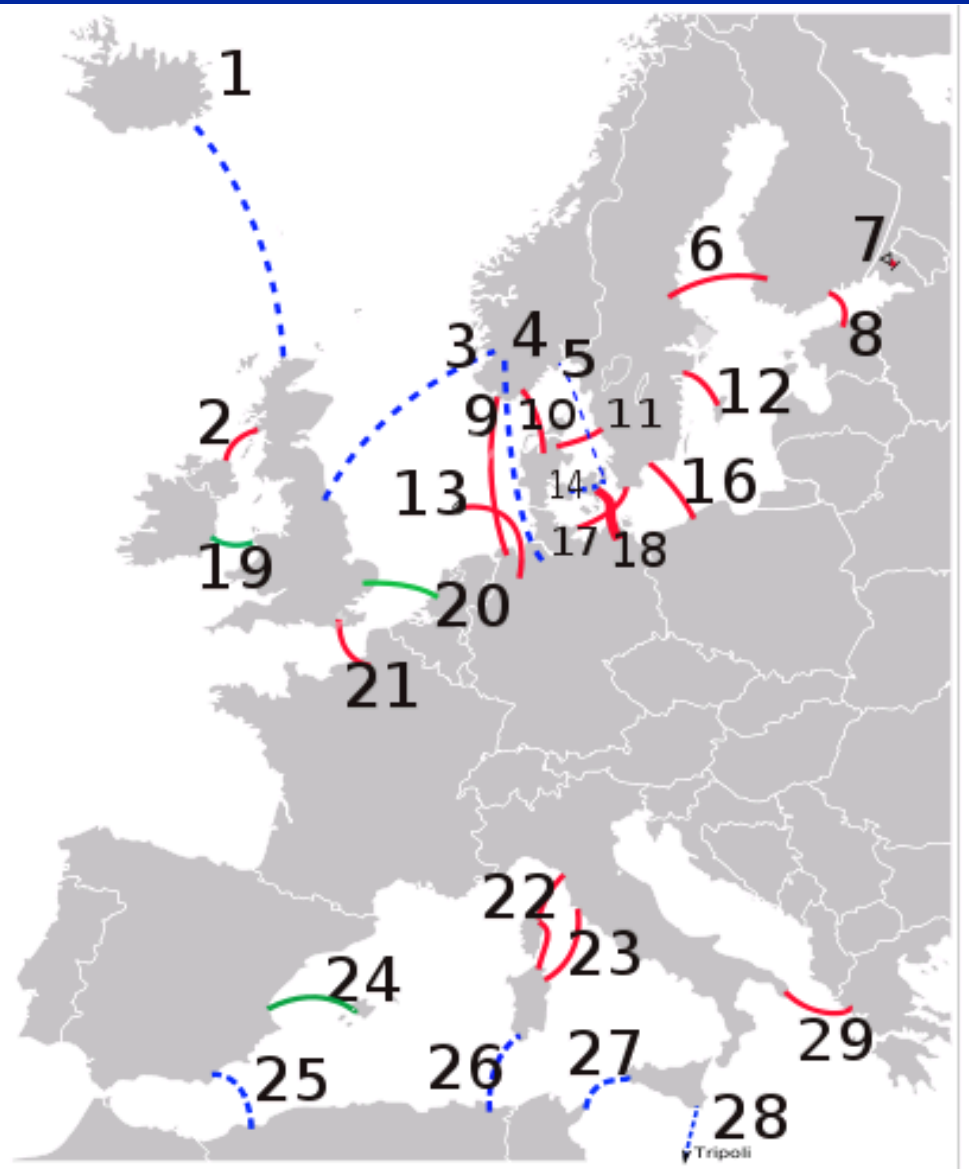




AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

Source: Rajesh Gupta, CSE, Calit2

Emerging "Smart Grid"- High Voltage DC Electrical Lines Are Widely Used for Crossing Sea Lanes

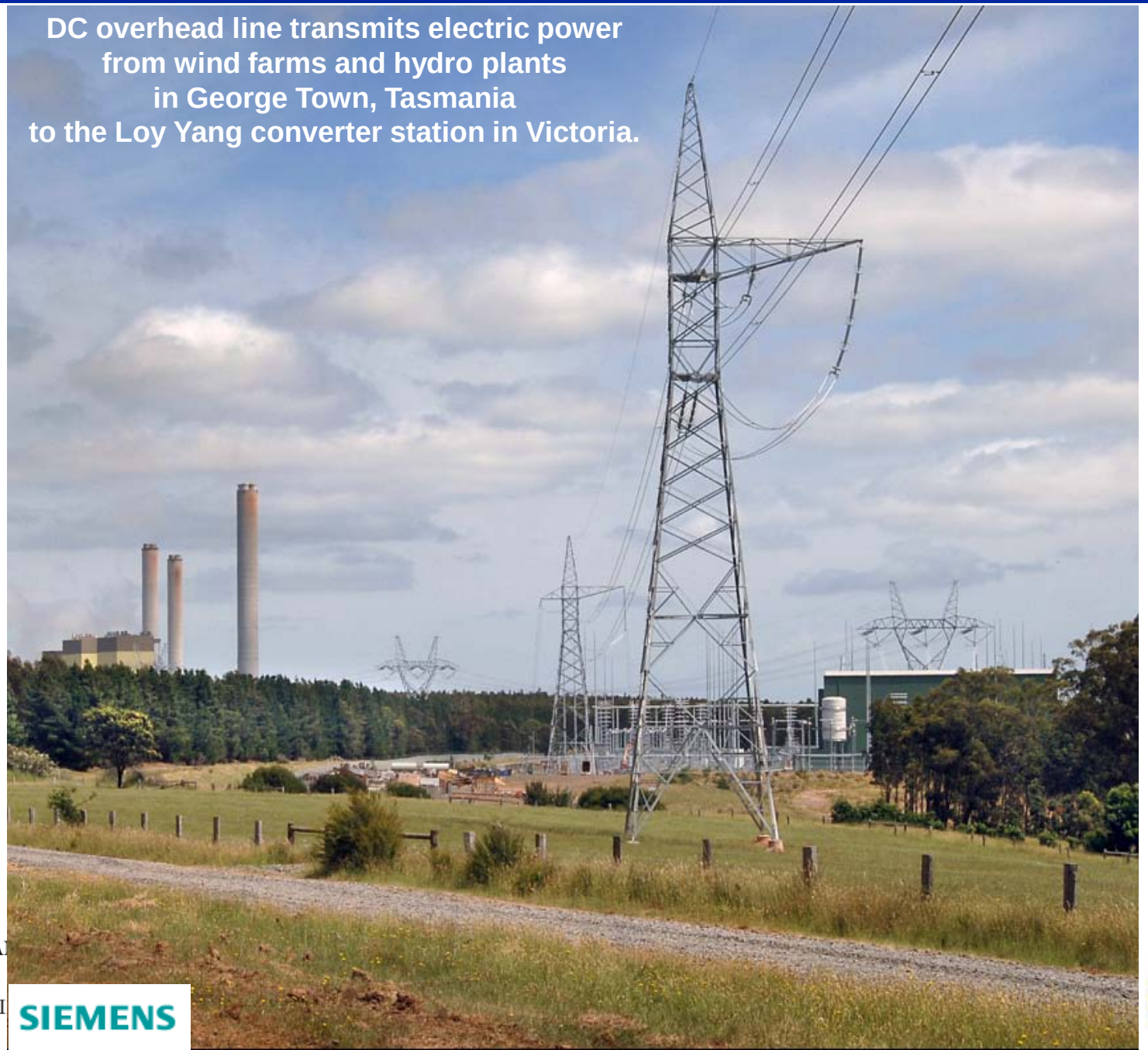


Medium to large HVDC interconnections in western Europe.

Source: http://en.wikipedia.org/wiki/List_of_HVDC_projects
J Jmesserly, et al.

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

HVDC Submarine Cable Link Between Australia and Tasmania



AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

SIEMENS

it²

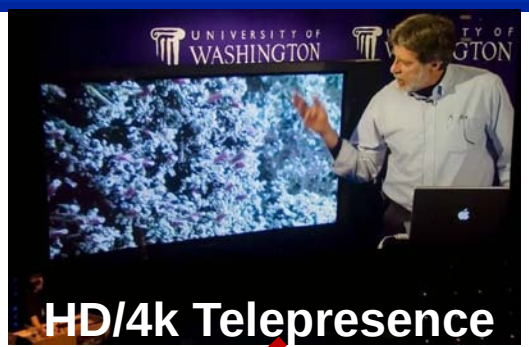
The Data-Intensive Research "OptIPlatform" Backplane for Cyberinfrastructure: A 10Gbps Lightpath Cloud



End User OptIPortal



Instruments



HD/4k Telepresence

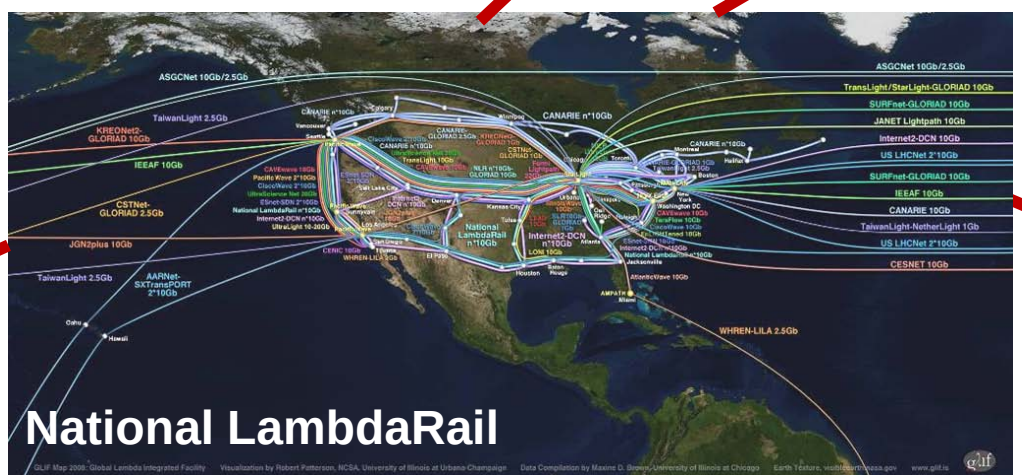


HD/4k Video Cams

HPC



10G Lightpaths



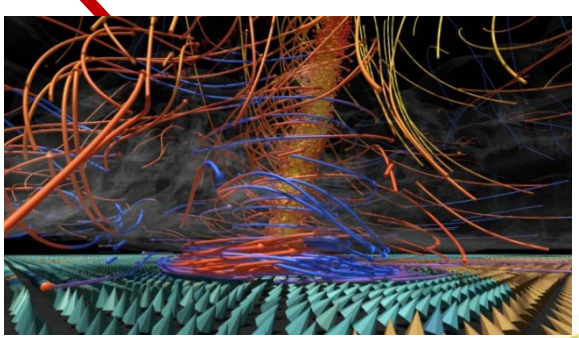
National LambdaRail

TeraGrid™

Campus Optical Switch



Data Repositories & Clusters



HD/4k Video Images

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE