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Calit2: A UC San Diego, UC Irvine Partnership

As Larry Smarr sat in his office in Atkinson Hall at the California Institute for Telecommunications and Information Technology (Calit2 or the "Institute"), he reflected with some disbelief that nearly 10 years had passed since the Institute's inception. Before him on his desk lay the report entitled "The Path Forward: Application Thrust Strategic Planning Document" ("The Path Forward"). For Smarr, it felt like only yesterday that he had joined as the founding director of Calit2. Calit2 represented an experiment in inventing the university research environment of the future. From its inception in 2000, the Institute was envisioned as a catalyst that could fuel innovation and address large-scale societal issues by bringing together multidisciplinary teams of the best minds. To date, more than 700 university scientists, artists, engineers, and social scientists and over 300 non-university partners from the private and public sectors were associated with the Institute. Pioneering research projects were being carried out in diverse fields such as environmental monitoring, human/robotic communication, digital archaeology, nanotechnology, health sciences, information technology, and telecommunications.

In preparation for its second decade of operation, over the past two years, Smarr and his colleagues had been engaged in an exhaustive strategic planning process (see **Exhibit 1**). Now in September 2010, working groups were meeting to develop a 10-year roadmap informed by the vision put forth in "The Path Forward" report. The final roadmap was to be completed by the spring of 2011.

As Smarr picked up "The Path Forward," he wondered once again about the sustainability of a new entity as disruptive as Calit2. It was not easy to codify the "secret sauce" of Calit2, but he believed that the Institute had started on a great trajectory, and he wanted to make sure that Calit2's influence would extend well past his tenure at the helm. There was still much to be done if Calit2 was going to fulfill its mission to "live in the future" and make a lasting impact on California's economy and its citizens' quality of life.

Calit2 Background

As Smarr thought about the future of Calit2, he reflected on the unique history that allowed its founding in the first place. Under the direction of Governor Gray Davis, the state of California helped the University of California launch four new research initiatives in 2000, which collectively later became known as the Governor Gray Davis Institutes for Science and Innovation (ISIs). Calit2 was one of the four, and it represented a partnership between University of California, San Diego (UCSD) and University of California, Irvine (UCI). The concept for the ISIs was developed during the height

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of the Internet bubble in 1999 that had resulted in a California budget surplus in January 2000. At the suggestion of Richard Lerner, president of the Scripps Research Institute in California, Governor Davis proposed a partnership between the state of California, the University of California, and California industry to "foster an environment that increased opportunities for cooperation between industry and the UC to speed delivery of public benefits from research and education." Davis hoped the ISIs would "increase the state's capacity for creating the new knowledge and highly skilled people to drive entrepreneurial business growth and expand the California economy into new industries and markets."[1] Davis later added, "With the money coming in from the dot-com boom, I believed we could make a down payment on California's future."[2]

The University of California president at the time, Richard Atkinson, embraced this idea as a way to create the "university of the future." Davis and Atkinson envisioned four multi-campus institutes focused on applying leading edge academic research to the emerging challenges facing California. The legislature agreed to invest $100 million for capital construction funds to each Institute that later took the form of lease-revenue bonds. In connection with the funding commitment, the state required each Institute to raise $2 of non-state leverage (industry and federal funds) for each $1 it received from the state. Robert Conn, then dean of engineering at UCSD, explained: "The commitment from industry to support these institutes was a key element of the plan. We submitted our proposal with endorsement letters and major financial commitments from 39 private sector partners." The state solicited proposals from all of the University of California campuses, and each proposal was required to include a lead campus and a partner campus. William Parker, former vice chancellor of research at UCI, recalled, "President Atkinson did not want some campuses to win and others to be left out. He urged all the campuses to go and find a partner." The state received 13 proposals, and Calit2 was one of the four ISIs selected. (See **Exhibit 2** for an overview of the four ISIs.)

Calit2: The Early Days

The Proposal

The Calit2 proposal was submitted by then UCSD Chancellor Robert Dynes and then UCI Chancellor Ralph Cicerone. The two Southern California campuses were within 100 miles of each other, and there was a great deal of mutual respect between the two faculties. Both schools had strong track records of basic research in telecommunications, information technology (IT), and nanotechnologies; in addition, both had developed applications of these emerging technologies to address some of the large-scale problems confronting California's future.

Dynes asked Conn to spearhead the UCSD effort to create a winning proposal, and Conn got right down to work, meeting with faculty throughout the campus during the first half of 2000. Conn explained:

> Some of my colleagues on the faculty around campus were really excited about the potential of building a new institute, while others were more circumspect. The other deans had all agreed to cooperate, and I, together with colleagues in the administration, met with faculty from various departments in big meetings and small groups, and we discussed how everyone at UCSD could benefit. It wasn't just the engineering school. I believed that a rising tide would raise everyone's boat and that it was not a zero-sum game. Eventually this philosophy pervaded the campus.

Simultaneously, a similar effort was underway at UCI led by Dean of Engineering Nick Alexopoulos.

Dynes and Cicerone knew that it would be critical to have the right leader for the Institute. Fortunately, the Department of Computer Science and Engineering (CSE) at UCSD was already in the process of recruiting Smarr to become a CSE professor, and Conn, as dean, was deeply involved in the courting process. Conn, Dynes, and Cicerone all came to believe that Smarr would be an excellent candidate for the position of director of Calit2. They wanted someone that had experience managing ambitious projects, and Smarr was widely respected as the founding director of the National Center for Supercomputing Applications (NCSA) at University of Illinois. At NCSA, Smarr was known for his ability to generate innovative ideas as well as a deeply-rooted "Midwestern humility." He had a well-deserved reputation for knowing how to "create stimulating open spaces where people could learn, play, and engage to address large scale opportunities." (See **Exhibit 3** for Smarr's background.) Over the course of several months, Smarr became increasingly intrigued by the promise of Calit2. Smarr finally agreed to run Calit2 because Dynes and Conn helped him to see it as an opportunity to "align my personal belief of where science and technology was going with an ability to create a world-class institute of researchers. Calit2 would be a place where we could exploit the opportunities created by the convergence of the fields of information technology, telecommunications, nanotechnology, and biotechnology. And there was obviously no way I could make as much of an impact on my own as a single professor."

In the fall of 2000, Smarr moved to San Diego as the founding director of Calit2, and helped complete the over-100 page proposal. Smarr explained, "There was a very deliberate, defined sort of forced march to create a proposal, with the proposal explicitly being used as a tool to identify and bring together the right faculty and to collectively develop a common vision."

Through the proposal process, the faculty involved came up with a detailed and well-defined vision of what Calit2 would be and how it would be led. The stated mission of Calit2 in 2000 was to extend the reach of the current information infrastructure throughout the physical world. The proposal outlined four "strategic applications" to guide the research direction: environment and civil infrastructure, intelligent transportation, digitally-enabled genomic medicine, and new media arts. To deal with the enormous challenges in these four areas, Smarr and his team felt that Calit2 would need to harness the collective brainpower of the best researchers in different fields. The Institute would be a catalyst for collaborations among engineering, physical sciences, digital arts, medicine, public health, as well as the biological, behavioral, and social sciences. The proposal also identified core enabling technologies (e.g., networked infrastructure) that would provide a scientific foundation for the research.

A key element of the proposal became a diagram (shown in **Exhibit 4a**), internally referred to as the "layer cake." Smarr explained the diagram:

> We built up the research program from the atomic level of materials and devices at the base, and then added layers that represented infrastructure, interfaces, and software systems. The next layer had the four applications in the physical world we hoped to impact. By environment and civil infrastructure we were referring to how we could monitor both the engineered and natural environment. Next was intelligent transportation, as we believed our entire transportation system would eventually transform into an Internet-connected transportation system. We also envisioned the current transformation of medicine as well as new media and the arts, by the continuing exponential change of information, telecommunication, and nanotechnologies. Then, on top of these applications was one last layer of policies, management, and socioeconomic evolution. These layers were framed by education on one side and industry on the other, both of which impacted all the layers.

Stephanie Sides, the director of communications when Calit2 began, added, "The layer cake diagram was helpful when Larry was meeting with faculty across the two campuses. Professors could visualize where they might be able to fit into the Calit2 mission, and it helped them see where they touched other layers, leading to more interdisciplinary conversations."

The proposal called for voluntary faculty participation in projects under the Calit2 umbrella. The submitted proposal listed 238 faculty and staff (136 from UCSD and 102 from UCI) who were aligned with each of the layers, along with a designated "layer leader" from each campus. (see **Exhibit 4b** for list of the layer leaders in 2000). Faculty would retain their offices in their home departments. Calit2 would not have the right to make academic appointments, and faculty reviews for promotion would remain the responsibility of their home departments.

Original Leadership Structure

Through the proposal process, ideas about the optimal leadership structure for the entire Institute began to emerge. Dynes and Cicerone agreed that each campus should have a "division director" (originally termed "associate director") who would report to Smarr. Conn suggested Ramesh Rao, an engineering professor at UCSD and director of the Center for Wireless Communication, for this role at UCSD. Rao was known for his research expertise, his management skills, fair-mindedness, and his ability to "get things done." Rao had been at UCSD since the 1980s, and Conn believed Smarr could build on Rao's strong relationships with faculty throughout the school. At UCI, Peter Rentzepis, an internationally respected chemistry professor was appointed as the first associate (later division) director. Rentzepis had been the head of physical and inorganic chemistry research at AT&T Bell Labs before joining the faculty at UCI where he had worked with Dynes, who had served as Bell Labs' department head of semiconductor and material physics research and director of chemical physics research. Ron Graham, one of UCSD's most senior professors of computer science and engineering, was designated as the chief scientist for Calit2, the same title he had held at Bell Labs. Prior to becoming chief scientist at Bell Labs, he had been director of information sciences at Bell Labs for over 30 years.

This depth of experience in how Bell Labs had facilitated interdisciplinary research was invaluable in the early days of Calit2. Smarr recalled, "We inherited a lot of the 'Bell Labness' because these senior people were so integral in setting up Calit2." Dynes wanted to emulate the culture of Bell Labs which fostered serendipitous interactions; he envisioned a "fluid" environment in which faculty could come and go based on their current projects. Cicerone explained, "Bell Labs played such a crucial role in the development and commercialization of science in the U.S. We saw this institute as a way to recreate aspects of Bell Labs on the west coast. We hoped to create a space where faculty could feel free, while still accomplishing a great deal."

The layer cake diagram helped guide the leadership of Calit2 as the layer leaders from both campuses were appointed to "coordinate projects in their respective areas and ensure that integration was achieved intellectually across the campuses."[3] Smarr elaborated:

> I said that if our goal is to build these cross-campus teams, as well as cross-disciplinary teams, then we've got to have each campus involved in each component of the layer cake. We needed nano-teams at Irvine and nano-teams at San Diego. The layer cake became a way of pulling us together, and then the layer leaders, who were well-known faculty among their own peers, helped pull together the nano-team. From the very beginning, we created a decentralized approach to managing the Institute.

These layer leaders collectively comprised the executive committees at each campus. The intention was to have the two committees meet monthly via videoconference, and quarterly face-to-face, alternating between UCSD and UCI.

Funding and Industry Support

Because the request for proposals called for a "lead" and one or more "partnering" campuses, the two chancellors agreed in the proposal to a division of the $100 million with $70 million going to the "lead campus" UCSD and $30 million directed to the "partnering campus" UCI. Both campuses planned to spend over 90% of the state funds on specialized facilities to serve as the local hub for Calit2 projects, while funds from industry and the government would be used to support the actual research. Throughout the proposal period, faculty solicited letters of intent from companies that wanted the opportunity to work with UC faculty on science and technology projects. Conn was able to leverage the school's relationships with companies and venture capitalists in the San Diego region, built over the previous seven years. He and his colleagues had built a large and successful corporate affiliate program during the 1990s, and Alexopoulos had carried out a similar process at UCI. Conn recalled:

> When the opportunity for Calit2 came up, the architecture for our industrial relationships was already in place. The bulk of the money came from turning to existing partners who had already ascertained the value of working with us. We said to them, 'This is worth backing.' Qualcomm was the first company to make a public announcement of support, and their commitment of $15 million in May 2000 (by the then CEO Irwin Jacobs at an event with President Clinton) helped us bring in other industrial partners such as Ericsson, IBM, Sun Microsystems, and many others. UCI attracted contributions as well, led by gifts from Emulex and other industrial partners.

The final proposal was submitted in October 2000 with $201 million of committed funds and another $56 million of matching funds.

Companies were interested in supporting Calit2 for a variety of reasons, including the opportunity to bring real-world problems into an academic environment. As the president of AT&T Labs said in his supporting letter for the Institute, "Calit2 provides a platform for components manufacturers, software innovators, device makers, and telecommunications providers to work together creatively on issues such as availability, quality of service, seamless operations between wired and wireless devices, and policy issues such as privacy."[4]

Industry partners hoped the Institutes would encourage UC campuses to revisit or rethink technology transfer policies and mechanisms. For example, many hoped that industry partners would be given the opportunity to work side-by-side with university academics in such a way that the need for formal intellectual property agreements could be reduced. Broadcom founder Henry Samueli reflected on the role of Calit2, "As industry has become increasingly competitive, companies need to focus on near-term innovation that can be brought to market within five years. We have come to rely on universities for longer-term research. That is the sweet spot of Calit2."[5]

Calit2 Facilities

UCSD – Atkinson Hall

From the beginning, Smarr and his team believed the physical space of the Institute would have an impact on the success of their venture. The Calit2 proposal called for buildings that would not only provide researchers with unique laboratories and cutting-edge technological capabilities, but would also facilitate innovative cross-disciplinary work vital to the success of the Institute. At UCSD, Smarr encouraged design input from a variety of academic departments to address the needs of the broad range of intended users. A number of design criteria were agreed upon, including:

- Flexible office and lab space that could be assigned on an as-needed basis
- Research orientation; no provision for classrooms
- Open environment; very few walls; all furniture mobile and reconfigurable
- All specialized equipment and laboratories shared by academic and industrial researchers
- 200-seat auditorium equipped with state-of-the art technology including a 4K digital cinema
- Clean room with nano-scale fabrication equipment
- Extensive wireless and network communications
- New media arts facilities with immersive visualization lab
- Art gallery space located next to lab space

The design team at UCSD worked with NBBJ, an international architect and design firm, to plan a six-story 215,000 square foot building (later named Atkinson Hall) that would be located next to the Jacobs School of Engineering.[6] They envisioned a building without any offices; instead, faculty and technical staff would work in shared spaces designed to encourage collaboration. The designers ended up traveling to Germany to find the "right furniture," furniture that could be reconfigured easily and quickly to bring together groups of various sizes.

Construction was started in 2002, and the building was dedicated at a ceremony on November 8, 2005. (See **Exhibit 5** for an overview of the building and the dedication ceremony.) The final building largely fit the design criteria identified in the proposal, although, in the end, the university required the inclusion of offices around the perimeter of most floors in the event that Atkinson Hall had to be repurposed at a later date.

Once the building opened, Smarr and his colleagues thought long and hard about where faculty should be placed in the building. For example, the art gallery was located near the nanotechnology clean room. Rao commented, "Artists and engineers make good teammates because artists like to create problems and engineers like to solve them." They saved several open spaces to be used for experimental purposes. In 2008, for instance, one of those spaces was turned into the StarCAVE. Thomas A. DeFanti, director of visualization at Calit2, explained, "The StarCAVE supports 20/40 vision and the images are very high contrast, thanks to the room's unique shape and special screens that allow viewers to use 3D polarizing glasses. You can fly over a strand of DNA and look in front, behind and below you, or navigate through the superstructure of a building to detect where damage from an earthquake may have occurred."[7] (See **Exhibit 6** for an image of a protein projected in 3D in the StarCAVE.)

UCI

The Calit2 building at UCI was up and running before the USCD building; in fact, it was the first completed building among the four ISIs. The 120,000 square foot building included research labs and media spaces, and was connected to the pre-existing 3,700 square foot clean room in the Integrated Nanosystems Research Facility. Unique features included 40 embedded seismic sensors that could measure ground motion and building motion, developed in collaboration with the U.S. Geological Survey. Like UCSD, the workspace was designed so that it could be configured according to the needs of a given team.

From the beginning, the Calit2 UCI Division nurtured young companies in its building. In 2005, CODA Genomics, which was spun out from UCI synthetic biology research, set up shop in Calit2's first-floor wet lab. The virtual incubator agreement enabled the startup to operate without initial capital investment in facilities, equipment and research staff. Instead, they accessed the tools and expertise readily available in the Irvine building by way of a recharge account. After gaining traction, CODA moved its headquarters to Carlsbad, California and later changed its name to Verdezyne.

In May 2010, a portion of the building was officially designated as a "business incubator" (known as the UCI TechPortal) to house entrepreneurial ventures started by UCI academics affiliated with Calit2. G.P. Li, at the time the UCI Division Director, explained, "We see TechPortal as a way to help entrepreneurs move their products from the lab into the marketplace." The first tenant to move in was the company BiMaple Technologies Inc., led by Chen Li, associate professor in the Bren School of Information and Computer Sciences at UCI. Li and his colleagues at BiMaple were developing cutting-edge methods to make on-line search faster and more responsive.

When asked about managing the Institute on two campuses, Smarr explained:

> One of the most difficult parts of bringing up Calit2 from a blank piece of paper was the requirement that we create a new mode of collaboration between two UC campuses. This has meant that I split my time being at UCSD and UCI. It takes about one and a half hours to drive between the campuses, and I've made over 150 day trips to Irvine. These visits enable me to have individual conversations with hundreds of faculty members. I have found that there are significant cultural differences between the two campuses, but yet there are wonderful unrealized opportunities for collaboration. It essentially was not anyone's job before to seek out these opportunities and facilitate the faculty coming together to pursue federal grants jointly. One of the ideas behind having a building on each campus is that this gives us an opportunity to explore the innovative uses of optical-fiber telecommunications systems – to 'tie' the two buildings into a common 'collaboratory.'[8]

Management, Operating Funds, and Oversight in 2010

Management

The management structure (with layer leaders and an executive committee at each campus) outlined in the original proposal continued to serve Calit2 well until the buildings were completed and occupied in 2005. At that time, based on the recommendation of the Advisory Board and the Institute Governing Board, a new structure was introduced. Divisional Councils with broad representations of faculty and staff were created at UCSD and UCI, and they were led by the division director at each campus. Rao served as the division director at UCSD from the beginning of Calit2; his organizational skills were seen as an ideal complement to Smarr's style. However, the UCI

director changed three times. G.P. Li, professor of electrical engineering and computer science, became the fourth division director in 2007, and remained in this position as of 2010. Li had been the materials science layer leader at UCI when Calit2 was started, so he had been involved with Calit2 all along. (See **Exhibit 3** for management biographies.) Smarr commented, "The turnover at UCI in the division director role made it a little difficult to get going at UCI, but Li has been doing a great job in getting UCI faculty excited about engaging with Calit2."

In 2008, as a result of the Advisory Board management review, Calit2 brought Smarr, Rao, Li, and Graham together into a unified director's office (see organizational chart in **Exhibit 7**). Jerry Sheehan, from the University of Illinois, who had joined Calit2's UCSD Division as a manager for government programs in 2004, was promoted to serve as the director's office chief of staff supporting both campuses. Sheehan and Smarr had worked together at NCSA from 1994 to 2001. As one person familiar with Sheehan observed, "At Illinois, Jerry had been one of Larry's right-hand men who kept things from falling between the cracks, picking up anything flying off of Larry's waving hands and making sure it got implemented." Rao explained, "Jerry is not constrained by having to speak as a faculty member of UCSD or UCI; he has the freedom to observe from the perspective of the Institute." Sheehan elaborated, "Larry, Ramesh and G.P. are the decision makers in the organization. My role is to advise on best practices, and to help identify what can go right or wrong. I then have responsibility for implementing the decisions made by the executive team."

From the beginning, Smarr felt it was important to attract top talent – not simply faculty, but also staff (non-tenure track professionals) to Calit2. He believed Calit2 needed smart, proactive staff with a customer-service orientation to support the kind of research they hoped to accomplish. Calit2 was run by a staff of 130 people at UCSD and 10 at UCI. The staff worked in a variety of functions, ranging from administration and communications to more technical roles such as managing theater equipment, assisting in the StarCAVE, and maintaining the clean room. The Calit2 staff also offered services to faculty such as grant support, special-events support, and promotion of their research agendas. Smarr believed that one of the most important staff roles was to serve as ambassadors for Calit2. Staff gave tours multiple times a day, and Smarr personally participated in several tours or promotional events each week. The Institute relied heavily on generating awareness through proactive communication about facilities, programs, lectures, and grants.

Attracting and retaining top talent was not easy given that there was limited advancement in career paths for most staff, so Smarr worked hard to ensure that staff members felt appreciated and part of the community. Rao believed, "Although there is a clear hierarchy at Calit2, ideas are more important than hierarchy. Smarr encourages careful listening even when there is disagreement. We must be clear about why we are taking positions and respect each other's opinions." Smarr also encouraged individuals to take responsibility, and he rarely interfered with operational decisions that could be made by others who were closer to the situation. Sheehan explained, "Larry is a macro, not a micro manager." Rao commented, "From the beginning, Larry crafted his position to be outward-facing. This freed him to focus on the high ground. Larry is particularly good at staking out visionary positions and helping others get there. He can draw attention to ideas that emerge from outside the organization, while I focus closely on the opportunities and constraints that UCSD presents." Sheehan expanded, "Larry is skilled at cross-pollinating ideas from internal and external forces." Conn described Smarr as "an exceptional leader who sees the potential and the future. He's a dot-connector extraordinaire who can see relationships between people and trends."

Operating Funds

Calit2 struggled to obtain the funds to compensate its staff to operate the Institute because the Institute did not have a permanent source of operating funds. Smarr had asserted to President Atkinson in early 2001 that a $100 million capital investment required a roughly $10 million per year operating budget for the staff and recurring expenses that were needed to make the buildings and laboratories "come alive." Operating funds from the state of California had reached the required $10 million in only one year during the past decade, although the state contribution had been fairly stable from 2007 through 2010 at approximately $7.5 million per year. Smarr sought out additional funds from grants and corporations to make up the shortfall, and in several years, Calit2 raised enough operating funds to exceed the $10 million target. (See **Exhibit 8** for Calit2 research and operations budget over the last 10 years.)

The senior leaders of Calit2 saw this operations funding gap as one of their biggest challenges. Smarr explained, "It is difficult to keep building for the future when we don't know if we will have the funds to cover our current operating expenses. We have designed a portfolio approach for income each year." Steve Beckwith, vice president for research and graduate studies at the University of California in the Office of the President, explained, "It's important to us that the Cal ISIs have the money to operate. We invested hundreds of millions of dollars in building out the facilities, and we have a responsibility to make it work or declare it a failure. We need to spend at least $5 million per year per institute to figure out if the experiment is working."

In recent years, the funding environment had only become more uncertain. Calit2 had cobbled together funds each year from different sources to cover its operating expenses; however, several industry partners had expressed reservations about giving funds to Calit2 that might end up being used for operating purposes instead of research. The fundraising efforts were both time-consuming and destabilizing for Calit2, and all the parties involved were seeking a more reliable source of annual funding. Sheehan explained, "Historically, funding issues have dominated meetings with our governing bodies and faculty groups. The fact that these conversations have gone on for a decade without resolution is frustrating to everyone."

Oversight

Within the university, the chancellors, executive vice chancellors, vice chancellors of research, and deans at both UCSD and UCI played a critical role of guiding and monitoring Calit2. Smarr reported directly to the UCSD and UCI chancellors, while the division directors reported to the vice chancellors of research.

The UCSD Division of Calit2 operated as an Organized Research Unit (ORU) within UCSD, which came with a defined set of guidelines and governance mechanisms detailed in the 1999 ORU Policy and Procedures guide:

> An Organized Research Unit (ORU) is an academic unit the university has established to provide a supportive infrastructure for interdisciplinary research complementary to the academic goals of departments of instruction and research. The functions of an ORU are to facilitate research and research collaborations; disseminate research results through research conferences, meetings and other activities; strengthen graduate and undergraduate education by providing students with training opportunities and access to facilities; seek extramural research funds; and carry out university and public service programs related to the ORU's research expertise. An ORU may not offer degree programs or formal courses for credit for students of the university or for the public.[9]

At UCI, the Calit2 division was designated a Special Research Program (SRP) in November 2000. The SRP designation was chosen to allow the campus to establish this division as a formal campus organization using a shortened time frame and expedited review process not possible in the creation of an ORU at UCI. SRPs at UCI were subject to the same policies and procedures as ORUs, including Academic Senate oversight and rigorous regular reviews of each SRP and its Director. Calit2 Irvine could transition into ORU status should that be seen as advantageous.

Calit2 was governed by three boards that impacted the strategy, budget, and operations of the Institute. Sheehan explained, "From the beginning we wanted a multi-layered system of governance assuring that we could get input from various stakeholders."

Advisory Board: The Calit2 Advisory Board consisted of 17 well-respected academic and industry visionaries drawn from outside of the UC system. (See **Exhibit 9** for a list of 2010 Advisory Board members.) The Advisory Board met twice a year (once in person and once via teleconference) and discussed issues relating to the long-term strategic direction of the Institute. When Calit2 was started, the Advisory Board did not have representatives from companies that provided funding, but this policy was changed in 2008 to incorporate the viewpoints of strategic industry partners. The Advisory Board also brought in experts in thematic areas of interest such as transportation and life sciences, and members rotated off after several years to bring in fresh ideas.

Governing Board: The Calit2 Governing Board was chaired by the deans of the engineering schools at both UCSD and UCI. It included the deans of the other schools or divisions on both campuses, the vice chancellors for research at both campuses, and the vice chancellor for marine sciences and director of the Scripps Institution of Oceanography, UCSD. Ex Officio members on the governing board included the members of the Calit2 director's office. The Governing Board met annually as a large group, but an executive committee of the group met quarterly. Suresh Subramami, UCSD executive vice chancellor, who sits above the Governing Board, explained, "We have been very pleased with the progress at Calit2. However, if there was a major performance problem, we would have the authority to investigate the issues and shut it down if the problem proved to be intractable."

Divisional Councils: UC faculty and research staff had an opportunity to influence the direction of Calit2 through university-sponsored "Divisional Councils" at UCSD and UCI. These councils were started in 2005, and each council was comprised of 25 to 30 researchers representing a cross section of affiliated faculty and Calit2 staff, which met quarterly. (See **Exhibit 10** for a list of Divisional Council members at UCSD and UCI.) Council members participated on subcommittees covering topics such as research development, academic personnel, collaboration across the two campuses, student programs, entrepreneurism, space allocation, seminar programs, communications, and special events. The subcommittees were formed with representatives from the councils as needed and then disbanded after they achieved their desired goals.

The insight and support provided by these three groups proved invaluable when Calit2 struggled with resistance from faculty that did not approve of Calit2's direction or the financial resources they were attracting. Smarr commented, "We are disruptive in principle; we cut across 24 departments and several different schools on two separate UC campuses, and we do things at a faster speed than almost any other part of the university." Dynes explained, "If you are going to do something disruptive, you need support from the deans and chancellors every step of the way." For example, when Smarr wanted to set up technology transfer guidelines that differed from those at other UC campuses, Chancellor Marye Anne Fox supported his approach. Fox explained how her management

style impacted Smarr and Calit2: "My philosophy is to watch people closely. If they do well, I leave them alone. Larry has done well."

Calit2 Research Initiatives

Faculty participation in Calit2 projects was completely optional, so there was pressure to attract academics that would benefit from the Calit2 resources and contribute to the broad research initiatives at the Institute. Like Smarr, both Rao and Li served as conveners with the goal of bringing people together that could collaborate effectively. The division directors made connections among individuals anytime and anyway they could, and they helped faculty prepare and submit proposals for research grants from federal agencies such as the National Science Foundation (NSF).

Their efforts had born fruit. It was clear that Calit2 enabled researchers to pursue large projects that cut across multiple departments, campuses, and disciplines. As Cicerone explained, "We found that faculty and students were interested in projects that were bigger than any single unit. We wanted Calit2 to help teams do what individuals could not accomplish alone."[10] During the first five years, the majority of the projects were geared toward the four sectors outlined in the original proposal: environment and civil infrastructure, intelligent transportation, new media arts, and digitally-enabled genomic medicine. Within each of these sectors, there were multidisciplinary groups focusing on specific projects, often supported by federally funded research grants. In response to the combination of 9/11 attacks, California wildfires in 2003, and Hurricane Katrina in 2005, Calit2 added a new application area – public safety and disaster response. (See **Exhibit 11** for synopsis of several research projects at Calit2.)

Many of the projects involved regional and global partnerships, with the goal of creating and testing solutions in a real-world context throughout the world. Smarr was willing to take on projects with long timelines. As Sheehan explained, "Larry often sees the potential of new research before others. He is comfortable investing resources to develop prototypes that demonstrate to the broader community the potential for emerging technologies." For example, in 2000, Smarr expressed interest in digitizing the coast of Southern California using sensors, cameras and other forms of monitoring the ocean and the coastline. Rao noted, "At the time, people told Larry his idea was 'pie in the sky,' but by 2010 there are many groups interested in the results of our investment."

One of the more ambitious partnerships was with the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. Like Calit2, KAUST's mission was to encourage bold and collaborative research that would address challenges of regional and global significance. KAUST, which opened in 2009, was an independent, merit-based institution, open to men and women from all cultures around the world. The inaugural class represented the first co-educational higher education opportunity in Saudi Arabia – 15% were women. Among other things, Calit2 was providing the expertise to connect KAUST with a network of universities across the globe through access to ultra high-resolution visual display and collaboration facilities. (See **Exhibit 11** for more details about the KAUST partnership.)

The Attraction of Specialized Facilities and Equipment

Calit2 provided office space and lab space for individuals that wanted to collaborate on projects, and researchers could use group space for months to years at a time. Calit2 was intended to serve as a project hub for faculty from different departments. Smarr explained, "In some university departments, department heads create moats around the department and faculty have a difficult time moving in or out. At Calit2, we are looking for faculty who want to cross those moats." For example,

Bill Tomlinson, associate professor of informatics at UCI, sought out Calit2 as a place to pursue his interdisciplinary research interests. Calit2 currently supported his work in the emerging field of "green IT," representing the intersection of two trends: concern about the global ecosystem and the use of digital tools and techniques for manipulating information. As one of the Advisory Board members observed, Calit2 was looking for "the butterflies, like Bill, who can cross-pollinate. Real discovery generally happens at the boundaries of disciplines."

Researchers were encouraged to follow certain technical guidelines when doing projects at Calit2. For example, Calit2 wanted faculty to use readily available, commodity equipment whenever possible, both to save money and to facilitate the dissemination and replication of ideas. Likewise, Smarr encouraged use of freely distributable software to provide increased transparency. For example, researchers at Calit2 created a HiPerSpace tiled visualization wall consisting of approximately 80 flat panel screens that could display panoramic images (see image in **Exhibit 6**). The flat panels used on this wall were standard Dell LCD PC screens that were easy to find, purchase, and assemble. Calit2 created a wiki with easy-to-follow instructions on how to replicate such "OptIPortals running CGLX software," and the software that runs the wall has been downloaded by hundreds of users around the world. Calit2 researchers were encouraged to leverage shared-use specialized facilities such as the clean rooms, photonics labs, and media spaces at both UCSD and UCI. Smarr's vision was to do more than offer high-end equipment in these spaces; he recruited non-tenure-track research professionals that could support a high level of professional execution.

For example, the Calit2 clean room at UCSD, known as the Nano3 Lab, was built and run by Bernd Fruhberger. His prior industry expertise and aptitude for serving researchers and industry collaborators was perfect preparation for his role as manager of the clean rooms. He worked with a team of six (including three PhDs). Calit2 enlisted faculty research leaders from the electrical and computer engineering, physics, and chemistry and biochemistry departments to establish the shared facility. Early projects such as the AFOSR nanosensor effort led by Professor Ivan Schuller and the National Institute of Health (NIH) NanoCancer grant led by Professors Esener and Carson played a key role in launching the research efforts in the clean room. Calit2's Nano3 facility brought together for the first time at UCSD three fields of nanoscale research and development (nanoscience, nanoengineering and nanomedicine). When the USCD Jacobs School of Engineering decided to create the nation's first Nanoengineering department, the new faculty were housed in Calit2 while their new building was under construction, providing easy access to the Nano3 Lab.

Steve Ross, assistant dean of the Jacobs School of Engineering at UCSD, who also served as a Calit2 assistant director, met with faculty during the planning stages, to come up with a cost-sharing and governance model. Ross explained:

> Although faculty were excited to have access to state-of-the art equipment, we had to get all the faculty to agree to a common charging model. It was ultimately decided that we should use a "recharge model" in which faculty budgets would be charged based on the time they used the equipment. This type of model was already in place at UCSD and at other facilities. We also needed agreement on how much to spend in support of the facility, what to buy, and how the facility would be governed. It took more than a year to reach agreement, but the process laid the groundwork for collaboration among faculty, and we ended up creating a governing structure that included a board with three faculty from science and three from engineering.

Smarr expanded, "Creating Nano3 was one of the formative cultural moments for the UCSD Division of Calit2. The Calit2 leadership had to resist the prior campus culture of dividing the clean room space up by faculty member or department. Instead, we facilitated discussions and encouraged the faculty to come back with an agreed-upon open and shared facility with pooled equipment

available to all." When the Nano3 clean room wing of Calit2 was completed, faculty agreed that the Nano3 had more space and equipment than any one department could have afforded on its own.

One of the most popular pieces of equipment in the Calit2 clean room, a scanning electronic microscope (SEM), had previously sat underutilized in one of the engineering buildings with limited maintenance and support as a result of funding limitations. Calit2 took over the equipment, and its integration into the larger organization at Nano3 allowed for the provision of readily available user support and equipment maintenance. The SEM was so heavily used by the UCSD research community that Nano3 was purchasing a second one to meet the demand.

By 2010, over 90 faculty at UCSD used the equipment, and multiple grants were awarded to professors based on the research they were doing at the facility. The clean room continued to be run as its own business; researchers were charged for their time in the space, and non-university affiliates were allowed to rent the space as well. The revenues covered a portion of the salaries of Fruhberger's staff and the equipment maintenance. Fruhberger explained, "We treat everyone as a customer and we strive to be 'always open.' The private sector users have helped us cover our costs, and we have been able to learn from each other. We have had over 50 companies in here interacting with the UCSD community, and the faculty have embraced the external users." However, the clean room was not entirely self-sustaining and looked to Calit2 for operational funds each year to cover the gap.

Surprises

When Calit2 was started, the founders envisioned a set of scientific projects that would benefit from the integration of advanced technology, the social sciences, the humanities, and the arts. So far, only a small number of social scientists and policy researchers were engaged with Calit2. Without these two contingencies, Smarr worried that larger social implications of Calit2's technological and scientific breakthroughs were not being fully examined. In contrast, the wide variety of new arts and humanities projects that leveraged Calit2 resources was an exciting and unanticipated outcome for the founders. Tom Levy, professor of archeology at UC San Diego, recalled his initial interactions with Rao after meeting him at a Calit2 open house: "He said to me, 'Tell me your dreams.' I explained how I wanted to use information technology as a portal for cultural heritage research, and within a week Rao organized a meeting with 10 visual artists, computer scientists, and computer engineers. I showed up for the meeting and didn't recognize anyone in the room, but we started talking about ways we could work together. Within a few months I had an office and a lab here and I started working on my digital archaeology project."

In February of 2007, the Center of Interdisciplinary Science for Art, Architecture and Archeology (CISA3) was launched as part of the UC San Diego division of Calit2 in collaboration with the Jacob's School of Engineering and Division of Arts and Sciences. Operating at the intersection of art and science, CISA3 was dedicated to playing a "leadership role in the use and development of new tools and techniques to reconstruct and analyze the history of great works of art and monumental structures as well as archeological sites and artifacts."

The Center built on the work of several Calit2 researchers, including the 30-year career of its current director, Maurizio Seracini. A pioneer in applying multispectral imaging and other diagnostics and analytical technologies to art and structures, Seracini used non-invasive scanning techniques to seek objective knowledge and a more factual basis for understanding art history.[11] Rao elaborated: "When we learned of Maurizio's work, many of us began to sense that he and Calit2 were made for each other. His techniques make him look like an engineer and a data analyst to many, but the objective of his inquiry is art and architecture, an unusual combination. It was not hard to

imagine developing a center around his unique perspective and the technological capabilities of scientists and engineers at UC San Diego and Calit2."

Sheehan elaborated on Calit2's role as a hub for cross-disciplinary work:

> Calit2 has become a birthing home for new cross-disciplinary centers that would otherwise not have a natural home in the university. The CISA3 initiative did not fit well within the existing boundaries of campus, since it was applied research that combined multiple disciplines in a novel fashion. However, within a short period the project has gone from one whose utility was questioned by the community to a showcase of the synergies of multidisciplinary research that Calit2 enables.

Smarr was glad to see that the Center for Research Computing and the Arts (CRCA) had a permanent home on the first floor of the Calit2 building in San Diego. Smarr explained, "There were some differences of opinion about giving artists prime space in the new building, but I felt strongly about this topic. I believed that avant-garde artists would enable us to see the future, and scientists could learn from the art world." Sheldon Brown, the New Media Arts Layer Leader for UCSD and CRCA Director said, "As an interdisciplinary research center of artists who are deeply involved in technology development with consideration of social outcomes, the opportunity to partner with Calit2 has provided both new productive methods and in-depth intellectual exchange with a range of new disciplines. We have found that in Calit2, the vanguard-hacker attitude that characterized our artistic approaches was embraced as a transformative methodology across new categories of human activity." Smarr recalled, with some chagrin, an incident in which he got "just what he had bargained for" when a Calit2 artist's "civil disobedience" project shut down some of the campus computers. "Part of our job is to live in the future of exponential Internet, and this artist was showing us what that might look like." Smarr continued, "I also wanted to give artists access to the high-end equipment that scientists use. Artists have been deprived of resources so long, and it doesn't have to be that way."

The State of Industry Partnerships

Industry partnerships represented a core component of the Institute, and they needed to be managed thoughtfully. As Frieder Seible, UCSD dean of engineering, explained, "We have found that each company wants something different from Calit2, and we work with companies on their own terms." For some projects, industry partners posed specific problems, and Calit2 formed a team with representatives from the university and industry to focus on the problem. Some industry partners used Calit2 as a center to test prototypes or commercial products. Qualcomm deployed a prototype cellular internet antenna on the UCSD campus for three years before it became available commercially. One industrial partner, Zeiss, installed over $3 million of advanced microscopy in the Calit2 building at UCI for several years and continued to upgrade the products. According to Daniel Mumm, associate professor of chemical engineering and materials science, "UCI researchers benefitted from continuously upgraded equipment to keep them at the forefront of advanced materials research, while Zeiss used our lab to demonstrate the capabilities of its instruments."

One of the most successful Calit2 initiatives at UCI was the LifeChips multidisciplinary research program that blended technology and life sciences at a microscopic scale to benefit human health. Although the initial funding for LifeChips came from government, the initiative was now receiving significant support from industry. The program was started in 2006 by Li when he and several colleagues at UCI were awarded a $2.9 million "IGERT" (Integrative Graduate Education and Research Traineeship) grant from the NSF to promote graduate student work in the combined

practices of engineering, physical sciences, biological sciences, and medicine. The program initially focused on teaching graduate students about applying micro and nanotechnology to life sciences using the specialized equipment in the Calit2 clean rooms. Li and Bachman's faculty team-taught course "Technology of Life" attracted both undergraduate and graduate students.

By 2010, the LifeChips program had expanded to include over 60 faculty interested in working together on new frontiers in biomedicine. Mark Bachman, assistant professor at UCI, explained, "LifeChips is a way to bring together faculty on campus with different specialties. We have a number of events that attract people from the medical school, biological sciences, business, and engineering. We host several symposia that draw researchers from around the world." The LifeChips program also attracted industry representatives that wanted to team up with academics. Smarr commented, "The UCI campus is located among 300 to 400 bio-instrument companies in Orange County, and the LifeChips events have come to serve as a hub for this ecosystem." Bachman described one example in which he and several students were working with a device company that wanted to develop microscopic sensors for blood bags. He explained:

> The company learned about our research through one of our LifeChips seminars, and they asked for our help. The work looked interesting to us because it offered a practical application of our research. We put together a proposal for the company, and now we are working together. We look at company projects from a strategic perspective. I always ask, "Will it further my research agenda? Will our graduate students be interested in this project?"

Funding from industry partners gave Calit2 the opportunity to offer seed money to projects in order to help them get started. Smarr explained how the seed money worked:

> Companies gave us some discretionary project funds. We can use those funds to bet on people and ideas. When we see early successes, we can use those funds to pour a little more fuel to add even more momentum. Nobody sees how many bets we make. It's like popcorn; no one sees how many kernels created the bucket of popcorn, and we don't know which kernels will pop. But we only make seed investments under $100,000. Some faculty see our great building and think we have millions of dollars to fund new projects, but that is not the case. We see our role as an enabler, not as a funding agent.

Qualcomm CEO, Paul Jacobs, observed that the uniqueness of Calit2 lay in its ability to "provide an environment in which innovation can get done there." For Qualcomm, Jacobs added, the support for Calit2 was not tied to the goals of the company – they never insisted that researchers work on particular projects. He added: "For me, it's much more about collaboration and the fact that they [Calit2] have been successful at having a public impact."

From the beginning, Calit2 attracted support from Connect, a 25-year-old organization dedicated to growing San Diego's innovation economy by linking scientists and inventors at top research institutions with investors, advisors, and support services so their new ideas could be commercialized. Duane Roth, CEO of Connect, made the following observation:

> I work in the research community every day, and yet when I have to really figure out some complex technology, I will go to Larry or Ramesh because I know that they have their fingers on the campus pulse. They're walking inventories of who's doing what. The other great thing about Calit2 is how they are connected to lots of places around the world where we don't really have contacts. And so to be able to access the faculty's outside connections is hugely important. Calit2 is looked at favorably and has really become, in terms of the business community, the go-to place for looking at big problems."

Looking Back: Factors Contributing to Calit2's Achievements

The Calit2 leadership team attributed the Institute's achievements to several key factors, including its decentralized management style, problem-solving mindset, and the university's support (though not necessarily in that order). Sheehan described Calit2 as "radically decentralized." He expanded, "We can't control what faculty work on, and we don't have authority over their career progression. Faculty work with Calit2 because we offer resources and a multidisciplinary collaboration environment that they don't find in their own departments. We encourage organic growth and we strive to be flexible to meet the needs of the researchers. If we tried to tell faculty what to do, it would never work." Instead, Smarr tended to ask questions that stimulated new thinking. Lev Manovich, professor of visual arts and director of the software studies initiative, recalled, "In 2006, Larry came to me and asked, 'How would you like to create a lab that will attract the best digital media thinkers in the world? What would you need to make this happen?' Larry doesn't start with preconceived notions. He is more likely to make introductions."

Phil Smith, the then co-chair of the Advisory Board and Sides both noted that Smarr knew what questions to ask because of his extensive scientific background and his intellectual curiosity. Smith commented, "Central to Larry's leadership was his long immersion in virtually every discipline of science and many in engineering." Sides added, "I was impressed with the way that Larry did his homework before each meeting. It enabled him to talk with specialists in all disciplines and gain their respect." Advisory board member John Seely Brown noted, "Larry is unique is his ability to listen across chasms within the academy and across the business world, and he never makes anyone feel like a second-class citizen." Smarr also valued his informal interactions with the research teams at Calit2. In fact, he moved his desk three times to be "closer to the action." Smarr explained, "Originally I had a big director's office on the fifth floor, surrounded primarily by administrative spaces. But after a while I felt it was too isolating. So I moved to the sixth floor near some of our projects, and later to the second floor near the music and CISA3 projects. I have many more chance encounters that way."

Smarr was also respected for his optimism and his celebration of incremental steps. Sheehan commented, "Larry's positive approach is critical to the success of Calit2. He realizes that it can take years, even decades, to achieve some of the goals he set for our organization. His ability to celebrate interim milestones has been a critical factor in keeping teams engaged. Although he is willing to be adaptive, he does not get defeated by naysayers. We find that cynics self-select out of the Institute." The Calit2 team members approached their work with a solution-oriented mindset. As Smarr explained, "When we see a problem, we seek a solution. We want to enable researchers and our industry partners to be successful." Likewise, if a Calit2 researcher confronted a research roadblock, Smarr offered assistance.

Although Calit2 was "disruptive by design," Smarr respected the university infrastructure. Calit2 worked closely with other departments, particularly the departments of engineering at both schools. Seible explained, "Calit2 is great for the department of engineering at UCSD. The Institute helps our engineers tackle complicated challenges, and our incentives are structured so that we don't care if funding grants come through Calit2 or our own department. I am happy to do fundraising for Calit2, as nearly 50% of the faculty affiliated with Calit2 are also affiliated with the department of engineering. Anything that helps Calit2 also helps us."

Smarr tried to leverage the university initiatives that complemented the work of Calit2, and managed to "abide by the letter of the law while still doing what he needed to do." He expanded, "We respect the values of UC but we let go of the bureaucracy." This unusual approach within the

highly structured UC system required the support of the three UC Presidents (Atkinson, Dynes, and the current president Mark Yudof), as well as the chancellors at UCSD (Dynes, Fox) and UCI (Cicerone, Drake). Collectively, these university officers helped protect and nurture Calit2 through its first decade. Chancellor Fox explained, they have "trust and confidence" in the Calit2 leadership team and this unwavering support helped the Institute operate in a less structured manner than almost every other unit at the University of California.

Smarr elaborated, "Part of our success relates to the entrepreneurial culture at UCSD. We are one of the youngest top-tier U.S. universities in science and technology. And we are located in the wild west of the UC campuses. It would be hard to create magic if someone was second guessing our decisions every step of the way."

Measuring Success

But just how successful was Calit2? One of the challenges Smarr and his team faced was measuring the impact of the Institute. Given Calit2's broad mandate and many stakeholders, there was an ongoing, very lively debate how best to measure the success of the Institute.

"Hard" Metrics

Not surprisingly, many based their assessments on the more quantifiable metrics such as the number of researchers affiliated with Calit2, the number of industry partners, the number of federal grants, and the amount of money granted to Calit2 from industry and the government. These numbers had exceeded Calit2's initial projections, one sign that the Institute was on a solid trajectory.

To date, Calit2 had attracted over 700 faculty from 24 different departments at the two campuses. These faculty worked with over 250 industrial partners who provided the Institute with over $100 million in funding since 2000. Calit2 received industry support in a variety of forms, including: funding to support research projects; cash gifts and in-kind donations of major equipment, products or services; instructors for classes and seminars; participation in Calit2 federal research grants; and recharge services associated with unique laboratory facilities run by the Institute. (See **Exhibit 12** for Calit2 industrial funding by category from 2001-2006 and **Exhibit 13** for a chart showing top 10 industrial supporters since 2000.)

The industry funding was further supported by over 450 Calit2 affiliated federal grants, many of which were over $1 million. Total federal funding for research exceeded $600 million. These federal grants allowed Calit2 to open up new focus areas, such as homeland security after the 9/11 events. Calit2 researchers across both campuses received over $20 million in grants from the National Science Foundation (NSF) and National Institutes of Health (NIH) for five distinct research projects related to public safety and U.S. homeland security. Rao explained, "Calit2 gives us the opportunity to tackle big problems, and we have received substantial federal grants to support our large-scale research objectives." For three years in a row (2002-2004), principal investigators (PIs) at Calit2 received the largest grants awarded by the National Science Foundation's Information Technology Program, despite stiff competition from long-established labs and universities. The large NSF grants included: $13.5 million over five years for the multi-institutional "OptIPuter grid-networking" project led by Smarr; $12.5 million to a joint UCI-UCSD project, "Responding to Crisis and Unexpected Events," lead by Rao and UCI's Sharad Mehotra; and $3.9 million to the "Laboratory for Ocean Observatory Knowledge Integration Grid," a joint project of Calit2, Scripps Institution of Oceanography, and the University of Washington (with Smarr as the co-PI). Two other sources of funds included grants

from non-profits ($57 million) and international collaborations ($13 million). (See **Exhibit 14** for total Calit2 funding by source.)

"Balancing the Scorecard"

Smarr and his colleagues sought out other measurements of success, as they knew that "hard" metrics alone could not tell the story of Calit2. They were pleased with the attention Calit2 had received from academic peers around the world. He explained, "When our peers from other universities tell us they are excited by what we are doing, that means a lot." Cicerone added, "I was impressed by the number of professors that showed up at Calit2 meetings. One way to measure the success of new initiatives is by the level of faculty engagement."

Li described success in terms of the "buy-in" Calit2 achieved in the academic and industrial communities, as well as among federal agencies. He explained, "Our goal is to disseminate our research and accelerate economic development. We need companies to adopt our research and we want to impact government policies. Our success can be measured through our transformative impact on California and the world." Their "convening power" was a growing asset they were still learning how to leverage.

As a part of the university system, Roth commented that Calit2 fulfilled an important mission:

> I would say that there are three players in the region: industry, government, and the universities. Governments change; we elect new politicians and they go in new and different directions. The industries change --there's constant turnover. The one constant player is the university. And so when there's really a big problem, whether it's national disasters, security issues or any other challenges we have as a nation, who do we go to first? We immediately start getting faculty on the phone to talk about how they can pull us together to address the challenge. You turn to your researchers, because they are the most trusted group – that's because they're enduring.

But as Beckwith explained: "One of our challenges is that it is difficult to calculate a return on investment for the Institutes. We have to ask, 'What are we getting from Calit2 that is qualitatively or quantitatively different than what we would get from faculty in their own departments? What is the added value of having everything under one roof?'"

The Second Decade: The Path Forward

The UC Office of the President conducted a five-year review in 2006 to assess the progress the Institute had made against its original proposal. The review was conducted by a nationally recognized committee composed of leaders with broad experience in managing universities, national laboratories, and large government agencies. In 2008, Smarr asked Smith to conduct a follow-on review with internal constituents. This review had laid the groundwork for the 2009-2011 strategic planning process that was now underway (See **Exhibit 1** for the strategic planning timeline). Smith's interviews with faculty and staff at UCSD and UCI had led to five major recommendations, including the idea to "Create a New Calit2 Vision Plan." Chief of Staff Sheehan drove this New Vision process, using innovative data mining software and calling numerous two-campus meetings. Sheehan described the planning process:

> We gathered data about everything being done at Calit2 over the last several years and met with faculty in multiple stages. We scheduled several 'all-hands meetings' simultaneously

conducted in the Calit2 auditoriums at both UCSD and UCI through videoconferencing. Between these meetings we created topical application working groups that provided faculty and staff a mechanism to have direct input on the plan. The goal was to model our future behavior on what was working, in terms of research areas and applications.

This process had resulted in a document entitled "State of Calit2 2009" which was reviewed and accepted by the Advisory Board and the Executive Committee of the Governing Board. In the document, a new conceptual model for the Institute was articulated to replace the earlier "layer cake" model of the original proposal. Four "application thrusts" for the next decade were identified: health, energy, environment, and culture (see **Exhibit 15**). They represented an extension of the sectors identified in the original proposal, as well as a broader focus on energy. The model also identified four core "enabling technologies" that could support these applications: wireless telecommunications, photonics, nanotechnology and micro-electro-mechanical systems (MEMS), and cyberspace.

The work on the conceptual framework laid the groundwork for the creation of the 2010 strategic planning document entitled "The Path Forward: Application Thrust Strategic Planning Document." The document included a new mission statement: "The mission of Calit2 was to unite faculty, students, and research professionals at UCSD and UCI with private and public sector partners to explore how emerging information technologies and telecommunications can transform areas vital to the state's economy and its citizen's quality of life."

There were some grumblings that the strategic planning process could have been more efficient, but the inclusive approach seemed to have paid off. For instance, Li believed the process played an important role in bringing even more faculty together at UCI. He observed: "The strategic planning process pushed all of us to think about how we could use our research to benefit the application thrusts that had been identified." Each of the application thrusts already had 10 to 20 active projects underway.

Fulfilling the Dream

For Smarr, the strategic planning process had helped the Calit2 community develop a collective view of the Institute's progress to date and the challenges that lay ahead. He was very proud of what they had accomplished, but he was quick to admit that his goals were much grander than what Calit2 had accomplished during the Institute's first decade.

Challenges Ahead

Smarr described his vision: "I want us to make unique, substantial contributions to the over-arching challenges of the 21st century, including healthcare, energy and climate change. We are going to see fundamental changes to our water sources and food supply in California, and we want to help the state navigate through these shifts." Sheehan expanded, "At Calit2, we believe we have a responsibility to give back to the state. We are part of a public university, and we continuously think about the relevancy of our research. We want our research to impact and empower our local community." Although Calit2 had made progress on this front, there was room to do so much more. Given the current economic condition of the state of California, securing funding even for their current operations was becoming a full-time job.

Smarr was relieved that UC system continued to support Calit2's efforts to nurture a collaborative research environment, yet there were still challenges. As UCI Chancellor Michael Drake had commented recently:

> As much as we say we want to do things in a new way, the fall-back is to revert to our traditional patterns of working alone. Collaboration takes energy. We also have to convince our faculty that investing in multi-disciplinary projects is a good use of their time. At research universities such as UCI and UCSD, faculty are rewarded for their individual contributions to their field. Assistant professors are granted tenure for original work that tends to be narrow and focused in one discipline. Then we turn around and encourage these faculty to work with other departments on wide-reaching projects. It's a bit of a leap of faith for them.

In the face of these realities, Smarr was pleased about the healthy number of collaborations among faculty within each of the universities. However, he believed that Calit2 could make the biggest impact by harnessing the collective intellectual capital at both UCI and UCSD; this was turning out to be harder than anticipated. Smarr commented:

> Bob Dynes had a dream about the power of 10 UC campuses coming together. He believed we could field a team of experts for every problem, making us the best university on the planet. The two-campus model has been powerful, but also difficult to manage. It is hard enough to get the organic chemists to talk to the inorganic chemists in the same building. At Calit2, not only are we asking the chemists to work with the physicists, but we are also asking them to work across 100 miles. One of my biggest roles at Calit2 is reducing barriers to collaboration, and the distance between the two campuses is a big barrier. We have every form of technology in place to connect our two schools, and we are learning what it means to live in a mixed physical-virtual world.

As Smarr reread the introduction to "The Path Forward," he continued to reflect on recent conversations with his team and the Calit2 boards. Once again, he found himself wondering about the sustainability of Calit2 and recalled a conversation from the previous Advisory Board meeting:

> Our Advisory Board asked me, "What do you need to do now so there is a Calit2 50 years from now, and it's just as vibrant and important for the future of California as it is today?" It's a tough question. Initially the proposal pulled people together, and then the architectural design, and then the strategic plan. How do I keep everyone engaged? How do I keep the magic? Calit2 has been so wonderfully productive, but it feels so institutionally fragile.

Atkinson reflected, "Calit2's biggest challenge will be transforming itself from an experiment into an enduring part of the two campuses and the University of California as a whole. But great institutions continue to thrive after their founders depart. Calit2's track record and momentum will make it attractive for Larry's successors to continue the institution." Smarr sure hoped Atkinson was right.

Exhibit 1 Strategic Planning Timeline

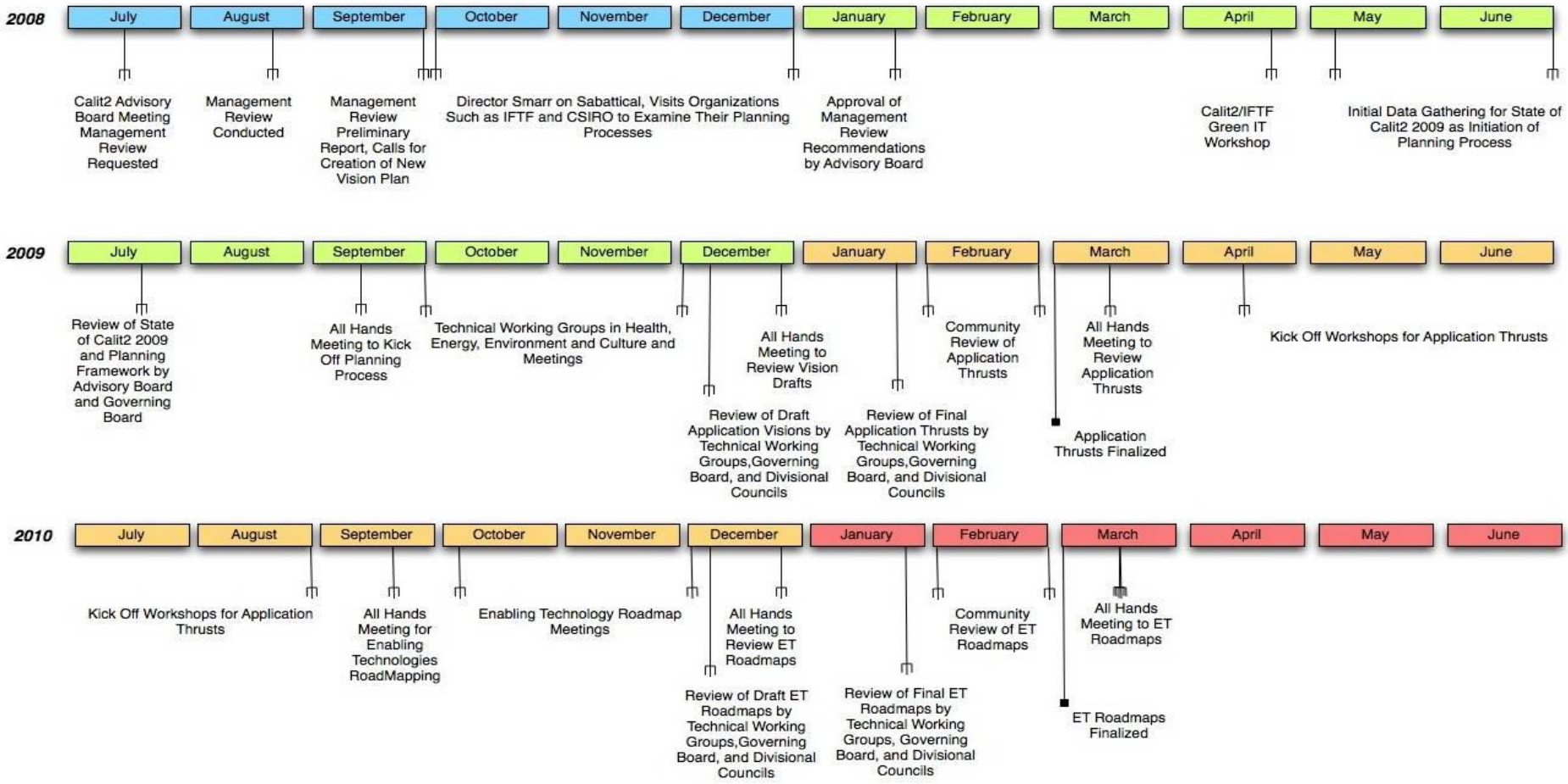


Exhibit 2 Summary of the UC Institutes

QB3: California Institute for Quantitative Biosciences

Lead campus: UC San Francisco; Cooperating campuses: UC Berkeley and UC Santa Cruz

The institute builds on strengths in the engineering and physical sciences at UC Berkeley, the mathematical sciences at UC Santa Cruz and the medical sciences at UC San Francisco, as well as on strong biology programs at the three campuses. In addition to the creation of fundamental new knowledge and potent new technologies, a major goal of the Institute is to train a new generation of students able to fully integrate the quantitative sciences with biomedical research. The institute involves more than 180 scientists housed in a new building at Mission Bay in San Francisco, a new building at UC Berkeley and two new facilities at UC Santa Cruz.

Calit2: California Institute for Telecommunications and Information Technology

Lead campus: UC San Diego; Cooperating campus: UC Irvine

The California Institute for Telecommunications and Information Technology will team UC San Diego and UC Irvine faculty, students and research professionals with leading California companies to develop the scientific and technological components required to create a new Internet. It will focus on gathering critical data and making it easily available for interpretation. The organization of the institute is farsighted: it will not be a loose collection of faculty research projects, but a well-considered strategic plan to conduct an interdisciplinary, integrated study of the impact of the new Internet telecommunications infrastructure on California. Institute scientists will "live in the future" as they create revolutionary advances in applications important to California's economy: environmental and civil infrastructure assessment, transportation, healthcare, artistic expression, e-commerce, and education.

CITRIS: Center for Information Technology Research in the Interest of Society

Lead campus: UC Berkeley
Cooperating campuses: UC Santa Cruz, UC Davis and UC Merced

The Berkeley-based Center for Information Technology Research in the Interest of Society will be the first to create and harness information technology to tackle society's most critical needs: energy, transportation, seismic safety, education, healthcare, farming, and the environment. The technology developed by CITRIS may create opportunities to: save as much as $8 billion in California's energy costs and 5 million metric tons of carbon each year; optimize traffic to conserve 37.5 million gallons of fuel annually; create an emergency lifeline network to save lives and minimize structural damage; serve more of California's students through distance learning and the delivery of undergraduate curriculum to UC Merced; monitor healthcare with state of the art devices; prevent environmental damage and develop more efficient farming.

CNSI: California Nanosystems Institute

Lead campus: UCLA
Cooperating campus: UC Santa Barbara

The California NanoSystems Institute, a research enterprise based on the idea of exploiting the realm of the very, very small, is creating new ways to manufacture products, advance information technology and transform the practice of medicine. The California NanoSystems Institute will explore the power and potential of manipulating structures atom-by-atom to engineer new materials, devices and systems that will revolutionize virtually every aspect of our quality of life, including medical delivery and health care, information technologies, and innovations for the environment.

Source: University of California, http://www.ucop.edu/california-institutes/about/cnsi.htm, accessed June 11, 2010.

Exhibit 3 Management Biographies

Larry Smarr, *Director, Professor, Computer Science and Engineering, Jacobs School of Engineering, UCSD*. Larry Smarr was the founding Director of the California Institute for Telecommunications and Information Technology (Calit2), a UC San Diego/UC Irvine partnership, and holds the Harry E. Gruber professorship in Computer Science and Engineering (CSE) at UCSD's Jacobs School. At Calit2, Smarr drove major developments in information infrastructure – including the Internet, Web, scientific visualization, virtual reality, and global telepresence – begun during his previous 15 years as founding Director of the National Center for Supercomputing Applications (NCSA). Smarr served as principal investigator on NSF's OptIPuter project and currently is principal investigator of the Moore Foundation's CAMERA project and co-principal investigator on NSF's GreenLight project. In October 2008, he was the Leadership Dialog Scholar in Australia.

Ron Graham, *Chief Scientist*, *Professor, Computer Science and Engineering, Jacobs School of Engineering, UCSD*. Ronald Graham held the Irwin and Joan Jacobs Endowed Chair in Computer and Information Science and was Chief Scientist of the California Institute for Telecommunications and Information Technology. He joined the UCSD faculty in 1999, after a 37-year career with AT&T. Graham received his Ph.D. in mathematics from U.C. Berkeley in 1962. From 1962-95, he was director of information sciences at AT&T Bell Labs, and from 1996-99 Chief Scientist of AT&T Labs. Graham has held visiting professorships at Rutgers, Princeton, Caltech, Stanford, UCLA, and U.C. Davis, and he holds six honorary doctorates. Graham served for 12 years as Treasurer of the National Academy of Sciences, and is a Fellow of Amer. Academy of Arts and Sciences, a past President of the American Mathematical Society, and a past President of the Mathematical Association of America. He has won numerous awards in the field of mathematics, including the Polya Prize in Combinatorics and the Leroy Steele Lifetime Achievement Award of the American Mathematical Society.

Ramesh Rao, *Director, UCSD Division, Calit2*. He held the QUALCOMM Endowed Chair in Telecommunications and Information Technologies in the department of Electrical and Computer Engineering at UCSD, where he had been a faculty member since 1984. He has led several major interdisciplinary and collaborative projects at Calit2 and has authored more than 225 technical papers. For his leadership in wireless communications, Prof. Rao was named an IEEE Fellow. He has twice been a member of the Board of Governors of the IEEE Information Theory Society. He is a Senior Fellow of the California Council on Science and Technology (CCST). He participated in many technical, academic and industry organizations, boards, and councils. He earned his Ph.D. and M.S. in electrical engineering from the University of Maryland, College Park, MD.

G.P. Li, *Director, UCI Division, Calit2.* Professor, University of California, Irvine, with appointments in: Electrical Engineering and Computer Science, Chemical Engineering and Materials Science, and Biomedical Engineering. He also serves as Director of UCI's Integrated Nanosystems Research Facility. He holds 18 US patents and has published over 280 research papers involving microelectronic technologies, microwave circuit design, Micro ElectroMechanical System (MEMS) for communication and biomedical instrumentation applications, and Bio-nano-IT technology He has been involved in several start-up companies as a cofounder or member of the technical advisory board. He currently directs TechPortal, a business incubator at UCI, to support university researchers commercializing their R&D and to effectively nurture young companies in a number of ways. His current research interests focus on developing technologies for efficient energy utilization and consumption, and LifeChips e-health: representing fusion of two large, important industries: Life Sciences (including biotech and biomedical devices) and IT (including consumer, computing, and communication) microelectronics (chips).

Jerry Sheehan, Chief of Staff, Calit2. Mr. Sheehan was responsible for strategic initiatives and research analytics for Calit2. During his career Jerry has focused on the intersection of public policy and information technology with a particular interest in applying academic innovation to "real world" problems. In addition to his executive management responsibilities, Jerry served as Senior Personnel on the National Science Foundation's GreenLight Project, a major research instrument effort focused on improving computer energy efficiency. Sheehan served as a member of the California Emerging Technology Fund Panel of Experts and as staff has supported the work of Governor Schwarzenegger's California Broadband Task Force and President Clinton's Information Technology Advisory Committee on Open Source Software for High Performance Computing. He received a Masters of Science degree in Political Science from Eastern Illinois University in 1991 and is a member of the American Association for the Advancement of Science (AAAS), the Institute of Electronics and Electrical Engineers (IEEE), and Educause.

Source: Calit2.

Exhibit 4a The "Layer Cake" Diagram

Source: Proposal for Calit2, Section D, "Research Plan," page 77, October 2000.

Exhibit 4b List of the Layer Leaders at Calit2 and Numbers of Participating Faculty in 2000

	Layer Leaders		*Additional Faculty*	
Layer	**UCSD**	**UCI**	**UCSD**	**UCI**
Materials and Devices	Ivan Schuller	G. P. Li	21	19
Networked Infrastructure	Paul Siegel	Magda El Zarki	22	11
Interfaces and Software Systems	Francine Berman	Daniel Gajski	21	17
Environment and Civil Infrastructure	William Hodgkiss	Maria Feng	17	10
Intelligent Transportation	Mohan Trivedi	Will Recker	8	13
Digitally Enabled Genomic Medicine	John Wooley	Pierre Baldi	13	10
New Media Art	Sheldon Brown	Al Terricciano	11	5
Policy, Management, and Socioeconomic Evolution	Peter Cowhey	Vijay Gurbaxani	6	6
Education	Gabriele Wienhausen	Robert Beck	8	3

Source: Calit2 internal document.

Exhibit 5 Overview of UCSD Calit2 Building and Dedication Ceremony

Excerpts from "Scenes from the Calit2@UCSD Building Dedication (Part II)"

San Diego, CA, November 18, 2005 -- The state of the art Calit2@UCSD building - named Atkinson Hall - was officially opened Friday, October 28. The all-day dedication event included more than 150 scientific research and art exhibits and demonstrations, representing nearly two dozen disciplinary areas. The dedication ceremonies kicked off the day with welcoming remarks from Ramesh Rao, Director of Calit2's UCSD Division. Celebratory remarks from university officials and keynote speaker, Paul Jacobs, CEO of QUALCOMM, and a few surprise announcements, followed. For those who were unable to attend the ceremony, streaming video of the dedication ceremony is now available for on-demand viewing from the Calit2 Multimedia archive.

The flowing music and the gathering people in the engineering courtyard set the tone for the festivities, and for the building itself: engineering, technology, art, science, culture and people woven together to begin the future. Music for Courtyard (2005), a sonic installation of synthetic and digitally produced sounds, was customized for the engineering courtyard and 'wormhole' pedestrian tunnel leading to the Calit2 entrance. The piece created a sonic environment of spatialized sound, filling and enhancing the public open space to portray the poetry and precision of mechanized processes. Based on custom algorithms written by Shahrokh Yadegari, UCSD Theater and Dance faculty, the piece was mixed real-time using sound layering and electronic audio techniques. Sound bytes were gathered from the flow of traffic and courtyard activity with digital filters and non-linear dynamics to create an evolving sound ambience. Three different layers of sounds were spatialized in the courtyard throughout the event. The synthesis process is based on principles found in non-linear dynamics whose parameters are controlled live during the processions of the event.

This new state of the art facility is also layered. Reconfigurable spaces allow for and encourage collaborations of all kinds, which can be rethought and redefined as needed. The clean room and materials characterization lab are located on the first floor with the new media arts facilities, auditorium and visualization laboratory. This design is intended to disrupt traditional boundaries and encourage new forms of collaboration between scientists and digital artists and musicians.

The multidisciplinary agenda is reflected in these shared facilities, which include clean rooms for nanofabrication, digital theaters for new media arts and scientific visualization, test and measurement labs for circuit design, smart spaces for experiments in augmented reality, testbeds for wireless and optical communications, and much more. At full capacity, Atkinson Hall will house 900 researchers, artists, engineers, students and staff, representing more than 20 departments across the campus.

Exploration of the six story, 215,000 square feet facility and the exhibits gave a sampling of what the future might bring. One wing of the first floor is devoted to the clean rooms, which provide the cleanest lab environment available on any U.S. campus. Class 100 Clean Room Modules (areas with no more than 100 particles larger than 0.5 microns per cubic foot of air) will be used for nano- and microlithography (e-beam lithography and photolithography modules). Class 1000 (1000 particles no larger than 0.5 microns per cubic foot of air) have facilities for metallization/thin film deposition, advanced dry etching, metrology, thermal and back-end processes, used in nano- and microfabrication. One micron (or micrometer) is approximately 1/25,000 of an inch, or one millionth of a meter. One nanometer is one billionth of a meter.

The hallway of the clean room wing served as "Nanotechnology Row" for the day, with several graduate students presenting their current work. Outside one of the clean rooms, Forest Bohrer, a graduate student in the Department of Chemistry and Biochemistry, presented "Fabrication and Chemical Sensitivity of Metallophthalocyanine ChemFETs." He expects that the clean rooms will be of great help, enabling a faster and higher yield once he has a stable, working, prototype. Reflecting the interdisciplinary core of the facility, Bohrer is a member of the AFOSR MURI Nanostructured Supersensors Group, which is comprised of faculty and student researchers from various fields, including Chemistry, Physical Chemistry, Physics, Mathematics and Electrical Engineering. He is enjoying exposure to fields that he would not have otherwise had the opportunity to learn. -- *Fabrication and Chemical Sensitivity of Metallophthalocyanine ChemFETs: Forest Bohrer, Cornel Colesniuc, Bernd Fruhberger, Andrew C. Kummel, Karla Miller, Jeongwon Park, Ivan K. Schuller, Amos Sharoni, William C. Trogler, and Richard Yang.*

Another wing of the first floor is devoted to New Media Arts, providing state-of-the-art facilities for audio, video and interactive art research, including a motion-capture studio, audio spatialization lab, and virtual reality space to prototype technologies. In addition to developing and extending media arts and entertainment applications, scientists benefit from advances in the art and science of visualization because of its power to reveal data in different ways, spatially and visually. Increased resolution results in greater ability to look closely at data and begin to unravel and understand the information contained in it.

The big auditorium is the home of the 4K Digital Cinema, a 200-seat theater with the world's highest-resolution projector, four times the resolution of high-definition (in partnership with Sony). The auditorium also has 3D sound, stereo imaging and telepresence conferencing capabilities. Invited attendees were treated to a sneak preview of "When Things Get Small," a documentary on nanomagnetism. The film was made by UCSD physicist Ivan Schuller and UCSD-TV science producer Rich Wargo in collaboration with Not Too Serious Labs. It received a very positive response from the audience, and lived up to its billing as an irreverent, madcap, comically corny romp into the quest to create the smallest magnet ever known. The film took three years to create. The goal was to make science more accessible, as well as fun, and to convey a sense of the scale of this research. The auditorium was designed to show films such as this; Calit2 Director Larry Smarr told the audience that he was thrilled to have it as part of the building dedication events. The world premiere of the documentary will be on UCSD-TV, November 30 at 8 p.m. After which, it will be distributed for viewing in community schools. For more information, please see their UCSD-TV web site.

The Calit2 'Cave' is a 360-degree multi-screen, multi-user total immersion environment with access to large database visualization servers. Artist Todd Margolis presented his work, "Special Treatment," an immersive and interactive Virtual Reality installation which examines the strength and persistence of memory. It is a chilling ride by train car which deposits viewers in a sparsely populated concentration camp, which was pieced together from plans, photographs and other artifacts from Auschwitz II/Birkenau, Poland. Viewers become visitors as they explore the camp and architectural structures, listening in on conversations and other pieces of the past, as they fade in and out of perception. The experience of the viewers is driven by the one person who is attached to the installation and interacting with it. They get the best perspective, their choices and experience determine the experience of everyone else. In addition to the immersive technology, the piece takes advantage of 3D technology. Next door to the 'Cave,' the 'Black Box' Theater is a two story, reconfigurable performance space, intended for multiple purposes, including experiments on an audience's relationship to the physical environment and mediated elements.

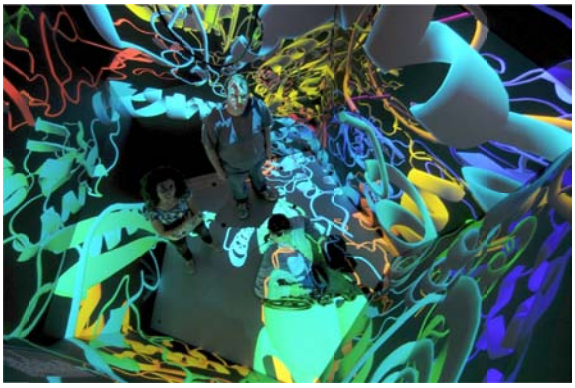
There were several exhibits about the work of Serge Belongie (faculty, Department of Computer Science and Engineering) and his Vision Lab on Recognizing Cars. The research group consists of faculty, graduate and undergraduate students. They have designed a car recognition system (embedded platform) for surveillance purposes, which, given low-resolution video data as input is able to maintain a database of the license plate and make and model information of all cars observed. It has a 90% accuracy rate, if the make/model are in the database. In addition to their 90% accuracy rate, their emphasis on using low cost hardware, and on not bundling their system with expensive, unnecessary hardware, makes them a very affordable choice for cities. Their system can be deployed over a cities' existing infrastructure. What is the future for this technology (other than driving tickets)? In addition to pursuing other classes of objects (for example, recognition of help in everyday life), there is some consideration of using it in robotic platforms. -- *Video-Based Car Surveillance: License Plate, Make, and Model Recognition, Serge Belongie, Louka Dlagnekov, Kevin King, and Stephan Steinbach.*

An interactive multimedia performance provided the finale of the dedication ceremonies. A special preview performance of SPECFLIC Version 1.0 was played in the courtyard. By way of introduction, master of ceremonies Rao said "SPECFLIC is a story that is not just told, but experienced." In response to instructions from SPECFLIC: "Please turn on your cell phones" - a phrase not often heard these days, attendees began dialing to formally open the institute's doors. When 'critical mass' was achieved, the building was unveiled amid banners, balloons, and glitter swirling above the courtyard.

Source: Calit2 article from 11/8/2005 - http://www.calit2.net/newsroom/article.php?id=744], accessed June 4, 2010.

Exhibit 6 Calit2 Advanced Visualization Facilities

StarCAVE: Images of Proteins Projected in 3D

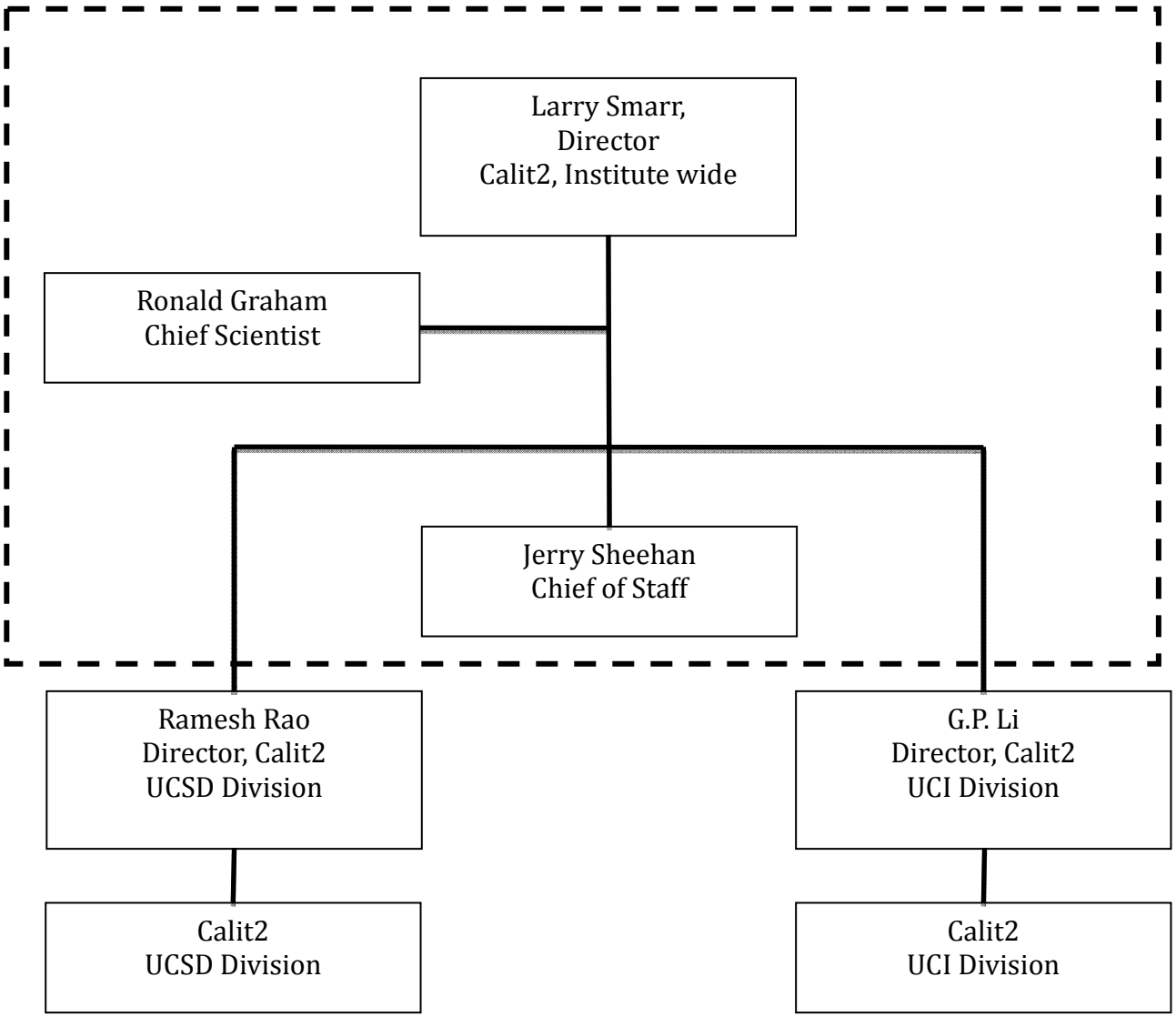


Source: Calit2 and http://ucsdnews.ucsd.edu/newsrel/general/09-083DVirtualReality.asp, accessed June 4, 2010.

Larry Smarr looking at satellite and remote video images of 2007 San Diego Wildfires on HiPerSpace

Source: Larry Smarr.

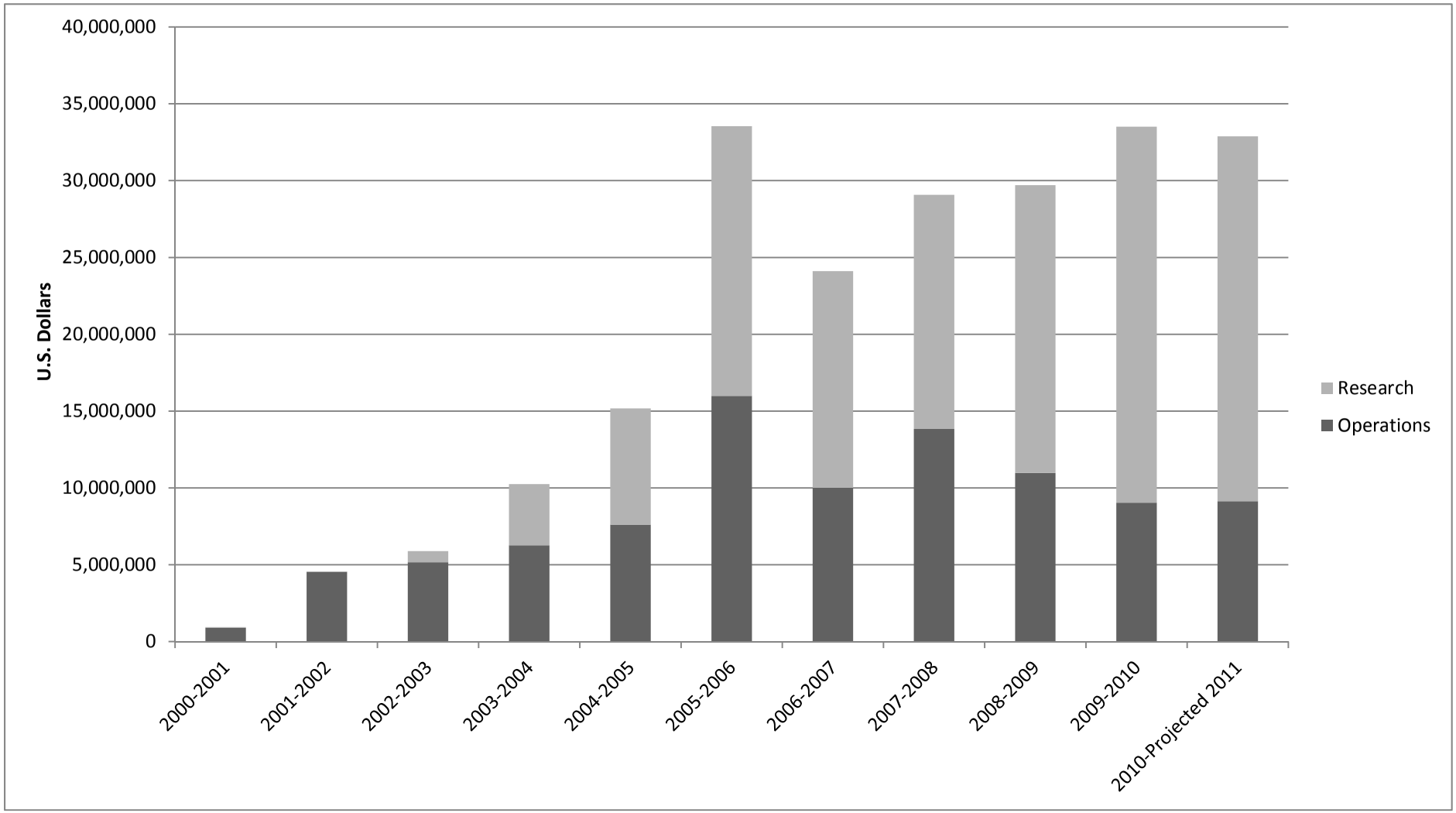
Exhibit 7 Organizational Chart for Calit2 after 2008



Source: Calit2.

Note: The dotted box indicates the unified director's office.

Exhibit 8 Calit2 Research and Operations Budget for the Past 10 Years including Proposed Budget for 2011



Source: Calit2 documents.

Note: These expenditures are a combination of operational funding, sponsored research (industry, federal, not for profit) and uses of gift funds.

Exhibit 9 Calit2 Advisory Board Members

Co-chair Phil Smith is one of the most senior science and technology policy experts in the nation, having been Executive Director of the National Research Council for 13 years and having served in every presidential administration from Eisenhower's to Clinton's.
Co-chair Anne Petersen served as Deputy Director of the National Science Foundation, was formerly Senior VP for Programs at the WK Kellogg Foundation; Founder and President of the Global Philanthropy Alliance; Deputy Director, Center for Advanced Study in the Behavioral Sciences, Stanford University
Mark Anderson, Chief Executive Officer, Strategic News Service
Vinton G. Cerf, Vice President and Chief Internet Evangelist, Google
Robert W Conn, President, The Kavli Foundation
Deborach Estrin, Professor of Computer Science & Director of Center for Embedded Network Systems, University of California, Los Angeles
Raouf Y. Halim, Chief Executive Officer, Mindspeed Technologies, Inc.
Dennis Lettenmaier, Professor of Civil and Environmental Engineering, University of Washington
Roberto Padovani, Executive Vice President and Chief Technology Officer, QUALCOMM
Duane Roth, Chief Executive Officer, CONNECT
Stanton Rowe, Corporate Vice President for Advanced Technology, Edwards Lifesciences
David Schramm, President and Chief Executive Officer, Maxwell Technologies
Drew Senyei, Managing Director of Enterprise Partners
Kathi Vian, Director-Ten Year Forecast, Institute for the Future
Andrew Viterbi, President, The Viterbi Group, Professor Emeritus, University of California, San Diego
Warren Washington, Senior Scientist at the National Center for Atmospheric Research
Telle Whitney, President and CEO, Anita Borg Institute

Emeritus members:

Forest Baskett is a venture partner in New Enterprise Associates and distinguished computer scientist at Stanford University when Sun Microsystems, MIPS, and SGI spun off, and he served for more than 10 years as CTO for SGI.
Don Beall, Former President , Chairman, CEO of Rockwell.
John Seely Brown, Independent Co-Chairman of the Deloitte Center of Edge Innovation
Bob Lucky, Former AT&T Bell Labs, Executive Director of Communications Services Research Division, and Corporate Vice President, Telecordia
Joseph Sussman, Professor of Engineering Systems and Civil and Environmental Engineering, Massachusetts Institute of Technology

Source: http://www.calit2.net/people/advisory.php, accessed June 4, 2010.

Exhibit 10 Calit2 Divisional Council Members

Council members were chosen based on the quality and diversity of their multidisciplinary research activities as well as their engagement with Calit2 during its start-up years.

UCSD Divisional Council
Ramesh Rao, Chair
Barbara Sawrey, Co-chair, Chemistry and Biochemistry
Dimitri Bassov, Chemistry and Biochemistry
Amin Vahdat, Computer Science and Engineering
Tom DeFanti, Calit2 researcher, networking and visualization
Mark Ellisman, Bioengineering and School of Medicine
Shaya Fainman, Electrical and Computer Engineering
Ross Frank, Ethnic Studies
Terry Gaasterland , Scripps Institution of Oceanography
Rajesh Gupta, Computer Science and Engineering
Jim Hollan, Cognitive Science
Trey Ideker, Bioengineering
Adriene Jenik, Visual Arts
Ingolf Krueger, Computer Science and Engineering
Larry Larson, Electrical and Computer Engineering
Yu-Hwa Lo, Electrical and Computer Engineering
Lev Manovich, Visual Arts
Alon Orlitsky, Electrical and Computer Engineering
Phil Papadopoulos, San Diego Supercomputer Center
Pavel Pevzner, Computer Science and Engineering
Rand Steiger , Music
Jan Talbot , Mechanical and Aerospace Engineering
Bill Trogler, Chemistry and Biochemistry
Frank Vernon, Scripps Institution of Oceanography

UCI Divisional Council
Aditi Majumder, Computer Science
John Crawford, Arts-Dance
Vijay Gurbaxani, Paul Merage School of Business
Crista Lopes, Informatics
Bill Tomlinson, Informatics
David Reinkensmeyer, Anatomy & Neurobiology
Ramesh Jain, Computer Science
Sharad Mehrotra, Computer Sciences
Bill Tang, Biomedical Engineering
R. Jayakrishnan, Civil & Environmental Engineering
Soroosh Sorooshian, Civil & Environmental Engineering
Phil Collins, Physics and Astronomy
Goran Matijasevic, CEO Roundtable
Amelia Regan, Computer Science
Carter Butts, Sociology
David Goldberg, Comparative Literature/UCHRI
Bruce Tromberg, Beckman Laser/ school of Medicine
Shaul Mukamel, Chemistry
Reg Penner, Chemistry
Martha Feldman, Planning, Policy & Design
Richard Matthew, Planning, Policy & Design
Kristen Monroe, Political Science
Paul Dourish, Informatics

Source: http://www.calit2.net/people/council.php, accessed June 4, 2010.

Exhibit 11 Examples of Research Projects at Calit2 in 2010

Overview of Calit2 Wildfire Initiative

Wildfires in Southern California (SoCal) can be devastating when driven by Santa Anna winds reaching speeds up to 100 miles per hour. In October 2007, these conditions conspired in San Diego County to create one of the largest wildfires in California's history, resulting in the largest fire evacuation in American history (500,000 citizens).

Since 2003, Calit2 had worked with emergency first responders under three federal grants. The first was from the Information Technology Research (ITR) program funded by the National Science Foundation (NSF) entitled Responding to Crisis and Unexpected Events (RESCUE, www.itr-rescue.org/). Further NSF investment was made at UC San Diego and UC Irvine to create instrumented testbeds for emergency response via the Responsphere program (www.responsphere.org/). In addition to information technology for crisis response, Calit2 has worked with the National Institute of Health through the Wireless Internet Information Systems for Medical Response in Disaster (WIISARD, www.wiisard.org/) project to develop next generation IT systems for dealing with intelligent triage of patients in mass casualty events, including clinical trials involving drill conducted with local first responders. First responders provided invaluable input on technology needs for crisis response and evaluated technical prototypes developed by the Institute as part of these collaborations.

Leveraging these three federally-funded research projects, Calit2 worked closely with San Diego's emergency response community and others to lend support as they managed the crisis. One of the first essential elements in the response was providing actionable data on the fire. San Diego State University's Web Fire Mapping Service (http://map.sdsu.edu/) was providing valuable Geographic Information Systems data on fire propagation, but their local campus infrastructure was being overwhelmed due to community interest. Calit2 used a recently installed optical fiber connecting Calit2 with SDSU to transition their data to a more robust Calit2 platform at the University of California San Diego, which could accommodate the load due to larger data storage and network access. In parallel to these efforts, Calit2 Director Larry Smarr was personally engaged with researchers at NASA Goddard to get satellite MODIS imaging processing of the fire area made an urgent priority. These images showed the many simultaneous fires across Southern California. With this detailed location data, NASA was able to aim its high resolution EO-1 satellite at individual fires which, using multi-spectral imaging, showed propagation of the fire through smoke obscuring direct visual observation. All of these images were transmitted to the San Diego County Emergency Operations Center to help guide firefighting efforts. Calit2 also collaborated with the San Diego Supercomputing Center's High Performance Wireless Research and Education Network (HPWREN), which has a ubiquitous wireless network including environmental sensors and cameras input to create real-time mashups that allowed first responders and the community to remotely monitor the event.

After the crisis, Calit2 called together the San Diego County Supervisor Ron Roberts, County Fire Chief William Metcalf, and Director of the County Office of Emergency Services Ron Lane under the auspices of the Future in Review Conference (FiRe) to discuss lessons learned from the crisis with corporate Chief Information Officers from some of America's leading information technology corporations. The high point of this conversation was the Fire Chief Technology Officer Challenge which bridged together the "lessons learned" from the public sector with a discussion by CTOs of potential technological innovation needed for better wildfire response.

GreenLight Project

The NSF-funded GreenLight Instrument (Principle Investigator Calit2's Tom DeFanti) marked a significant milestone in the effort to "green" modern campus cyberinfrastructure. Campus networks, which enabled computational and data-intensive approaches to research, typically were housed in ad hoc and sub-optimal energy environments in departmental facilities. As the amount of energy usage per computer rack increased, these computing clusters required more sophisticated and energy efficient cooling and power mitigation. Development of GreenLight Instrument enabled communities of application scientists — drawn from metagenomics, ocean observing, microscopy, bioinformatics, and the digital media — to better understand how to measure and minimize computational energy consumption by leveraging UCSD's innovative energy/cooling sources and employing middleware that automates and optimizes compute/power strategies.

Using OptIPuter and Quartzite methods developed under earlier NSF awards, cumbersome computing clusters were relocated to pre-fabricated campus "machine rooms," where they were remotely monitored for energy efficiency via the GreenLight Instrument GLIMPSE measurement system (http://glimpse.calit.net). GreenLight provided, via service-oriented architecture methodology, real-time sensor outputs that allowed researchers to study the energy cost of at-scale scientific computing from anywhere in the world.

GreenLight enabled researchers to make deep and quantitative explorations in advanced computer architectures, including alternative circuit fabrics, direct-graph execution machines, graphics processors, solid-state disks, and photonic networking. The resulting quantitative data allowed engineers to compare "computational work per watt" across full-scale applications running on at-scale computing platforms and transform systems engineering for green cyberinfrastructure.

King Abdullah University of Science and Technology

King Abdullah University of Science and Technology (KAUST) and the University of California, San Diego developed a special partnership in 2008 to collaborate on world-class visualization and virtual reality research and training activities. KAUST, located near the Red Sea in the Kingdom of Saudi Arabia, was inaugurated in September 2009 as an international, graduate-level research university dedicated to catalyzing a new age of scientific achievement in the Kingdom, the region, and the wider world. The campus featured world-class facilities and programs funded by a $10 billion endowment from King Abdullah Bin Abdulaziz Al Saud, the current ruler of Saudi Arabia. The goal of the new university, stated King Abdullah, was to become "the world's great institution of research; that it educate and train future generations of scientists, engineers and technologists; and that it foster, on the basis of merit and excellence, collaboration and cooperation with other great research universities and the private sector. The University shall have all the resources that it needs to pursue these goals."

Under a four-year agreement with KAUST, the UC San Diego division of Calit2 provided expertise in visualization, virtual-reality and collaboration tools to support KAUST's ambitious plan to deploy state-of-the-art technologies for scientific research. The technologies allowed materials scientists, biomedical researchers, electrical engineers and other researchers to speed development of new technologies. The partnership has enabled collaboration between researchers at KAUST and UC San Diego, using visualization facilities linked via global high-speed optical fiber networking. A 10-person team from Calit2 and the Electronic Visualization Laboratory (EVL) at the University of Illinois, Chicago, spent nearly two months in Saudi Arabia working with the KAUST visualization team as the facilities were constructed. Many of the display systems for the Visualization Laboratory Showcase at KAUST were developed and fully prototyped in the KAUST-funded VirtuLab at the Calit2 UC San Diego campus. One project was the development of a virtual environment for the visual exploration of Saudi Arabia, to provide interactive tools for the examination of 3D geological structures and dynamic seismic processes as well as atmospheric processes. The KAUST facilities included the region's fastest supercomputer, Shaheen, as well as some of the world's most advanced facilities for visualization.

"KAUST and Calit2 share a common interest in using new technology to tear down the traditional walls between scientists, disciplines and even countries," said Ramesh Rao, director of the UCSD division of Calit2 and a professor of electrical and computer engineering in UCSD's Jacobs School of Engineering. "Effective research involves visualizing huge data sets and collaborating on solutions in real time with colleagues who may be down the hall or around the world. Calit2 has made a substantial investment in visualization and collaborative tools, and we are delighted that KAUST has targeted this area as a critical building block and selected UCSD as a partner in this endeavor."

Center for Interdisciplinary Science for Art, Architecture, and Archaeology

One researcher who found a home at Calit2 and CISA3 was Albert Yu-Min Lin. After earning a Ph.D. in material science in 2008 from the Jacobs School of Engineering, Lin conceived of a seemingly impossible dream – to discover the lost burial site of Genghis Khan. Initially, Calit2 provided Lin with a space to work and infrastructural resources (non-salary support). Later, Lin was provided partial so-called "bridge" support to insulate the impact of inconsistencies in grant funding. Lin reflected that Calit2 offered a "series of infrastructure, specifically technologies that allow the amplification of your ideas very quickly, particularly in the beginning, which is the most difficult time. This incubator leveraged a strong internal communications team to further drive the application of the project by developing outside attention and support."

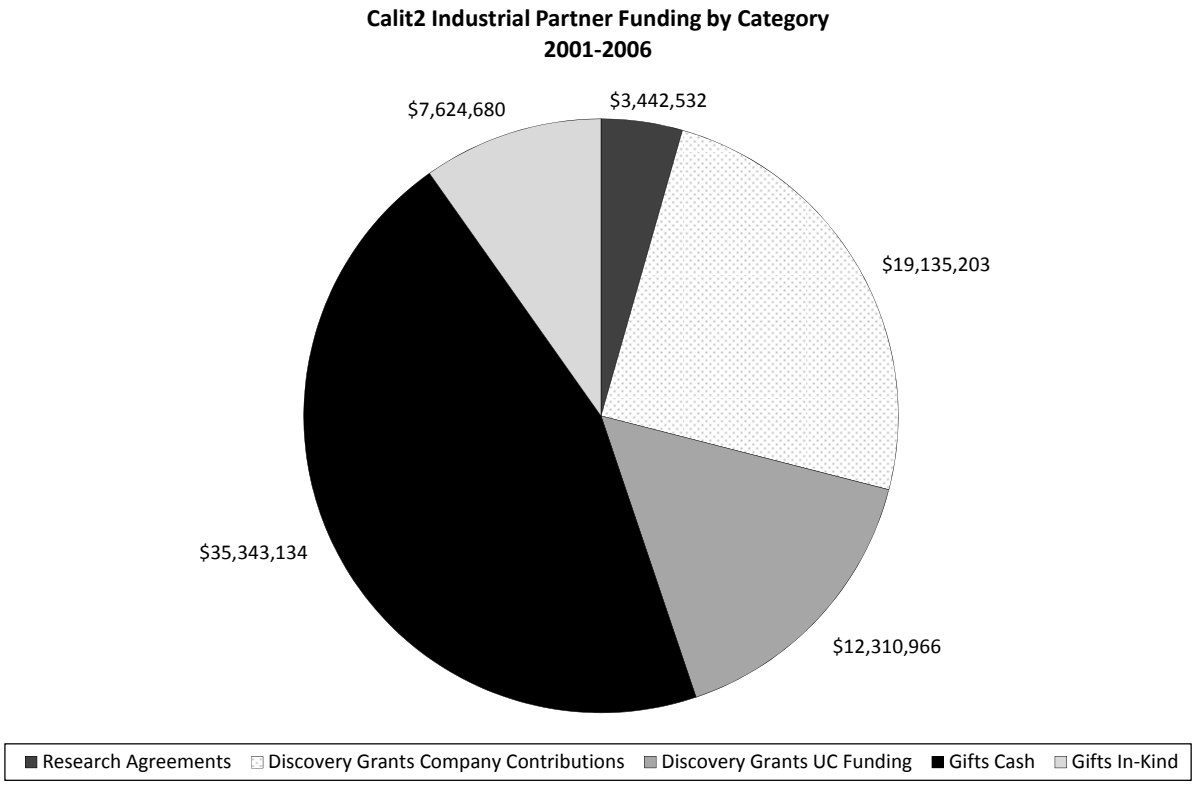
With some friends, Lin built a website for his Valley of the Khans Project and successfully garnered public interest in the project. After learning about Lin's work, the head of the GeoEye Foundation (non-profit organization established in 2007 to help train people to map, monitor, and measure the earth) offered to provide high-resolution satellite imagery that would allow the team to search for signs of archaeological remains. Lin and his team decided to develop a "crowdsourcing" platform to locate potential archaeological dig sites. In 2010, with the help of National Geographic Digital Media, they launched an online platform "Field Expedition: Mongolia" that encouraged participation from the public to search for the lost tomb of Khan. Using the satellite imagery from the GeoEye Foundation, people could analyze real-time data and maps direct from the field to mark anomalies that might be ancient ruins. Lin elaborated: "Our idea was that we would leverage this collective consciousness, this understanding that people as a whole could know what was ancient and what looked weird. As a computer algorithm we wouldn't be able to approach that problem so adaptively to any kind of image…. A problem can be distributed and useful information can be aggregated from very simple task-driven support from pretty much anybody. They don't have to be well trained. In fact, that's the thing that is a driver in public participation, there's elements in the human experience that we all have and take for granted and yet are still extremely complicated."

Since the website launched, more than 6,000 taggers have categorized more than a million points of interest. Lin has been on three expeditions to Mongolia, including the so-called "forbidden precinct," that has been undisturbed except by local healers for centuries. During the expeditions, researchers provided blog updates and reports from the field that allowed thousands of online participants to virtually experience the expeditions. "Overwhelmingly we found this be completely successful. We went to a bunch of different sites that the crowd had picked out and they were more than half of the time absolutely right, and the rest of the time there was something there but it wasn't ancient." Using cutting-edge non-invasive tools like satellite imagery, ground-penetrating radar, and remote sensors, Lin and his team were able to make archaeological discoveries while respecting the traditional beliefs of indigenous people.

In May of 2010, Lin became the founding director of a National Geographic Society-sponsored and CISA3-managed Engineers for Exploration program meant to provide graduate and undergraduate students hands-on experience in developing new remote imaging software and hardware for explorers.

Source: Calit2, public sources.

Exhibit 12 Calit2 Funds Received from Industry by Funding Category



Source: Calit2 Five Year Report, page 35, 2006.

Exhibit 13 Calit2 - Top 10 Industrial Partners Measured by Fiscal Support

	Company Name	HQ Location	Industry	Mkt Cap*
1	Qualcomm	San Diego, CA	Communications Equipment	$58.6 B
2	Ericsson	Stockholm, Sweden	Communications Equipment	$37.3 B
3	Boeing	Chicago, IL	Aerospace and Defense	$51.0 B
4	CODA Genomics	Laguna Hills, CA	Biotechnology	private
5	Intelsis			
6	Microsoft	Redmond, WA	Software	$231 B
7	Volkswagen	Wolfsburg, Germany	Automotive	$33.6 B
8	Unilever	London, UK	Food Processing	$80.9 B
9	Samsung	Korea, US	Electronics	private
10	Intel	Santa Clara, CA	Semiconductors	$119.8 B

*Market capitalization as of June 17, 2010.

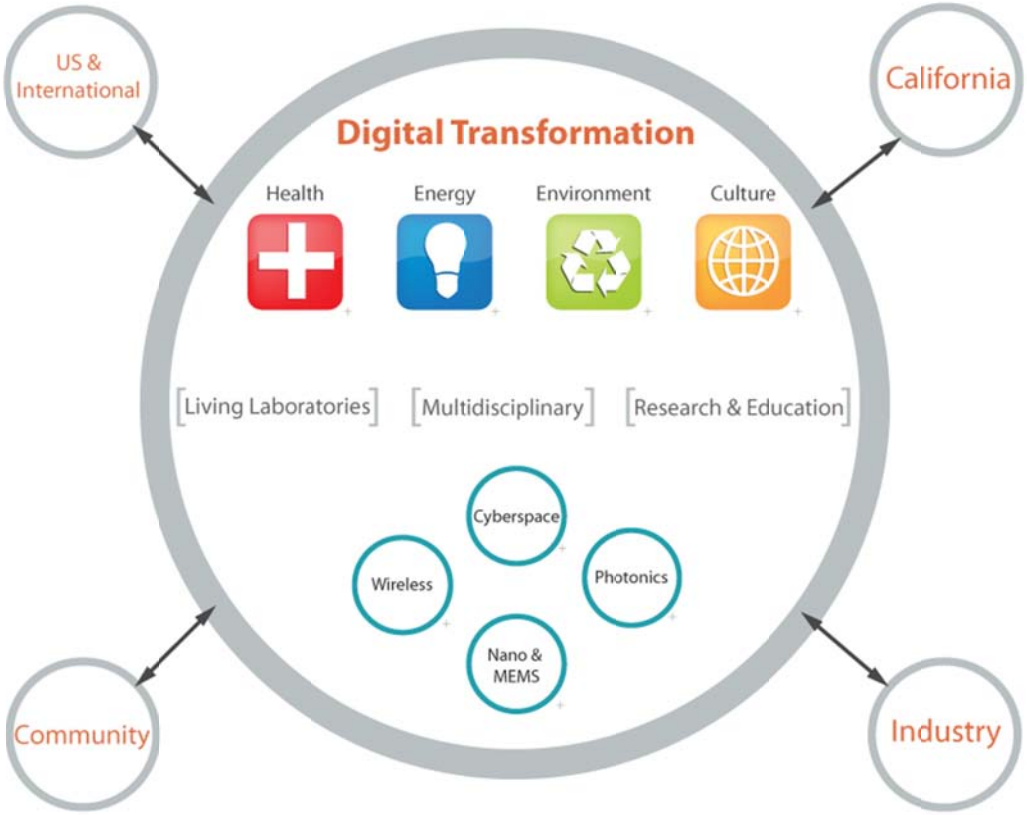
Source: Calit2, public sources.

Exhibit 14 Calit2 Funds By Source (2000-2010)

Source	Details	Total (2000-2010)
Federal	Administered by Calit2, Calit2 Provides Space, Calit2 Provides Staff, Calit2 Provided Leverage	$540 million
Industry	Research-including Total Value of UC Discovery Funds, Gifts-Cash & In Kind, Recharge Usage	$105 million
Not for Profit	Administered by Calit2, Calit2 Provides Space, Calit2 Provides Staff	$57 million
International Collaborations	Administered by Calit2, Calit2 Provides Space	$13 million
TOTAL FUNDING		$715 million

Source: Calit2 Five Year Report, page 1, 2006 and Calit2 2006-2010 metrics, July 2010.

Exhibit 15 State of Calit2 2009 Conceptual Model



Source: Calit2, State of Calit2 2009 website.

Endnotes

[1] University of California Strategic Communications, Office of the President, http://www.ucop.edu/california-institutes/background/history.htm, accessed December 2, 2010.

[2] Gray Davis, Remarks from Calit2 10th Anniversary Plenary Ceremony, December 7, 2010.

[3] Proposal for Calit2, Section G, "Leadership and Management Plan," page 102, October 2000.

[4] Proposal for Calit2, Section F "Industry Participation," page 99, October 2000.

[5] Henry Samueli, Remarks from Calit2 10th Anniversary Plenary Ceremony, December 7, 2010.

[6] Richard Atkinson was a professor of cognitive science and psychology at UCSD as well as president of University of California from 1995-2003.

[7] Source: http://www.calit2.net/newsroom/release.php?id=1383.

[8] Source: http://www-chancellor.ucsd.edu/qa_smarr.asp).

[9] Source: http://research.ucsd.edu/orus/index.html, accessed December 13, 2010.

[10] Ralph Cicerone, Remarks from Calit2 10th Anniversary Plenary Ceremony, December 7, 2010.

[11] Source: http://cisa3.calit2.net/index.php, accessed December 13, 2010.