Part of the Cal-(IT)² LambdaGrid Living Laboratory

Integrated Visualization Theaters: Enabling Collaborative Analysis

1 Visitors to Scripps' facility view topographic data in three dimensions on Panoram Technologies' display.

2 Satellite imagery draped over topography shown at SDSU facility.

3 Scientists using the Scripps facility study the surface of Mars to determine possible landing sites for the next mission.

Cal-(IT)²'s two immersive visualization theaters established at UCSD's Scripps Institution of Oceanography (SIO) and San Diego State University (SDSU), linked by an optical network, comprise a new kind of infrastructure to support collaborative scientific analysis, academic instruction, and public education.

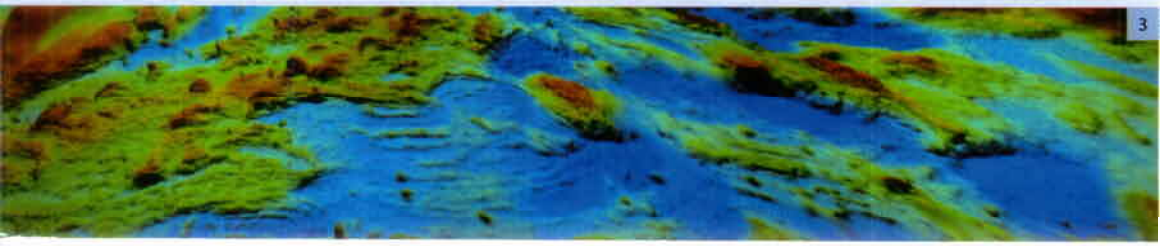
Many such theaters exist around the world, particularly in the oil-and-gas and manufacturing industries. But these are two of the first such theaters that have been *networked together* to support real-time sharing and collaborative analysis of large-scale (including three-dimensional) data sets.

This infrastructure links lead campuses of the University of California and the California State University in an unusual experiment. It provides a neutral environment for vendors to test their technologies and integrate them with others in a real-world setting. And, in light of September 11, it presages the possibility of networked command-and-control centers for crisis management.

These facilities have been used to study

- Integration of real-time Earth systems science data related to southern California
- Seismicity from around the globe with a focus on active faults in Southern California
- Surface topography of Mars for selection of future landing sites
- Fault-related crustal deformation and subsurface fault geometries
- Structure and dynamics of coastlines
- Impact of global warming on Earth's climate
- Environmental change studies of the Caspian Sea

Potential applications are limitless . . .



Cal-(IT)² "Living Labs" Provide Glimpses of Future Mass Markets

These immersive visualization theaters are an early incarnation of Cal-(IT)²'s vision of moving academic research prototypes and industrial partners' early products into the field for system integration and testing. These "living laboratories" provide an opportunity to experiment, revealing a glimpse of future mass markets three to five years before the markets themselves come into being.

Such labs enable participants—academic, industrial, and governmental—to live in the future. Researchers can "plug in" new algorithms and experimental devices to receive immediate feedback. Industrial partners gain first-hand experience with product prototypes and identify applications and services that their new products may enable. Policymakers, business management experts, cognitive scientists, artists, and educators study the effect of this technology on human interaction, expression and creativity, learning, and productivity. Students are challenged by this environment to become the next-generation research and development leaders in telecommunications, information technology, and driving applications such as the geosciences. (Early Cal-(IT)² living laboratories include technology-driven, applications-driven, and culturally driven labs, as described in pp. 5–14 of the Cal-(IT)² brochure).

These immersive visualization theaters form part of Cal-(IT)²'s LambdaGrid living laboratory. This lab is based on the emerging concept of the *grid*, a set of network-connected, but geographically dispersed, resources like computers, data servers, visualization devices, and laboratory instruments.

Where previous network technology encoded information on a single beam of light traveling on a fiber, now information can be encoded on individual wavelengths of light—called *lambdas*—with multiple lambdas able to trave along a given fiber.

Such advances in fiber-optic technology are increasing potential network capacity to the point where bandwidth ceases to be the traditional bottleneck in connecting resources across metropolitan and larger areas. This increased capacity is beginning to support the next step in scientific investigation: enabling geographically distributed scientists to explore, interactively and collaboratively over large distances, massive amounts of previously uncorrelated data.

The National Science Foundation recently funded a six-institution, five-year research grant to develop the intergrated software and hardware systems—termed the *OptIPuter*—necessary to realize this vision.

1, 2 Debi Kilb, science director of the Visualization Center at Scripps, takes visitors on a virtual tour of Southern California topography. This tour includes image 2, "flying" below the Earth's surface to view the locations of 40,000 earthquakes recorded by a Scripps operated ANZA seismic network over the past twenty years (see image 1, p. 4).

3 SDSU facility showing three interactive, three-dimensional visualizations of the San Diego region.

This Living Laboratory Teams Vendors and Academic Researchers

Founding vendors:

- TeraBurst Networks
- Panoram Technologies
- SGI
- Cox Communications

Other vendors:

- ASGA
- ESRI
- Interactive Visualization Systems
- Landmark Graphics
- Microvision
- Paradigm Geophysical
- Polexis
- Schlumberger
- TGS
- R.W. Welty Technologies

Academic research units:

- California Institute for Telecommunications and Information Technology
- Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics
- Scripps Institution of Oceanography
- San Diego State University
- San Diego Supercomputer Center

Technical Specifications

Hardware components:

- **TeraBurst Networks' Wide Area Visualization Solution**, based on a high-performance, optical networking platform to enable transmission of massive amounts of data between multiple locations. This technology enables video, audio, and data to be transmitted simultaneously over a wide-area optical network to geographically distributed centers.
- **Panoram® GVR-120E curved, floor-to-ceiling screen** (8'6" x 28'4") featuring 3.2-megapixel resolution. The system is equipped with transmitters and LCD shutter glasses, which permit stereographic 3-D viewing of high-resolution images. Three projectors use Panoram technology to blend the edges where their video outputs meet. The immersive environment is well suited for groups of up to sixty people.
- **SGI® Onyx® 3400 visualization system**, driving the Panoram display, equipped with InfiniteReality3™ graphics, sixteen processors, and 1.5 TB of disk storage. SGI also provides OpenGL Vizserver™ software, a method of interconnecting visualization centers and remote devices into a *Visual Area Network*. Visual Area Networking allows anyone anywhere, anytime, on any device to connect to a central graphics computer, to other participants in a decision-making process, and to a full decision model in a command-and-control center.
- **Cox Communications' 44-mile, 2.6-gigabit-per-second optical-fiber network** linking the two facilities. Cox Communications' network link has the capacity to support multiple OC-192/10-GB connections and provide voice and video connectivity.
- **Microvision head-mounted displays** that overlay data sets on images of the physical world. These single- and full-color laser systems allow output of the visualization system to be sent to an individual on location (for example, a fire battalion chief) so that critical information can be seen in context. This technology also enables distinguishing between "public" versus "private" displays of multiple data sets on the big screen.

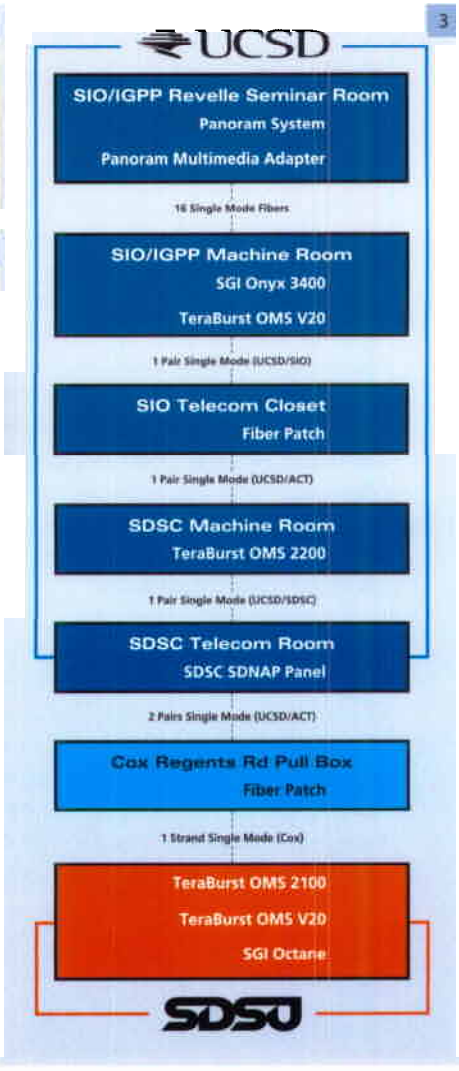
Software components:

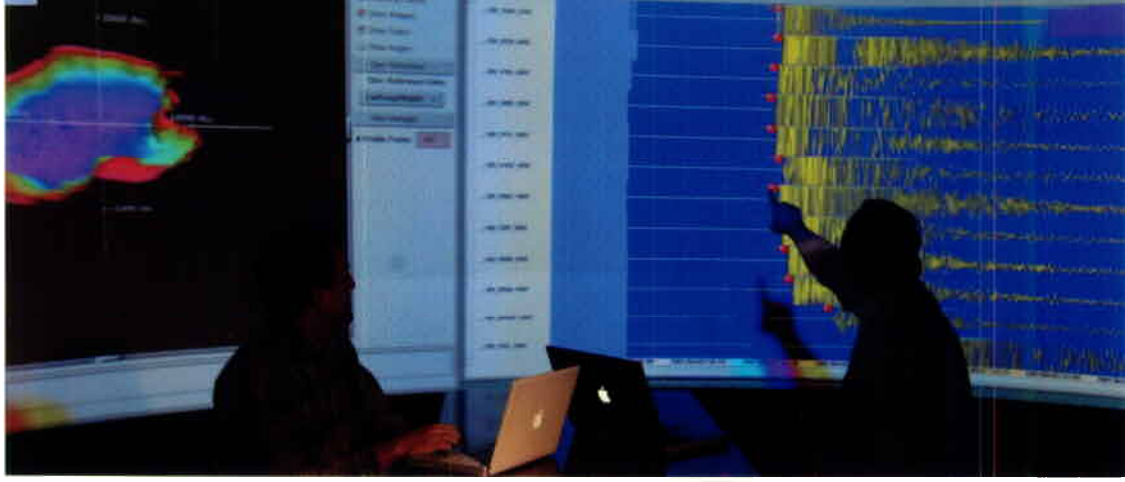
- **GOCAD**, by ASGA. This program can be used to model, view, and manipulate surfaces and natural objects, such as oil reservoirs, especially in three dimensions.
- **ARC products**, by ESRI. New products support 3-D analysis and fly through of world data sets related to security, environmental planning and watershed management, and wireless location-based services.
- **Fledermaus and Data Magician**, by Interactive Visualization Systems. Fledermaus enables the user to interactively explore very large 3-D data from any angle or viewpoint. It allows input of a wide variety of data types (including output from many Geographical Information System packages) and provides simple graphical tools to convert these into color-coded and shaded 3-D scenes. Fledermaus allows draping or texture mapping of imagery data over digital terrain models and provides a wide variety of analytical tools.
- **Volume visualization and decision-making software**, by Landmark Graphics. This software allows interaction and real-time analysis of complex data sets displayed on the immersive visualization systems.
- **Focus 3-D, VoxelGeo, and GeoDepth**, by Paradigm Geophysical. Focus 3-D is a seismic-processing environment. VoxelGeo is a volume-visualization environment that enables exploration of large volumes of seismic data. It can produce QuickTime movies for interpretation. GeoDepth is an imaging environment that enables advanced velocity model building and imaging in both time and depth.
- **Extensible Information Systems**, by Polexis. This software provides the "glue" that enables multiple applications and databases to interact with each other on a cross-platform basis. It enables an enterprise to integrate relevant information from many domains into one cohesive solution.
- **GeoQuest**, by Schlumberger. This software for oil/gas exploration and production facilitates geophysical data processing, display, and decision making.
- **Amira and OpenInventor**, by TGS. These software suites support processing 3-D image data and displaying 3-D graphics, which are compatible with immersive visualization systems and real-time analysis, particularly in engineering, medicine, Earth science, and manufacturing.
- **Videoteleconferencing and software-based collaboration applications connecting the facilities**, by R.W. Welty Technologies. Applications include computer, Web-based, and vendor-specific capabilities for synchronous and asynchronous collaboration and geospatial analysis.

1 TeraBurst Networks' optical switching device that enables connection between multiple immersive visualization theaters at OC-48 and OC-192 speeds.

2 SGI Onyx 3400 16-CPU system that drives the Panoram Technologies' display at the Scripps facility.

3 Network infrastructure linking the Scripps and SDSU facilities through the San Diego Supercomputer Center.





1 Graham Kent, left, and Frank Vernon, both of SIO, discuss their data sets. The image behind Kent shows color-coded bathymetry data of Lake Tahoe. The image behind Vernon shows readouts from his network of seismic sensors in Anza, California.

Academic Research Units

California Institute for Telecommunications and Information Technology

The California Institute for Telecommunications and Information Technology (Cal-(IT)^2) is one of four institutes funded through the California Institutes for Science and Innovation (Cal ISI) initiative. Created in late 2000 by Governor Gray Davis, Cal-(IT)^2 seeks to extend the reach of the current information infrastructure throughout the physical world—enabling anywhere/anytime access to the Internet. More than 220 professors, senior researchers, and students from UCSD and UCI and more than fifty industrial partners are collaborating on interdisciplinary projects. See www.calit2.net or contact Stephanie Sides, Cal-(IT)^2 Communications, ssides@ucsd.edu, (858) 534-5131.

Institute of Geophysics and Planetary Physics

The Cecil H. and Ida M. Green branch of the University of California Systemwide Institute of Geophysics and Planetary Physics (IGPP) is located in La Jolla and linked to the Scripps Institution of Oceanography (SIO) through joint faculty appointments, research interests, and shared facilities. Other IGPP branches are at the Los Angeles, Irvine, Santa Cruz, and Riverside campuses and the Los Alamos and Lawrence Livermore National Laboratories. IGPP research in La Jolla includes global seismology, marine seismology and geodesy, geodynamics, high-frequency seismology and arrays, geomagnetism, nonlinear dynamics, sea-floor electromagnetic sounding, geodesy (including satellite geodesy), geophysical fluid dynamics, geophysical inverse methods, acoustical oceanography, marine acoustics, planetary physics, and physics and oceanography. For more information, see igpp.ucsd.edu, ROADNet.ucsd.edu, and siovizcenter.ucsd.edu.

Scripps Institution of Oceanography

Scripps Institution of Oceanography (SIO) at UCSD is one of the oldest, largest, and most important centers for global science research and graduate training in the world. Its mission is to seek, teach, and communicate scientific understanding of the oceans, atmosphere, Earth, and other planets for the benefit of society and the environment. The scientific scope of the institution has grown since its founding in 1903. A century of Scripps science has had an invaluable impact on oceanography, understanding of the Earth, and society. More than 300 research programs are underway today in a wide range of scientific areas. Scripps operates one of the largest U.S. academic fleets with four oceanographic research ships and one research platform. See scripps.ucsd.edu.

San Diego State University

With more than 34,000 students, San Diego State University (SDSU) is the second-largest university campus in California. Last year, SDSU attracted more than $140 million to fund research and administer contracts. SDSU now offers bachelor's degrees in seventy-eight areas, master's degrees in sixty-one, and doctorates in fourteen. For more information, see www.sdsu.edu. The Center for Immersive Telecommunications for Global Exchange is in the College of Sciences' Chemical Sciences Laboratory building and located in the TeraBurst Optical Networking Center. The center was established for use by researchers and teachers in Earth science, mechanical engineering, life sciences, chemistry, geography, public health, performing arts, sports, and other disciplines. Contact Eric Frost, eric.frost@sdsu.edu, (619) 594-5003, or see earthview.sdsu.edu.

San Diego Supercomputer Center

The San Diego Supercomputer Center (SDSC) is an organized research unit of UCSD and the leading-edge site of the National Partnership for Advanced Computational Infrastructure (NPACI). SDSC's mission is to develop and use technology to advance science. SDSC provides leadership nationally and internationally in computing, data management, biosciences, and other areas. As a national laboratory for computational science and engineering, SDSC is funded by the National Science Foundation through NPACI and other federal agencies, the state and University of California, and private organizations. See www.sdsc.edu and www.npaci.edu, or contact David L. Hart, SDSC Communications, (858) 534-8314, dhart@sdsc.edu.

0102-645

Contact Information and Scheduling

The Visualization Center at Scripps is led by Graham Kent, director, and Debi Kilb, science director. To schedule the facility, contact Kitty Haak, khaak@ucsd.edu, (858) 534-0229.

For information on the SDSU Center for Immersive Telecommunications for Global Exchange, contact Eric Frost, eric.frost@sdsu.edu, (619) 594-5003.