



The Adventure of Discovery

USC Advances on New Frontiers

Since President Norman H. Topping placed USC on a path as a research university in the 1960s, it has taken this role seriously and with pride. While traditional colleges see their role as transmitting existing knowledge, leading research universities make it their goal to test that accumulated learning, and to create knowledge along the way. The result is that the entire campus community—from freshmen to senior faculty—is immersed in an environment of discovery, and the larger society benefits from the subsequent innovation.

By 1969, USC had been elected to the Association of American Universities, the consortium of leading North American research institutions. This milestone has helped USC's faculty drive revolutions in cinematic arts, aerospace, personal computing, the Internet, and other key emerging areas.

Zohrab Kaprielian, who joined USC as an engineering faculty member in 1958, deserves considerable credit for the university's stunning progress in its early years as a bona fide research institution. As an administrator and dean at the USC Viterbi School, and later as the university's executive vice president, he recruited rising young faculty stars, including George Olah (who would become USC's first Nobel laureate decades later), Solomon Golomb, and Irving Reed—all of whom would go on to earn international distinction as pioneers in emerging fields. Kaprielian established key alliances with government and industry and, in 1972, brought to USC the famed Information Sciences Institute, which helped give shape to the Internet and the entire digital age.

Building academic strengths where competing institutions were weak, and utilizing USC's unique assets to shrewdly make the most of its advantages, Kaprielian perhaps created the template that future administrations would follow to great effect.

Like Kaprielian, C. L. Max Nikias arrived at USC as a faculty member in electrical engineering—and as an avid champion of the power of university

USC faculty, with a fresh infusion of some of the world's best scholarly talent, moved into leadership positions on some of the most important intellectual frontiers of this century, including neuroscience and the interdisciplinary study of the brain.



research to drive societies and economies forward. To boost its research capacity and national standing, USC's leaders tapped Nikias early on to lead an ambitious effort to win an Engineering Research Center (or "Center of Excellence") that would be funded by the National Science Foundation. After several years of patient alliance building and planning, overcoming obstacles along the way, Nikias and his colleagues succeeded with a proposal to the NSF that beat out those from research giants like UC Berkeley, Michigan, and 115 other institutions. USC's Integrated Multimedia Systems Center (IMSC), established in 1996, would be home to the country's first national multimedia research center.



The Collaborative High Altitude Flow Facility (CHAFF) chamber, part of the USC Viterbi School of Engineering, can be cryogenically cooled to below -300 degrees Fahrenheit. The cold walls of the chamber maintain a simulated space environment by condensing and trapping thruster exhaust gases.



Annette Kim (second from left) was recruited from MIT to head USC's Spatial Analysis Teaching Laboratory (SATLAB) and Spatial Analysis Lab (SLAB). In the spring of 2015, she taught the first class in the SATLAB, titled "Urban Spatial Ethnography and Critical Cartography."

That achievement set the stage for the university to punch above its weight, in research terms, on multiple occasions in the following years. Nikias went on to serve as associate dean of the USC Viterbi School and became dean in 2001. He worked alongside Professor Mark Humayun to establish still another NSF-funded Center of Excellence, the Engineering Research Center for Biomimetic MicroElectronic Systems (known as BMES), which allowed USC to leap forward in the crucial, nascent field of biotechnology. And working with Viterbi professor Randolph Hall (who would eventually become USC's vice president of research), Nikias established the National Center for Risk and Economic Analysis of Terrorism Events (CREATE), the first Center of Excellence to be funded by the Department of Homeland Security.

By the time Nikias was elevated to provost in 2005—having mentored Humayun, Hall, and others successfully in their efforts to build top research programs—he was determined to broaden and expand the ways in which USC faculty in every field could create innovative cross-disciplinary research alliances.

American research universities had drawn criticism in the prior years, especially due to the high costs of building and maintaining state-of-the-art laboratories and the devotion of many senior faculty to research and discovery



rather than to classroom teaching. While acknowledging that research universities needed to make changes, Nikias, as USC's provost, offered a spirited defense of the institutions and their work, arguing that they were the key reason that the world's best minds moved to the United States and thereby benefited the national economy and society.

In his 2009 Pullias Lecture at the USC Rossier School of Education, he argued that the academic community at a great American research university was uniquely gifted to bring new light to society—in much the same way that the legendary titan Prometheus stole fire from the gods and delivered it to a humanity lurking in darkness:

These are the modern Prometheans, storming Mount Olympus in order to encounter Athena and the wisdom she offers, in order to find fire, and in order to bring those blessings back to humanity.

And these persons cannot be headquartered anywhere. They are at home only in an environment that encourages collaboration across disciplines, that encourages experimentation, that allows them to make mistakes over and over, and then to start fresh the next morning. Can the modern corporation allow such an environment? Can a government laboratory? Of course not—only the American research university can.

Clockwise from top left: Alexander McDowell of the USC School of Cinematic Arts has been one of the most influential scholars in the area of narrative media; Laurie Eisenberg of the Keck School of Medicine of USC has advanced research in auditory perception, pediatric hearing loss, and the development of sensory devices; Leslie A. Saxon, also of the Keck School of Medicine, has guided progress in cardiology and the development of cardiac devices and wireless health systems; and Daphna Oyserman of USC Dornsife has detailed how small factors create significant differences in educational and healthcare outcomes.

Our American research universities indeed have fire to capture, and to carry forward to humanity, to warm it and to enlighten it and to enliven it.

In a presidential address to the faculty a few years later, Nikias would again visit the theme of finding new intellectual light—and how USC was poised to play a special role in a thrilling next age of enlightenment:

For the faculty of USC, this continues to be our moment. It is in times such as these—moments of disruption—in which we see the most promising developments. These are moments of new light, a re-illumination of the human mind and spirit.

In the Late Middle Ages, Petrarch ignited one moment of re-illumination, when the first wave of humanists took accumulated wisdom and the classics, and used them to spark a new intellectual encounter, and to brighten our understanding of humanity's place in the cosmos. Francis Bacon would later fashion modern notions of rigorous, empirical inquiry. In his monumental book the *Novum Organum*, human inquiry smashed through ancient barriers, opening vast new worlds for exploration.

Our own world is opening up, in the 21st century, in no less dramatic ways.... This is the Age of the Pacific—and yes, this is the century of biology and medicine. In this era, human inquiry is being informed by the extraordinary convergence of Pacific Rim cultures, by the rich blending of a new world into the existing one.

This is an era in which the crucial issues of how we live, and how well we live, and how long we live will be illuminated by creative and collaborative adventurers across the sciences and engineering, the humanities, the arts and social sciences, and the professions. As a private, comprehensive research powerhouse, here at the greatest cultural and commercial crossroads of the Pacific Rim, USC finds circumstances working in its favor. Located in this place, at this time, with our unique assets, we find that destiny has dealt us a favorable hand. Let us play this out wisely.



The Interdisciplinary Advantage

In recent years, information technology and immersive, digital media have begun to reshape the landscape in education and every realm that involves human communication. The university's faculty was again determined to play a significant role.

Interdisciplinarity was by now the watchword within American higher education. It was recognized almost universally that the greatest intellectual breakthroughs would happen at the borders and bridges of different academic disciplines—in contrast to the manner of narrow hyper-specialization that had characterized the last century of scholarly inquiry. Here, USC's many



President Barack Obama poses in front of a light stage in 2014 so that USC's Institute for Creative Technologies researchers can create 3-D portraits of him for the Smithsonian Institution. The project is overseen by Paul Debevec, ICT's chief visual officer and a research professor in the USC Viterbi computer science department.



This two-dimensional photo is one of a multitude of images that ICT combined to create its full, 3-D image of President Obama.

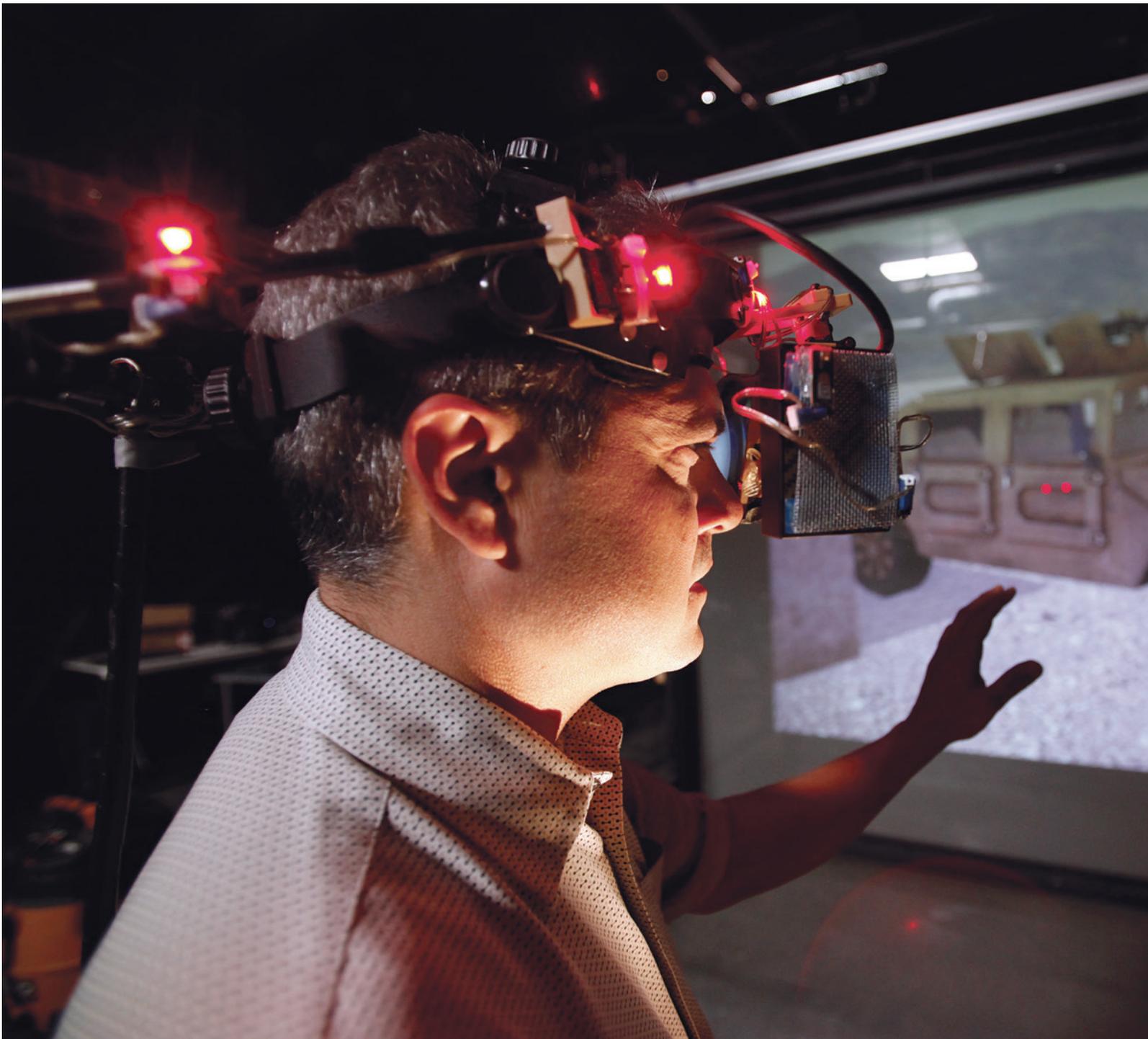
independent but interdependent schools represented an invaluable mix of breadth and depth. With humanities, sciences, arts, social sciences, and professions frequently working together, the university's faculty moved swiftly into uncharted academic territories.

"I'm proud of the fact that USC has not been copying anyone else or chasing anyone else in this area," Nikias told the faculty in his annual State of the University address in early 2014. "USC has been experimenting and exploring, and has been leading the way for others."

A capacity for interdisciplinary approaches would prove especially useful in pushing forward new frontiers, particularly those that involved both technological and human aspects. "Big data" was one such example.

By 2010, big data had emerged in the public consciousness as a formidable concept. This growing field will allow information to assume an even more imposing and hopefully constructive presence in the world, allowing societies to make intelligent decisions based on solid data, rather than on hunches, biases, ideologies, or wishful thinking.

"Given the role that our faculty and students have played in the information revolution so far, USC is poised to lead the 'big data' era," said Provost Michael Quick, in the spring of 2015. "Big data has implications



for communications, health and medicine, the arts and humanities, and seemingly every aspect of human life. So it's one of those areas where our faculty can truly play a shaping role.”

The Viterbi School of Engineering, the Dornsife College, the School of Cinematic Arts, the Annenberg School for Communication and Journalism, and the Keck School of Medicine all represented strong assets in USC's effort to shape the development of big data. In 2014, the university received a landmark National Institutes of Health Big Data to Knowledge Grant—about \$23 million for two new Centers of Excellence. That constituted 20 percent of the entire nation's investment in big data. It came on the heels of a \$16 million National Institute of Mental Health grant a month earlier; together, the



USC researchers from numerous disciplines have worked through ICT to develop virtual-reality and virtual-human technologies that help train U.S. military personnel for more effective service.

awards served as proof that USC’s faculty could both compete and win in an increasingly uncertain federal funding environment.

Scholarship of Consequence

Elizabeth Garrett, USC’s provost from 2010 to 2015, encouraged the faculty to focus on “scholarship of consequence,” which can meaningfully shape and improve the workings of society. This principle guided the development of Dr. Verna and Peter Dauterive Hall, which opened in 2014 to serve as an intellectual crossroads that would stimulate social science scholarship and meaningfully inform public policy discussions. Dauterive Hall became host to four centers with precisely that objective:

- The Center for Economic and Social Research, which focuses on the behavioral sciences and related areas;
- The USC Schwarzenegger Institute for State and Global Policy, which explores post-partisan policy approaches;
- The USC Dornsife Mind and Society Center, which takes a scholarly and empirical approach to examining the manner in which human minds and society shape one another; and
- The Leonard D. Schaeffer Center for Health Policy and Economics, which explores the economic and human dimensions of healthcare delivery.

The Schaeffer Center was created in 2009 through a major gift from Leonard and Pamela Schaeffer. Its mission is, by utilizing an unusual breadth and depth of expertise, to improve healthcare through evidence-based policy solutions that could transcend conventional partisan bickering. The university recruited the eminent health economist Dana Goldman to lead the center, which would combine insights from faculty within USC’s Price School of Public Policy, School of Pharmacy, and other units.

Technology for a Human Purpose

As with so many other aspects of USC’s academic rise, the rapid growth of its research enterprise was enabled by collaboration within widely disparate fields. This involved scholarly partnerships among the sciences, social sciences, arts, humanities, and professions.



Through the aid of innovative cinematic technologies, the USC Shoah Foundation has been able to create enduring encounters with survivors of the Holocaust.

Observers have noted the gradual marginalization of the humanities at many American research universities in recent decades, but the USC faculty has moved to revitalize scholarship in this area, launching a public humanities initiative in order to connect the work of numerous scholars to pressing issues of the day. Alice Villaseñor, an expert on 19th-century British literature and women writers, took on the role of director of the initiative.

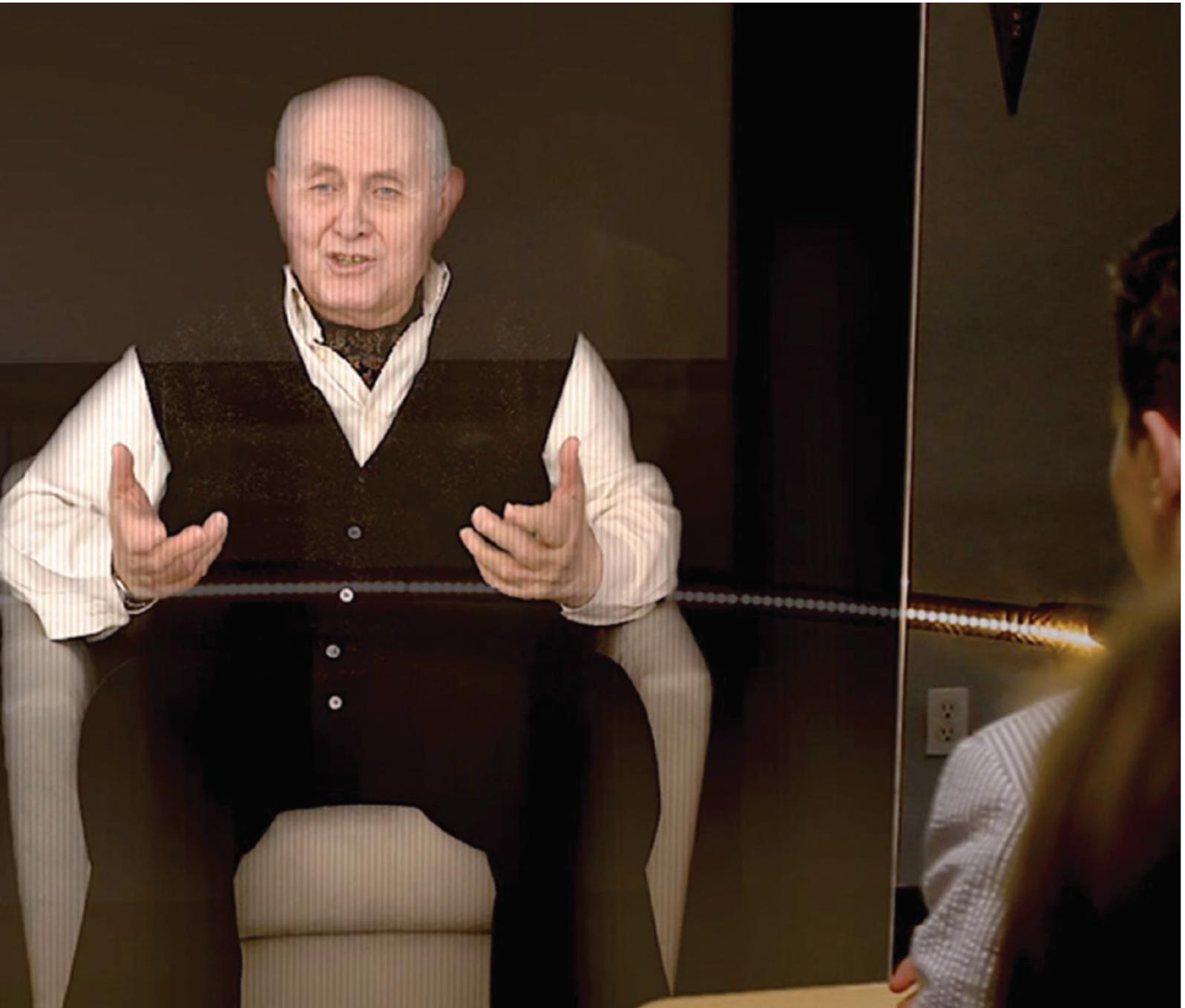
In 2014, the Andrew W. Mellon Foundation awarded the university a \$1.9 million grant for the USC Digital Humanities Program, which will train graduate and postdoctoral students in key academic areas at the intersection of the humanities, technology, and the social sciences.

“We’re at a really early phase,” said Peter Mancall, vice dean for the humanities at the USC Dornsife College and principal investigator for the grant. “The digital humanities can embrace new ways of doing research. Part of doing this project will be to figure out what those ways actually are.” Other faculty leaders for the program include Philip Ethington, professor of history, political science, and spatial sciences within USC Dornsife, and Tara McPherson, associate professor of critical studies at the School of Cinematic Arts.

Additional innovations in humanities scholarship involved the development of disciplines such as sound studies, an interdisciplinary field that



Audience members at the Shoah Foundation interact with a 3-D holographic rendering of an individual survivor. After hearing his story, they can ask specific questions about his experiences, to which the holographic subject retrieves and articulates pre-recorded answers in real time.



examines the sonic elements of history and culture. Joshua Kun, a professor in the USC Annenberg School for Communication and Journalism, became active within both sound studies—especially the study of popular music—and the university’s public humanities initiative, curating exhibits and editing non-academic books, among other projects.

The Convergence of Technology, Entertainment, and Education

USC’s Institute for Creative Technologies has been at the forefront of the development of “virtual humans” and “virtual environments” for educational purposes. ICT was created in 1999 with funding from the United States Army. In 2011, the Army extended its partnership with ICT, through \$135 million in funding over the next three years.



As in so many cases involving university-government partnerships, the work began with a national security dimension, then branched out into all realms of society. ICT enabled trainers to use virtual-human technologies to equip more than 75,000 soldiers for combat, negotiation, and diplomacy, as well as recovery from post-traumatic stress and brain injuries.

At the same time, Paul Debevec, ICT's chief visual officer and a Viterbi professor, was working with his colleagues at ICT to create virtual worlds and new 3-D images for Hollywood, notably in the landmark film *Avatar*. And as video gaming promised to become far bigger and widespread than cinematic entertainment had ever been, ICT researchers took state-of-the-art gaming concepts to a higher level, for the purposes of both education and entertainment.

One of the more poignant marriages of technology and the humanities is demonstrated in the work of the USC Shoah Foundation—The Institute for Visual History and Education. The foundation has archived and organized 53,000 testimonies from Holocaust survivors in order to teach and connect with a broad audience of people in the coming generations. Working with partners at ICT, and the concept developer Conscience Display, Shoah has invented unique ways to bring the Visual History Archive to life.

The team began by capturing detailed, extended interviews with

At USC's 2014 Global Conversation in New York, Provost Professor Scott Fraser discusses interdisciplinary work that can prevent blindness in many patients.

Holocaust survivors using special technologies that present each subject in 3-D holographic form. These interviews were then combined with an interactive component that can hear a question from a member of the audience and—in real time—provide an appropriate sound bite from the interviewee. For instance, a schoolchild might ask, “Did you ever see your family again?” and the holographic image would, in an instant, move to that part of his or her story.

Stephen D. Smith, the executive director of the USC Shoah Foundation, explained their goal: that the content “must be natural language video conversations rendered in true holographic display, without 3-D glasses.”

Reflecting on these emerging technologies, Nikias commented, “All this just hints at the incredible future of storytelling and the future of teaching and learning. And these virtual experiences are increasingly available by mobile devices, anywhere, anytime. The only limit to all these possibilities is our own imagination.”

To CREATE a More Secure World

The United States Department of Homeland Security established the National Center for Risk and Economic Analysis of Terrorism Events (CREATE) at USC in 2004, to allow a coalition of universities and research institutions to assess and address security threats to the nation. In the fall of 2010, DHS renewed its relationship with CREATE with a \$15.3 million grant.

CREATE teams have developed strategies for making security checkpoints and patrols more effective; improved security processes for the Los Angeles and Long Beach ports (the busiest in the nation); modeled economic resilience following a catastrophic regional event; and explored the links between threats, disasters, and human behavioral responses. Along the way they have also produced hundreds of articles, book chapters, reports, and other publications advancing scholarship in this field.

Powering the Health Revolution

USC entered the second decade of this century determined to be a leader in the burgeoning revolution in healthcare and the biological sciences. In order to do so, it needed to connect its strong programs in engineering, medicine,

health, and other areas and leverage them more fully. This led to several academic success stories in short order.

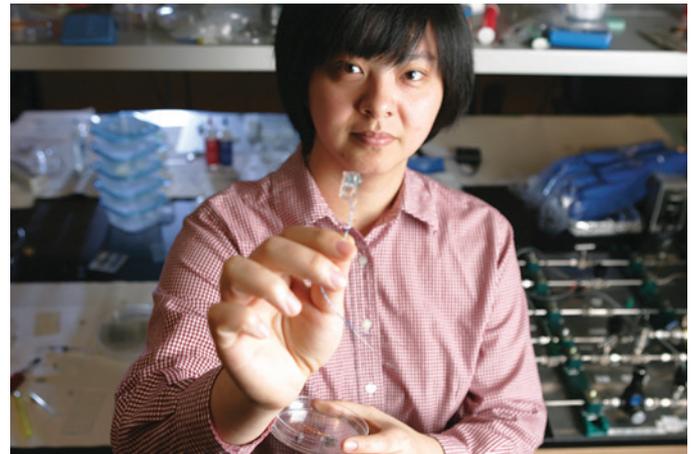
The Engineering Research Center for Biomimetic MicroElectronic Systems (BMES) was established in 2003 with \$17 million in funding from the National Science Foundation. Based at USC, it represented the alliance of a number of important business and academic institutions, including Caltech and UC Santa Cruz. Both USC officials and local civic leaders believed the center had significant potential to move Southern California to the vanguard of the rising biotech industry.

BMES is led by biomedical engineer and ophthalmologist Mark Humayun, who worked with Nikias during the latter's time as engineering dean to establish the center. It aimed for unprecedented breakthroughs in the treatment of blindness, cognitive decline, paralysis, and loss of neuromuscular control. When Professor Humayun and his colleagues announced in 2013 the development of an artificial retina that restored partial sight in some blind patients, the news quickly traveled around the world.

The BMES center is just one key component of a major USC effort to drive research breakthroughs in health and medicine. Broadly strengthening the faculty has been an even more urgent priority. University officials, led by President Nikias, former Provost Garrett, and, now, Provost Michael Quick, wooed some of the world's best talent to build preeminent centers in major fields.

Andrew McMahon came from Harvard in 2012 to serve as the chair of the newly created department of stem cell biology and regenerative medicine at the Keck School, and director of the Eli and Edythe Broad Center for Regenerative Medicine and Stem Cell Research at USC. He also received an appointment in the department of biological sciences in USC Dornsife, symbolizing the university's attention to cross-disciplinary approaches that integrate both of its major campuses.

Scott Fraser, a pacesetter in both biology and engineering research at Caltech, came to USC in 2012 as Provost Professor of Biological Sciences, Biomedical Engineering, Physiology and Biophysics, Stem Cell Biology and Regenerative Medicine, Pediatrics, Radiology and Ophthalmology. As the many areas of specialty in his title indicate, his mission was to put the assets



Clockwise from top left: Andrea Armani of the USC Viterbi School of Engineering explores the interaction of light and biology, with implications for biomedical devices; Kevin Knight of USC's Information Sciences Institute has developed new approaches to cryptography, code breaking, and artificial intelligence; and Ellis Meng, also of USC Viterbi, was named to *MIT Technology Review's* list of top innovators for breakthroughs in next-generation drug-delivery pumps.

of a broad, interdisciplinary research institution to work in what he called an “exciting effort to build a new convergence of fields.”

Arthur Toga and Paul Thompson brought their elite Laboratory of Neuro Imaging (LONI) to the university from UCLA in 2013, and along with it a team of 110 top-flight researchers and staff. The following year, Raymond Stevens and Peter Kuhn joined USC, along with their 50-member team from Scripps Research Institute, to make faster progress in molecular biology.

Translating Ideas into Innovation

Too often, no tangible societal benefit comes from brilliant ideas that arise within an academic community. USC, entrepreneurial in nature since its earliest days, made a determined effort to make sure that ideas could be translated into beneficial innovation. The USC Stevens Center for Innovation, established in 2004 by a \$22 million gift from Trustee Mark Stevens and his wife, Mary, catalyzed the process of spurring innovation across both university campuses. USC Stevens gave faculty a well-staffed, well-equipped ally that could protect their intellectual property; allow them to benefit from it; and help them develop it into promising products and services that could make a real difference in the world.



By 2015, some 70 companies had been founded using the USC Stevens Center for Innovation, which attracted more than \$355 million in venture capital funding. Licensing revenue increased from \$3.2 million in 2007 to \$6.5 million by 2015.

Promoting Diversity in Science and Engineering

The university has made a concerted effort to support women and underrepresented minorities in its research departments. The USC Women in Science & Engineering (WiSE) program, leveraging a \$20 million endowment and founded by former vice provost Jean Morrison, develops greater diversity among faculty and students within these fields. Viterbi School of Engineering professor Maja Matarić, who has been named one of the 25 most powerful women in technology by *Business Insider*, has played a prominent leadership and mentoring role within WiSE.

Among several indications of the program's success: Women now comprise roughly 38 percent of the freshmen class at USC Viterbi—about double the national average. And six women on the engineering school's faculty have been named to *MIT Technology Review's* annual lists of "Top 35 Global Innovators Under 35" since 2009.

Included in these honorees were professors Maryam Shanechi and

Clockwise from top left: Michael Habib of the Keck School of Medicine has detailed the development of large feathered dinosaurs, pterosaurs, and the origin of flight in birds; Julie M. Zissimopoulos of the USC Price School has earned acclaim for her research into the economics of aging and new approaches to healthcare policy; Theodore Berger of the USC Viterbi School has drawn notice for his work in the neurophysiology of memory and learning; and Maryam Shanechi and Bhaskar Krishnamachari, also of USC Viterbi, were named to *Popular Science's* 2015 "Brilliant 10" list for their work on neurological interfaces and wireless networks, respectively.



Clockwise from top left: Maja Matarić has developed advanced robotic devices while also nurturing academic diversity and mentoring junior faculty members; Roberta Diaz Brinton has gained national attention for her studies of Alzheimer’s disease and the effects of drugs on the human brain, and for developing treatments to prevent and remedy memory disorders; Hao Li gained renown as an expert in CGI, 3-D digitization, animation, and motion-picture technology; and Elizabeth Currid-Halkett of the Price School has driven progress in scholarship involving urban planning and social networks, while also exploring the economic impact of art and culture.

Bhaskar Krishnamachari of the Viterbi School’s Ming Hsieh Department of Electrical Engineering. In the fall of 2015, both were also named to *Popular Science’s* annual “Brilliant 10” list. In 2013, Andrea Armani, the Fluor Early Career Chair in Engineering, was also recognized in that ranking.

The university makes a point of recruiting exceptional early-career faculty members from other institutions. Daphna Oyserman, who received a W. T. Grant Faculty Scholar Award and a Humboldt Scientific Contribution Prize from the German Alexander von Humboldt Foundation, came to USC from the University of Michigan in 2013 as a Dean’s Professor of Psychology, and professor of psychology, education, and communication.

Julie Zissimopoulos, formerly a senior economist at the RAND Corporation, now serves as associate director of USC’s Leonard D. Schaeffer Center for Health Policy and Economics. She is also a network associate of the MacArthur Foundation’s Research Network on an Aging Society, and co-directs the Resource Center for Minority Aging Research (funded by the National Institute on Aging).

Student Research Opportunities

In recent years, higher education experts have seen America’s universities as overly focused on research at the expense of undergraduate teaching. USC,





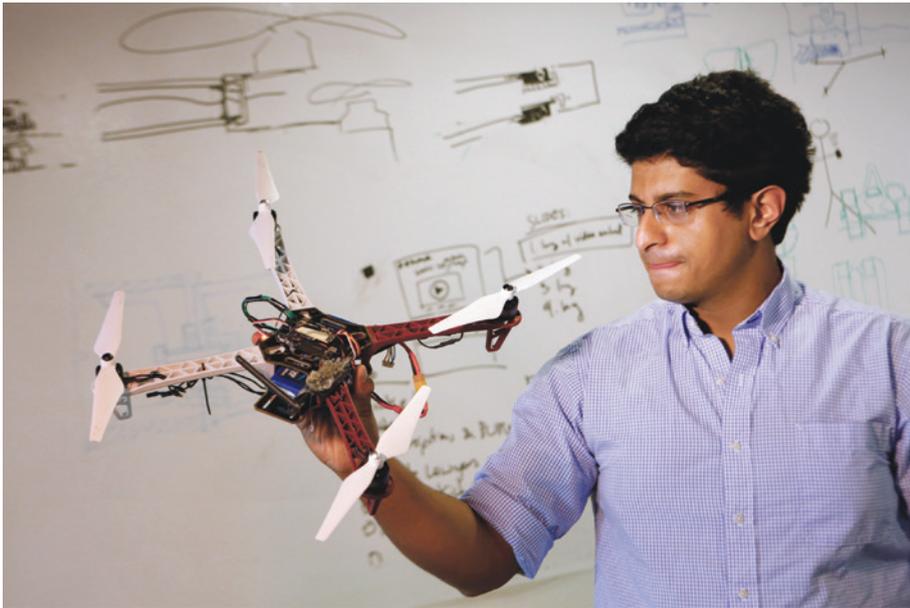
Billed as the world's leading undergraduate rocket research group, USC's Rocket Propulsion Laboratory has steadily progressed toward its goal of sending the first rocket designed and built by students to the boundary of space.

by contrast, has moved to underscore how student-faculty collaborations can offer unique educational opportunities to create knowledge.

During Nikias's tenure as provost, the university introduced the Discovery Scholars program to incentivize students across every discipline to participate actively with faculty in creating original academic and artistic works. The Discovery Scholar designation, granted annually at commencement, was bestowed upon 70 graduating seniors in the spring of 2015. Ten of those students received \$10,000 awards for the most exceptional work.

As dean of the Viterbi School a decade ago, Nikias allocated \$160,000 to fund a student group that aspired to create the first entirely student designed and built rocket to reach space and safely return. In 2006, the newly created Rocket Propulsion Lab launched its first effort, dubbed Del Carbon, which reached a maximum altitude of 21,500 feet and speeds of up to Mach 1.4.

By 2015, the lab was refining a Del Carbon Extreme, setting its sights on reaching more than 10 times the altitude of the original rocket and four times the speed. USC's faculty, recognizing the ability of such projects to give invaluable experience to students in the job market, have worked to coordinate and expand these programs through the Space Engineering Research Center and related efforts.



The Viterbi Startup Garage is a venture incubation program that nurtures emerging businesses. The program, launched in 2013, offers students and alumni a combination of funding and guidance from the USC Viterbi School of Engineering.

A Research University in Blossom

In his 2014 annual presidential address to the faculty, Nikias praised their ability to compete for a piece of a shrinking funding pie. “Nationally, there has not been a tougher funding climate in our lifetimes,” Nikias said. “Still, funding for USC research is at an all-time high. Over the previous year, total federal expenditures once again topped \$450 million, and total research expenditures topped \$600 million again.” He also cited the university’s strategic recruiting of superstar faculty as having a galvanizing effect, injecting more than \$120 million in high-profile research grants over the previous three years alone.

Ultimately, though, the goal at USC wasn’t to approach the wonder of discovery in conventional ways, or to measure it according to the usual metrics. As Nikias noted in his 2009 Pullias Lecture, delivered while he was provost, “the future cannot be micromanaged.” As he put it:

Even the best efforts to predict the future fall short of the best efforts of the human imagination in action. The future is generally more peculiar, and more wonderful, and more textured, than we could have imagined. We need not predict the future with great certainty; rather, we need to create a dynamic environment in which we can react and change rapidly.

At USC, that dynamic environment was just beginning to emerge.





Army-funded research efforts at USC explore the use of camera-enabled quadrotors, drones, and other robotic technologies.