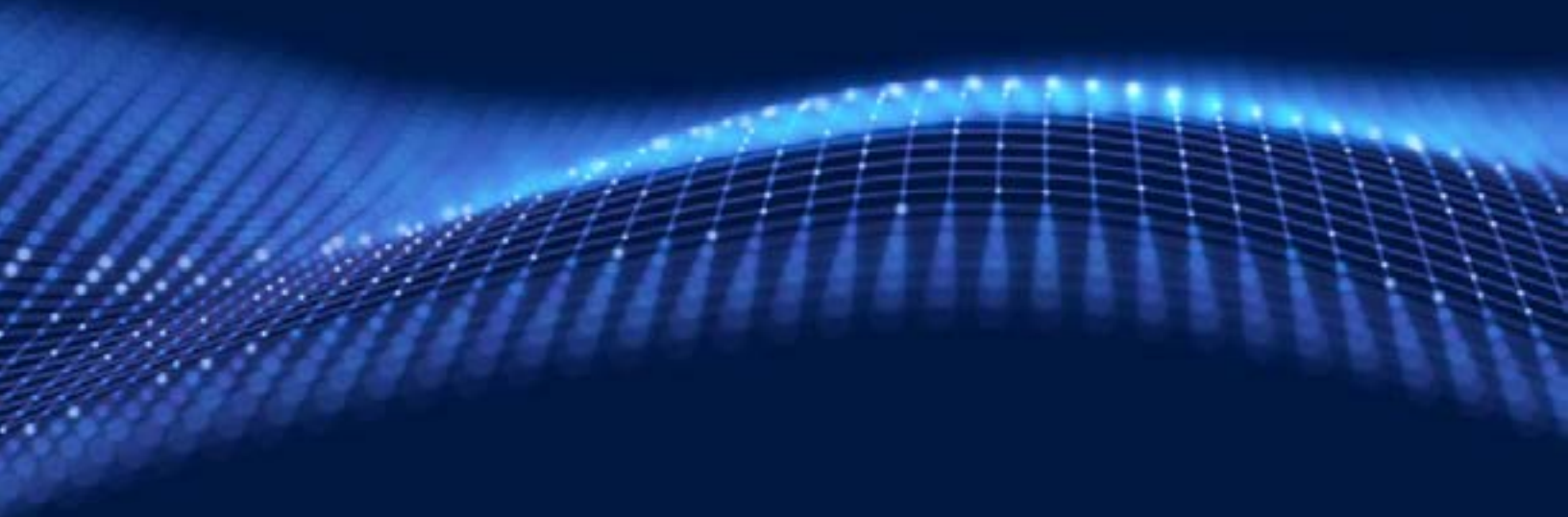


CENIC

COMMUNITY REPORT

JULY 2022–2024



CENIC connects California to the world — advancing education and research statewide by providing a world-class network essential for innovation, collaboration, and economic growth.

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01

PLANNING FOR THE FUTURE

PRESIDENT'S LETTER: INNOVATION,
INCLUSION, AND COMPETITIVENESS

STRATEGIC DIRECTIONS AND ACCOMPLISHMENTS

Innovation, Inclusion, and Competitiveness

All of the achievements you'll read about in this Community Report are natural extensions of both facets of our CENIC mission: to ensure broadband equity for all Californians; and to put advanced network capacities within reach of every community in California — urban, rural, and tribal — to advance their collective goals and to ensure that every community can compete in a rapidly changing global economy.

The most powerful current driver of that rapid change is the dawn of artificial intelligence and machine learning, highlighted in 2023 by the National AI Research Resource Task Force report as needing a national-level infrastructure. Happily, CENIC provides an excellent organizing principle through which an AI/ML-focused cyberinfrastructure can rapidly coalesce in California, the CENIC AI Resource (CENIC AIR). As well as being the most powerful and heavily used section of the National Research Platform (NRP), CENIC AIR also provides a smooth transfer path for network and big-data science between educational member segments, important in a state with an integrated master plan for education.

All this research will reflect back on the network itself of course, meaning that the network must advance to keep up with it — and the CalREN backbone is now operating at 400 Gbps, with the groundwork laid for an even more energy-efficient 800 Gbps backbone in the near future. CENIC also initiated an upgrade program to accept native 400 Gbps handoffs from members at key backbone node sites as well as ongoing network automation and security upgrades — and of course circuit upgrades for all segments as well.

We also stepped outside of our historical focus on community anchor institutions only and were asked to partner with the State of California to help design and deploy the most ambitious middle-mile network in US history. It has been an exciting, vexing, and consuming effort, and with strong support from the CENIC Board of Directors, and from the team at CENIC, we created a bespoke organization, CENIC California Middle Mile Broadband Initiative (dba GoldenStateNet), building on CENIC's mission, talent, and experience.

As my R&E colleagues and I highlighted in a publication entitled "The Minds We Need":

"We cannot know where the next Edison, Carver, Curie, McClintock, Einstein, or Katherine Johnson will come from, and if we are to address the many global existential threats we face — including the decline of natural resources; the collapse of ecosystems and loss of biodiversity; global warming and human-induced climate change; chemical pollution of the Earth system, including the atmosphere and oceans; rising food insecurity; and pandemics and untreatable diseases — we need to enable R&E infrastructure broadly."

In this report, you will read about many CENIC and community initiatives supporting the innovative, inclusive, and competitive environment that we commit ourselves to every day for California and the nation. From all of us at CENIC, it's an honor and inspiration to pursue this mission with you, our associates and partners.



LOUIS FOX
CEO & PRESIDENT

Louis Fox
President & CEO, CENIC

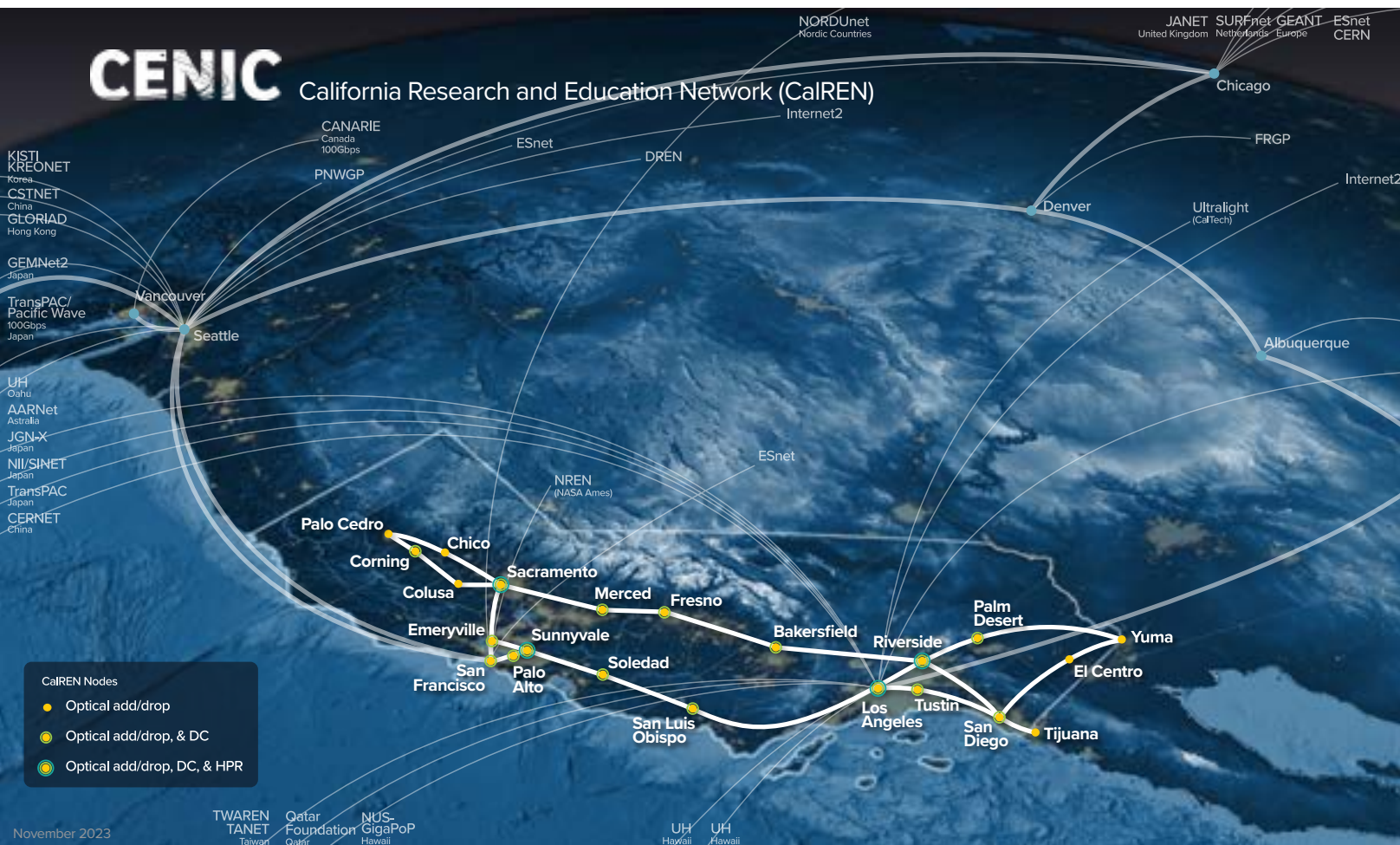
Strategic Directions & Accomplishments

The Vision for CENIC

The organization and staff are driven by a shared vision to build on decades of experience running networks and services for our diverse communities, meeting exponential traffic growth, and enabling future-facing levels of connectivity for sites that lack it partially or entirely. We do this while continuously supporting existing members and sustaining network performance, reliability, and resilience while remaining cost-effective, as we have for 20+ years.

The Crossroads

Owned infrastructure requires space and power, the costs of which continue to increase—likely in larger increments as time goes on—given the consolidation in the telecommunications industry. Security, and in particular, resilience, and reliability (for one of the world's most complex and diverse networks), are tremendous challenges to sustain organizationally, operationally, and economically.



Evolution of the CENIC Network

The plan for the future of CalREN includes the following elements: (1) the network must be cost-effective and manage/flatten the cost curve; (2) it must be reliable and resilient; (3) it must meet the capability and capacity needs of all CENIC segments; and (4) it must be “facilities efficient,” deploying cost-saving innovative technologies that decrease both capital and operating expenses, often in partnership with other networks.

Some of the most recent accomplishments toward the overall vision are described below.

The CalREN Backbone

- Enhanced the reliability and support of the CalREN backbone by migrating the Coastal Route from Cal Poly SLO to Lumen SLO.
- Upgraded aggregation routers at all major hub sites and installed next-generation Cisco NCS1010 optical line systems on the Coastal Route to support 400 Gbps connections, including 400G ZRP pluggables. These upgrades reduce deployment time, cost, equipment, and carbon footprint while increasing bandwidth and laying the foundation for further increases.
- Deployed 40 Gbps hosted connections to Oracle Cloud in Los Angeles and Sunnyvale, reducing complexity and cost for our members to connect directly and providing geographic resilience. We are currently collaborating with Azure and Amazon Web Services on similar connections.
- Deployed SmokePing to improve the visibility of network connectivity performance for key services, including tests on internal and external connections and services, tracking liveliness, and latency. This tool is currently being used to monitor connections to AT&T, Spectrum, K-12 testing, and DNS services, among many other uses.

A Connected California

- Supported the Middle Mile Broadband Initiative during the development, planning, and now implementation phases by designing the network backbone and security architectures.
- Completed Year 3 of the Broadband Infrastructure Grant and secured additional resources for continued program administration for Year 4.
- Supported the transition of Imperial COE as the new aggregator for California's libraries.
- Contributed to the CPUC's Broadband Equity, Access, and Deployment (BEAD) plan.



Cybersecurity

- Enhanced the DDoS Mitigation Service (DMS) detection functionality by deploying AMON-SENSS, an open-source system for scalable, accurate DDoS detection and signature generation in large networks. This is now employed for:
 - All County Offices of Education through 86 K–12 node sites
 - All University of California main campuses
 - Two CSU campuses: San Diego State University and Cal Poly SLO
 - San Diego Community College District
- Completed all critical cybersecurity projects planned for FY 2023–24, with the result that CENIC's cybersecurity program is tracking higher than the industry average across all Center for Internet Security (CIS) Control Groups.

Communications & Engagement

- Completed CENIC Conference successfully in March of 2024, with a record number of attendees and sponsors.
- Produced consistent editorial: regular, targeted content for each of our segments, partners, and stakeholders across all segments with a broad range of topics aligned with our strategic themes.
- Produced workshops & community-driven presentations that showcased CENIC member impacts and the value of CENIC.
- Launched the CENIC Community Technology Affinity Group (C2TAG), a forum for representatives from all segments to share information and expertise and serve their colleagues as trusted advisors.
- Launched the CENIC AI Resource (CENIC AIR), the California portion of the National Research Platform (NRP), voluntarily contributed to and used for research and instruction in AI/ML and data-driven disciplines by a rapidly growing number of CENIC member institutions.
- Created a new broad engagement strategy and framework customized for each segment.

02

GOVERNANCE, MEMBERSHIP, & FINANCIALS

[ABOUT CENIC](#)[BOARD OF DIRECTORS AND C2TAG](#)[MEMBERSHIP](#)[FINANCIAL STATEMENTS](#)

About CENIC

CENIC connects California to the world — advancing education and research statewide by providing a world-class computing network essential for innovation, collaboration, and economic growth.

Established in 1997, this nonprofit organization operates the California Research and Education Network (CalREN), a high-capacity computer network with more than 8,000 miles of optical fiber. The network serves over 20 million users across California, including the vast majority of K–20 students together with educators, researchers, and individuals at other vital public-serving institutions.

CENIC is governed by representatives of the Charter Associates it serves: California Community Colleges, California K–12 schools, California’s public libraries, the California State University, the University of California, and private universities (Caltech, Naval Postgraduate School, Stanford University, and University of Southern California).

CENIC’s resources provide cost-effective, high-bandwidth networking to support our community members—responding to the needs of their faculties, staff, students, and associated research groups—and to facilitate excellence in scientific, education, government, and private sector collaboration and innovation.

In addition, CENIC is closely involved with important efforts to develop and expand networking capacity across the region, the nation, and the world. [Pacific Wave](#), a joint project of CENIC and the Pacific Northwest Gigapop (PNWGP), is a wide-area distributed exchange platform that provides research and education networks throughout the Pacific Rim and the world with access to state-of-the-art peering and exchange services, Science DMZs, and software-defined exchange (SDX) and software-defined networking (SDN) capabilities. The [CENIC AI Resource](#) (CENIC AIR) functions as the California portion of the [National Research Platform](#) (NRP), which integrates its 50+ member institutions’ Science DMZs into a high-capacity national system that enables processing and transfers of large scientific datasets for research and instruction.



Board of Directors and C2TAG

CENIC is governed by its member institutions by means of the Board of Directors. Director seats are held by representatives of the CENIC Charter Associates—the segments of the California research and education community for and by which CENIC was created, as well as significant segments that joined later. Typically, directors serve 3-year terms.

CALIFORNIA COMMUNITY COLLEGES

Jennifer Coleman • Executive Director • CCC Technology Center

John Hetts • Vice Chancellor of Digital Innovation, Data, Evidence, and Analytics • CCC Chancellor's Office

Carmen Lidz • Vice Chancellor & Chief Information Officer • Los Angeles Community College District

CALIFORNIA INSTITUTE OF TECHNOLOGY

Jin Chang • Chief Information Officer • California Institute of Technology

CALIFORNIA K–12 SCHOOL SYSTEM

Terry Loftus • Assistant Superintendent & CIO • San Diego County Office of Education

Kristina Mattis • Digital Equity Broadband Coordinator • California Department of Education

Andrew Schwab • Superintendent • Dos Palos-Oro Loma Joint Unified School District

CALIFORNIA PUBLIC LIBRARIES

Josh Chisom • Manager, Broadband Opportunities Program • California State Library

Nancy Schram • Library Director • Ventura County Library

CALIFORNIA STATE UNIVERSITY

Kendra Ard • Chief Infrastructure Officer • CSU Chancellor's Office

Ed Clark • Chief Information Officer, Information Technology • CSU Chancellor's Office

Samuel Sudhakar • CFO and VP of Finance, Technology and Operations • CSU San Bernardino

STANFORD UNIVERSITY

Sylvie Cosgrove • Executive Director, Communication Services & IT Facilities • Stanford University

UNIVERSITY OF CALIFORNIA

Joe Bengfort • CIO, Senior Vice President, and Associate Vice Chancellor • UC San Francisco

Ramesh Rao • Director of Qualcomm Institute & Professor • UC San Diego

Van Williams • CIO and Vice President for Information Technology Services • UC Office of the President

UNIVERSITY OF SOUTHERN CALIFORNIA

Nick Scheib • Associate Chief Information Officer for Infrastructure • University of Southern California

INDEPENDENT DIRECTORS

Ron Johnson • Vice President & CIO Emeritus, & Professor • University of Washington

Marla Meehl • Network Engineering and Telecommunications Section Head & Front Range GigaPoP (FRGP) Manager • University Corporation for Atmospheric Research (UCAR)

Larry Smarr • Science Advisor • Distinguished Professor Emeritus • University of California, San Diego

CENIC (EX OFFICIO)

Louis Fox (Director) • President & CEO • CENIC

Bill Paik (Ex Officio Director) • Treasurer & CFO • CENIC

CENIC Community Technology Affinity Group



The CENIC Community Technology Affinity Group (C2TAG) is an evolution of the CENIC Technical Advisory Committee (TAC), which was created for members to provide technical guidance to CENIC, helping architect the original iteration of the network. As CENIC grew, the need for technical guidance from our members lessened, and the TAC evolved into a group of IT professionals who met quarterly to receive updates from CENIC engineers and discuss technology trends.

The C2TAG will continue this tradition and provide additional value for CENIC members.

The C2TAG is a forum for representatives from all CENIC member segments to share information and expertise about network technologies, creating a community of like-minded professionals who serve their colleagues as trusted advisors. It also allows members to engage CENIC staff and explore recently deployed network services and their applications among CENIC segments.

By joining the C2TAG, technology professionals are connected to a network of their peers in an informal setting. Through our mailing list, Slack, and various meetings, we share best practices, discuss problems and solutions, and gain valuable insights into industry trends.

Steering committee members include the following:

- Aaron Lusk, San Joaquin Valley Library System
- Alan Worthy, Sacramento Public Library
- Amanda Armitage, Ventura County Library
- Anjali Jauregui, Irvine Valley College
- Dustin Koelzer, Sacramento County Office of Education
- Erik Latrope, University of California, Berkeley
- George Peek, University of California, Santa Cruz
- Jose Sanchez, Cypress Community College
- Joseph Goodwin, University of California, Los Angeles
- Keoni Kamura, South Orange County Community College District
- Luis Wong, Imperial County Office of Education
- Matt Duhon, Black Gold Cooperative Library System
- Matt Hughes, CSU Chancellor's Office
- Mike Ferguson, Chapman University
- Shane Greene, Getty Institute
- Tamara Broman, Sacramento Public Library
- Willie Peng, CSU Fullerton



Charter Associates

These founding and governing research and education members have full access to CENIC's portfolio of networks and services. Charter Associates' representatives comprise the CENIC Board of Directors, setting policy and guiding the organization. [Learn more about CENIC membership levels.](#)

- University of California
- California State University
- California Community Colleges
- California K–12 Schools
- California Public Libraries
- California Institute of Technology
- Stanford University
- University of Southern California
- Naval Postgraduate School



Associates

These independent research, educational, medical, and technology institutions and organizations engage with and connect directly to the broader CENIC community. Associates have direct access to CENIC's portfolio of networks and services.

- City of Hope
- Chan Zuckerberg Biohub
- NASA Ames Research Center
- Montage Health

Sponsored Associates

These are cultural, scientific, or artistic institutions or organizations with a close tie to a Charter Associate that serves as a sponsor. Sponsored associates have direct access to an abbreviated portfolio of CENIC’s networks and services.

- California Academy of Sciences
- Exploratorium
- Jackson Labs
- Lockheed Martin Advanced Technology Center
- National Oceanic and Atmospheric Administration (NOAA)
- SFJAZZ Center
- Wrigley Marine Science Center

Auxiliary Associates

Auxiliary Associates are smaller institutions and organizations that engage with the CENIC community and have direct access to an abbreviated portfolio of networks and services.

- Carnegie Mellon Silicon Valley
- Chapman University
- Getty Center
- Internet Archive
- Los Angeles Philharmonic
- Northeastern University
- Salinas Valley Memorial Healthcare System
- University of San Diego

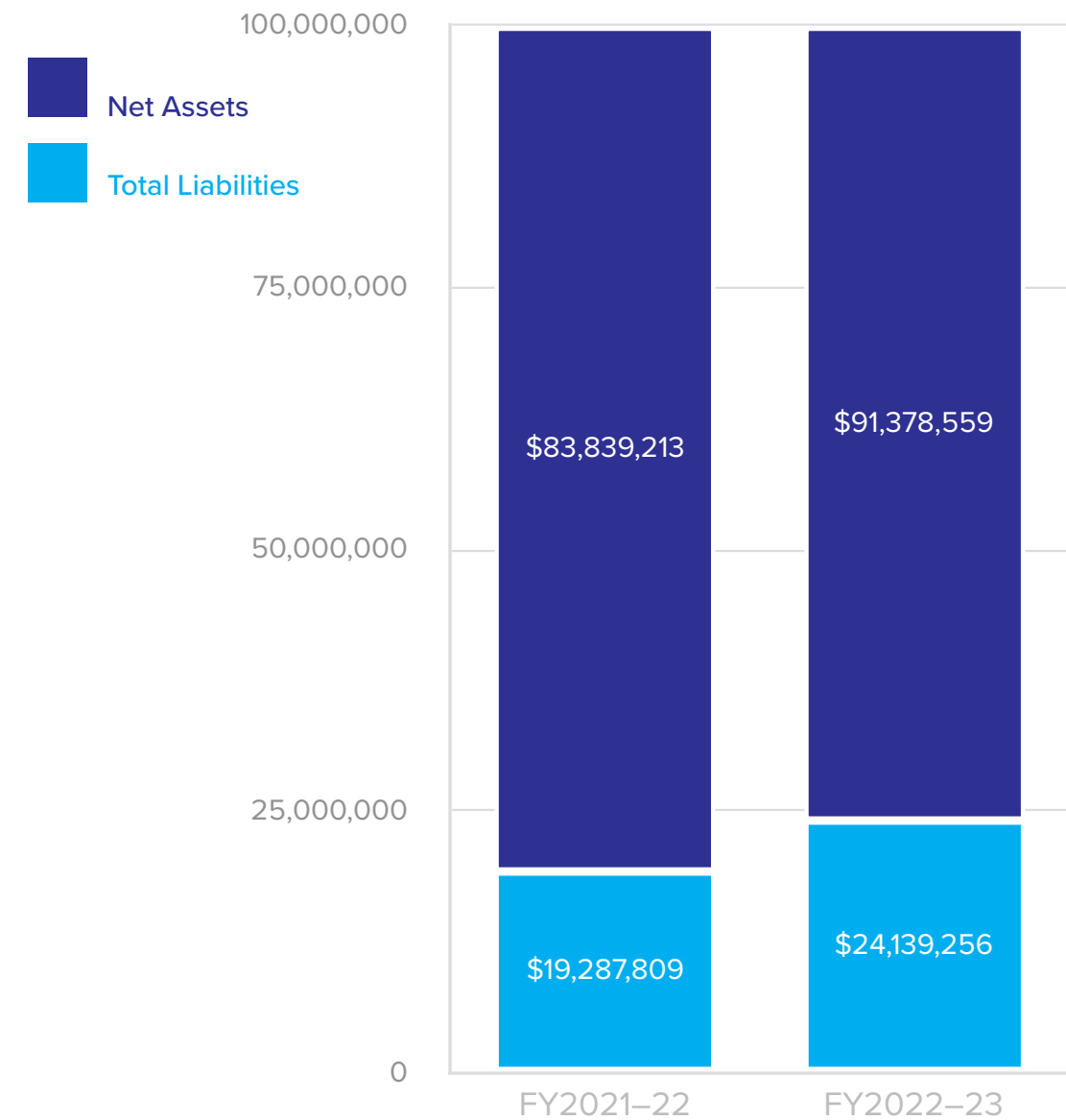
Affiliates

These educational and research institutions and organizations make use of CalREN indirectly through a Charter Associate that serves as an Affiliate’s connection to the network.

- ArtCenter College of Design
- Broad Art Foundation
- Charles Drew University
- Claremont College
- Colburn School
- Dell’Arte School of Physical Theatre
- East Bay Community Law Centers
- Hopkins Marine Station
- International Computer Science Institute
- J. Craig Venter Institute
- John Hopkins University Applied Physics Laboratory
- Lick Observatory
- Loyola Marymount University
- Mount Saint Mary’s University
- National Marine Fisheries Service
- Occidental College
- Pac-12 Enterprises
- Salk Institute for Biological Studies
- Scripps Research
- Stanford Linear Accelerator Center

CENIC Financial Statement 2021–2023

	FY2021–22	FY2022–23
Total Assets	\$103,127,022	\$115,517,815
Total Liabilities	19,287,809	24,139,256
Net Assets	\$83,839,213	\$91,378,559



To contribute resources and connect to CENIC AIR, a campus will need to implement a Science DMZ. A Science DMZ is implemented via the campus's border router, enabling a research-dedicated local area network that allows very large volumes of data traffic to bypass the common campus gateway firewall and primary campus network, thereby preventing the broader campus network from becoming overwhelmed by research traffic.

Thanks to their collaborative user communities, CENIC and the NRP are ready to help such institutions architect, deploy, and support a Science DMZ and offer guidance on funding proposals for NSF CC* awards that can help campuses acquire the necessary on-premises AI compute equipment and campus networking improvements.

CENIC AIR and the NRP provide much more than just infrastructure.

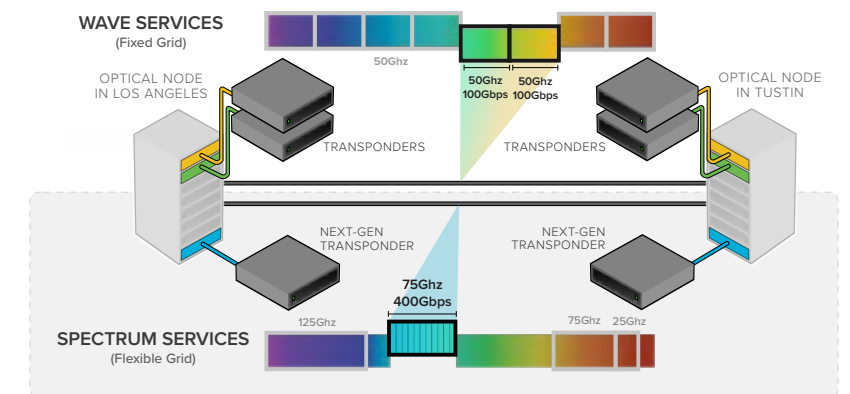
The strong, accomplished research communities behind them offer invaluable mentorship and collaboration, including live networking conferences and events. This collaborative potential is even more powerful in California, where CENIC's K-20 R&E community benefits from the cross-segmental 25-year head start by working together on network technology and its diverse applications.

Balancing CaREN Energy Budgets with Innovative Services

In 2010, CENIC used one full rack of equipment for 10 Gbps of data traffic. Thanks to groundbreaking innovations in power, equipment, and service provision, we can now achieve 400 Gbps or more with only 1/24th as much equipment, and CENIC is pursuing [power-thrifty innovations](#) that promise even greater savings.

Spectrum Services: Optical Services over Middle-Mile Networks

CENIC's [Spectrum Services](#) is an excellent example of one such innovation in Optical Services that allows far more data to be exchanged over a fiber network. It uses only one pair of next-generation transponders to achieve much greater throughput whereas two, three, or more were needed previously to achieve less. It also allows more complete use of the available optical bandwidth of a given pair of fibers.



CENIC Validates Coherent Pluggable Optics over Long Distances

Another innovation that promises to move more data with less equipment are the coherent pluggable optics that enable an optical signal to be terminated directly on a switch or router, without having to pass through a transponder. Such coherent pluggables – both with and without an integrated amplifier – were tested by CENIC in 2022 and 2023. During tests of ZR Plus coherent pluggables, [CENIC turned up a long-distance 300 Gbps optical service](#) over CalREN's production line system between Los Angeles and Sunnyvale and confirmed error-free performance with a comfortable operating margin.

Scale Beyond to the Commercial Cloud

With the CENIC AIR Platform, researchers and educators can also easily access cloud offerings such as Amazon AWS, Google Cloud Platform, and Microsoft Azure, as well as NSF HPC centers, should they need to scale beyond the National Research Platform (NRP) set of resources and have the allocations, funds, or cloud credits to use HPC cloud services.



A list of [Frequently Asked Questions](#) is available at the [CENIC AIR website](#), where you can also find a video introduction from our 2024 Biennial Conference and the latest news on the infrastructure itself and user communities.

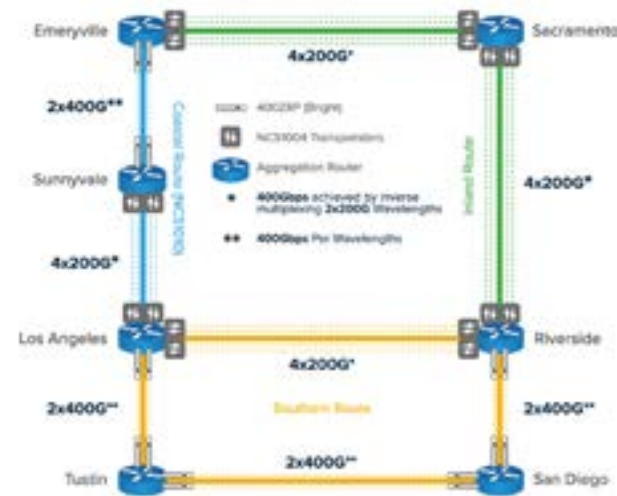


CaREN Backbone Upgrades to Support New Services

400 Gbps and Beyond: How CENIC Provides the Sustainable Growth in Bandwidth Your Institution Needs

In the 2022–23 fiscal year, CENIC upgraded its backbone bandwidth to 400G through a combination of some routes running natively at 400 Gbps and the inverse multiplexing of 200 Gbps links on others.

The next step is the deployment of IP-over-DWDM (IPoDWDM) on a more compact and power-efficient backbone infrastructure. This will take advantage of the previously mentioned coherent pluggable optics to obviate transponders where possible, an upgraded line system, and low-loss fiber that can carry a data signal for longer distances without regeneration and broadens the frequencies of light that can be used and hence the potential throughput.



Furthermore, with these innovations in place at select node sites, an 800 Gbps backbone becomes possible and is CENIC’s vision for the coming years. This vision will double the CaREN backbone capacity with a 45% reduction in total cost of ownership (TCO) and a 40% reduction in capital expenditures. Furthermore, the power, space, and carbon footprint reductions are projected at 54%, 77%, and 55% respectively.

Improvements Supporting Spectrum Services

In support of CENIC’s Spectrum Services, engineers successfully augmented the spectrum termination capabilities in Los Angeles and Sunnyvale by 16 flexible-grid-capable ports, each with the capacity to terminate services between 100G and 800G. This new infrastructure can support colorless, directionless, and contentionless (CDC) technologies, which are prerequisites for enabling software provisioning in the optical layer.

Among the initial users of the enhanced Los Angeles and Sunnyvale infrastructure will be Pacific Wave, a joint National Science Foundation-funded project of CENIC and the Pacific Northwest Gigapop that connects Asia-Pacific and Oceania research and education networks to North American research and education networks and major commercial research cloud services.



Supporting 400 Gbps Customer Handoffs

CENIC began a program of upgrading major node sites to support native 400 Gbps handoffs from member institutions, beginning with the San Diego node site located at the San Diego Supercomputer Center (SDSC) at UC San Diego. Formerly, while the CaREN backbone could support 400 Gbps of data traffic, that traffic could only enter the backbone in 100 Gbps increments. For example, a researcher wishing to send or receive data via 400 Gbps services would have to connect to the CaREN backbone via four 100 Gbps links.

Thanks to the completion of this program, users connected at the San Diego, Sunnyvale, Emeryville, Sacramento, Riverside, Tustin, and Los Angeles node sites can now simply use one 400 Gbps link.

Robust Services and Faster Turn-up Boosted by MPLS

Another important backbone upgrade has been the migration of member services to Multiprotocol Label Switching (MPLS) VPNs via segment routing, an exciting achievement that enables a range of elegant new MPLS-enabled services to be built on top of the newly upgraded infrastructure. Over half of CENIC members have already been migrated to MPLS with all new overlay services being provided this way.

MPLS enables the provision of Layer 2 and Layer 3 VPN overlay services over the CaREN-DC network. As an example of an overlay service, when the Sierra County Office of Education wanted to consolidate its services with those of its Loyalton High School location behind a single firewall, CENIC was able to offer an E-LINE, connecting those two sites over existing circuits and providing solid service and resilience.

The end results of migration to MPLS services for CENIC and our members are automatic routing around networking issues and thus better network resilience, improved scalability, and faster service turn-ups.

The implementation of overlay services via MPLS is also important where geography makes it challenging to travel between sites for support or to obtain circuits. It can also simplify the configuration of related sites while enhancing throughput and resiliency.

CalREN Network Management Tools Improve Services and Security

CENIC's Integrated, Multi-Tool Approach to Network Configuration Management

CENIC's California Research and Education Network (CalREN) is not only one of the most extensive and complex regional networks in North America but also facilitates collaborative research and education in the largest public education and library systems in the world and some of the most accomplished private, cultural, and scientific institutions.

Hence, if California's K-20 research and education community is to retain its leadership position, CalREN must not only remain in operation 24/7/365 no matter what but also grow in bandwidth and services to exceed that community's accomplishments. With a well-designed, well-integrated NCM system in place, achieving this becomes much more scalable, efficient, and cost-effective.



Targeted Network Impact Announcements for CENIC Members

The CENIC Network Operations Center implemented an eagerly anticipated enhancement to customer service: targeted network announcements, whereby authorized contacts at connected sites throughout California receive tailored email announcements should a planned or unplanned outage specifically impact their service.



The keystone to this was the creation of an exhaustive relational database containing full, standardized network circuit, equipment, and site contact information for the many thousands of complex components that comprise the CalREN backbone and all customer connections to it, from end to end.

Thanks to this database and CENIC's custom-created software, called Cobber, which maintains up-to-date awareness of the device components in the network, CENIC engineers can now perform rapid automated calculation of impacted sites in the case of unplanned outages and planned maintenance events.

Minding our MANRS: Ensuring Global Internet Routing Security



MANRS

Today's global Internet supports not only the foundations of society but also the activities of those who would undermine it, be it for illegal profit, to sow social or political disorder, or simply as the result of an accident. Often these activities revolve around surreptitiously altering network routing.

To ensure trustworthy routing, a consortium of ISPs and other commercial and nonprofit entities whose networks comprise the Internet has created the Mutually Agreed Norms for Routing Security (MANRS) initiative to address the most common ways in which network traffic can be incorrectly routed. By joining this initiative, CENIC has committed to collaborating with other participants, and our policies in support of this initiative include the following:

- A site connected to CalREN must advertise its own IP addresses to be globally reachable. As an example of prefix filtering, CalREN permits these sites to advertise only their own IP addresses.
- Anti-spoofing policies ensure that all data packets from CENIC's downstream sites are sourced with the correct IP addresses, preventing them from impersonating other sites or carrying out DDoS attacks.
- Organizational participation in MANRS includes ensuring that our own contact information is up-to-date and working to ensure the accuracy of the global address databases that underpin the Internet.



Supporting Global Research and Education Networking

RouteViews on Pacific Wave Improves Network Operations for International Research and Education

The resolution of routing-related issues in international research and education networks (RENs) has been augmented with the availability of a RouteViews instance on the Los Angeles node of the Pacific Wave international distributed peering exchange for research and education networks in the Pacific Rim. Pacific Wave's RouteViews collector is an addition to the set of global RouteViews collectors already publicly available to network operators. It is physically deployed in Los Angeles and is designed so that any Pacific Wave participants connected at Los Angeles, Sunnyvale, or Seattle can choose to peer with it. Network operators anywhere in the world can then login to this collector to view routing information specific to these RENs.

With this access, network operations engineers worldwide can diagnose routing and domain reachability issues related to Pacific Wave's REN participants without having to coordinate with multiple Network Operations Centers.

WRN Western Regional Network



Supercomputing's SCinet

CENIC, the Pacific Northwest GigaPop (PNWGP), and Pacific Wave have continued to support the Supercomputing conference with network infrastructure and expertise.

In 2021, CENIC and key partners were able to facilitate 600 Gbps of capacity for demonstrations between PRP member institutions and the show floor in St. Louis. Scientific, research networking, and private sector partners who led these demonstrations included Caltech, UC San Diego, the Global Network Advancement Group (GNA-G), Internet2, ESnet, Ciena, Arista, StarLight, SURFnet, KISTI, and Pacific Wave.

After SC21, a decision was made to retain the network infrastructure developed in support of dynamic, multi-domain path provisioning developed for the event. With the network left in place, further improvements could be implemented which, when added to the improvements made by CENIC to CalREN and its interconnectivity with its partner networks, transformed Supercomputing's network infrastructure into an even more powerful catalyst for data-intensive research.



In support of SC22's planned demonstrations, CENIC and Pacific Wave facilitated a total of 900 Gbps from Los Angeles and Seattle to the venue in Dallas.



Supporting OFCnet



Connection is the Catalyst

In March 2023, academic, research, and corporate leaders in the optical communications and networking industries came together at the OFCnet Conference and Exhibition at the San Diego Convention Center to meet and greet, teach and learn, make connections and move the industry forward.

Starting in 2021, CENIC announced that its infrastructure would support optical demonstrations at the conference requiring connectivity beyond the show floor, and that this infrastructure would be left in place until 2027 to support future OFC conferences. This is achieved via a fiber connection from the San Diego Convention Center to the CENIC's

California Research and Education Network (CalREN) optical backbone node at San Diego, which provides up to 34 Terabits per second of capacity to the OFC exhibition floor. This bandwidth was used in demonstrations by members of the CENIC community.

Two New 100 Gbps Connections to CENIC and Pacific Wave for ESnet



In May 2023, CENIC announced the turn-up of two 100 Gbps connections in Los Angeles: one between the Energy Sciences Network (ESnet) and CENIC and the other between ESnet and the Pacific Wave international distributed peering facility for research and education (R&E) networks. These two new connections now function alongside ESnet's existing 100 Gbps connections to Pacific Wave in Sunnyvale, CA and Seattle, WA.

With these new connections, researchers at ESnet enjoy better performance and latency when collaborating with researchers both worldwide and within California—particularly with facilities in the southern part of the state, such as Caltech, the San Diego Supercomputer Center, and UCLA.

Harvey Newman, Professor of Physics at Caltech drew attention to the importance of the new connections for international big-data research as well, saying that the new peering and 100 Gbps connections between CENIC and ESnet in Los Angeles represent a major step forward for US and international partners who are working to meet the needs of the Large Hadron Collider and other data-intensive science programs.



Examining Innovative Ideas for Middle-Mile Networks

Product Testing and Validation Testbeds as a Service over Middle-Mile Infrastructure

Members of research and education networking communities around the world know of CENIC's long-time support for the annual Supercomputing conference network SCinet and the annual OFC conference's OFCnet, both purpose-built research and education networks that support the cutting-edge tests and demonstrations that take place during premiere global networking events.

However, new middle-mile fiber infrastructures being built across the US take solution and product testing and validation to a whole new level. For vendors, service providers, and research teams, this new fiber infrastructure can play the role of an elastic testbed that matches real-world production networks.

With California and other states initiating significant fiber-based network infrastructure projects, these new middle-mile fiber infrastructures offer the potential to generate revenue for these networks and spur innovation. This even applies to small research teams, who may have thought themselves unable to access a real-world fiber-based testbed for their product development. Through a bundled combination of short, medium, and long-term fiber leases, high-capacity services at Layers 1 through 3, and colocation, validation testbeds can give fiber-based middle-mile networks a whole new way to provide value to academic or commercial network researchers and service providers.



Connecting Last-Mile Customers at 100 Gbps Leveraging High-Launch-Power Coherent Pluggable Optics

On an ongoing basis, service providers—including middle-mile providers – strive to identify cost-effective, environment-friendly solutions to connect last-mile customers at data rates between 1 and 100 Gbps (as well as for rates of hundreds of Mbps).

However, a new set of solutions is emerging for delivering 100 Gbps connectivity to last-mile providers in a more efficient manner. These solutions leverage high-launch-power (i.e., high-transmit-power) coherent pluggable optics that can be installed in switches, routers, and small factor space- and power-optimized optical shelves. The latest generation of high-launch-power coherent pluggable optics compliant with the OpenZR+ Multi-Source Agreement (MSA) can deliver 100 Gbps connectivity over an unamplified metro segment up to 80 km—and beyond with low-loss metro fiber.



Creating a Bespoke Organization in Support of the California Middle-Mile Broadband Initiative

In the spring of 2021, the California Administration and Legislature unveiled an ambitious plan to invest unprecedented levels of federal and state resources culminating in the passage of Governor Newsom’s “Broadband for All” initiative (SB 156) by the State Legislature. This was a historic accomplishment and infused the largest amount of resources—\$6 billion—into broadband in California.

Recognizing CENIC’s success in bringing connectivity to schools, libraries, rural agricultural resources sites, healthcare institutions, and Tribes, the Legislature integrated CENIC into the final bill as the third-party administrator to partner with the state and create the visionary aspiration of a statewide open-access middle-mile network.

As the initiative transitioned to implementation, it was clear that success would depend on quickly finding and enlisting the best minds to meet the complex technical, geographic, and collaborative challenges involved in creating a sustainable statewide broadband middle-mile infrastructure for all Californians.

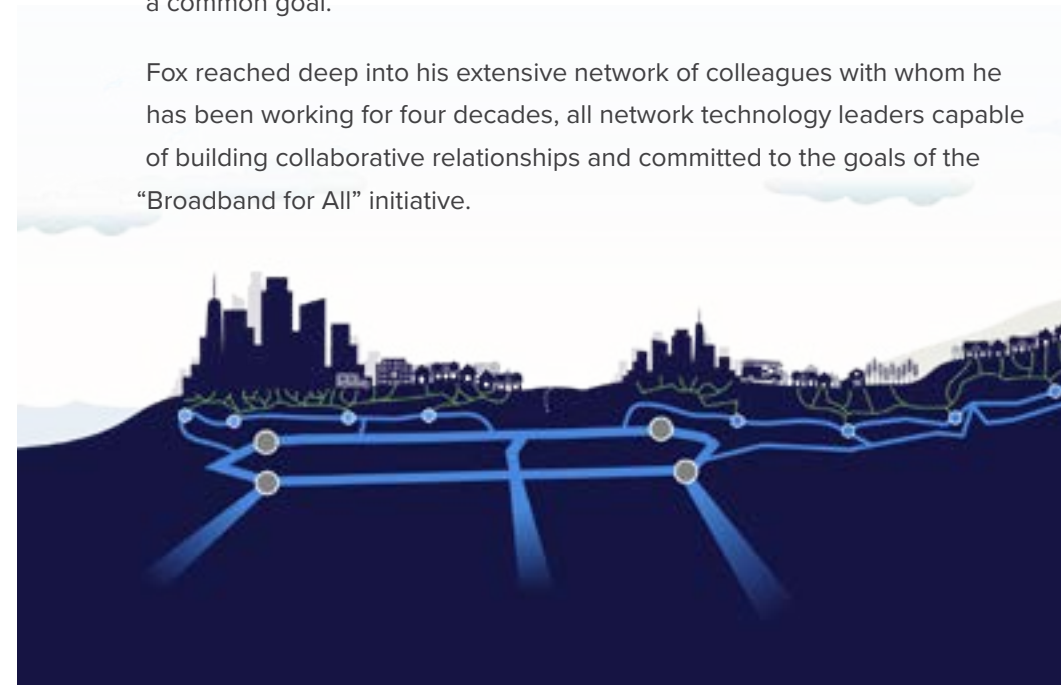
“It was clear we needed to launch a new entity that could serve this important initiative on behalf of California,” said CENIC President and CEO Louis Fox. “And that’s when GoldenStateNet, the CENIC California Middle Mile Broadband Initiative, LLC, was born—as a solely owned subsidiary of CENIC that could attract world-class technology professionals adept at working with a diverse array of partners and stakeholders working towards a common goal.”

Fox reached deep into his extensive network of colleagues with whom he has been working for four decades, all network technology leaders capable of building collaborative relationships and committed to the goals of the “Broadband for All” initiative.



CENIC has developed a series of concise, easy-to-read PDFs that can get any interested party up to speed on the hottest topic in networking today: Middle-Mile Networks. At CENIC’s website, you can find [links to each of the individual one-sheets](#) listed below, or you can [download the entire set](#).

- Middle Mile Networks: What and Why
- Build or Buy? Diverse Solutions
- Service Product Offerings on a Middle-Mile Network
- Optical Services over Middle-Mile Networks
- Resilient Communities Need Resilient Networks
- Transit, Peering, and Exchange Points
- Middle-Mile Network Access for California’s Tribes



Promoting Equity and Access

Old Problems Need New Solutions: Digital Equity in California

“To solve problems that have never been solved, we must do things that have never been done.”

This was the message shared by California leaders in economic development, higher education, policy, and infrastructure during the “Digital Equity in California” panel at CENIC’s 2022 conference. Panelists described creative new approaches to funding, infrastructure, partnering, and community engagement used by their organizations to expand broadband access to historically un- and underserved communities in California. These approaches included:

- The issuing of bonds by Golden State Connect to finance a new open-access municipal model for broadband deployment in which service providers can all use the same publicly owned network to provide services to homes and businesses.
- Being closer to Asia than anywhere else in the continental US, California’s north coast is a perfect location for a subsea cable landing station. This together with inexpensive alternative power for large data centers persuaded Google, Facebook, and Trans Pacific Networks to offer support for improved local broadband.
- CETF’s “Get Connected” program offers a call center to help people apply for reduced-cost internet. People obtaining new broadband access often need an introduction to make the most of their new connection, so the CETF team works with libraries and organizations already known and trusted in these communities to provide training to these users.
- Fixed wireless can fill last-mile gaps and act as a pseudo-fiber replacement. It is also typically much faster to deploy than fiber and reaches areas that fiber can’t or won’t.



The Minds We Need: Toward a National Strategy for Cyberinfrastructure

At the CENIC biennial conference in 2022, a panel of leaders in innovation and national networking, with extensive experience in engaging underrepresented communities in STEM, convened to discuss what happens when millions of vitally needed imaginations and perspectives have no access to the cyberinfrastructure that makes global collaboration possible – and how to extend that cyberinfrastructure to include them.

The panelists highlighted strong cases for the powerful roles played by institutions serving historically underrepresented populations and highlighted platforms and programs that increased the participation of these institutions, including the PRP and Internet2’s Minority Serving Cyberinfrastructure Consortium (MS-CC). Another important facet highlighted by the panel was the importance of a need-driven cyberinfrastructure, as the needs experienced by historically underrepresented communities are often different from those experienced by the majority, with differing perspectives driving research in critical directions.



Tribal Broadband Connectivity: Obstacles, Opportunities, and Optimism

Some of the broadband needs of Tribal communities in southern California have been addressed by a connection between the Tribal Digital Village Network (TDVNet) and CENIC backbone, which provides TDVNet with extremely cost-effective backhaul. However, persistent obstacles to dedicated Tribal broadband infrastructure remain.

At CENIC’s 2022 conference, Tribal telecommunications experts Matthew “Speygee” Douglas, Linnea Jackson, and Matt Rantanen shed light on a few of these obstacles—what they are and how they complicate Tribal broadband deployments in California—and how progress has been made in the face of them.

The reacquisition of 10,000 acres of ancestral land for California’s Hoopa Valley Tribe at the end of 2023 may hint at the future of broadband in these areas, since the FCC’s Tribal Priority Window for the 2.5 GHz licenses (Education Broadcast Spectrum or EBS) only applied to their existing lands. Now that the Tribe has reclaimed these 10,000+ acres, wireless may become even more critical to serving needs in an area this large.

CHALLENGE	WAY FORWARD
Construction on Tribal land involves multiple levels of complex permitting.	Wireless extensions require less construction to install a tower or towers compared to fiber-optic cable. Environmental sensitivity can sometimes be used to promote new infrastructure installations, joint builds, or sharing of space on existing installations used for research, disaster response, or the National Park Service.
Wireless spectrum licenses are not granular enough to complete last-mile/yard connections on Tribal lands.	Wireless spectrum “carve-outs” over Tribal land of active licenses held by large providers can play a crucial role in last-mile/yard solutions for these Tribes.
Obtaining funds for development on Tribal lands comes with unique issues due to their nature as sovereign land.	Full-strength wireless spectrum licenses count as bankable assets that Tribes can use to obtain loans in addition to using the licenses for last-mile and last-yard circuits where wireless solutions are ideal.
Most telecom equipment is not performance-tested in the types of environments where many Tribal communities reside.	Tribes can leverage wireless spectrum licenses to work out trade deals with incumbent providers for spectrum frequencies that may offer better signal penetration and distribution in areas with trees and other obstacles.
Timelines associated with common sources of funding are often either unrealistic or unpredictable.	The establishment of 3-day Tribal Broadband Bootcamps during which Tribal experts on broadband network design, planning, and implementation can meet to pool experience and expertise has gone a long way to enabling Tribes to manage these timelines.

The Broadband Infrastructure Grant (BIG) Identifies and Connects Schools to CaIREN

In 2019, the Broadband Infrastructure Grant (BIG) program was funded to provide fiber broadband connectivity to California’s most poorly connected schools and promote digital learning opportunities. As BIG enters Year 4, CENIC is proud to have successfully connected all 44 recipients from Years 1, 2, and 3. The program has provided 1 Gbps connectivity to approximately 14,000 students, teachers, and staff in 13 different counties.



In Year 4, the BIG program hopes to expand to several more counties across California and support several thousand more students, teachers, and staff. To learn more, any K–12 public school that lacks a 1 Gbps fiber connection and would benefit from this program can fill out the [application form](#).

04

THE RIGHT CONNECTION: 2022 AND 2024 CENIC BIENNIAL CONFERENCES

CONNECTING SPEAKERS, PARTICIPANTS, AND COMMUNITIES

INNOVATIONS IN NETWORKING AWARDS



Connecting Speakers, Participants, & Communities

For over two decades, CENIC's Biennial Conference "The Right Connection" has been the premier research and educational networking event on the West Coast and one of the top events in the world. The Conference attracts attendees and presenters from public and private research universities; public libraries; scientific, cultural, and performing arts institutions; private sector technology businesses; public policy and government; healthcare; and R&E partners from across the country and around the world.

Crafting a useful and engaging conference program for such an accomplished audience is done by the CENIC Biennial Conference Program Committee, composed of representatives from all CENIC member segments as well as all disciplines and levels of technology expertise. Together, they suggest, recruit, and choose presenters, topics, panels, and demonstrations that make the program broadly useful, future-facing, and grounded in experience while ensuring that the needs of their communities are well represented.



AI Research & Education Infrastructure Takes Center Stage at CENIC's 2024 Biennial Conference

Artificial Intelligence for research, education, and networking itself and the cyberinfrastructure needed to make it effective and equitable were addressed throughout CENIC's 2024 biennial conference "[The Right Connection](#)" that was held in March 2024 in Monterey, CA. Attendees also enjoyed presentations and panel discussions on next-generation network technology, the international networking ecosystem, digital equity, and funding, and of course select programming was streamed live for remote viewers and can be found on the [CENIC News YouTube channel](#). Highlights included the following:

A Community of Innovation: Research and Education Networks in North America

In this session, leaders of North American NRENs discussed their partnership with each other and within the global fabric, and reflected on innovations, new directions, common (and unique) challenges, and ways that those participating in the CENIC community (and our partners) can participate in this regional and global R&E fabric, if they are not already so engaged.

- Moisés Torres Martínez, Director General, University Corporation for Internet Development (CUDI)
- Kathryn Anthonisen, President and CEO, CANARIE
- Howard Pfeffer, President and CEO, Internet2
- Inder Monga, Director of the Scientific Networking Division, Lawrence Berkeley National Laboratory, and Executive Director, Energy Sciences Network (ESnet)

Advances in the CENIC AI Resource

The National Research Platform (NRP) currently enables user access to over 1,300 GPUs, 20,000 CPU cores, and 32 FPGAs plus over 10,000 Terabytes of 40-to-100Gbps-connected high-speed storage, thus creating a national-scale AI and cyberinfrastructure resource. The California portion of the NRP, the CENIC AI Resource (CENIC AIR), is available to all CENIC member organizations who choose to participate, enabling their faculty and students to launch containerized software applications from their home campus onto CENIC AIR for both research and education purposes.

- Larry Smarr, Professor Emeritus, UC San Diego
- Christopher Bruton, CENIC

Connecting California: From Community Perspectives to Funded Projects

California, the world's fifth biggest economy, is 30 months into the state's \$6.8B digital equity initiative, including the \$3.8B middle-mile component and \$2B last-mile grants, which significantly exceeded the available funding with 483 proposals totaling \$4.6B. Community and broadband leaders from California addressed the funding environment and its role in creating the state's middle-mile and last-mile networks.

- Kevin G. Harbour, Sr., President, BizFed Institute
- Rachelle Chong, Consultant, Government Relations, GoldenStateNet
- Sylvie Wong Cosgrove, Executive Director for IT Infrastructure, Stanford University
- Barbara Hayes, Chief Economic Development Officer, Rural County Representatives of California
- Erik Hunsinger, President and COO, GoldenStateNet
- Tony Naughtin, Senior Advisor, GoldenStateNet
- Matthew Rantanen, Director of Technology, Southern California Tribal Chairmen's Association
- Connie Stewart, Executive Director of Initiatives, CalPoly Humboldt, and Chief Policy Advisor, California Center for Rural Policy

Face-to-Face Once Again: CENIC's 2022 Biennial Conference

As the world emerged from the COVID-19 pandemic and began to embrace the return of in-person events, CENIC was delighted to welcome attendees, sponsors, and presenters back to our [September 2022 Biennial Conference](#) in Monterey – the first in-person conference since 2019 and a resounding success. If you couldn't make it to Monterey, the 2022 presentations are still available at the [CENIC News YouTube channel](#). Highlights included the following:

[The Minds We Need: Toward a national strategy for cyberinfrastructure](#)

- Richard Aló, PhD: Dean of the College of Science and Technology, Florida Agricultural and Mechanical University
- Ilkay Altıntaş: Chief Data Science Officer, San Diego Supercomputer Center
- Ana Hunsinger: Vice President, Community Engagement, Internet2
- Larry Smarr: Professor Emeritus, UC San Diego

[CENIC's Spectrum as a Service and MPLS Services](#)

- Fady Bekhit: Senior Core Engineer, CENIC
- Sana Bellamine: Director of Regional and International Infrastructure, CENIC
- Dennis Cagampan: Core Engineering Manager, CENIC

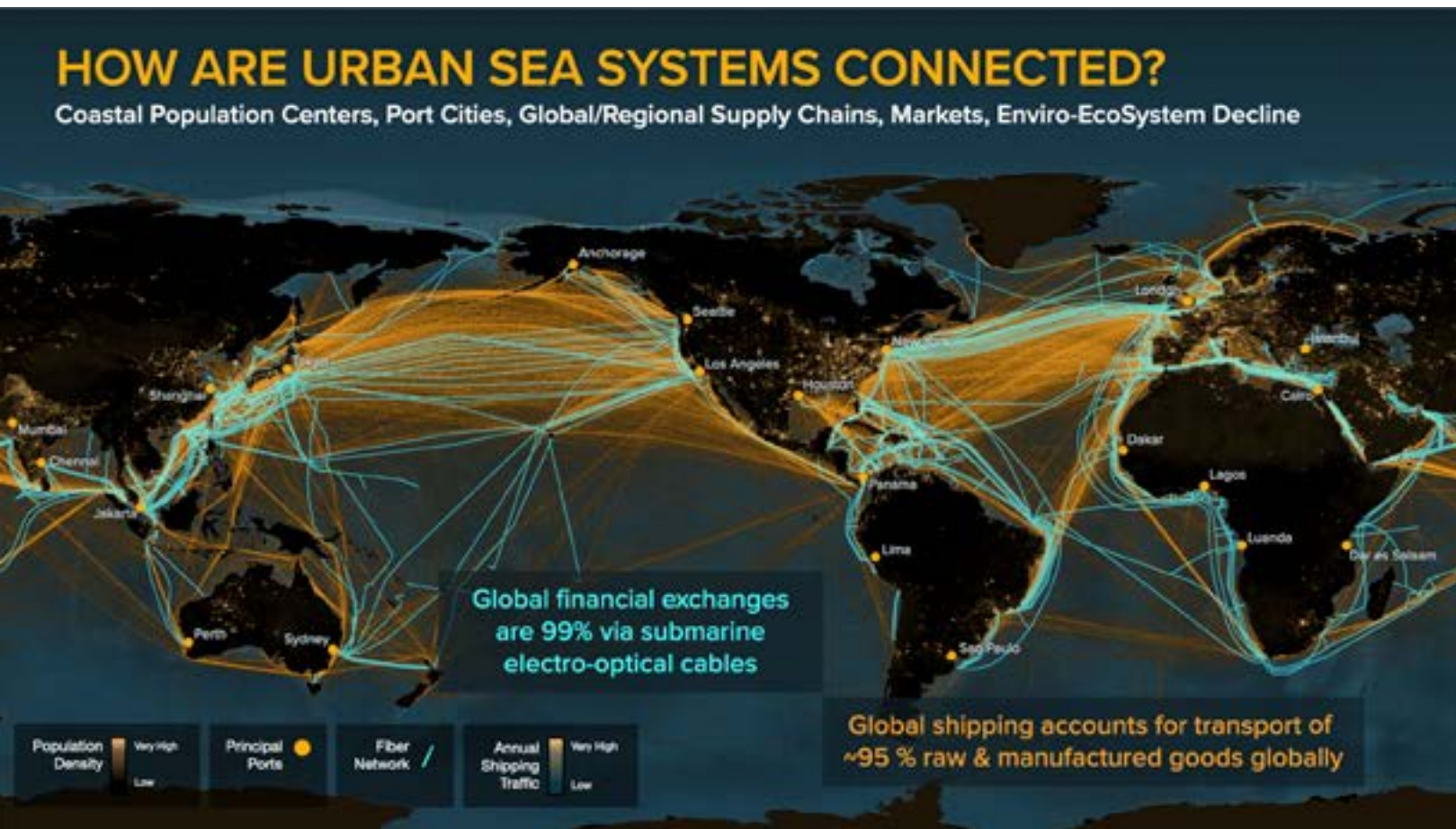
[Tribal Partners in Building Broadband Infrastructure](#)

- Matthew Douglas: Broadband Manager, Public Utilities District, Hoopa Valley Tribe
- Linnea Jackson: General Manager, Hoopa Valley Public Utilities District
- Matt Rantanen: Senior Advisor, Tribal Broadband, GoldenStateNet

Ocean Expert John Delaney on Urban Sea Stewardship

Many large port-related communities across our planet play vital roles in regional and global supply-chain economies. However, these urbanized coastal centers suffer severe environmental and ecological decline and are vulnerable to natural and manufactured disasters. Rising sea levels and intense storms may soon render low-lying, near-shore urban enclaves unlivable for lower-income communities.

In this session, renowned marine researcher and Professor Emeritus of Oceanography at the University of Washington John Delaney addressed how next-generation stewardship of heavily populated shorelines requires bold strategies and cutting-edge technology to ensure constant, up-to-date assessment of rapidly changing conditions triggered by the combined impacts of urbanization and climate change.



2024 Innovations in Networking Award Winners

The [CENIC Innovations in Networking Awards](#) are presented during our biennial conference to highlight the exemplary innovations that leverage ultra-high-bandwidth networking, particularly where those innovations have the potential to transform the ways in which instruction and research are conducted or where they promote the deployment of broadband in underserved areas.

During our 2024 conference, eight awards were made in the following areas:

- Broadband Applications:** The [Tribal Broadband Bootcamp](#) in recognition of its success in fostering a network of Indigenous people working across Tribal lands to build broadband networks and develop best practices ensuring communities have high-quality Internet access.
- Experimental Applications:** The [Zhan Group of Observational Seismology](#), led by California Institute of Technology Professor of Geophysics Zhongwen Zhan, for its work demonstrating how fiber-optic cables can be used as vast and cost-effective seismic sensor nets.
- Research Applications:** The [High Performance Computing Program](#) (HPCP) at CSU San Bernardino in recognition of its work supporting faculty who wish to avail themselves of all the National Research Platform (NRP) has to offer.
- Public Safety:** A collaboration between UC San Diego's [ALERTCalifornia](#), the [California Department of Forestry and Fire Protection](#) (CAL FIRE) and industry partner [DigitalPath](#), a public-private partnership that has been essential for building, training, and launching a new AI tool to improve wildfire detection and response.
- Network-Enabled Cloud Applications:** The [San Diego Community College District](#) (SDCCD)'s project to move their Enterprise Resource Planning (ERP) to the Oracle Cloud Infrastructure (OCI), thus ensuring a more efficient, scalable, and secure management of resources.
- Equitable Access to Cyberinfrastructure:** The Technology Infrastructure for Data Exploration (TIDE) Project, a partnership between [San Diego State University](#) and the [San Diego Supercomputer Center](#) (SDSC), extends the [CENIC AI Resource](#) (CENIC AIR), the California portion of the [National Research Platform](#), beyond SDSU to three additional CSU campuses: CSU San Bernardino, Cal Poly Humboldt, and CSU Stanislaus.
- Network Partner:** The [Pacific Northwest Gigapop](#) (PNWGP) in recognition of its outstanding achievements in high-bandwidth networking that have enriched and expanded the global advanced research and education (R&E) network ecosystem.
- Corporate Partner:** [Juniper Networks](#) in recognition of its product innovations, responsiveness, and the extraordinary value and cost savings Juniper has facilitated for CENIC, Pacific Wave, and their communities.



In addition to these eight awards, the **2024 Christine Haska Distinguished Service Award** was presented to [UC San Diego's](#) İlkay Altıntaş. Chief Data Science Officer of the [San Diego Supercomputer Center](#) (SDSC) and Founding Fellow of the [Halicioğlu Data Science Institute](#), Altıntaş was recognized for her visionary and foundational contributions to the field of data science, an indispensable pillar in a multitude of research areas today and more so in the future.

05

TECHNICAL OPERATIONS SERVICES & IMPROVEMENTS

CONTINUOUS IMPROVEMENTS TO LAYERS 1, 2, AND 3

CENIC'S NETWORK OPERATIONS CENTER

CIRCUIT ADDITIONS AND UPGRADES

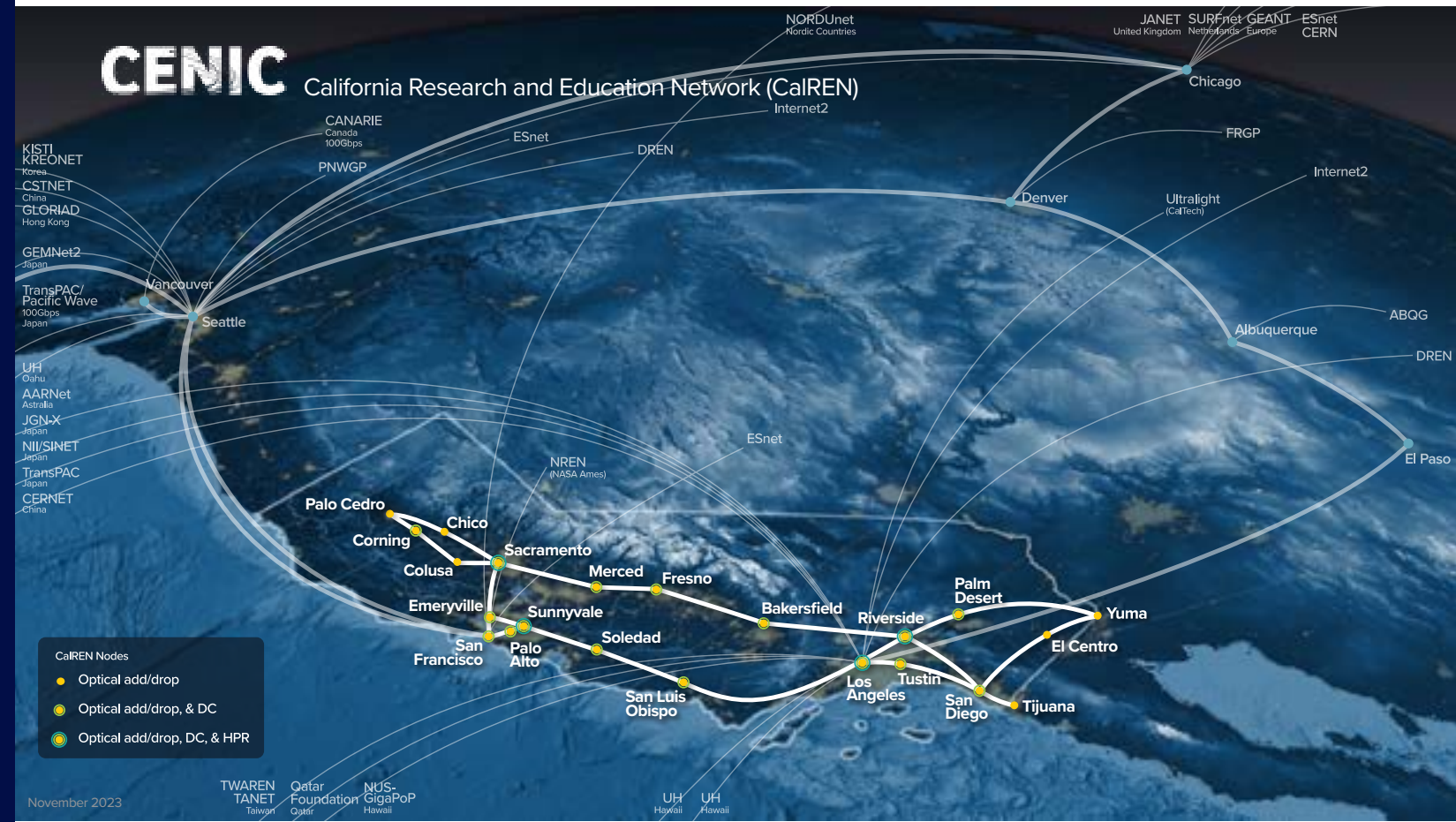
Continuous Improvements to Layers 1–3

CENIC's California Research and Education Network (CalREN) is a multi-tiered, advanced network-services fabric serving the majority of research and education institutions in the state. The CalREN backbone includes roughly 8,000 miles of CENIC-owned and managed fiber, last-mile fiber, and hundreds of optical components.

CENIC engineers perform regular upgrades at the three network layers outlined below. As of July 2021, recent network upgrades include the following:

LAYER 1: OPTICAL BACKBONE

- Upgraded the 400G backbone successfully along all paths with 16 Cisco NCS1004 transponders
- Deployed next-generation Cisco NCS1010 optical line systems on the Coastal Route to support 400 Gbps connections, including 400G ZRP pluggables
- Completed a proof-of-concept for 400G IP-over-DWDM between Emeryville and Sunnyvale using coherent pluggables on next-generation optical line system, paving the way for future 800 Gbps backbone capabilities
- Standardized node site equipment with next-generation optical technology, enhancing capability and bandwidth, and achieving significant power savings
- Improved the reliability and support of the CalREN backbone by migrating the Coastal Route from Cal Poly SLO to Lumen SLO





LAYER 2: DC/HPR CUSTOMER ACCESS, COMMODITY PEERING TRANSPORT, AND PACIFIC WAVE EXCHANGE

- Deployed a RouteViews collector at the Pacific Wave Los Angeles peering location, allowing network operators globally to view routing information and diagnose issues with networks peering
- Established 100 Gbps connections in Los Angeles between the Energy Sciences Network (ESnet) and CENIC, and between ESnet and Pacific Wave
- Completed the installation of Hosted Oracle connections, providing 2x10G connections at both Los Angeles and San Jose for our members to use with Oracle FastConnect services to Oracle Cloud
- Completed the installation of Hosted AWS connections, offering 1x10G connections at both Los Angeles and San Jose for our members to use with AWS DirectConnect services to AWS Cloud

LAYER 3: ROUTED NETWORKS (DC/HPR BACKBONES)

- Upgraded all major CalREN hub sites—Los Angeles, Sunnyvale, Emeryville, Triangle Court, Riverside, Tustin, and San Diego—to support native 400G connections
- Developed Hybrid ScienceDMZ routing options for members to connect to CENIC AIR, offering greater flexibility and removing the need for a border router in their ScienceDMZ configurations
- Enhanced network automation and programmability across all layers with Network Configuration Management, ensuring quicker delivery and secure connections through automated network device configurations, standardized management, and configuration audits for better security and compliance
- Introduced explicit-path options for L2VPNs, allowing members to manually define their L2VPN connections across CalREN

CENIC’s Network Operations Center

Once an institution is connected to CalREN, CENIC’s Network Operations Center (NOC) is the first point of contact for any issues or questions that arise regarding all services provided over the California Research and Education Network (CalREN) and is monitored 24 hours a day, 7 days a week, 365 days a year.

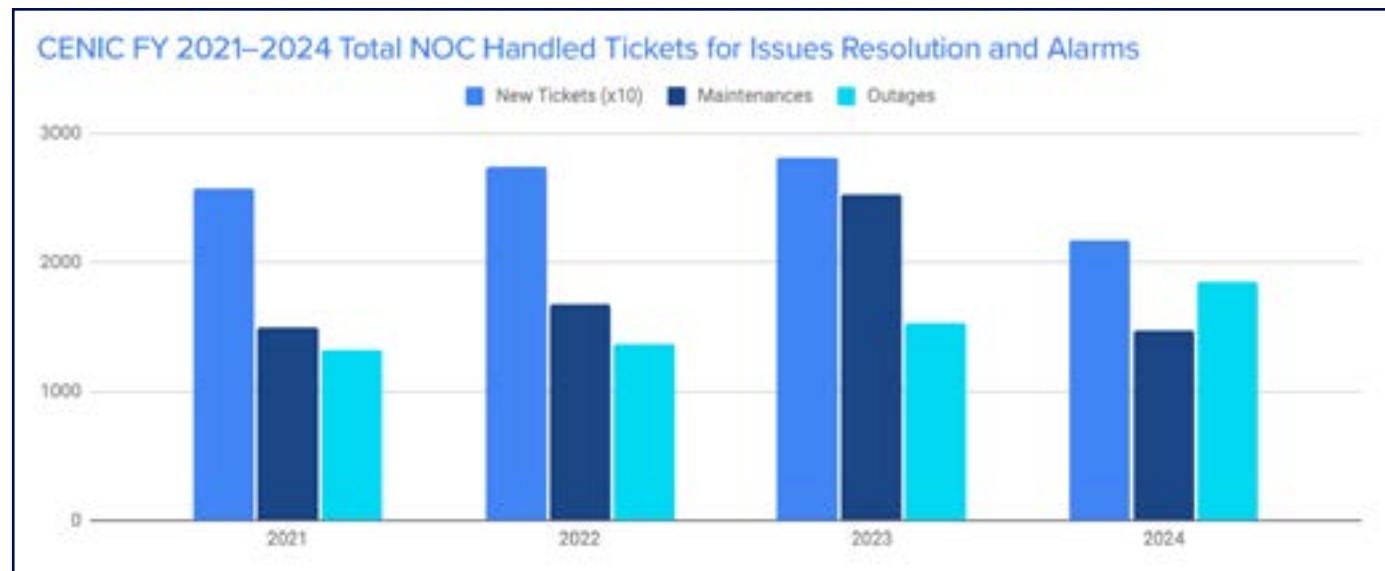
NOC engineers perform the many technical functions required to maintain and manage the optical (Layer 1), Ethernet (Layer 2), and routing components (Layer 3) of the network. Network engineers diagnose and resolve network problems; upgrade, refresh, and decommission equipment; perform circuit installations, service upgrades, and backbone upgrades; respond to abuse complaints; and coordinate and communicate third-party maintenance and repair activities.

CENIC members who experience a problem notify the NOC and are placed in immediate contact with an experienced, highly trained network engineer who begins to troubleshoot with them. These engineers have sufficient experience to resolve most issues, and fewer than 1% of incoming tickets are escalated to a more senior engineer.

The engineers who staff the NOC also diagnose and resolve problems identified by network monitoring tools that generate an alarm when an issue is detected on the network. This alarm system often allows engineers to detect problems before they affect users, and work to quickly resolve them.



NOC staff from left: (back row) Dan Hegarty, Ethan Cope, Carlos Barron, Matthew Elliott, Bryan Barnett, Mark Swank, Gilbert Marin, Mark Lozada, Tomik Markarian, Viet Do (front row) Larissa Esteban, Ozzie Reyes, Phat Tran, and Andre Noblejas.



The NOC uses a ticketing system to track issues that need resolution. While many issues can be resolved on the same day, some are more complex and take longer. During the time covered by this Community Report, the NOC resolved and assessed the following total tickets and alarms:

	2022	2023	2024 (TO 6/30)
RESOLVED TICKET	19,866	20,814	14,291
LAYER 1 ALARMS	46,604	88,274	58,444

NOC engineers also coordinate and communicate third-party maintenance and repair activities; perform equipment updates, replacements, and upgrades; decommission retired equipment; and handle tasks in support of circuit installations, service upgrades, and backbone upgrades. During the time covered by this Community Report, the NOC completed the following total maintenance procedures:

	2022	2023	2024 (TO 6/30)
MAINTENANCE PROCEDURES	1,673	2,532	1,476
OPERATIONAL READINESS TICKETS	335	265	232

Engineers who work in the NOC gain broad experience and a deep understanding of CENIC. As a result, they become valuable assets to the organization and are frequently promoted elsewhere within CENIC, bringing their expertise to departments such as Internet Services and Core Engineering.

Circuit Additions & Upgrades



As a member-driven organization, CENIC and its member institutions continually assess networking needs and plan connectivity upgrades to ensure constituents continue to enjoy the highest level of service. This assessment and planning includes network management and monitoring provided by CENIC's 24/7/365 Network Operations Center.

However, California's K-20 research and education communities enjoy other benefits that come from having all their networking needs represented by CENIC. These include substantial cost savings in circuits and equipment, thanks to CENIC's bulk purchasing power, and process efficiencies that come from CENIC's project management of quotes, contracts, installations, upgrades, and more.

This all results in a network with greater capacity and responsiveness to research and education's unique needs than can be expected from a commercial network. Examples of this growth of capacity for each member segment can be seen in the following lists of circuits that were initiated or authorized from July 2021 through June 2024.

University of California (40 total)

- 17 new circuits
- 12 circuit upgrades
- 11 circuit renewals

K-12 System (119 total)

- 47 new circuits
- 24 circuit upgrades
- 45 circuit renewals
- 3 circuit moves

California State Universities (51 total)

- 14 new circuits
- 31 circuit upgrades
- 5 circuit renewals
- 1 circuit move

Libraries (662 total)

- 178 new circuits
- 66 circuit upgrades
- 396 circuit renewals
- 22 circuit moves

California Community Colleges (175 total)

- 139 new circuits
- 19 circuit upgrades
- 10 circuit renewals
- 7 circuit moves

Other Universities and Colleges, Scientific, and Cultural Institutions (25 total)

- 17 new circuits
- 7 circuit upgrades
- 1 circuit renewal

CENIC

SOUTHERN CALIFORNIA:

16700 Valley View, Ste 400

La Mirada, CA 90638

NORTHERN CALIFORNIA:

Pier 35, Suite 202

San Francisco, CA 94133

PHONE: 714.220.3400

WEB: www.cenic.org

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