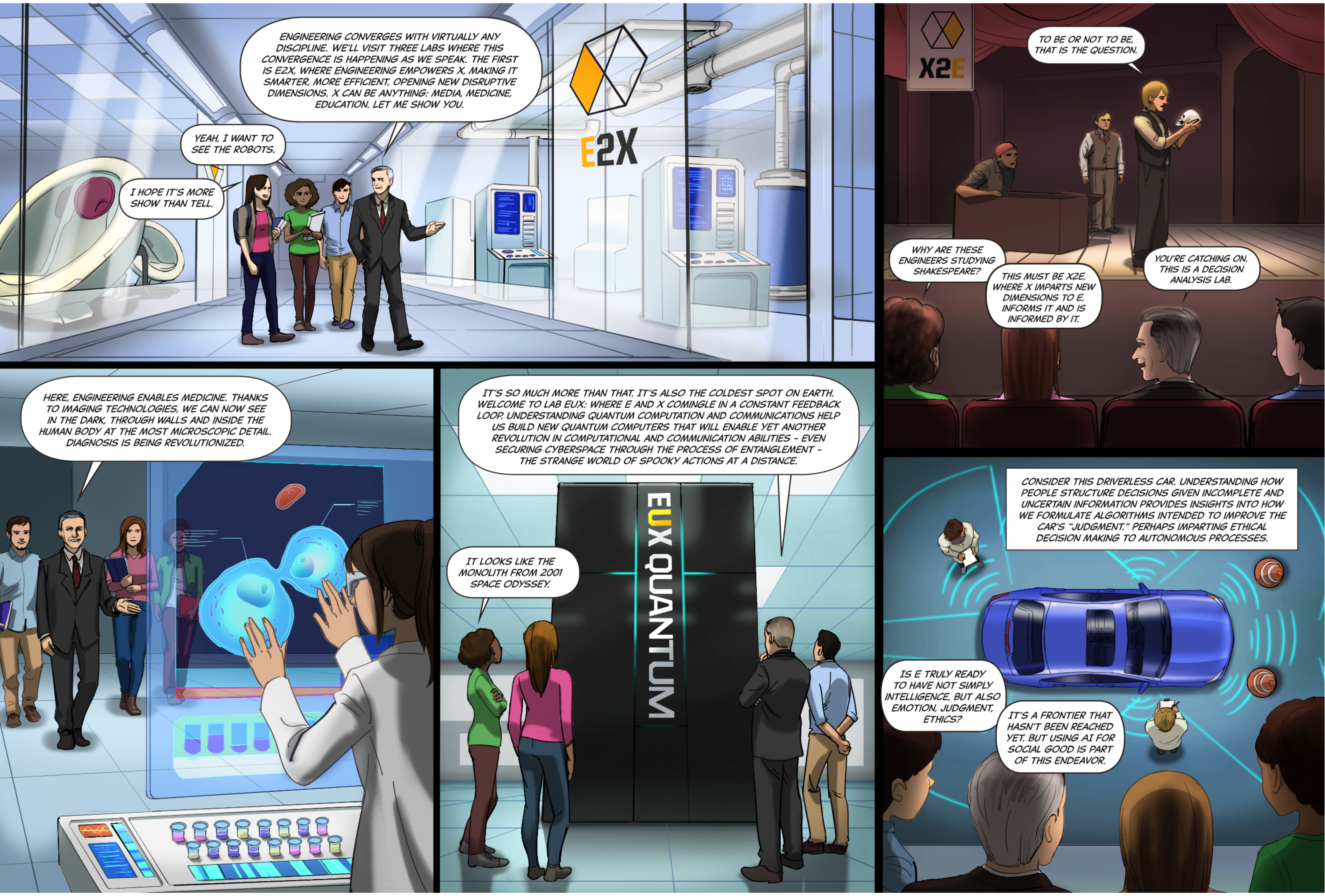
E2X
ENGINEERING CONVERGES WITH VIRTUALLY ANY DISCIPLINE. WE'LL VISIT THREE LABS WHERE THIS CONVERGENCE IS HAPPENING AS WE SPEAK. THE FIRST IS E2X, WHERE ENGINEERING EMPOWERS X, MAKING IT SMARTER, MORE EFFICIENT, OPENING NEW DISRUPTIVE DIMENSIONS. X CAN BE ANYTHING: MEDIA, MEDICINE, EDUCATION. LET ME SHOW YOU.
YEAH, I WANT TO SEE THE ROBOTS.
I HOPE IT'S MORE SHOW THAN TELL.
X2E
TO BE OR NOT TO BE, THAT IS THE QUESTION.
WHY ARE THESE ENGINEERS STUDYING SHAKESPEARE?
THIS MUST BE X2E, WHERE X IMPARTS NEW DIMENSIONS TO E, INFORMS IT AND IS INFORMED BY IT.
YOU'RE CATCHING ON. THIS IS A DECISION ANALYSIS LAB.
HERE, ENGINEERING ENABLES MEDICINE. THANKS TO IMAGING TECHNOLOGIES, WE CAN NOW SEE IN THE DARK, THROUGH WALLS AND INSIDE THE HUMAN BODY AT THE MOST MICROSCOPIC DETAIL. DIAGNOSIS IS BEING REVOLUTIONIZED.
IT'S SO MUCH MORE THAN THAT. IT'S ALSO THE COLDEST SPOT ON EARTH. WELCOME TO LAB EUX: WHERE E AND X COMINGLE IN A CONSTANT FEEDBACK LOOP. UNDERSTANDING QUANTUM COMPUTATION AND COMMUNICATIONS HELP US BUILD NEW QUANTUM COMPUTERS THAT WILL ENABLE YET ANOTHER REVOLUTION IN COMPUTATIONAL AND COMMUNICATION ABILITIES - EVEN SECURING CYBERSPACE THROUGH THE PROCESS OF ENTANGLEMENT - THE STRANGE WORLD OF SPOOKY ACTIONS AT A DISTANCE.
EUX QUANTUM
IT LOOKS LIKE THE MONOLITH FROM 2001 SPACE ODYSSEY.
CONSIDER THIS DRIVERLESS CAR. UNDERSTANDING HOW PEOPLE STRUCTURE DECISIONS GIVEN INCOMPLETE AND UNCERTAIN INFORMATION PROVIDES INSIGHTS INTO HOW WE FORMULATE ALGORITHMS INTENDED TO IMPROVE THE CAR'S "JUDGMENT." PERHAPS IMPARTING ETHICAL DECISION MAKING TO AUTONOMOUS PROCESSES.
IS E TRULY READY TO HAVE NOT SIMPLY INTELLIGENCE, BUT ALSO EMOTION, JUDGMENT, ETHICS?
IT'S A FRONTIER THAT HASN'T BEEN REACHED YET. BUT USING AI FOR SOCIAL GOOD IS PART OF THIS ENDEAVOR.

**E2X** **EUX** **X2E**

I view engineering and technology as "leveraging phenomena for useful purposes", a definition borrowed from Brian Arthur. "Leveraging" here is meant to imply the creation of engineered systems and its endowment with "smart" or "intelligent" properties. "Phenomena" are, in increasing complexity of physical, chemical, biological, geological, cognitive and social origin. Finally, "useful purposes" brings in complementary ethics and legal considerations, required for decision-making, revealing in the process the potential for unintended consequences.

Engineering and technology live inherently in the space of convergence, with the specific goal to create "intelligent" systems. In my mind, convergence has a number of flavors: From an engineering-centric perspective, it reflects the nature of technology and engineering to empower practically every discipline. I call this **Engineering + X**, where **X** is any other discipline. Its most overt manifestation is the pathway **Engineering to X** (call it **E2X**): where engineering empowers X, making it "smarter", introducing efficiencies, helping open vast new opportunities, and acquire new dimensions and properties, many of which can be disruptive. E2X is the ubiquitous digitization of almost everything and will increasingly be affected by the incoming torrent of cyber-physical disruption with the Internet of Things.

The second pathway is where **Engineering and X** co-mingle (**EUX**). Examples abound when X denotes natural sciences, such as biological sciences, quantum physics, quantum communications, etc. Here, the "useful purposes" of the above definition is "enabling new scientific discovery," and will in turn lead to new "useful purposes". A tightly intertwined "double helix" of (mostly) natural sciences and engineering, EUX supports the development of new technologies and infrastructure while setting additional frameworks for solving Grand Challenges. I would parallel such technological development with the "exponential technologies" cited in "The Second Machine Age."

**EUX** is also relevant to socio-technical systems, many of which are inherent to the development of engineered systems and to technology incubation. These include: systems engineering, design, technology startups, technology and engineering management, etc.

The final convergence element is the **X2E** pathway, where X imparts X-mimetic processes and principles – biomimetic processes being most common. For certain X-mimetic processes, **X2E** is the shortcut for obtaining optimal answers to complex problems that nature has uncovered through a "natural" optimization practiced over millions years of evolution.

Interesting questions arise when X represents a discipline or processes dominated not by logic or the natural sciences, but rather by social sciences, by emotions, or by legal or ethical considerations or by character.

How do the **E2X** and **X2E** pathways look then? Rapid advances are being made in the **E2X** pathway, for example, in behavioral informatics, neuroscience and psychology, entertainment, human-machine interaction, and built environment-human interaction among others. The reverse pathway, endowing engineering and technological constructs with uniquely human properties is not only disruptive, but potentially world-changing. As technology continues its exponential march, related ethical and moral questions will inevitably arise with vast ramifications. Consider ethics and decision-making in the operation of autonomous systems, such as drones or driverless cars alongside other human-machine interfaces. Fast growing movements, such as "AI for Social Good", suggest an increasing awareness of the relevance of these issues.

On the converse side, when X refers to societal-emphasis disciplines (e.g. social work), progress towards the solution of X-type grand challenges (such as Social Work Grand Challenges) can only be realistically be achieved if technology and engineering, in their most general sense, are brought to bear.

Yannis C. Yortsos

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## USC Viterbi at a Glance

USC Engineering began in 1905

**Student Population**
Approximately 2,600 undergraduate students and 5,200 graduate students

**Faculty**
180 tenure-track faculty, with 62 endowed chairs and professorships, 64 NSF Career Awardees, 22 full-time, tenure-track NAE members (36 total affiliated), 7 NAS members, 13 MIT TR35 winners

**Academic Departments**
Eight

**Alumni**
More than 60,000

**Annual Research Expenditures**
More than $185 million, with more than 46 research centers and institutes

**Research Centers and Institutes**

*Home to:*
» Information Sciences Institute (ISI)
» The Ming Hsieh Institute
» The Daniel J. Epstein Institute
» Two (now graduated) National Science Foundation (NSF) Engineering Research Centers (ERC)
  › Integrated Media Systems Center (IMSC)
  › Biomimetic MicroElectronic Systems Center (BMESC)
» University Center of Excellence of the U.S. Department of Homeland Security - Center for Risk and Economic Analysis of Terrorism Events (CREATE)
» DOE/White House Materials Genome Initiative Center
» Center for Energy and Nanoscience at USC
» Biomedical Informatics Research Network (BIRN)
» HTE@USC (Health, Technology and Engineering@USC)
» LADWP/DOE Smart Grid Demonstration Project
» USC-Lockheed Martin Quantum Computation Center
» Center for Interactive Smart Oilfield Technologies (CiSoft)
» Pratt & Whitney Institute for Collaborative Engineering (PWICE)
» Airbus Institute for Engineering Research (AIER)
» Infosys Center for Advanced Software Technologies (CAST)
» NIH Center on Genomics and Phenomics of Autism
» USC Energy Institute

*Affiliated with:*
» Alfred E. Mann Institute for Biomedical Engineering (AMI)
» USC Institute for Creative Technologies (ICT)
» USC Stevens Center for Innovation

**Education Centers**
» Division of Engineering Education
» KIUEL (Klein Institute for Undergraduate Engineering Life)
» VAST: Viterbi Adopt-a-School, Adopt-a-Teacher
» Maseeh Entrepreneurship Prize Competition (MEPC)
» Viterbi Student Innovation Institute (VSI2)

USC Viterbi
School of Engineering


2016 **DEAN'S REPORT** *convergence*