

## **Vision and Strategy USC Viterbi School of Engineering**

### **Vision Statement**

The vision and strategy of the USC Viterbi School of Engineering are informed by the exponential advances in technology, where there are no steady states or steady states of growth, and by the intended and unintended consequences these have on engineering education and research in the context of a brick-and-mortar institution. We view engineering and technology as the enabling discipline of our times, because of its power of convergence, and of its extraordinary capacity to improve the human condition worldwide. We want to empower creative thinkers and innovators to propel and build engineered solutions for tomorrow's grand challenges through the convergence of transdisciplinary scholarship. We are aware of the need for agility and for cultivating mindsets of growth, to help thrive in our fast-changing world. We are also cognizant of the technology unintended consequences, and the need for ethical and human-centric technology decision making. In our engagement in engineering education and research we benefit strongly and unequivocally from our unwavering commitment to diversity and inclusion, for all our constituencies, students, faculty and staff. We consider our societal and global impact as the most important part of our mission, as measured by education outcomes, the value added to our constituencies, research scholarship, innovation and the generation of intellectual property, societal outreach and the development of best practices. These notions comprise our vision and inform our strategy. In this quest, we strive to be undisputed national and global leaders, to change the conversation about engineering, shape its evolution globally, and to inspire generations of students, alumni and the society-at-large for the collective benefit.

### **The Evolving and Convergent Nature of Engineering and Technology**

Our definition of Engineering and Technology transcends traditional stereotypes. It consists of the following widely applicable notion\*:

*Technology is leveraging phenomena (and systems, devices and tools, and combinations thereof) for useful purposes (including discovering of new phenomena)*

Historically, and in increasing order of complexity, such phenomena included *physical*, *chemical*, and *geological*, phenomena. In recent years, the increasing power of technology has allowed us to engage with higher complexity, associated with *biological* phenomena, and more recently, through the unprecedented advances in computational power and data sciences, with fast emerging couplings with *social* and *behavioral* phenomena as well. We note that included in this description are also *combinations* of phenomena and *hierarchical* technologies, as in the notion of *systems* (from mechanical to biological to societal) that bring new complexity but also empowerment to engineering and technology. As well, included are the *discovery* of new phenomena and relations, and the *invention* of new technologies, in this constantly repainted canvas. It is this all-encompassing approach to engineering and technology that makes the discipline empowering and convergent, a manifestation of what we have coined *Engineering +*. These concepts, ideally suited for USC, a university with likely the largest number of disciplines anywhere, serve as a pole of attraction to USC Viterbi of high-caliber talent in faculty and students from all over the world.

\*Adapted from W. Brian Arthur's "The Nature of Technology" (2009)

## Four Strategic Pillars

As these extraordinary forces continue reshaping the environment of engineering education and research, the Viterbi School relies on the following four fundamental pillars of enduring value.

1. Be a Global Attractor of Talent (Students, Faculty, and Staff) from anywhere in the world and Provide the Culture and a Diverse and Inclusive Environment for them to Flourish.
2. Continuously Add Value to Curriculum, Programs, and Infrastructure, in our Fast-Changing World.
3. Global Thought Leadership to Solve Global Challenges: from Energy and Sustainability to Security and Infrastructure, to Health and Medicine, to Life Enrichment and to the Scientific and Technological Discovery.
4. Use Engineering and Technology as the Catalyst for Innovation, Best Practices and Active Outreach, including through STEM K-12, to Fuel the Economic Growth of Los Angeles, Southern California, the United States, and the World.

The four pillars underscore the importance to USC Viterbi of *People, Programs, Papers and Patents*, for the respective four areas; of the need for constant innovation in programs and initiatives in a world that moves at an increasingly faster pace; of the importance of mindsets of growth to continuously adapt to these fast-changing times; and of the undisputable power of engineering to solve crucial global problems, and to enable prosperity and the well-being for all humanity. In the process we are keenly aware of the needs: to attract, engage and empower all segments of the population; to equity, diversity, and inclusion (EDI), including parity and gender balance in engineering faculty and students; to help empower with technological literacy and expertise many underrepresented groups, thus preventing yet another societal divide; to include diverse groups and cultures, thus benefiting the very process of innovation through the diversity of ideas and experiences; and of the corresponding imperative to *change the conversation* about engineering. It is this fundamental philosophy that helps us achieve our strategic goals.

## Engineering + X

Engineering + X (where X is anything and, increasingly, more *human-centric*) can be accomplished through any of following three pathways:

E => X (Engineering Empowers X)  
X => E (X empowers Engineering)  
EUX (Engineering and X comingle)

Engineering empowering X makes X “smarter”, more “efficient”; it opens new dimensions, many of which are disruptive; and it represents the ubiquitous *digitization* of everything. In X empowering engineering, we envision *X-mimetic*, for example, biomimetic, processes, reflecting Nature’s optimization through evolution. But the most dramatic manifestation of convergence is when E and X *comingle* (EUX): now X provides new context and new phenomena, which then create a new E, leading to a new X, etc. in an ascending “double helix” of E and X. This exponential technology process advances both E and X in a powerful exponential way.

This synergy provides a spectacular advantage for a university such USC, where different disciplines (different Xs) abound. It serves as a strong attractor of faculty and student talent and the impetus for the creation of new innovative programs. It is in this spirit that we envision, and already have developed, multiple strong partnerships between USC Viterbi and other USC schools. As well as within the various disciplines of engineering within the Viterbi School. Such initiatives, including the possible creation of virtual academic entities across multiple schools, for example between Viterbi and Keck, in Biomedical Engineering, between Viterbi and Price, in Civil and Environmental Engineering, or Viterbi and Gould, in the CS areas of government and law, privacy and security, are constantly being conceived and designed by our faculty and empowered by the school.

*For example, consider: initiatives that will bring the data sciences, machine learning and artificial intelligence revolutions across all areas of the university (with the Center for AI for Society- CAIS- a research partnership with the School of Social Work, or the Center for Human-Applied Reasoning and the Internet of Things- CHARIOT- a research partnership with the Rossier School of Education, as two such examples); the strengthening of the partnership between engineering (Viterbi) and medicine (Keck), for example through the Institute for Biomedical Therapeutics (IBT) and the Institute for Neuroengineering (ITEMS); the strengthening of the partnership between Viterbi and Dornsife in the areas of convergence between biology and engineering, e.g. in the Michelson Building, or between Physics, Electrical Engineering and Computer Science in Quantum Technologies and Quantum Computing; the enablement of all media and entertainment technologies through partnerships with the Arts schools, following, for example, the nation-leading Games program between Viterbi and the School of Cinematic Arts; the strong partnership between Viterbi and Price in the areas of Homeland Security, through the DHS Center CREATE, in transportation through the USDOT Center METTRANS, and in the new Center for Sustainable Solutions.*

We must note an important and unique differentiator for engineering and computer science at USC Viterbi, namely the existence of two key research centers, absent from practically any other university: i. The Information Sciences Institute (ISI), founded in 1971, a world leader in research and development of advanced information processing, and computer and communications technologies; and ii. the Institute for Creative Technologies (ICT), founded in 1999, specializing in artificial intelligence, graphics and virtual reality to advance immersive techniques and technologies. Combined with the Department of Computer Science, these two institutes create a triad of excellence in computer science (CS@SC), unparalleled in the nation. More importantly, they contribute to national needs, including defense, while their versatility in research projects from basic to applied to systems, allows for a wide spectrum of partnerships with many USC schools. These are unparalleled assets that help and will continue to help USC Viterbi innovate and lead in the explosive growth in all aspects of information, communication and data sciences.

*With over \$100M annual research expenditures from federal agencies and the private sector, ISI has helped conceive, design and implement the Internet, including communications protocols and the Domain Name System (DNS). Based in Marina del Rey, CA, it also maintains offices in Arlington, VA, and Waltham, Mass. ICT, a DoD-sponsored University Affiliated Research Center (UARC), offers important new dimensions, in collaboration with the U.S. Army Research Laboratory, in the rapidly growing areas of graphics, virtual reality, educational and entertainment technologies.*

## **Engineering and Technology: Creating a Better World for All Humanity**

It is in the above light that we view Engineering as the Enabling Discipline of Our Times: because it is *Exponentially Growing* and because it is fundamentally *Convergent*, thus enabling practically all other disciplines. But this is not its only attribute. Powerful, fast evolving, convergent technology also allows us to set achievable *Goals for all Humanity*. Engineering, then, becomes the indispensable way for creating a *Better World for All Humanity*, through the solution of *Grand Challenge-like problems*, such as the National Academy of Engineering Grand Challenges, or the United Nations Sustainable Development Goals or other Grand Challenges present or likely to emerge in the future, including in our own community in Los Angeles and Southern California, or in space. These challenges address fundamental issues in *Sustainability, Resilience, Health, Security and Enriching Life*. In many ways, they represent Maslow's hierarchy, but translated for our communities, for society, and for planet Earth. Indeed, these challenges are global, spanning countries and borders and positioning engineering as a global asset for good. USC Viterbi is espousing such a vision, and has as goal to implement them in its offerings, both in education and research, thus helping position itself as an institution of global eminence, influence, appeal and attraction.

With their wide spread, such challenges, like the NAE Grand Challenges, can be attacked by practically all of the traditional engineering disciplines (e.g. civil, environmental, chemical and mechanical engineering, in the areas of energy, materials and sustainability; biomedical, electrical and computer engineering in the areas of health, and systems engineering; computer science in the areas of security; and almost all disciplines, and particularly computer science, in the area of enriching life). It is thus, not surprising that individual engineering disciplines (e.g. industrial and systems engineering, environmental engineering, and engineering for earth) have articulated their own sets of grand challenges. We note the same in both articulated and non-articulated grand challenges for our immediate urban environment in Los Angeles and Southern California, which also help to provide test beds for the testing of ideas and solutions at a large scale. Such a view of *Engineering for Good* contributes to the change of conversation, the shattering of stereotypes and the attraction to the discipline of diverse groups of talented faculty and students.

Choosing goals (such as solving Grand Challenges) is an *Ethical Decision*, particularly in today's times, where technology is extraordinarily powerful. In this context, we believe that *all disciplines* can benefit from articulating Grand Challenge-like topics. Indeed, USC Viterbi has partnered with the School of Social Work to help the Social Work discipline articulate corresponding Grand Challenges for Social Work. And we are actively working with the USC sustainability community to articulate similar Grand Challenges for Sustainability. But significantly, and of increasing relevance, for articulating similar goals are data-driven disciplines, such as AI for the benefit of Society, and Human-Centered Computing. Such efforts are continuously spawned and nurtured at USC Viterbi.

*To fulfill these goals, we must develop key enabling tools. We have strong presence and envision further strengthening in emerging areas that offer new career opportunities and business models. Artificial Intelligence, encompassing machine learning and robotics, is one such tool. Human-machine interaction is another. Data science, encompassing not only data analytics but also protecting privacy in the presence of a plethora of data, as well as security, is another. The end of Moore's law also offers tremendous opportunities for impactful tools to sustain the exponential growth of computing via, for example, specialized ASICs intended to solve a particular problem, or, in the future, quantum computing. Industry 4.0, which includes smart sensors and sensing systems, cyber-physical systems, the Internet of things, cloud computing, and cognitive computing is another area of enabling tools. Yet another is smart/advanced materials.*

*Advanced engineering technologies, such as smart sensing, artificial intelligence, robotics, resilient infrastructure design and emergency response systems, among others, are key to addressing many of the challenges in building safe and inclusive communities. While advances in health can be supported with technologies in precision medicine, i.e., analysis of digital health records, decision making support and treatment recommendations; human-machine interaction for personalized care; research in portable smart devices and democratized health; and other tools in supporting public health, monitoring disease outbreaks, and addressing the immunization and vaccine crises.*

### **Innovation and Impact**

Achieving technology goals will ultimately be based on innovation and entrepreneurship and the dissemination and adaptation of best practices. Needs and goals dictate research and invention, and these ultimately lead to outcomes. After all, innovation is another manifestation of convergence, this time between *Feasibility* (Technology), *Viability* (Business) and *Desirability* (Culture). Cultivating a thriving environment for innovation and entrepreneurship, with its underlying mindsets of the freedom for experimentation, the launching of bold new initiatives, and of grit and perseverance, is an important and fundamental tenet of the Viterbi School.

The NSF I-Corps Innovation Node Los Angeles (IN-LA), established in 2014 at USC Viterbi, as a partnership between USC, Caltech and UCLA, and one of only seven in the US, supports, strengthens and grows the Southern California startup and technology ecosystem (known as *Silicon Beach*). Along with the establishment of incubation processes and facilities (such as the Viterbi Startup Garage) and the new Maker Space at USC Viterbi, they highlight the increasingly vital role of the development of Intellectual Property, and of Innovation and entrepreneurship at USC Viterbi. We aspire to be the leading educational institution in Silicon Beach in shaping technology innovation and entrepreneurship. This aspiration is all the more compelling if one notes that Southern California is the region in the US with the largest number of engineering and computer science graduates.

USC Viterbi will further reinforce its position as a major hub for technology and innovation in Southern California. We recognize that folding fundamental research into new knowledge while addressing the needs and interests of industry is a necessity in reaching our vision to impact society and the future workforce. As such, we will continue to expand the scope of the school's technology innovation programs and create new programs for faculty engagement with industry and the innovation ecosystem in the southern California region. Furthermore, we will make specific efforts to engage with policy makers and other stakeholders, locally, state-wide, nationally and globally.

In this effort, fostering stronger relations with the Marshall School of Business, as well as with the Alfred E. Mann Institute for Biomedical Engineering (AMI), are important priorities. In addition, extending and constantly re-inventing our traditional strong ties with the ecosystem of engineering and technology companies and industries, which now encompasses practically any venture or thriving corporation, enriches our engineering education and research programs, provides first destinations for our students and further leverages our strengths and capabilities. Such ties will need to be constantly nurtured and re-imagined.

*It should be re-emphasized that the Viterbi School also educates engineering professionals that fuel the growth of locally based large companies and organizations with global reach as well as startups and other companies represented in Silicon Beach. We intend to maintain and grow such symbiotic relations between the Viterbi*

*School and Southern California-based companies to satisfy their needs for professional and innovative workforce, and the needs and expectations of our students for exciting careers in cutting-edge engineering.*

### **Technology Ethical Decision-Making**

Goals are driven by values. But the very definition of Technology encompasses unintended consequences, which are increasingly powerful. Indeed, our definition of *leveraging phenomena for useful purposes* contains the very seed for unintended consequences and the need for Technology Ethics. Indeed, what is *useful* for one, is *not useful* for another, specifically when the one developing the technology is a malicious actor. Which bring up issues of how society must react to these, through policy, legislation, or politics. Technology ethical decision-making lies at another convergence, namely at the intersection of *smart, legal and ethical*. Today, the extraordinary growth of technology brings up unprecedented new problems with deep ethical concerns, where many of the technology branches emanating from a new, and powerful, technology can fall outside the ethical intersection in the above Venn diagram.

Unintended consequences will always be there, because of our complex, non-linear world. These will vary across our multiple endeavors. For example, they are found: in the synergy of humans with technology, e.g. Human Machine Interaction (HMI), Building Machine Interaction (BMI), Socially Assistive Robotics (SAR); in Autonomy, Automation and Human Labor; in Personalized Customization (from medicine to preferences and human desires) and the risk of Loss of Privacy; in the use of Machine Learning and AI to model and leverage human and societal behavior, and to inform future action, which inherently including biases; in Reverse Engineering the Brain, which probes truly fundamental aspects of what it means to be human; in Synthetic Biology; etc. They bring fundamental questions to what we value as society- from the individual to the collective- and to how we educate our students. It becomes incumbent upon us, therefore, to revise our standard curricula and help our students understand their responsibility in the development and stewardship of their increasingly potent technologies. This is another convergent area that calls for utilizing the strengths of our colleagues in Philosophy and Ethics at the Dornsife College and the Gould School of Law.

### **Changing the Conversation: A New Engineering Education**

This rapidly changing landscape dramatically compels us to *change the conversation* about engineering and technology. USC Viterbi aspires to be one of the leading global players in this transformation, in all its endeavors, from the education of our students, to the research of our faculty and to the creation of best practices and culture. Namely, to lead in redefining of *what we do, who we are and what we look like*. The exponential technology disruption requires agility, adaptability, and new mindsets. Such *mindsets of growth* must add to the traditionally offered in a brick-and-mortar institution *knowledge and skills*. They demand from us to keep re-inventing ourselves, our curricula as well as the outside-the-curricula activities, and our research programs. In order to constantly invent new programs, new flexible entities, and grow new ideas. To include in the engineering experiment all our population and human talent. In short to keep adding new value, at an increasingly faster pace.

Our vision and strategy in this area includes the goal for all our engineering students to develop the following key mindsets:

1. *Hug the exponential*: Acquiring the superb technical skills to lead the exponentially changing technology.
2. *Engineering +*: Changing the conversation about the empowering nature of engineering and the empowering of all segments of our population.
3. *Innovation in the broadest sense*: Helping create the new markets, the new jobs, and design the new self.
4. *The cultural mind*: Becoming culturally aware, with culture broadly interpreted (local to global, past, present and future) to help thrive in today's fast changing world and to solve global problems.
5. *Heroic engineering*: Embracing the notions of the beneficial impact of engineering to society (including the importance of technology ethics)

These five mindsets address the needs of the 21<sup>st</sup> century engineer: Exceptionally skilled technically, immersed in convergence and multidisciplinary, capable and confident for constant innovation and re-invention, having a deep understanding of human cultures and their behavioral drivers, and steeped with the ethical attributes in decision-making and the societal impact of engineering. In parallel, we must keep innovating to strengthen the technical content of our educational programs, for example by an all-disciplines effort to integrate data sciences across the engineering curriculum. While a significant effort needs to be devoted to formulate methods and practices, many outside the curriculum, or through a rebranded and refocused Engineering Writing Program, that will help imbue the other mindsets. These efforts, led by our talented faculty, will help form the new engineer, across all our undergraduate majors.

We note that these mindsets are consistent with the WEF report on added skills for the 21<sup>st</sup> century, namely Creativity, Leadership, Perseverance, and also with the *Engineer of 2020* study of the National Academies. They parallel the competencies identified in the NAE Grand Challenges Scholars Program, conceived and pioneered in 2009 by USC Viterbi, Duke Engineering and Olin College, now adopted by more than 80 schools nationwide, and having become an NAE signature program. While currently offered to a small fraction (about 10%) of our undergraduate class, our aspiration is to make it the blueprint for the education of all our students- undergraduate or graduate, and to extend it as a model for our K-12 outreach as well. In fact, we believe that this program can be extended across the entire university. Indeed, we currently have an effort underway to create such a program in the area of sustainability.

Engineering is a global discipline, both figuratively and literally. It is therefore not only natural, but also necessary, that Viterbi has such global reach. To this goal, USC Viterbi has for several years, and must continue having in the future, a strong presence overseas, particularly in the two largest countries in the world, India and China. In this outreach effort, we are aided by the Distance Education Network (DEN), a home-grown instructional technology, now nearing a half-century of existence, which allows our faculty and their courses to reach anyone, anywhere. The technology enables innovative multi-university programs, such as our own *i-Podia* program, which utilizes DEN as a platform for intra-university collaborations across many institutions worldwide. Moreover, such in-house technology expertise is invaluable for a variety of agile new programs, from continuing education, which is becoming a necessity for professionals in today's rapidly

changing skill set needs, to enhancing our own instructional delivery methods in a brick-and-mortar institution.

In parallel, engineering and technology's convergent and ubiquitous nature has led to its becoming quintessential to the education of practically every student and professional, regardless of background or major. Some view engineering and technology as an indispensable part of today's liberal arts education. We prefer to view them as essential convergent elements, and believe that exposure to them is as beneficial to everyone, as is for engineering students and professionals to be steeped in values, the humanities and technology ethics. USC Viterbi is cognizant and responsive to the former need, with the offerings of information technology content through its Information Technology Program (ITM). We believe that the education of all undergraduate (and many graduate) majors at USC can be enhanced by a supplement to their degree of a strong technology and engineering segment, certainly in the area of data sciences.

### **Changing the Conversation: Diversity and Inclusion in Engineering**

In this change of conversation, diverse and inclusive environments and cultures are essential to accomplishing our vision. Our goals are for student, faculty and administration in all academic departments and the school overall to be gender-balanced and representative of the US population-at large, in terms of backgrounds, demographics, experiences and talent. This will produce environments that are vibrant, inclusive, stimulating and will lead to a thriving body of students and faculty. This goal, consistent and harmonious with the articulated mindsets of growth, is to be relentlessly pursued.

As part of this effort, we have led a national initiative to increase the diversity of engineering schools: USC Viterbi spearheaded in June 2015 and completed in 2016, what is now an ASEE (American Society for Engineering Education) initiative, which has been signed by more than 210 engineering schools, nationwide. It was highlighted at an event on August 4, 2015 at the White House by US President Obama. The initiative commits engineering schools to activities in four areas: Creating a comprehensive diversity plan, outreach to K-12, Community Colleges and 4-year degree institutions, and increasing faculty diversity. The Viterbi School, having established in 2016 the office of Vice Dean for Diversity and Strategic Initiatives, is a national leader in the pursuit of the goals of this initiative.

*We should note some progress in this area: i. The Freshman class of Fall 2019 is almost 50% women, a gender-balanced achievement that we aim to become permanent; ii. Viterbi has the largest number of women engineering students nationwide; and iii. In the last two decades, the number of women engineering faculty has increased by almost 7-fold.*

Strengthening the diversity of engineering schools nationwide requires substantial STEM Outreach to the K-12 schools. This effort has been underway at USC for several decades, and it is now further supported by additional resources in the Center for Engineering Diversity and the STEM Center. In an another initiative under development in this area, we would like for engineering students and faculty to volunteer in helping mentor and train in STEM K-12 students in the general Los Angeles area, with the goal of reaching 100,000 volunteer hours per year. It is only through such engagement that we can strengthen the K-12 STEM pipeline nationally, and ultimately help create an inclusive and diverse engineering force for the nation.



### **Means to Support Vision and Strategy**

Like any other engineering school in a brick-and-mortar institution, implementing the vision, mission and strategy is not possible without excellence in human resources, infrastructure, fundraising, and communications outreach. Technology is rapidly becoming an essential enabler of many administrative functions, and it is an important area where the Viterbi School aspires to lead, both at USC and nationally. To this effect, the school stands to benefit from the recently created Office of Chief Technology Officer. Nonetheless, it is our staff, in partnership with our faculty, who will guide, enable and nurture the daily implementation of our strategy. Their excellence and commitment are inseparable from our success.

External fundraising through philanthropy is essential to acquiring the means for success, in today's rapidly changing landscape of higher education, the role of technology in educational offerings and the evolving societal expectations on the fundamental nature and the affordability of higher education. While USC Viterbi has successfully completed two consecutive fundraising initiatives between 2001-2007 and 2010-2019, its focus must continue on establishing ambitious but reachable fundraising targets; articulating and communicating the excellence and importance of the school in solving grand challenges and preparing our students for the same; and otherwise helping attract enthusiastic and generous support to enable its vision and impact.

### **Culture**

The traditional academic settings of disciplines trace their origin to several centuries ago. Today's world of exponential changes, with the concomitant needs for agility, convergence, growth and adaptation, exerts significant strains in what we can collectively denote as "culture". Such challenges, in fact, also exist within one's own narrower academic discipline. It has been said\* that culture "wants to be enduring and prevailing". It is an objective of USC Viterbi to work towards reducing even eliminating such barriers, both internal and external, both in engineering education and in research.

We view the culture of an organization in an analogy with the state of a physiological organism. Just like organisms have an inherent *homeostasis* that governs their well-being, so do organizations, such as the Viterbi School, whose homeostasis is the close and systematic pursuit of its *overarching vision and values*, for example, as articulated in this document, but also as advocated by the university overall. And just as departures from homeostasis in an organism trigger intrinsic alerts and a resulting remedial action, so we want any departures from our collective values to trigger alerts and then the remedial action that will bring the organization to its desired homeostasis. The fast growing technology can help provide the means to sense and measure such departures promptly and accurately and to help restore the approach to our enduring values. In this effort, power asymmetries and power differentials between various groups, faculty, students, and staff should be eliminated from influencing behavior on all matters, and particularly on discouraging Equity, Diversity and Inclusion. In this goal, we expect that our talented faculty, students and staff, will constantly lead, with the goal of maintaining and advancing a culture consistent with our highest values and aspirations.

\*Antonio Damasio, "The Strange Order of Things"

## **Conclusion**

Powerful and Convergent Technology Helps:

*Setting and Solving Humanity's Goals- and  
Changing the Conversation about Engineering*

This drives USC Viterbi and it helps attract and transform talent- faculty, students and staff. It empowers them to innovate, create new technologies and solutions and to reinvent brick-and-mortar engineering institutions for the benefit of the world.