High Performance Geographic Information Systems

CalGIS 2003 Conference

Convention Center, Palm Springs, CA

April 11 , 2003

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technologies

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

UCSD

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The Next S-Curves of Internet Growth: A Mobile Internet Powered by a Planetary Grid

- **Wireless Access--Anywhere, Anytime**
  - Broadband Speeds
  - "Always Best Connected"
- **Billions of New Wireless Internet End Points**
  - Information Appliances
  - Sensors and Actuators
  - Embedded Processors
- **Emergence of a Distributed Planetary Computer**
  - Parallel Lightwaves in Optical Backbone
  - Storage of Data Everywhere
  - Scalable Distributed Computing Power

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NSF Is About to Launch a Major Funding Initiative to Create a Distributed Cyberinfrastructure

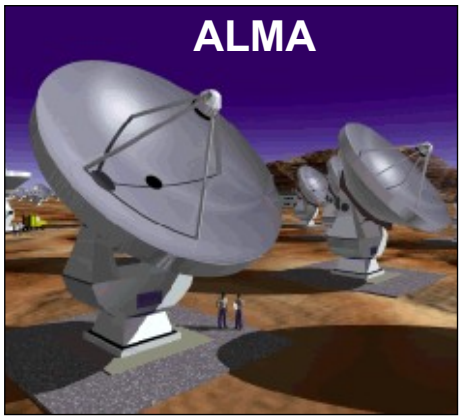


Concept: Ruzena Bajscy, CISE NSF
Slide: SDSC

Similar Needs for Many Other e-Science Community Resources

NEPTUNE
A Fiber-Optic Telescope to Inner Space

GENOMES to LIFE
BIOLOGICAL SOLUTIONS FOR ENERGY CHALLENGES
U.S. DEPARTMENT OF ENERGY



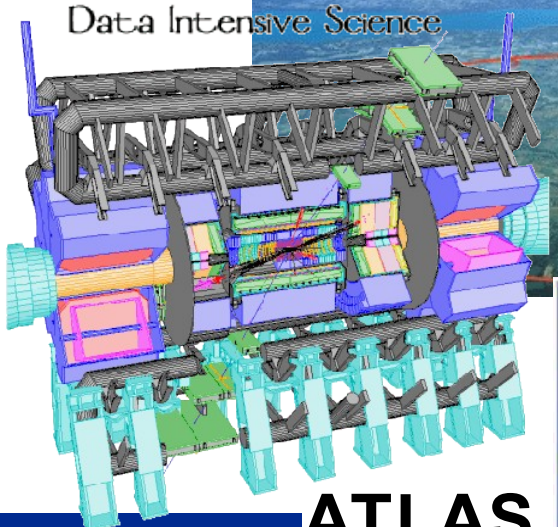
GriPhyN
Data Intensive Science

NEES



BIRN

NEON
National Ecological Observatory Network





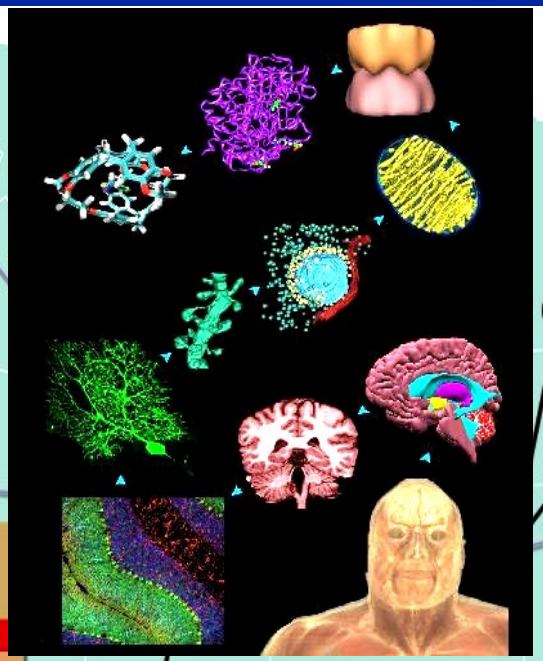
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NIH is Creating a Federated Repository Biomedical Informatics Research Network



Northern Lights Network
University of Minnesota

Abilene
University of Iowa

Nox
Harvard I
Harvard II

Abilene
Stanford

CalREN-2
Caltech
UCLA
Irvine
NCMIR
UCSD II

BIRN Central NOC
SDSC

Abilene
LANL
University of New Mexico

NCNI
Duke I
Duke II
UNC

Mouse
Brain Morphology
Functional Imaging/Human
Abilene Backbone

NIH Plans to Expand BIRN to Other Organs and Many Laboratories

National Center For Research Resources

Part of the UCSD CRBS
Center for Research on Biological Structure

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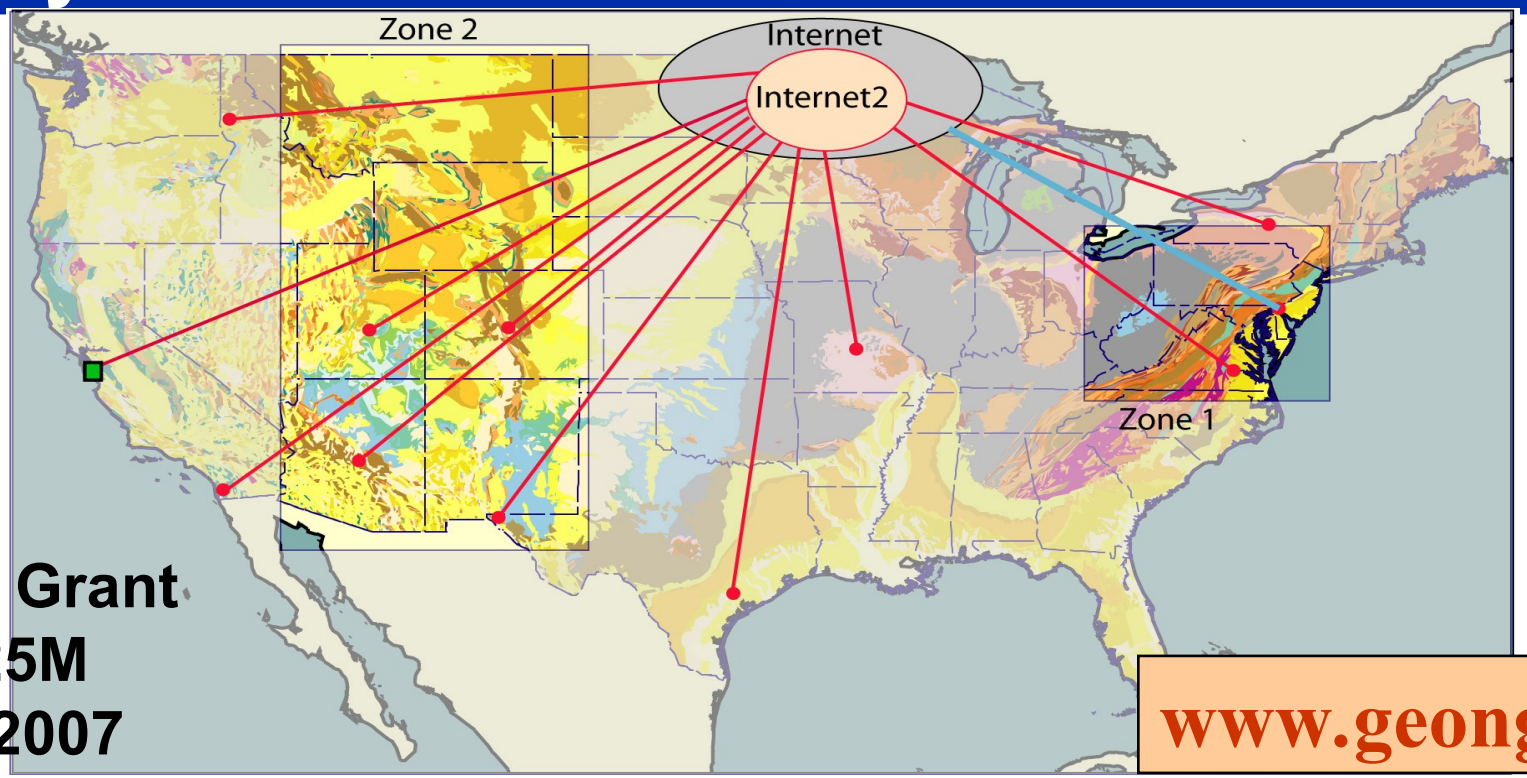
NBCR

NPACI

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

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GEON
Cyberinfrastructure for the Geosciences



NSF ITR Grant
$11.25M
2002-2007

www.geongrid.org

IT: SDSC, Penn State, San Diego State University

Geosciences: Arizona State University, Bryn Mawr College, Cornell University, Rice University, UNAVCO, University of Arizona, University of Idaho, University of Missouri, University of Texas El Paso, University of Utah, Virginia Tech

Education and Outreach: DLESE, Cornell, UNAVCO

Agency Partners: USGS, Livermore Labs

Industry Partners: ESRI, GeoFusion, IBM

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GEON Visualization

- **Partnering with ESRI ArcGlobe and GeoFusion**
  - **Fly-Through of 2.5D GIS Data Extended to Provide Stereovision**
  - **Extending Software to Enable Fly-Through Visualization of 3D Data**
- **Hi-Tech Coast GIS**
  - **With Cal-(IT)², SDSU, and UCSD SIO**
  - **Integrating Multiple GIS Layers Using ArcGlobe**
  - **ArcGlobe Will be an Add-on to ESRI's 3D Analyst**

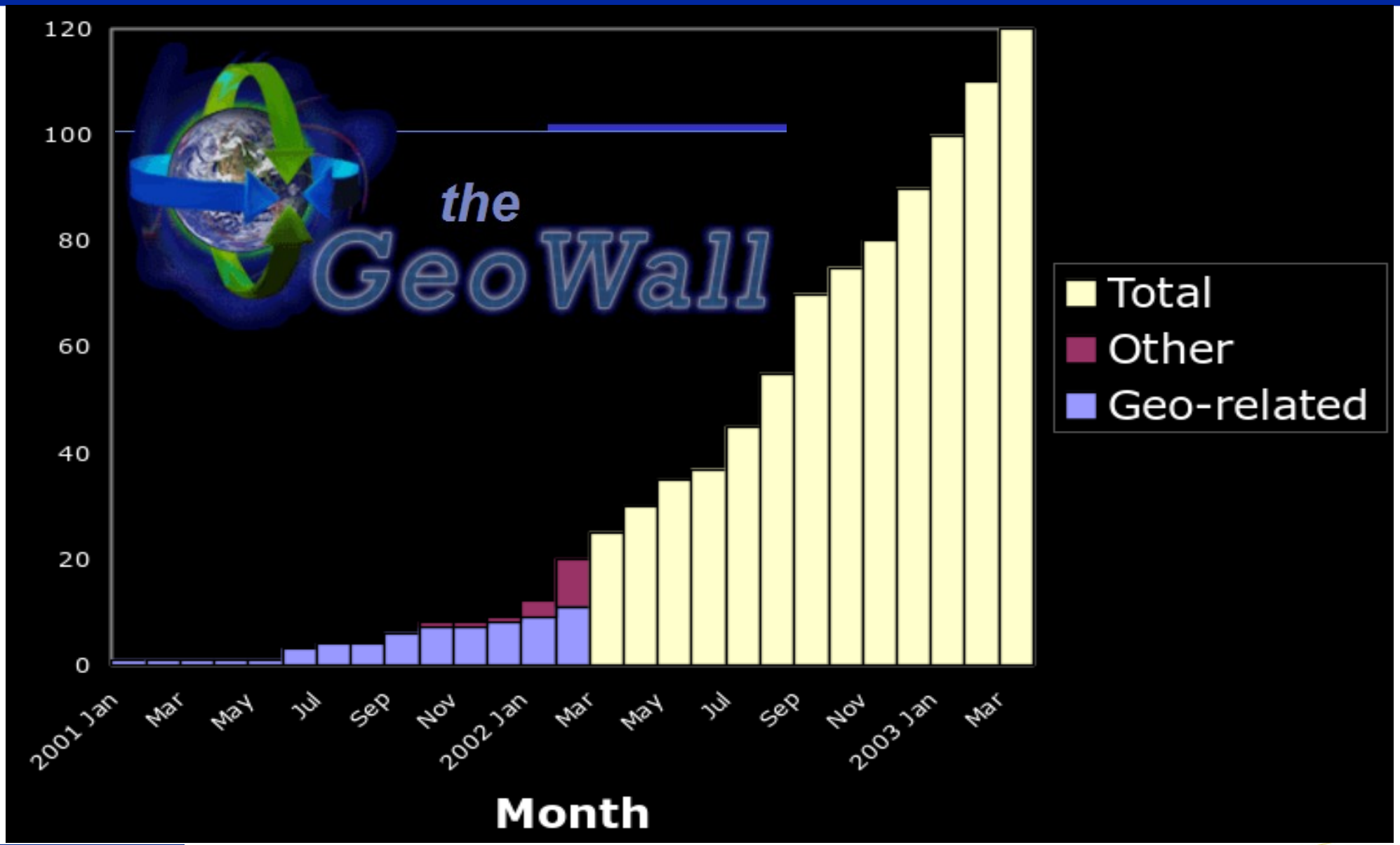


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Source: Chaitan Baru, SDSC

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Commodity PCs & Projectors Enable Rapid Growth of the GeoWall Consortium



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Source: Andy Johnson, Jason Leigh, EVL, UIC

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GeoWall at the American Geophysical Union Dec 2003



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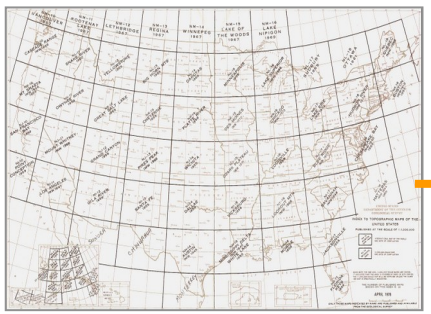
Source: John Orcutt, SIO, President AGU

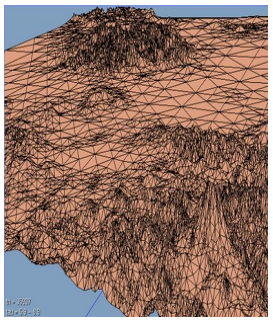
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Building Visualization Pipelines

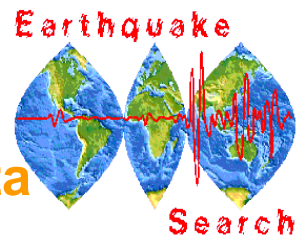
http://vis.eng.uci.edu

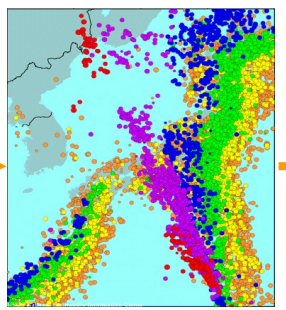
USGS Digital Elevation Maps





NEIC Earthquake Data



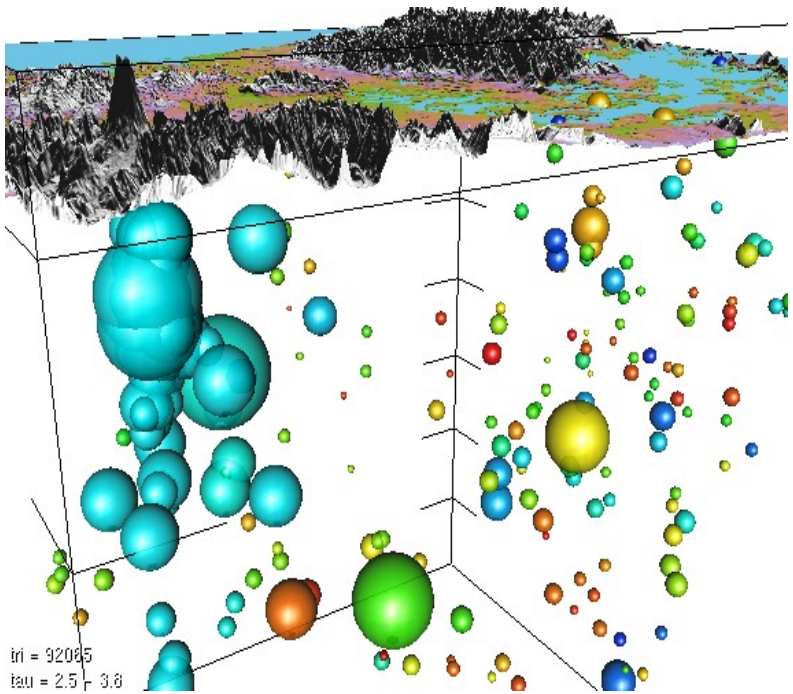


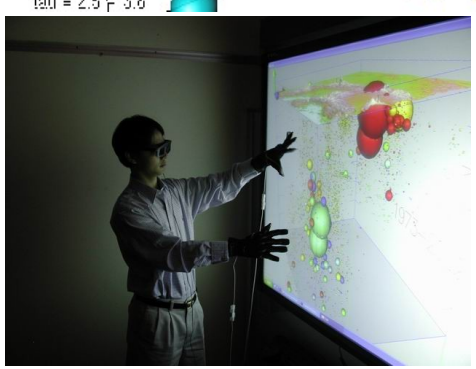
Terrain Textures





Real-Time 3-D Visualization



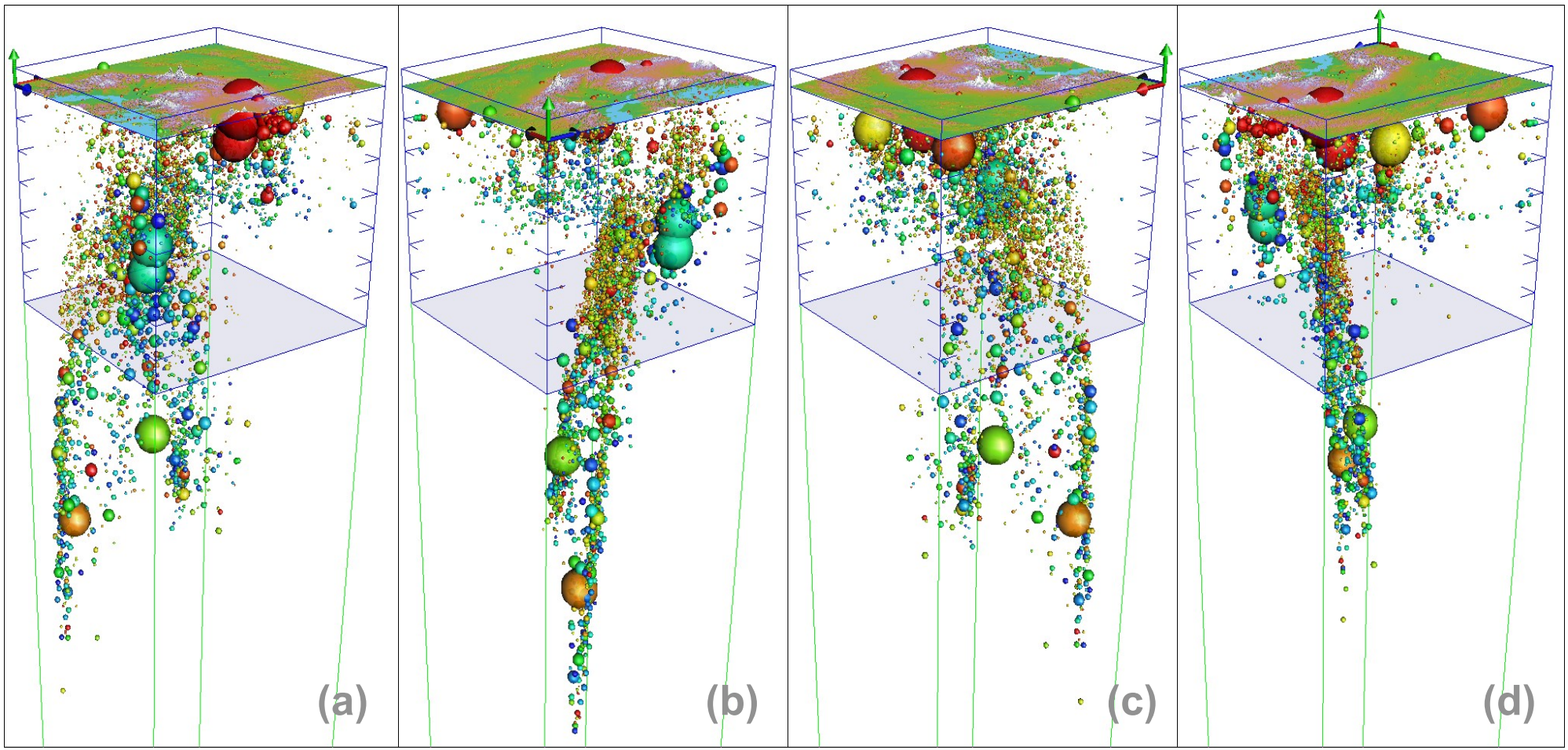


UCSD UCIrvine

Source: Falko Kuester, UIC

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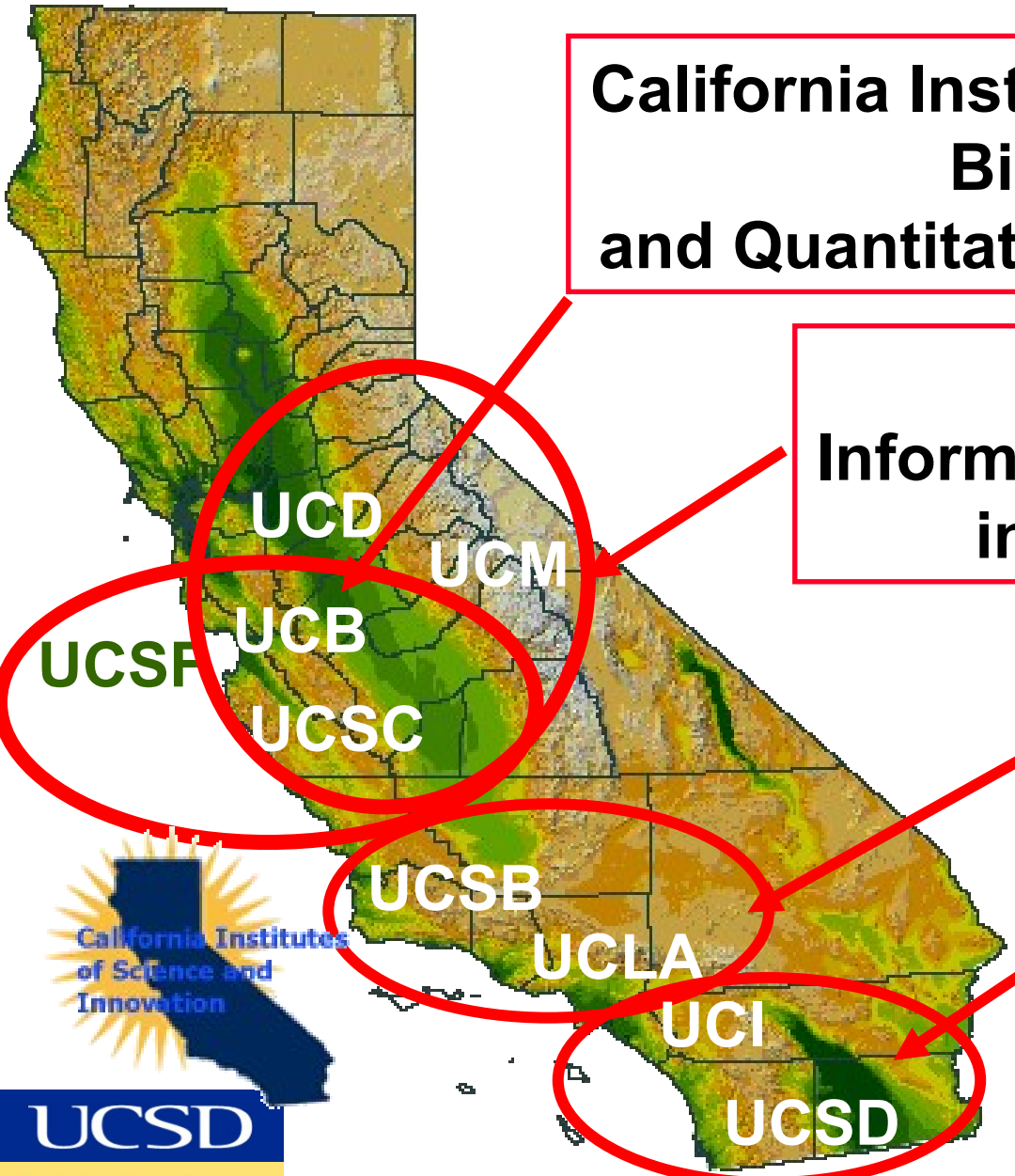
Data Fusion (Anchorage, 1973-2002)



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California's Institutes for Science and Innovation
A Bold Experiment in Collaborative Research



California Institute for Bioengineering, Biotechnology, and Quantitative Biomedical Research

Center for Information Technology Research in the Interest of Society

California NanoSystems Institute

California Institute for Telecommunications and Information Technology

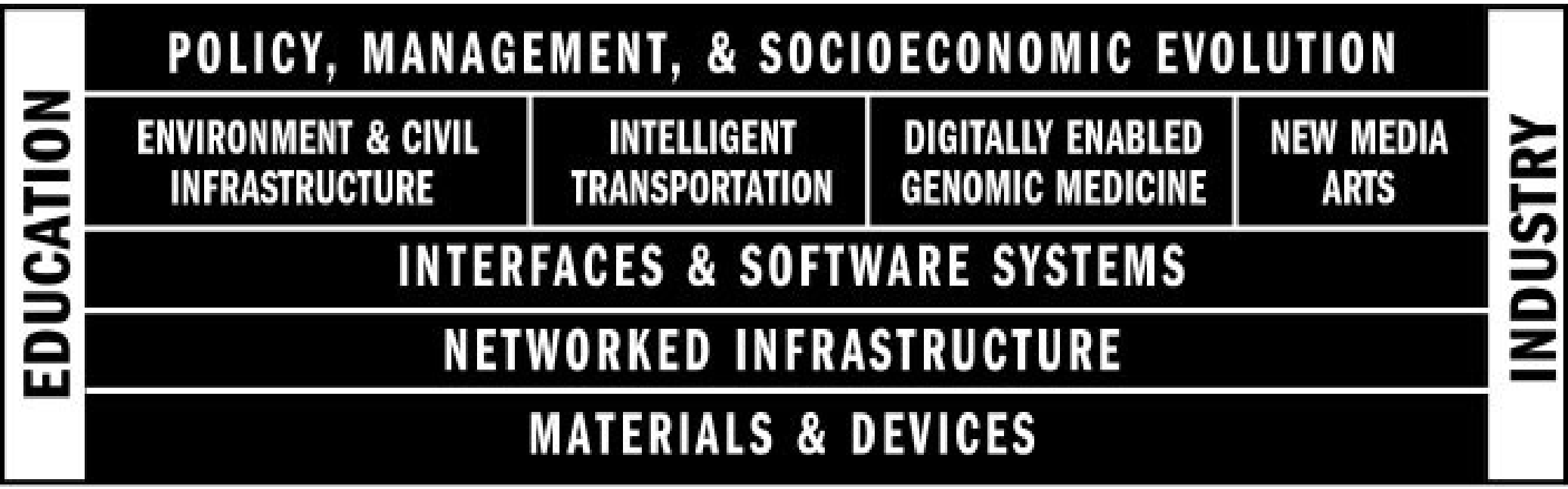
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www.ucop.edu/california-institutes

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Cal-(IT)^2--An Integrated Approach the Future of the Internet

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



The State's $100 M

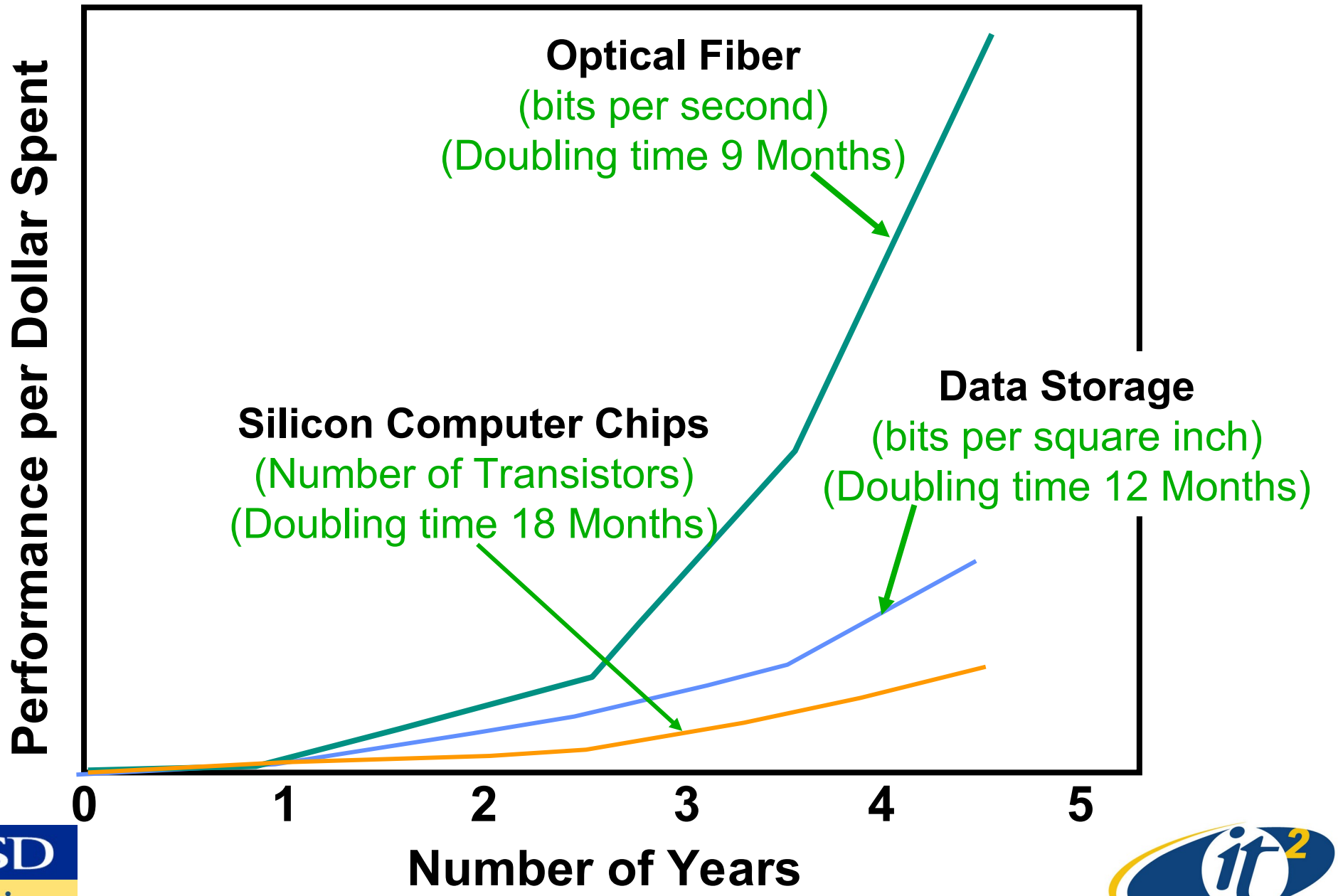
Creates Unique Buildings, Equipment, and Laboratories

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UCIrvine

www.calit2.net

it^2

Why Optical Networks Are Emerging as the 21st Century Driver

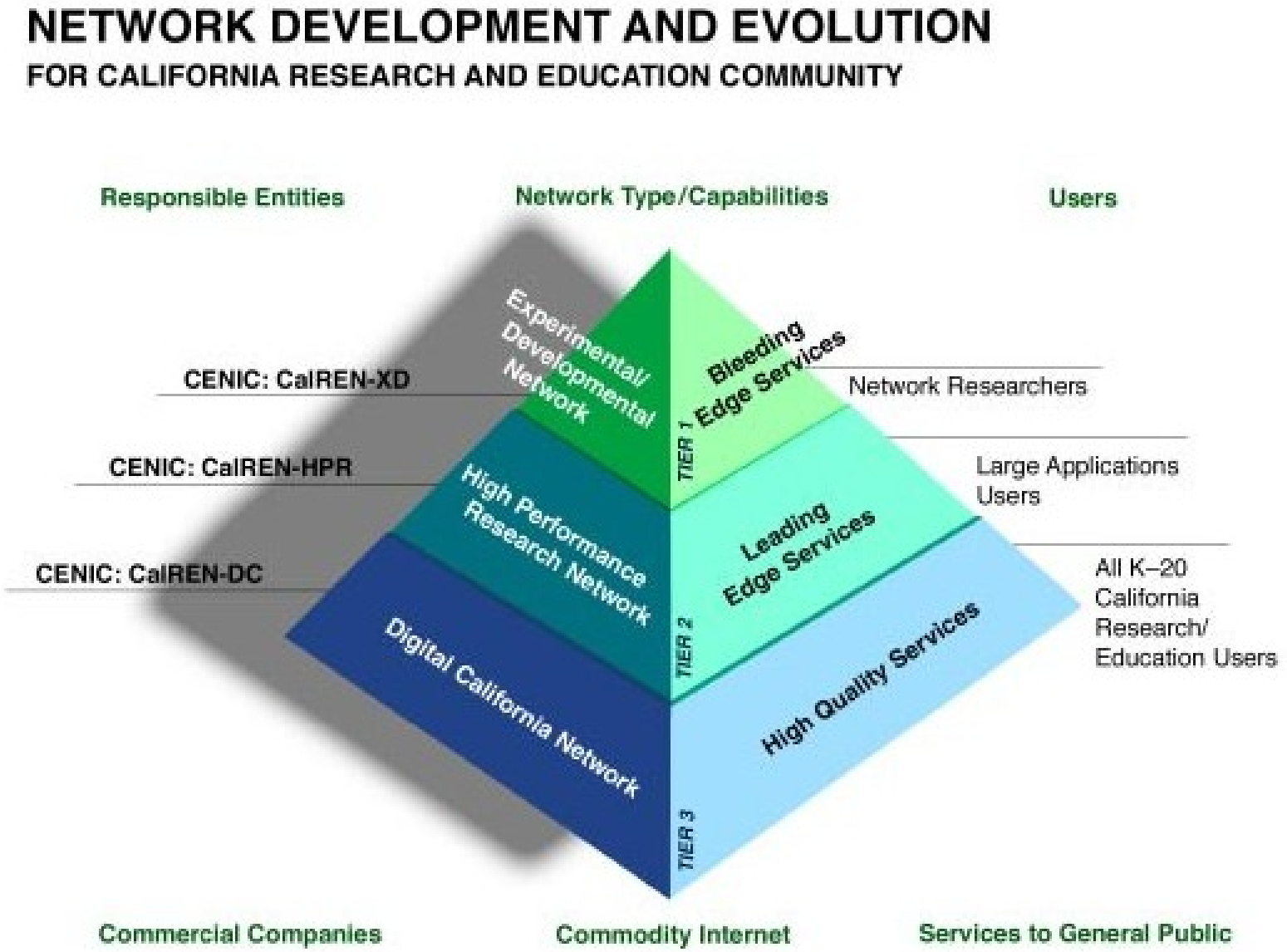


Scientific American, January 2001

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UCIrvine

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CENIC Three Tier Architecture
Innovation Flows Downhill!



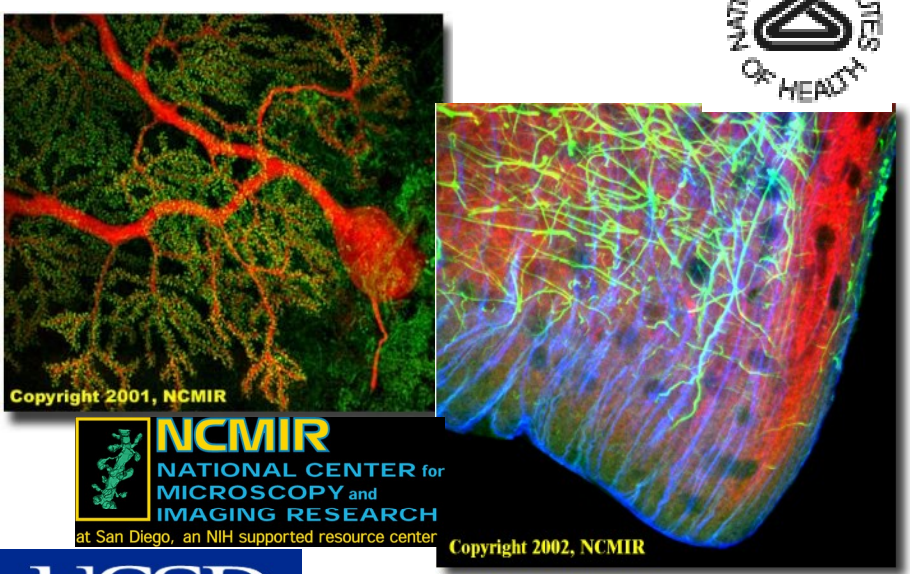
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www.cenic.org

OptIPuter Data-Intensive Application Drivers: BioScience and GeoScience

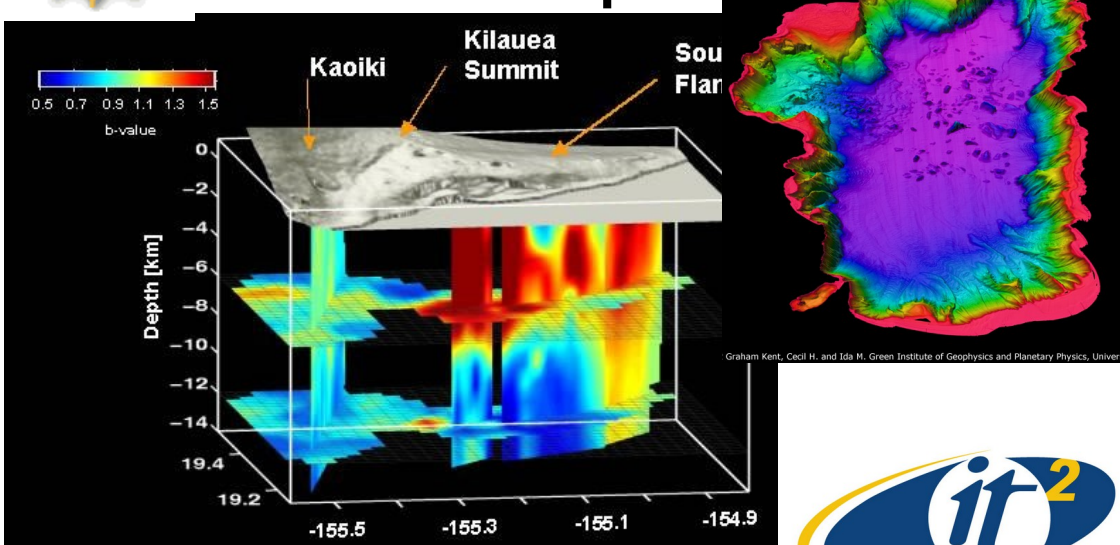
- NSF Large Information Technology Research Proposal
  - UCSD and UIC Lead Campuses—Larry Smarr PI
  - USC, UCI, SDSU, NW Partnering Campuses
- Industrial Partners: IBM, Telcordia/SAIC, Chiaro, Calient
- $13.5 Million Over Five Years

NIH Biomedical Informatics Research Network



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

NSF EarthScope



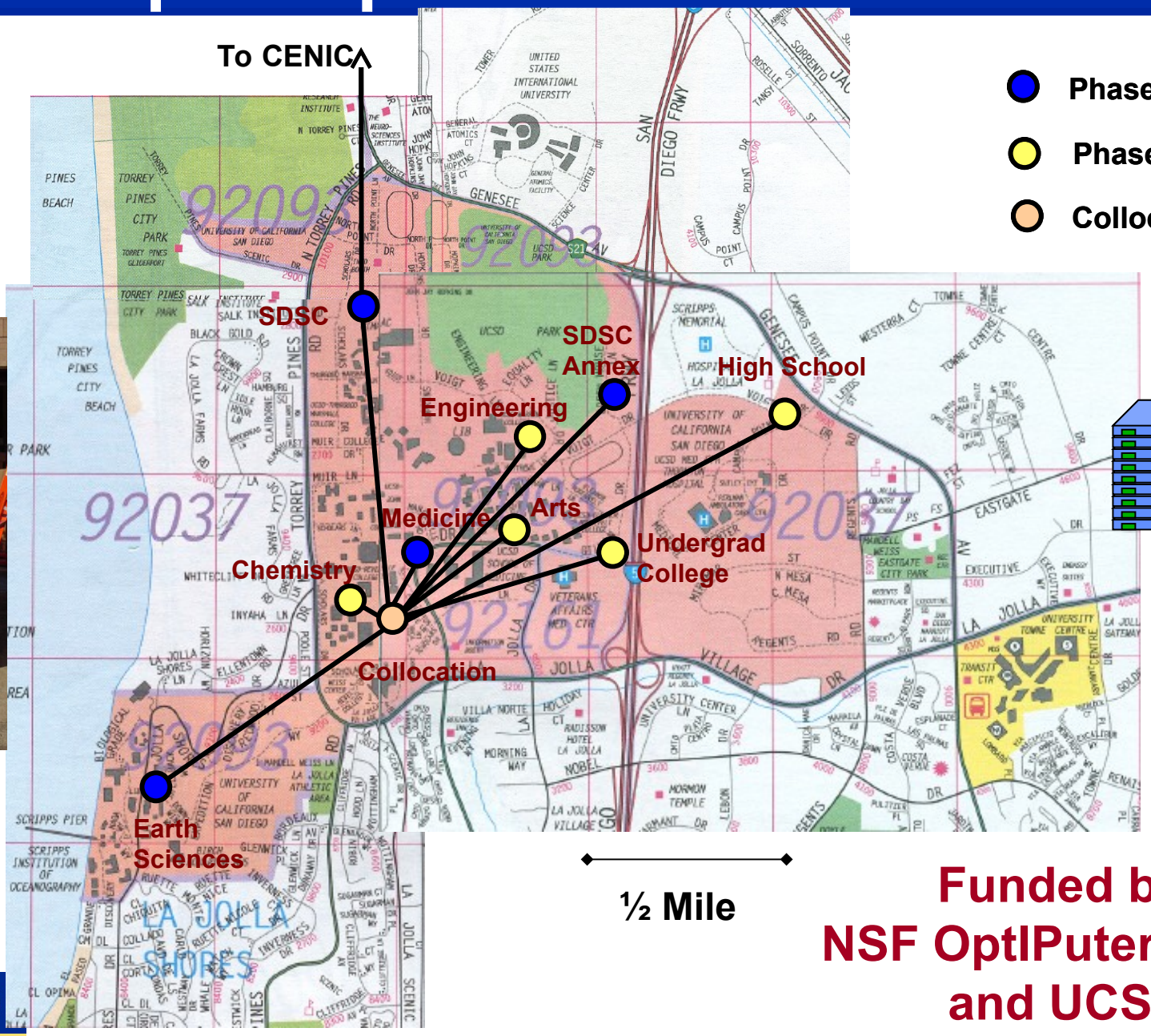
siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

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We Are Creating an Ultra-High Bandwidth Campus Optical Backbone Network





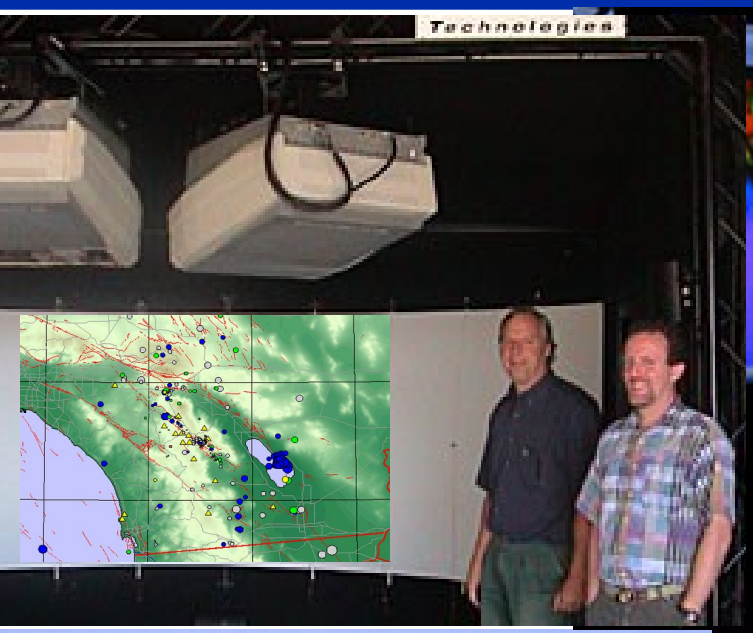
Funded by NSF OptIPuter Grant and UCSD

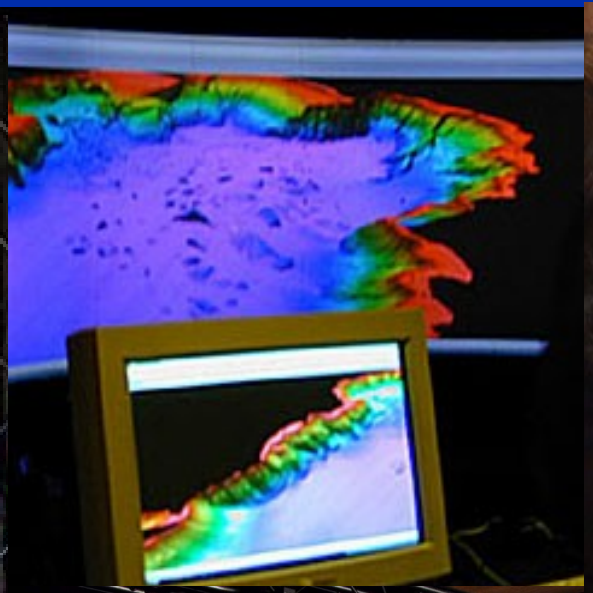
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Source: Phil Papadopoulos, SDSC; Greg Hidley, Cal-(IT)²

Multi-Megapixel Displays are Required for Seismic and Geosciences Monitoring













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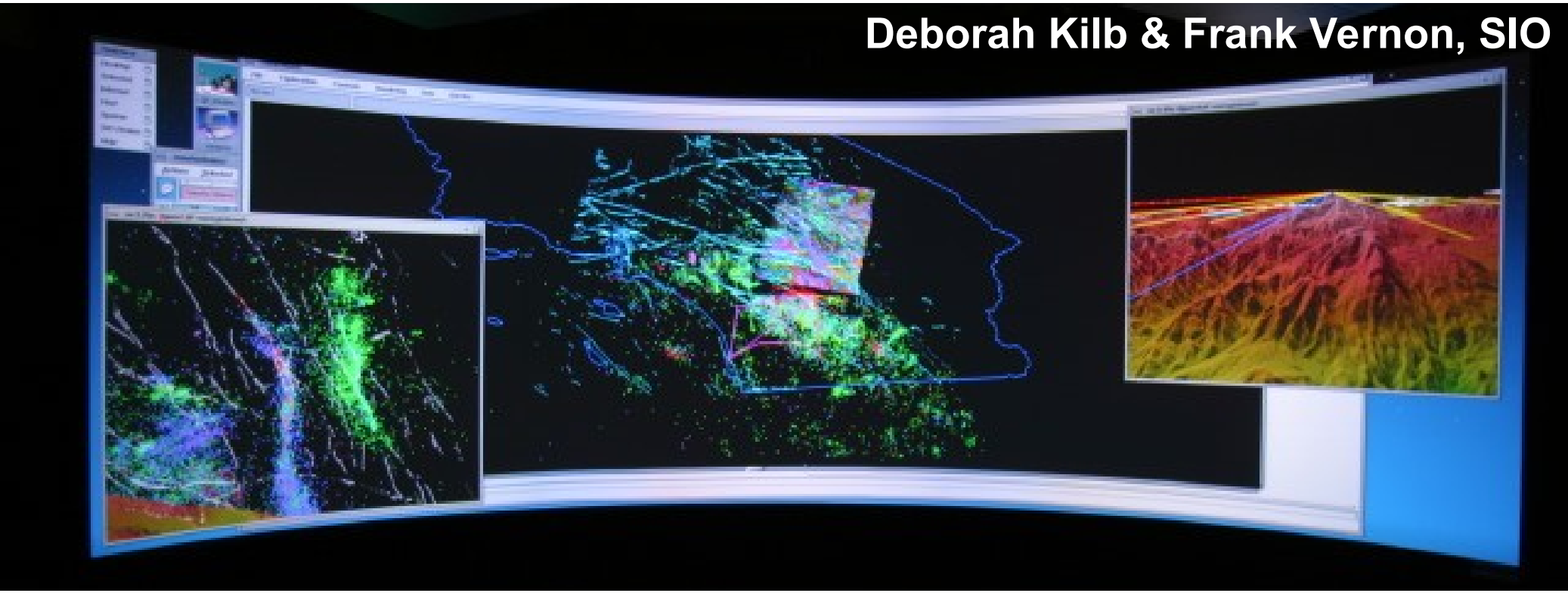
Cal-(IT)² Visualization Center
at Scripps Institution of Oceanography

it²

SIO Uses the Visualization Center to Teach a Wide Variety of Graduate Classes

- Geodesy
- Gravity and Geomagnetism
- Planetary Physics
- Radar and Sonar Interferometry
- Seismology
- Tectonics
- Time Series Analysis

Deborah Kilb & Frank Vernon, SIO



Multiple Interactive Views of Seismic Epicenter and Topography Databases

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http://siovizcenter.ucsd.edu/library/gallery/shoot2/index.shtml

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Remote Collaborative Visual Analysis of Large Datasets

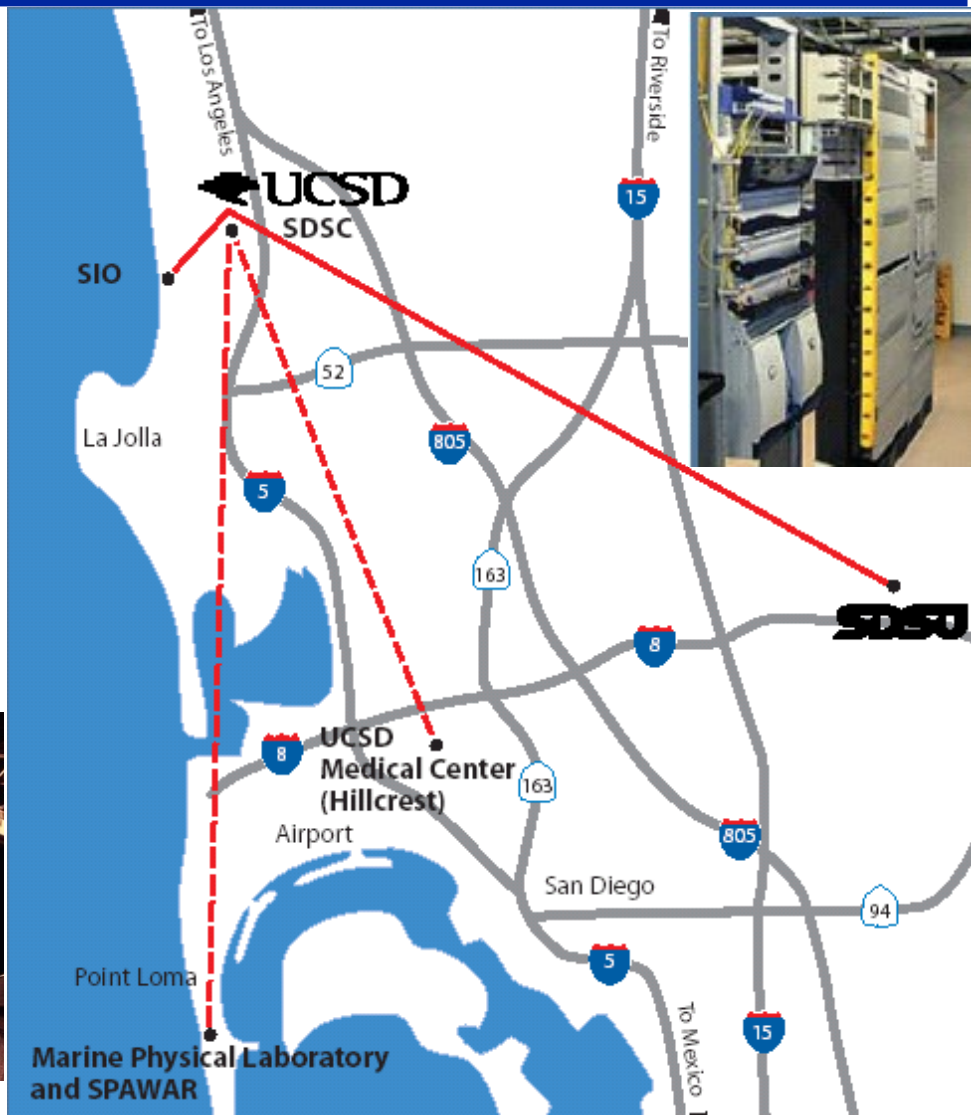
- **Driven by SensorNets Data**
  - Real Time Seismic
  - Environmental Monitoring
  - Emergency Response
  - Distributed Corporations
- **Linked UCSD and SDSU**
  - Dedication March 4, 2002





UCSD ⟷ SDSU

44 Miles of Cox Fiber



Cox, Panoram, SAIC, SGI, IBM, TeraBurst Networks SD Telecom Council

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Shell's Visualization Center
Local Collaborative Decision Support



Over a Hundred Installed in Oil and Gas Industry

"By being able to view the data together and talk on the spot, we were able to prepare for a pressure change not anticipated by people working on their own computers…and save significant amounts of money"

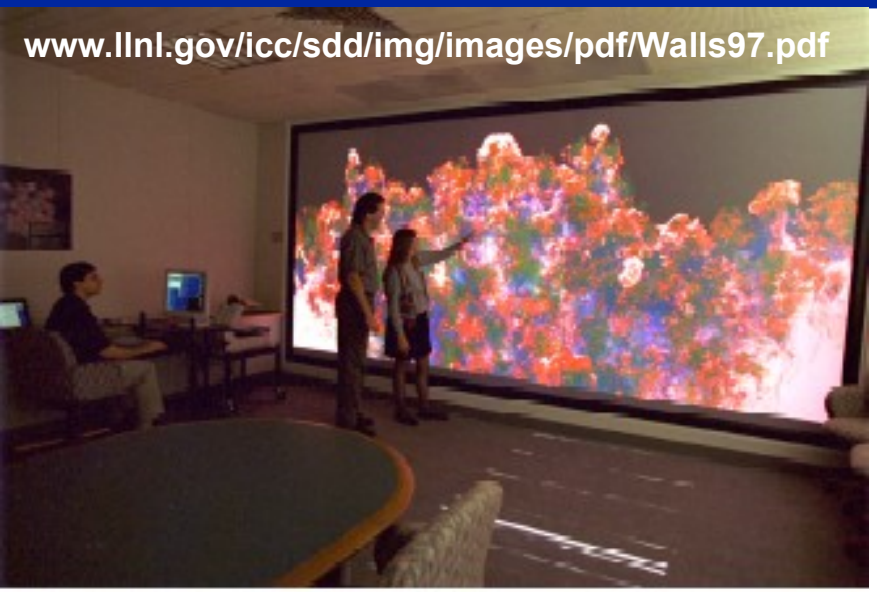
Shell Exploration & Production Company

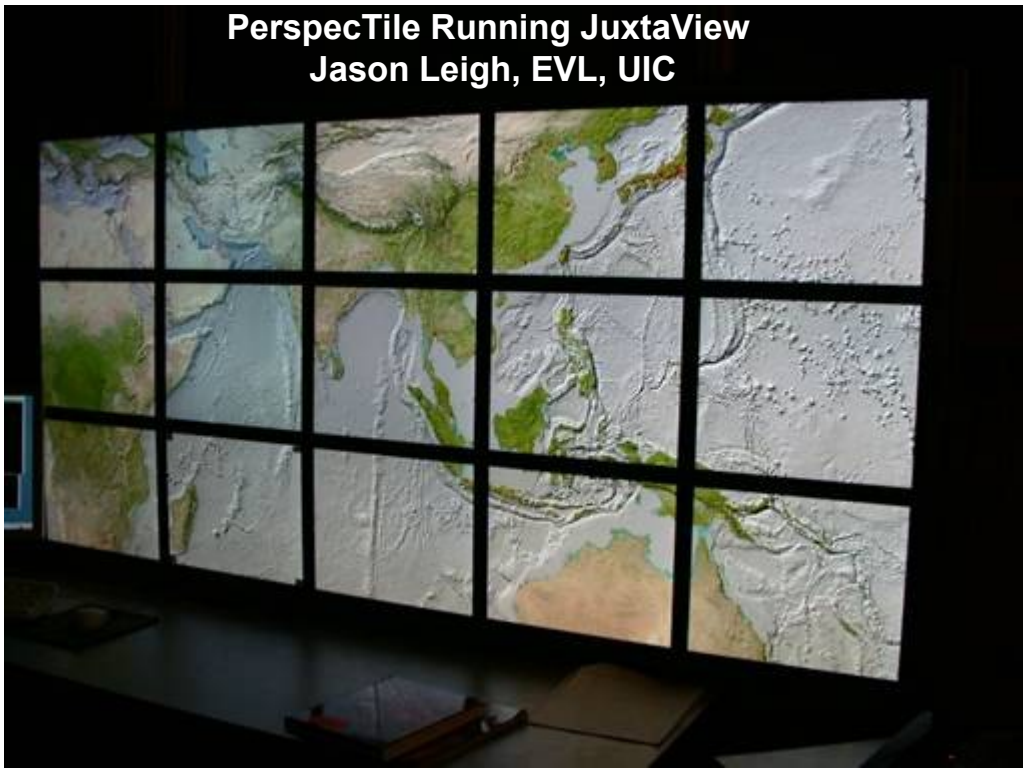
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www.shellus.com/sepco/technological_excellence.pdf

it²

Many Groups Are Building Tiled Displays For Large 2 and 3D Image Viewing





LCD Panels



Video Projectors

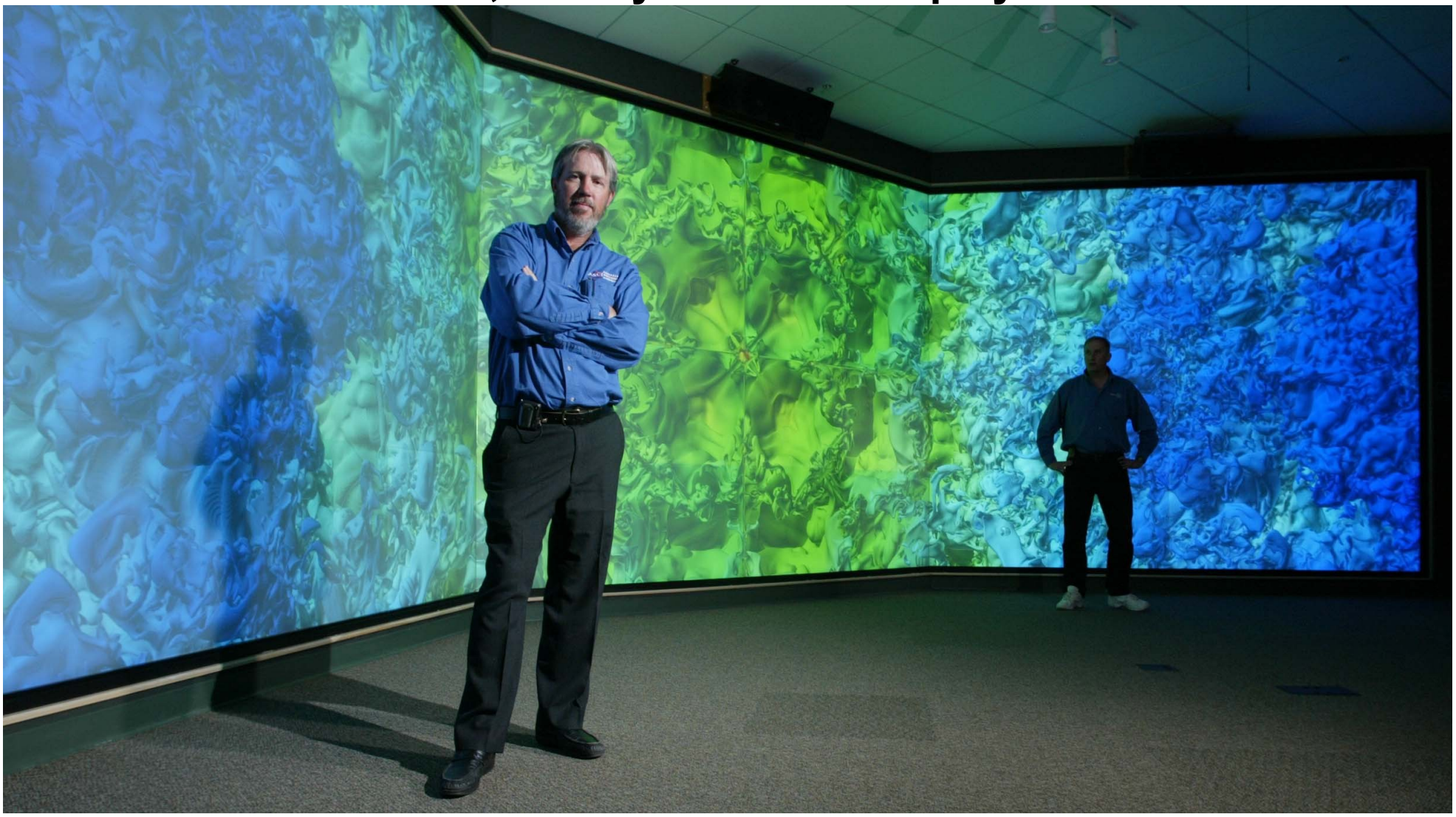
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UCIrvine

Each 3x5~20 Megapixels Total

it²

Current Bleeding Edge--60 Million Pixels Driven By Commodity PC Cluster!

At 15 Frames/s, The System Can Display 2.7 GB/Sec



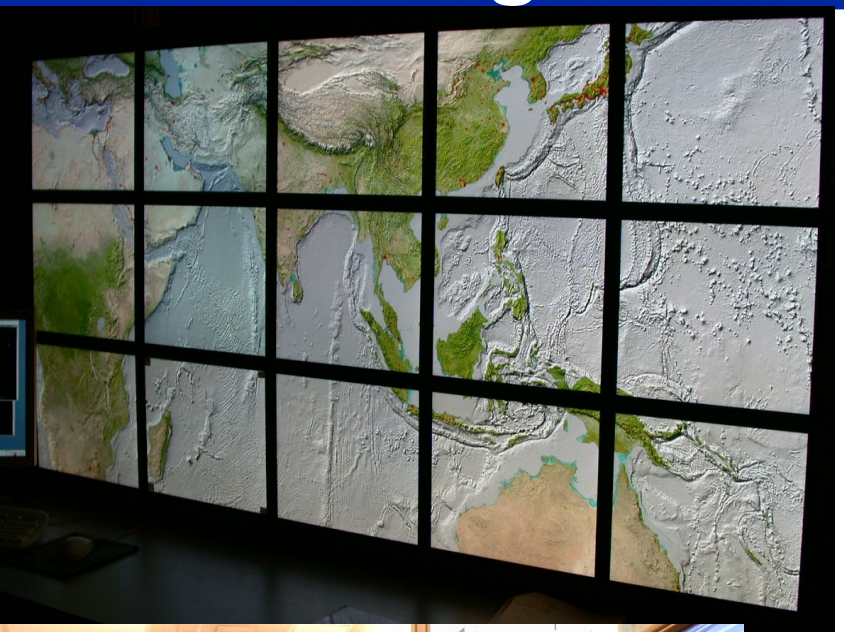
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Source: Philip D. Heermann, DOE ASCI Program

Sandia National Laboratories

it²

JuxtaView : Extremely High Resolution Digital Montage Visualization





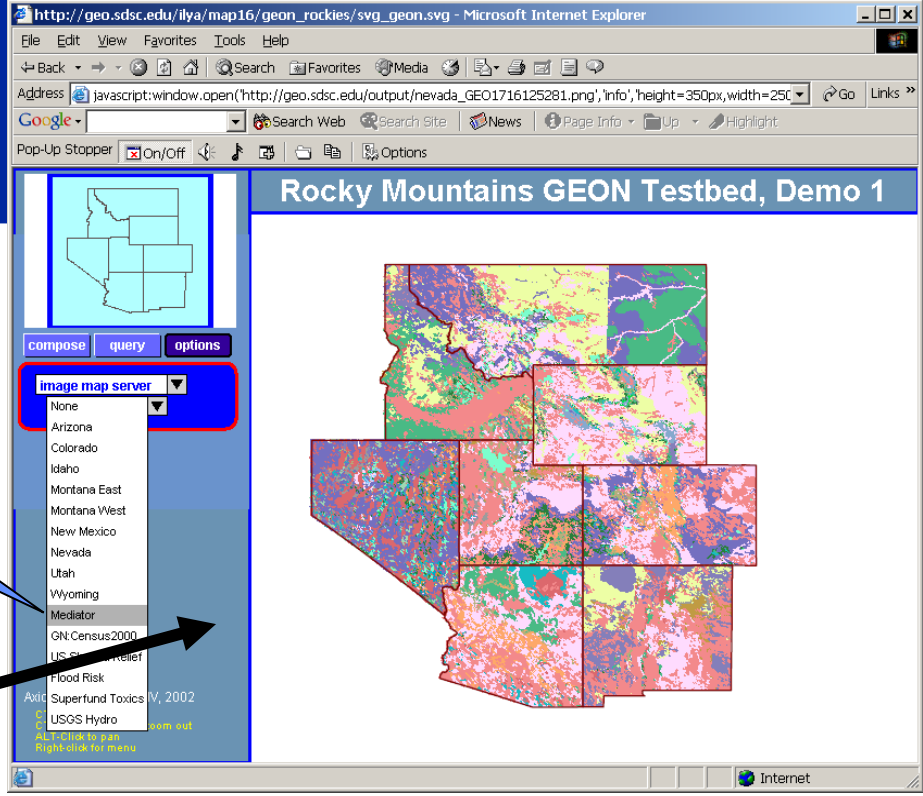
- Digital montage Viewer for PerspecTile LCD Wall
- USGS EROS Center Data:
  - 133 Urban Areas:
  - 5643 Tiles
    - Each 5000x5000 Pixel Resolution
  - ~ 375,600x375,600 Pixels for Each Urban Area
  - 394GB per Area
  - Total Data ~ 51 TB
- Hi-Tech Coast GIS Project
  - Link GIS of San Diego and Orange County with Baja
  - Anchor with High Resolution Montage of Aerial Photos

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Source: Jason Leigh, EVL, UIC

it²

GEON Seamlessly Integrates Geologic Data From Multiple Sources Using Ontology and Map Assembly Web Services



GEON

Mediator

Ontology

Legend Generator Map Assembler

...

GRID SERVICES FOR MAP INTEGRATION

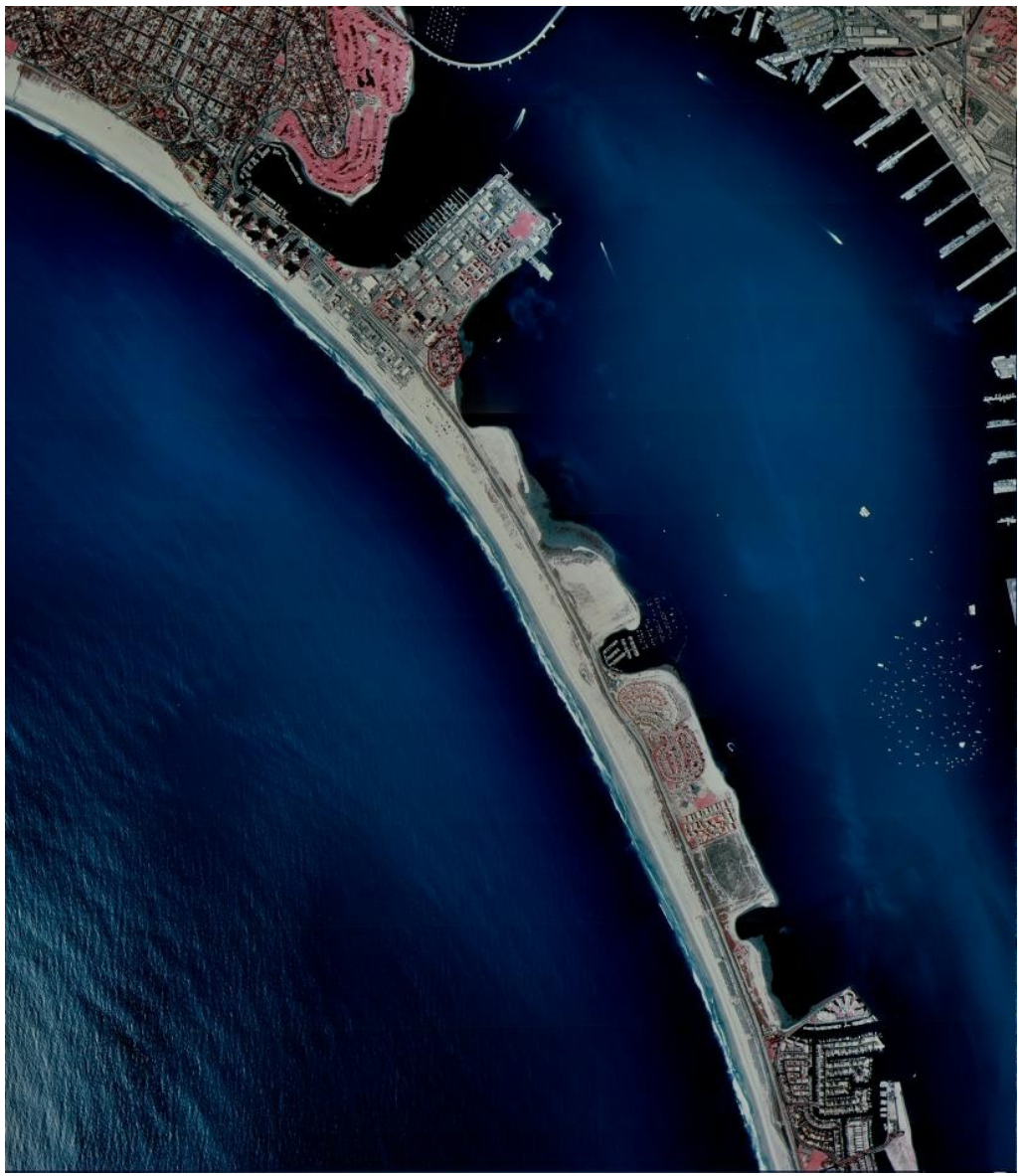
Source: Chaitan Baru, SDSC

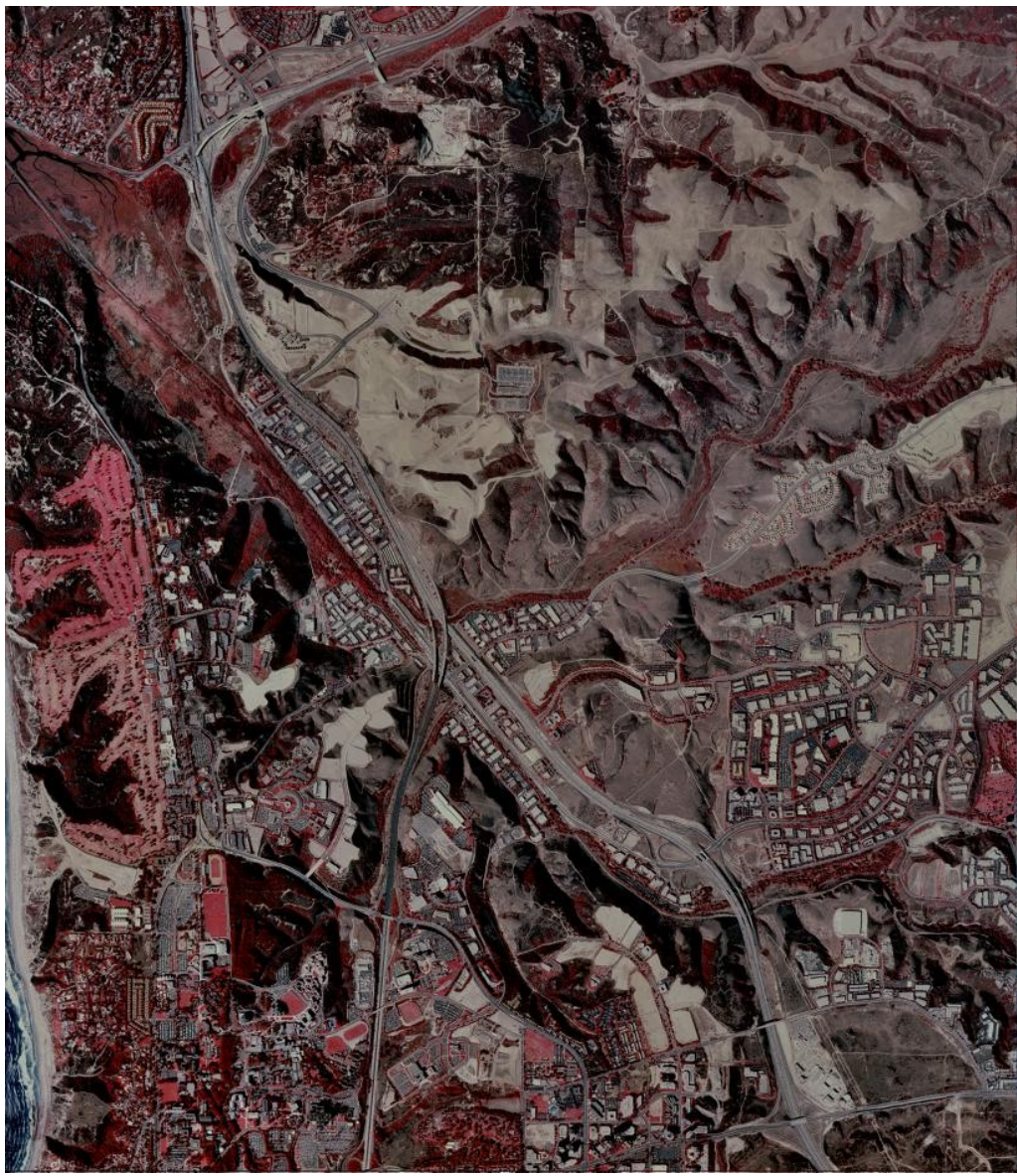
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ArcIMS Services wrapped In WSDL/SOAP

it2

USGS Aerial Photos for Ultra High Resolution Urban Area Project





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San Diego-Point Loma

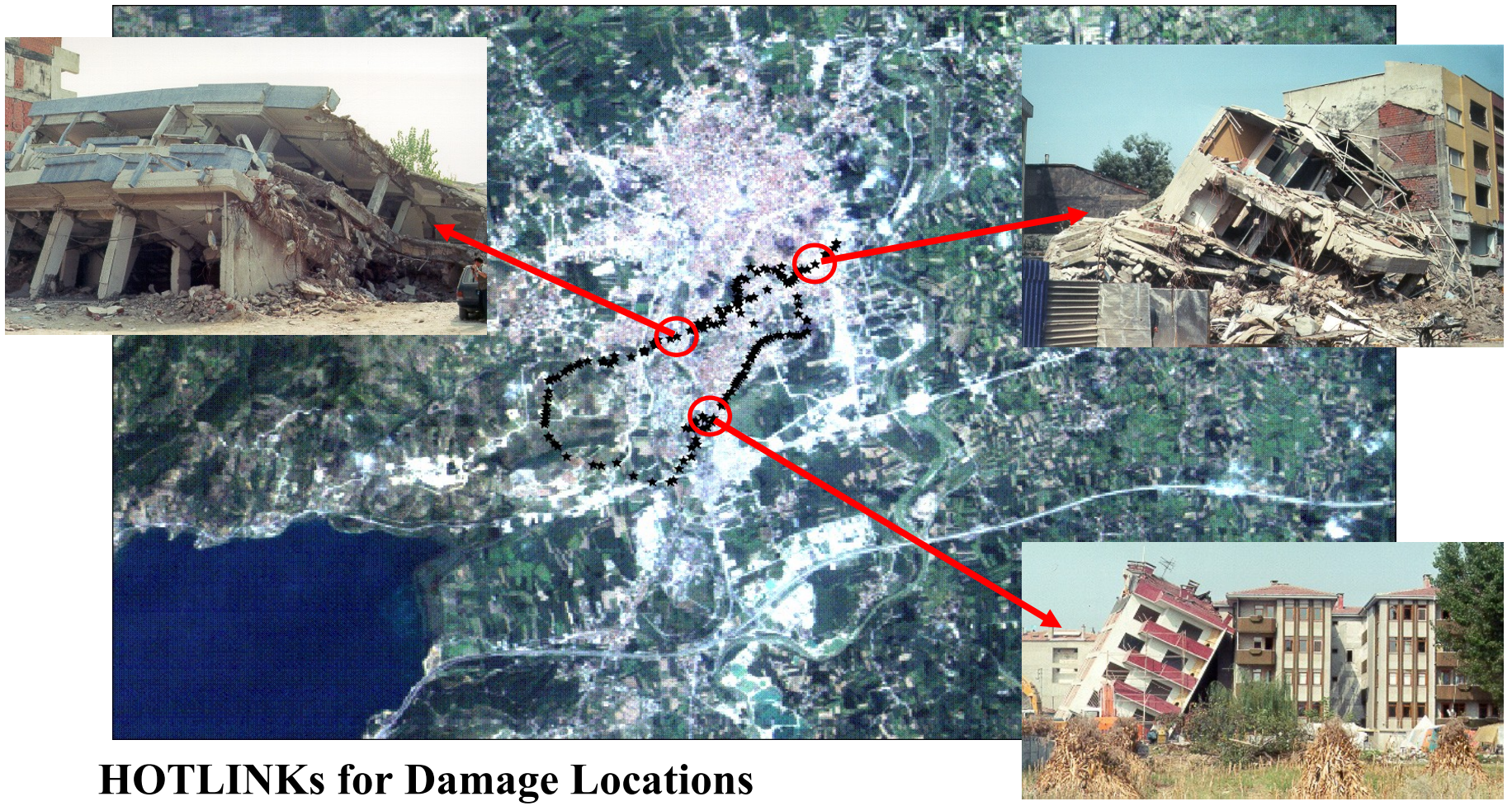
San Diego-Del Mar

it²

USGS EROS Center


Shane DeGross, Teles
We Require Interactive
Visualization of 3D Data
cudi
Corporación Universitaria
para el Desarrollo
de Internet
it

Integrate Remote Reconnaissance with Satellite Imagery and Ground SensorNets

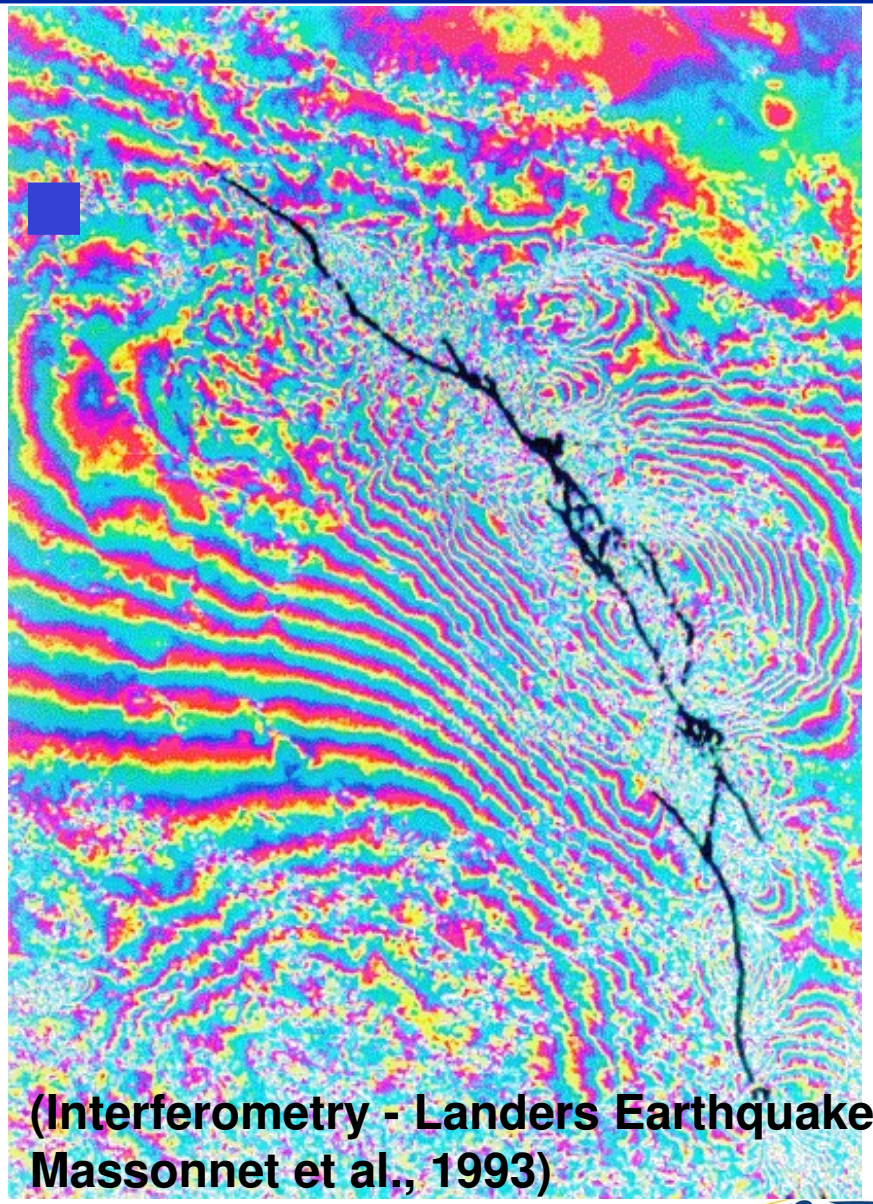


HOTLINKs for Damage Locations using GPS and Digital Photos on GIS

Maria Feng
UCI Civil & Environmental Engineering

Integrating Real-Time Geo Changes with SAR and GPS Geodesy

- Western North America Crustal Dynamics Research: WInSAR Consortium
- Monitor Strain Accumulation And Release Along The North American/Pacific Plate Boundary With An Emphasis On The San Andreas Fault Zone
- Crustal Dynamics Community Energized By Interferograms Of 1992 Landers Earthquake
- Future-Need Near Near-time Access To SAR Data



(Interferometry - Landers Earthquake Massonnet et al., 1993)

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Source: David T. Sandwell, SIO, UCSD

it²

Need to Have Many Real-Time Web and Video Feeds Simultaneously



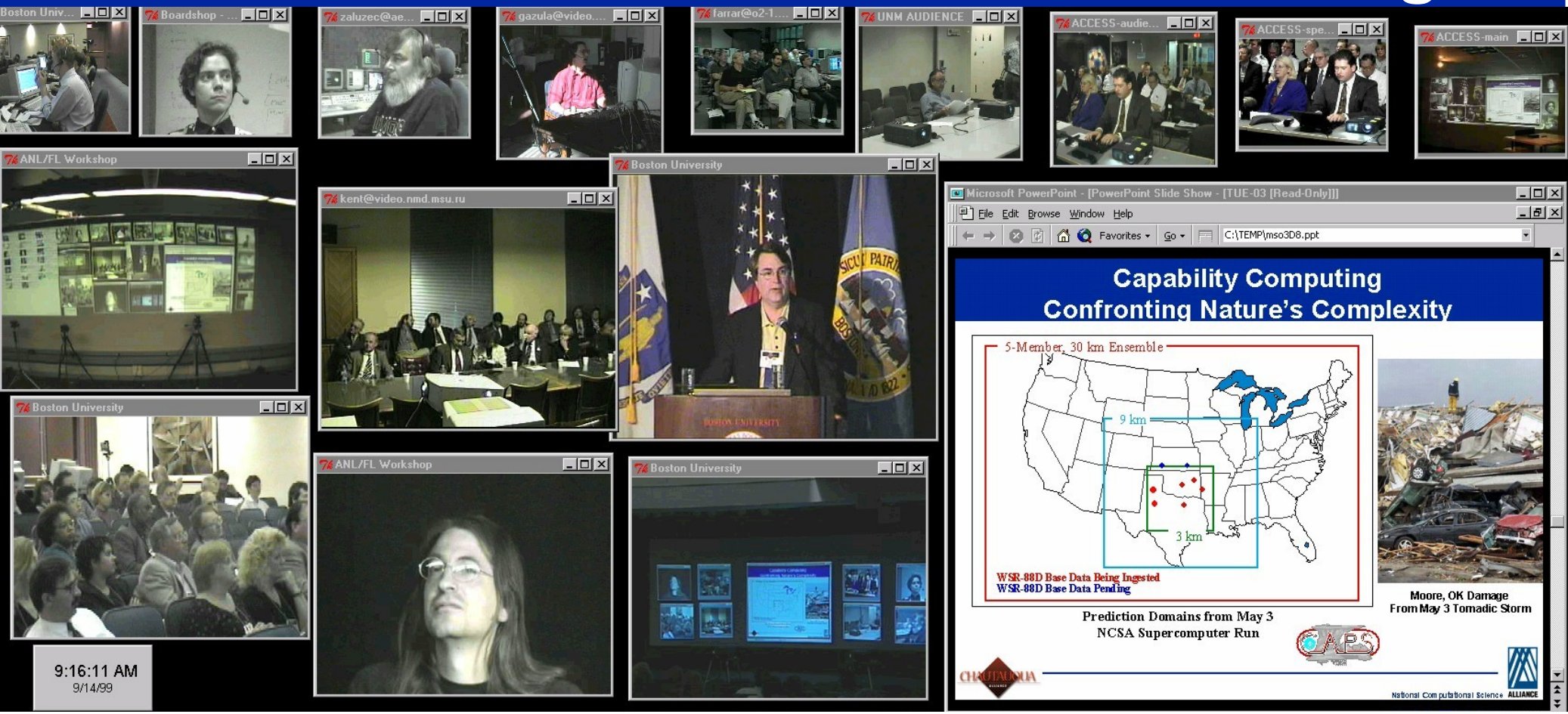
Muse Software with 52 Real-Time Feeds to Create Virtual Operations Center for Data Synthesis SDSU 6-Sided Room

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UCIrvine

Source: Dave Warner, SDSU

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From Telephone Conference Calls to Access Grid International Video Meetings



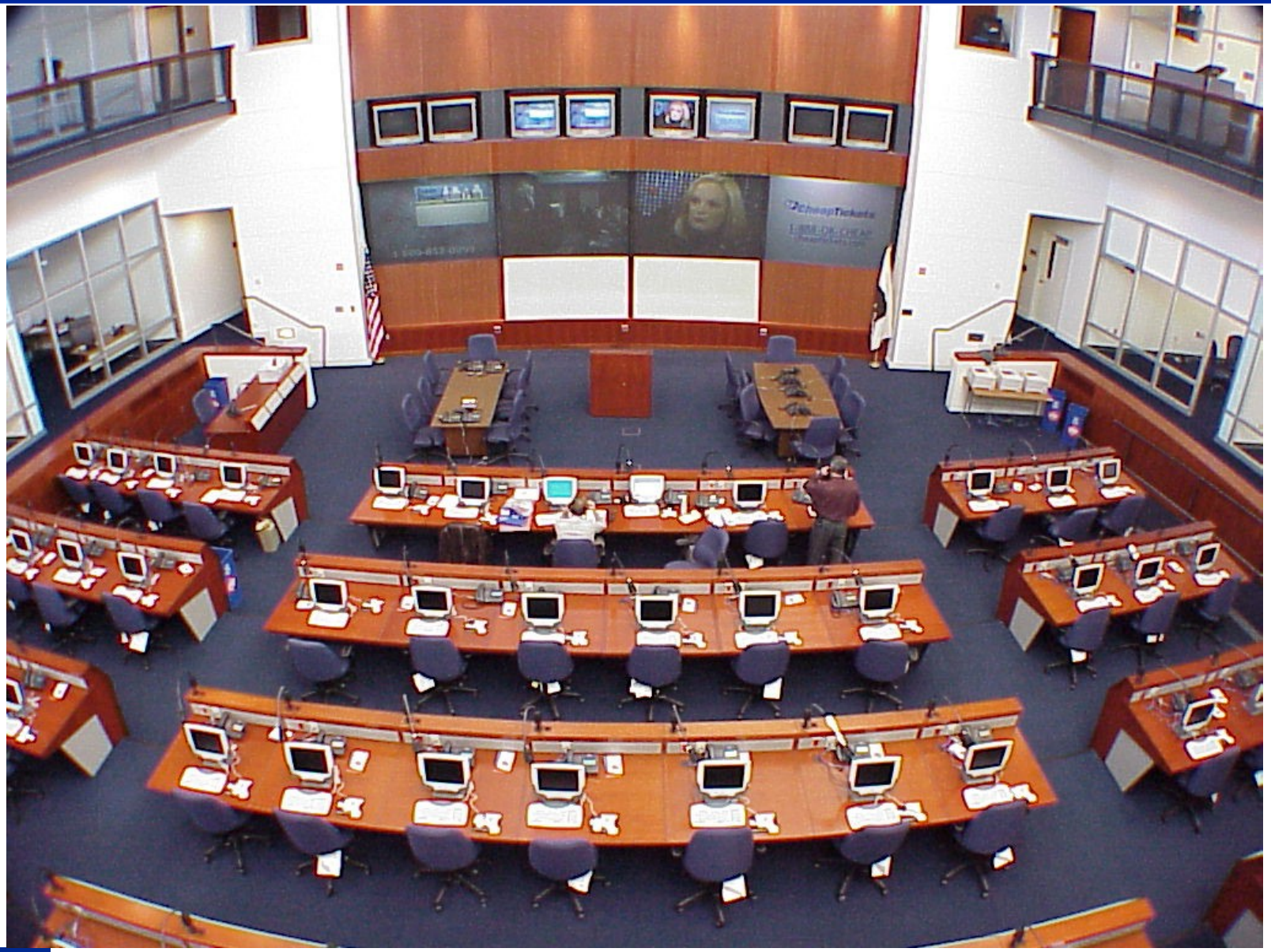
Can We Create Realistic Telepresence Using Dedicated Optical Networks?

UCSD
UCIrvine

Access Grid Lead-Argonne
NSF STARTAP Lead-UIC's Elec. Vis. Lab

it2

Planning for Optically Linking Crisis Management Control Rooms in California

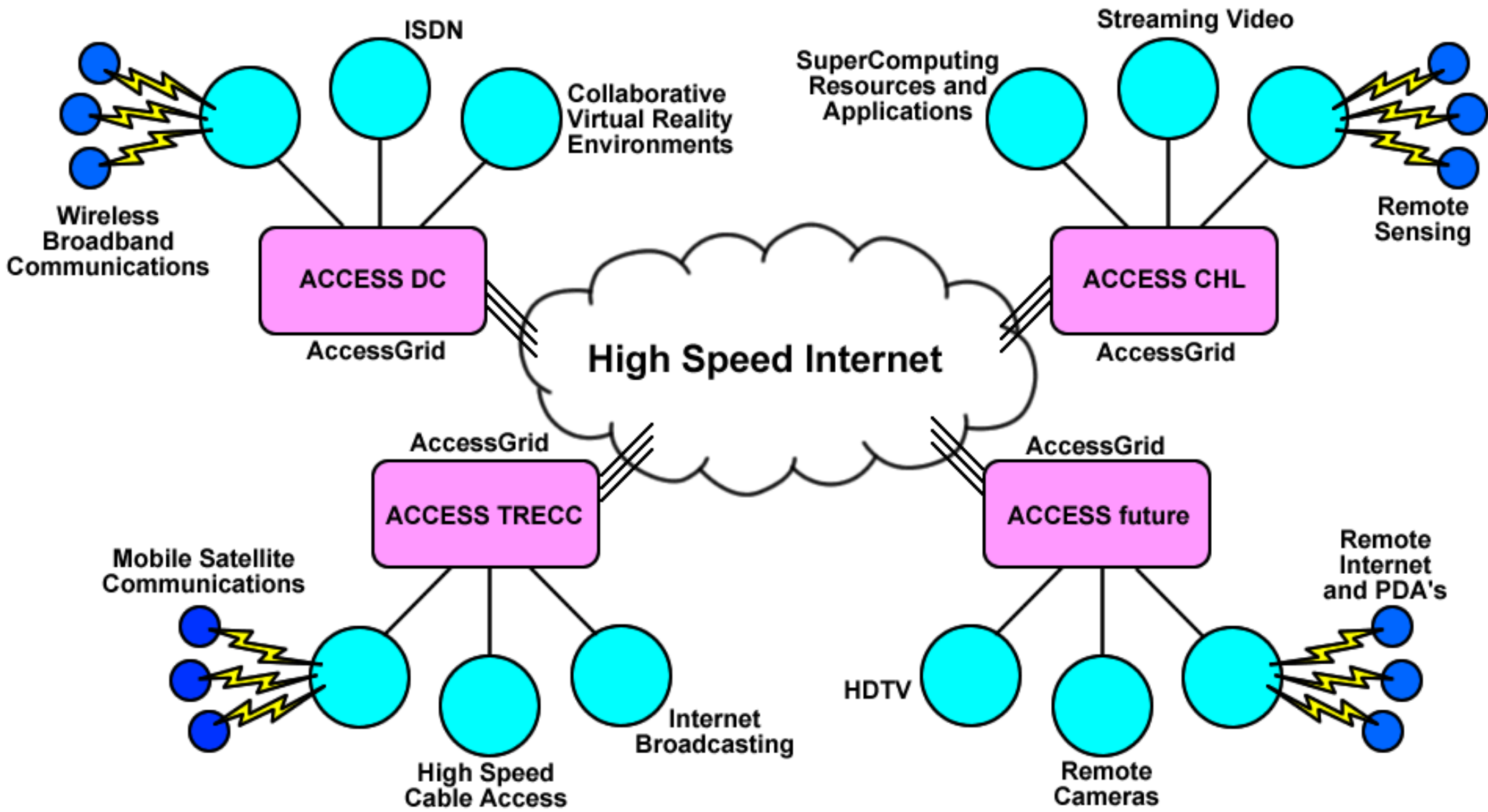


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California Office of Emergency Services, Sacramento, CA

it²

What is Needed--
Distributed Visualization Centers Model

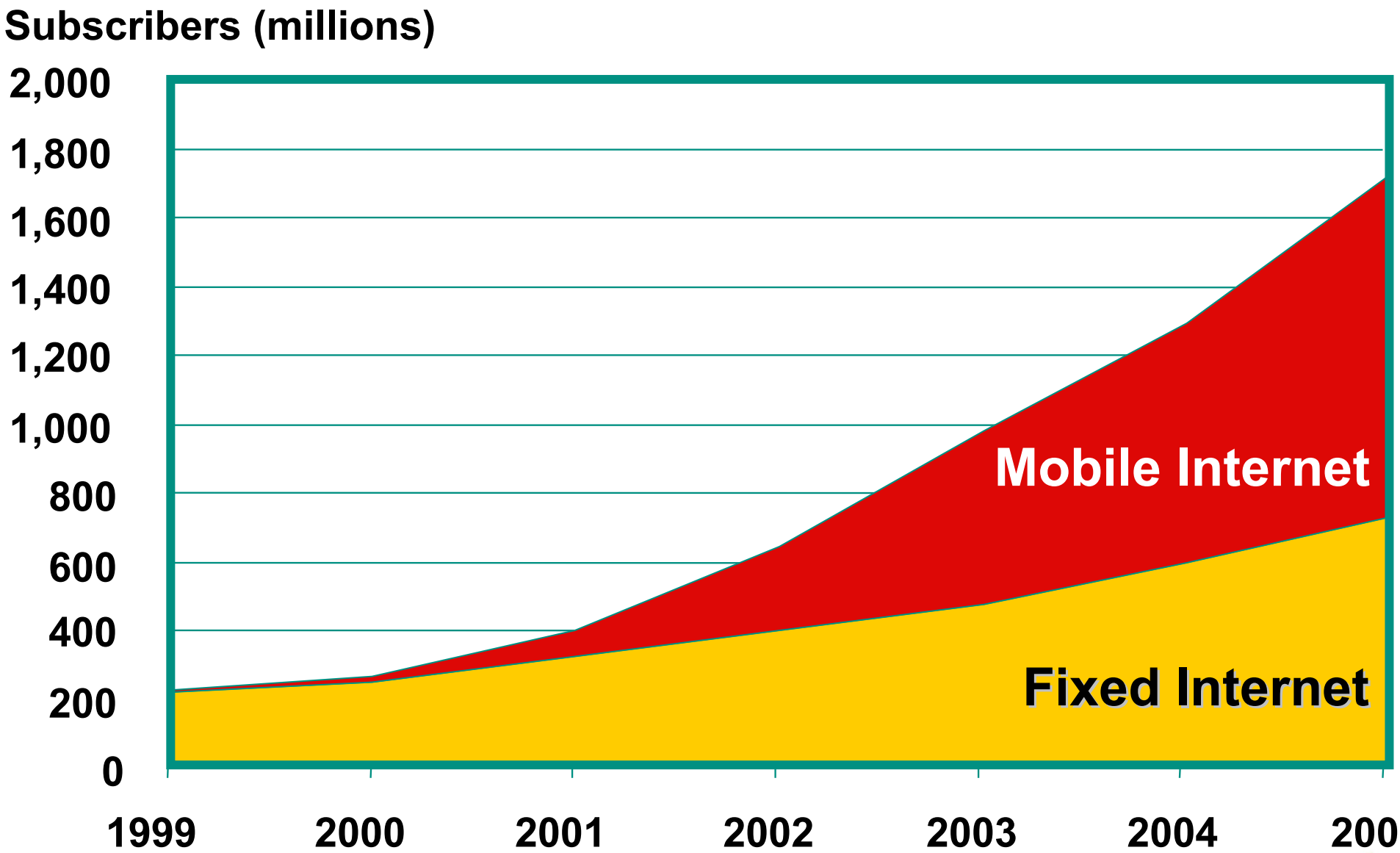


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Source: Janet Thot-Thompson, ACCESS-DC

it²

The Internet is Becoming Mobile



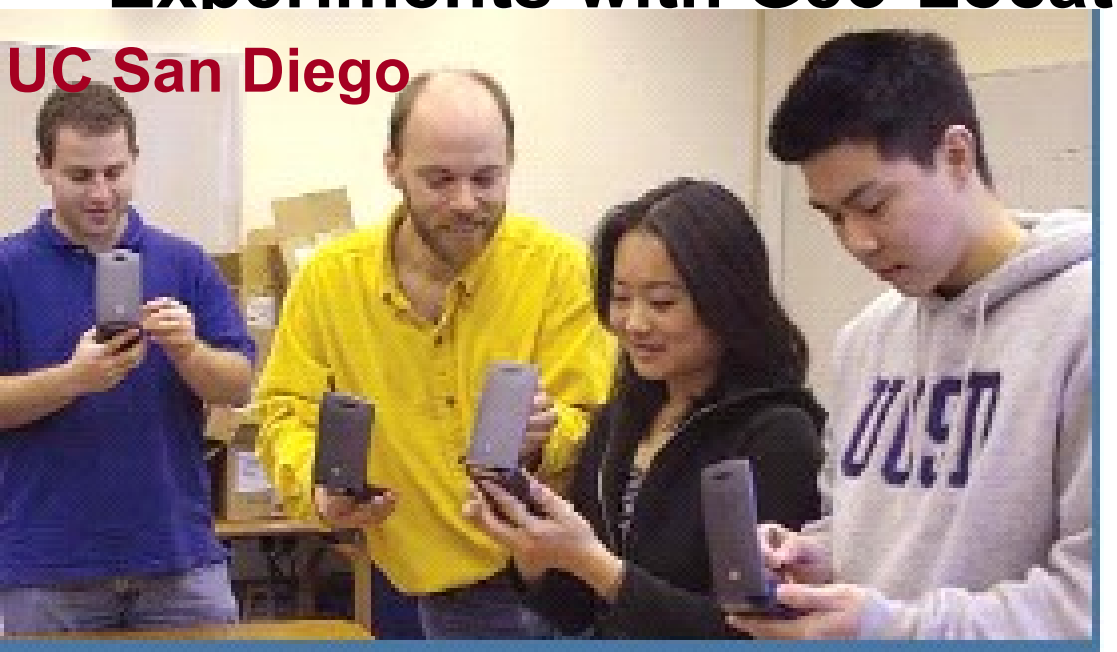
Source: Ericsson

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Using Students to Invent the Future of Widespread Use of Wireless Devices

- **Broadband Internet Connection via Wireless Wi-Fi**
  - **Over 600 Access Points on the Campus**
- **Year- Long "Living Laboratory" Experiment 2001-02**
  - **500 Computer Science & Engineering Undergraduates**
- **300 Entering UCSD Sixth College Students—Fall 2002**
- **Experiments with Geo-Location and Interactive Maps**



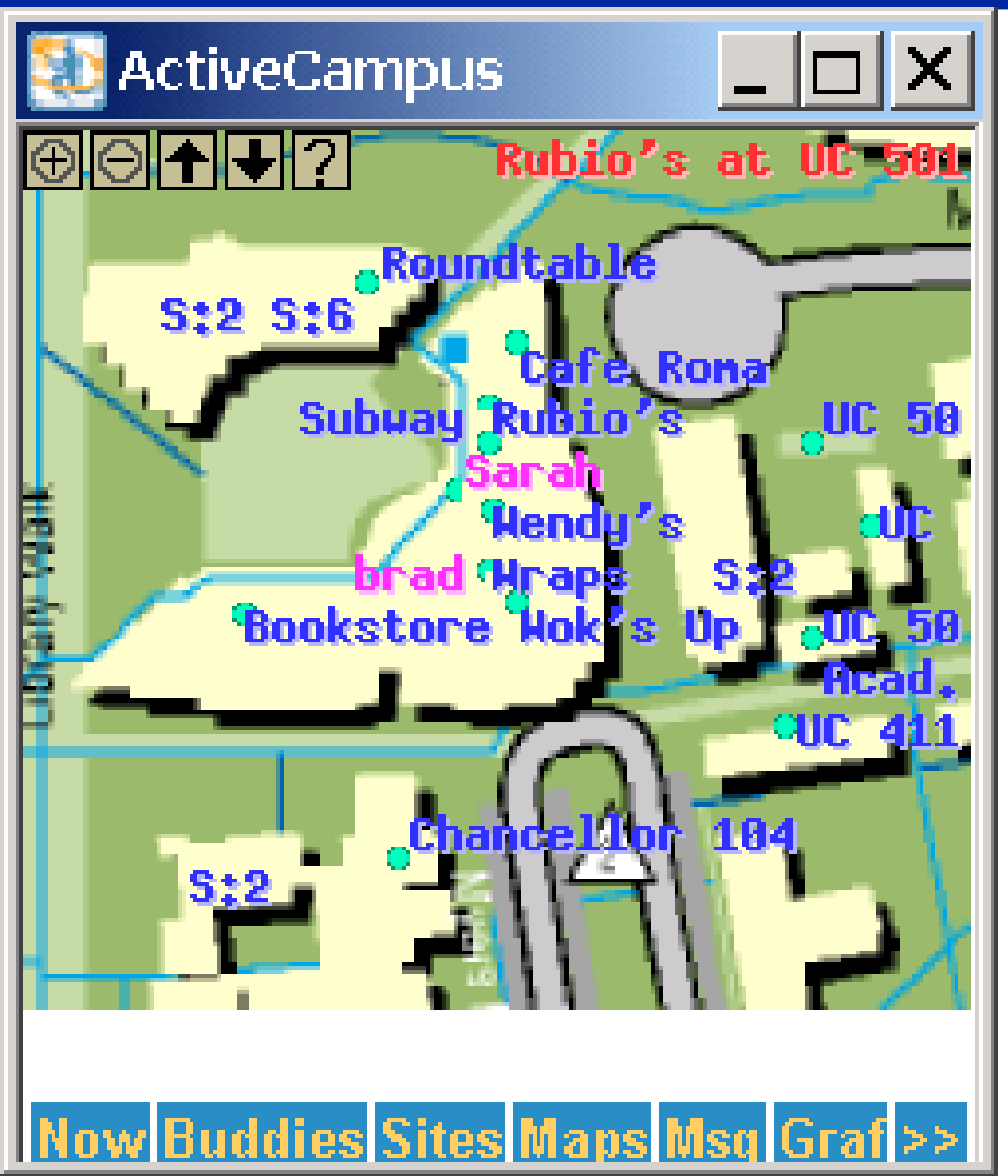


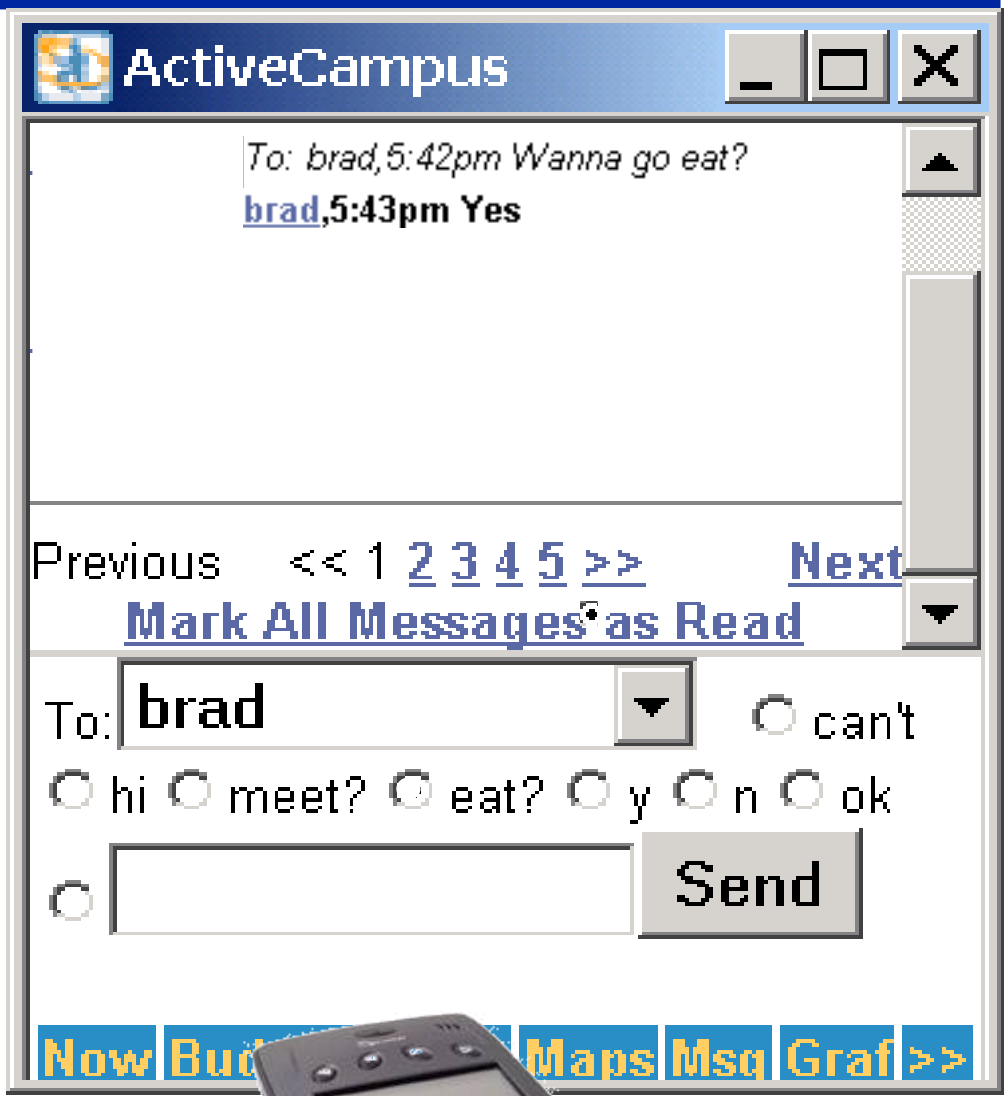
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Cal-(IT)² Team: Bill Griswold, Gabriele Wienhausen, UCSD; Rajesh Gupta, UCI

it²

The Undergraduates are Explorers of the New World of Mobile Geolocation







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Source: Bill Griswold, CSE, UCSD

"Always-On" Internet
Enables Continuous Data Entry and Retrieval

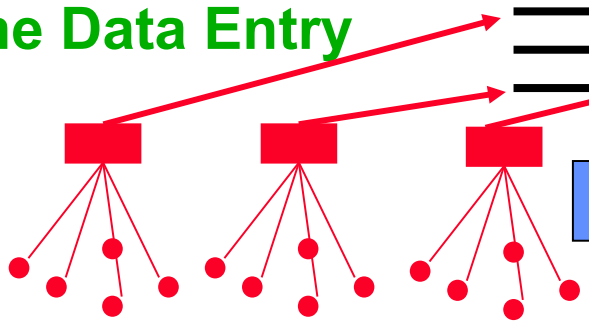
Web Portal Customized to User Device

PDAs, Laptops, Phones
- **Real-Time Data Access**





SensorNets
- **Real-Time Data Entry**



Visualization and Display

Data Mining, Simulation, Modeling, Analysis, Data Fusion

Knowledge-Based Integration
Advanced Query Processing

Database Systems, Grid Storage, File Systems

High speed networking

Networked Storage (SAN)



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Source: UCSD/Cal(IT)²

it²

Local Wi-Fi Can Be Linked With Wide Area Cellular Internet

- First US Taste of 3G Cellular Internet
  - UCSD Jacobs School Antenna
    - Two Years Before Commercial Rollout
- Linking to 802.11 Mobile "Bubble"
  - Tested on Campus CyberShuttle
  - From Railway to Campus at 65 mph!



Rooftop Qualcomm 1xEV Access Point





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www.calit2.net/news/2002/4-2-bbus.html

NSF's ROADnet—Bringing SensorNets to the Dirt Roads and the High Seas

- **High Bandwidth Wireless Internet**
  - Linking Sensors for:
    - Seismology
    - Oceanography
    - Climate
    - Hydrology
    - Ecology
    - Geodesy
  - Real-Time Data Management
- **Joint Collaboration Between:**
  - SIO / IGPP
  - UCSD
  - SDSC / HPWREN
  - SDSU
  - Cal-(IT)^2 Industrial Cost Sharing

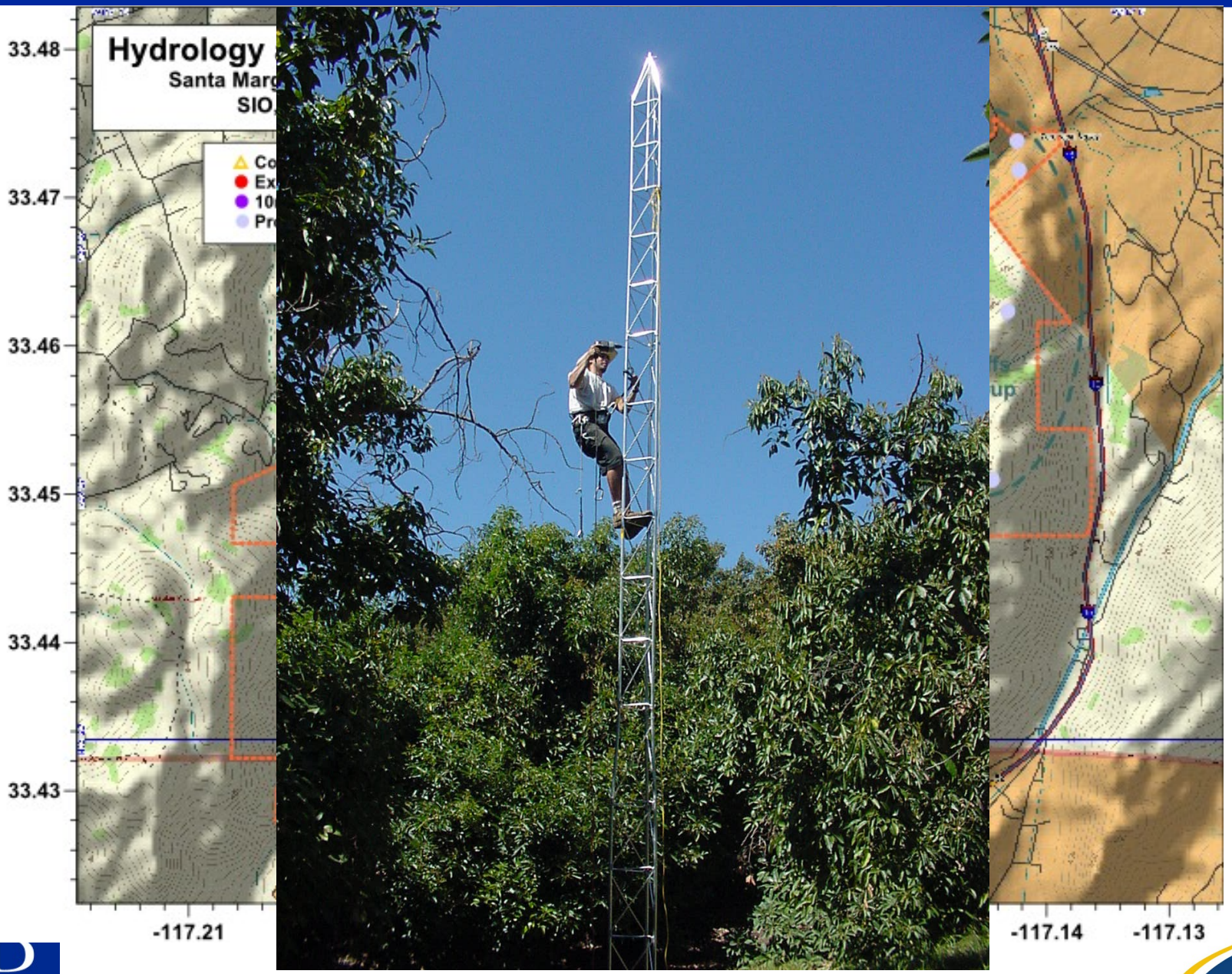




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http://roadnet.ucsd.edu/

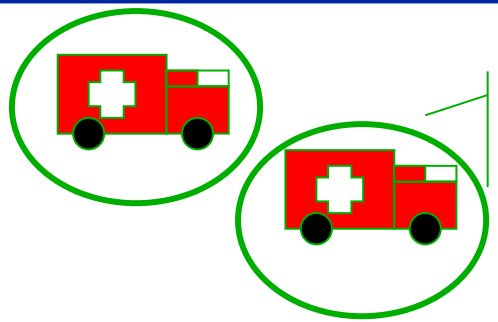
Environmental SensorNets--Water and Climate Instruments in the Santa Margarita Ecological Reserve



Source, Dan Cayan, UCSD SIO

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CAL-(IT)² WIISARD Wireless GIS Scenario for Improving Emergency Medical Response



Transportation Assets
With Mobile Internet
Bubble

2-Way Telemedicine
Control Room
GPS Tracking
High Bandwidth

Hot Zone

Hospital #1

WMD Attack

Prevailing wind

Stadium

Compromised
Transportation

Corridor

First Responder PDAs
Electronic
record of
field care



Field
Treatment
Station

Warm
zone

Mobile Bubbles
Patient RF IDs

Incident
command
center

Transport
station

Hospital #2

Source: Dr. Leslie Lenert, UCSD SOM

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