ENGINEERING CHANGE LAB USA

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THE ENGINEERING IDEAS INSTITUTE II

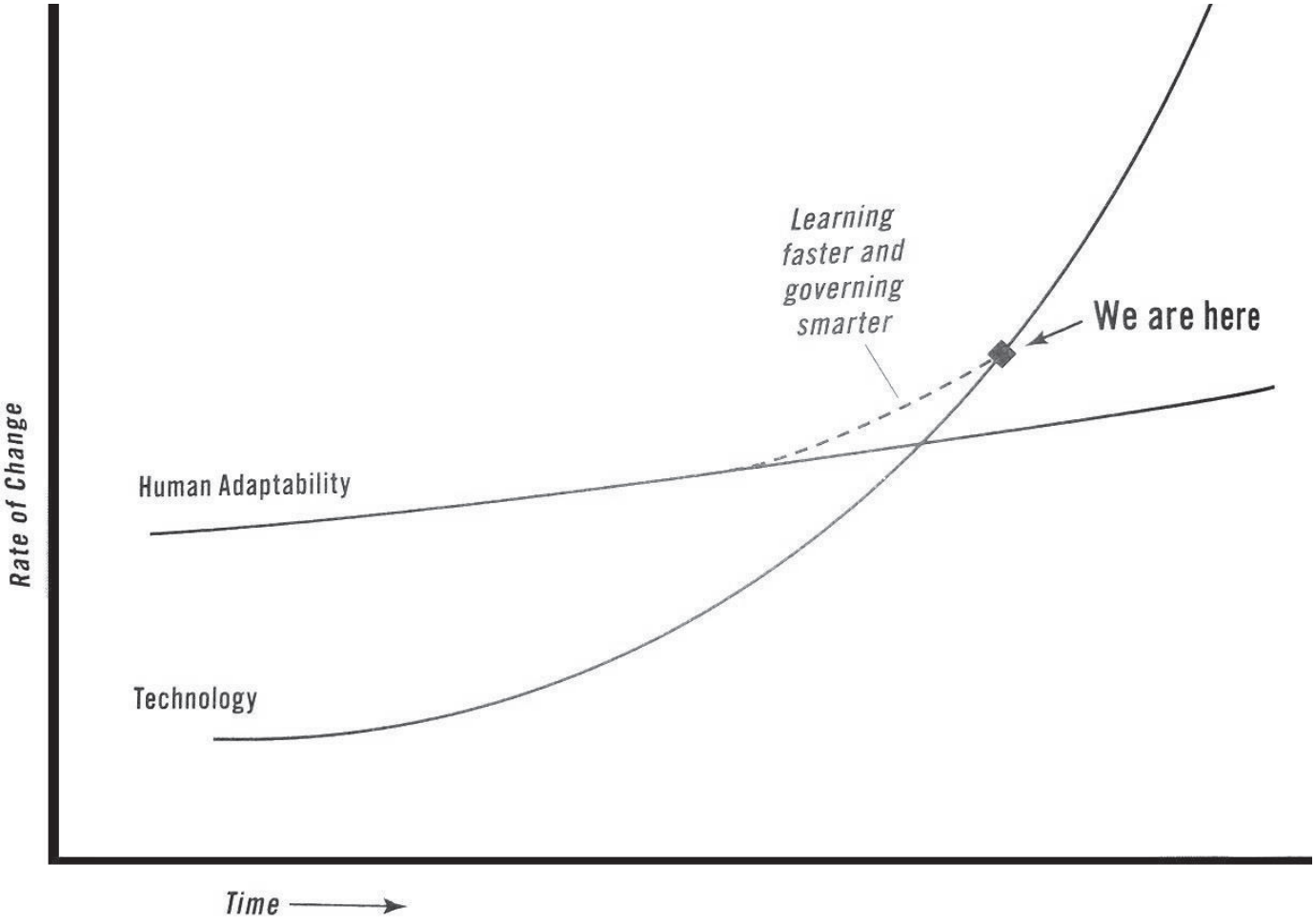
ENGINEERING IN AN AGE OF ACCELERATION

Summit 13 Report
October 11-13, 2021

Engineering in an Age of Acceleration

The concept for the Engineering Change Lab – USA (ECL-USA) **Engineering Ideas Institute** is to offer an extended deep dive into the most complex issues facing the engineering community. The second edition of the Institute (first in-person) was held from October 11-13, 2021, at the Colorado Chautauqua in Boulder, Colorado. One of the focus areas for the 2021 Institute was "**Engineering in an Age of Acceleration**." The concept for this section of our work stems from the observation in Thomas Friedman's 2016 book Thank You for Being Late, that the gap between technological progress and humanity's ability to adapt to technological change is growing ever wider. This concept is illustrated in the exhibit below. At the Institute, we explored the role that engineering can play in helping society close or cope with this gap. We also examined whether and how that gap manifests within the engineering community itself and identified strategies for increasing the adaptability of the engineering community.

Eric Teller's Adaptability Curve



Engineering in an Age of Acceleration

PROVOCATEURS

Provocateurs **Bob Prieto**, Chairman and CEO of Strategic Program Management and former Senior VP with Fluor, and **Bruce Bartolf**, Executive Consultant and former Principal and CTO at Gensler, provided valuable background and context regarding the forces of technological change. They traced the accelerating trajectory of technology, including technologies that could potentially bend the curve of human adaptation. They also described new capacities that the engineering community needs to develop to help society successfully close the gap, including new approaches to projects and overcoming our aversion to risk. **Allison Wood**, Assistant Professor of Environmental Engineering at Olin College, described how Olin is helping to create a new engineering education paradigm, utilizing its unique academic community to prepare engineering students to "do good in the world" by making "values" an integral part of engineering and the development and application of technology.

Bruce Bartolf
EXECUTIVE CONSULTANT FORESTAY CONSULTING

Bruce Bartolf brings a wealth of knowledge and experience built over a 29-year career in AEC IT, operations, consulting, management, and strategic leadership. As Principal and CTO of Gensler, Bruce built and managed the technology infrastructure of the global design powerhouse, while also engaging with clients in areas of workplace technology, change management, and IT operations. Currently he is conducting executive education, IT consulting, and mentoring future IT leaders. He has a BA and BS from Miami University, completed graduate work at USC Annenberg, and has several IT certifications.

Bob Prieto
CHAIRMAN & CEO
STRATEGIC PROGRAM MANAGEMENT LLC

Bob Prieto is currently Chairman & CEO of Strategic Program Management LLC focused on improving capital efficiency in large capital construction programs and strengthening engineering and construction organizations. Previously Bob was a senior vice president of Fluor focused on the development and delivery of large, complex projects worldwide. He is author of nine books, over 850 papers and presentations and four issued patents. Bob currently serves on the Mott MacDonald Shareholders Committee as an independent member and Saudi based Dar al Riyadh Group as a non-executive director.

Alison Wood
ASSISTANT PROFESSOR OF ENVIRONMENTAL ENGINEERING
OLIN COLLEGE OF ENGINEERING

Dr. Alison Wood's professional objectives are creating more sustainable and equitable communities and developing community members who work toward equity and inclusion while building sociotechnical systems to facilitate those outcomes in the future. Her interests include interdisciplinary integration, decision making in complex systems, and the transformation of engineering education to prioritize sustainability and equity. She has earned a B.A. in Dramatic Literature, a B.S. in Civil Engineering, a M.S.E. in Environmental and Water Resources Engineering, and a Ph.D. in Civil Engineering.

Provocation

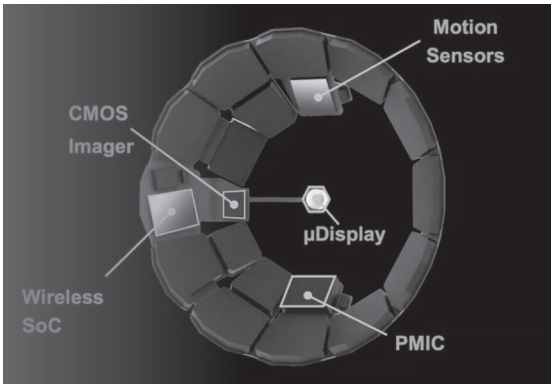
FORCES OF CHANGE

BRUCE BARTOLF
EXECUTIVE CONSULTANT FORESTAY CONSULTING

Bruce Bartolf began his provocation with several examples from the past of rapid technological change – the shift from the horse to the car over 13 years in the early 1900s, the rapid development of the airplane over the 1930s and 1940s, and the exponential increases in data storage capability over the 2010s. These lessons from the past highlight our need to learn faster and govern smarter. According to Bartolf, we need to "bend the curve of human adaptability."

Bartolf described the tools for augmentation of human senses, mechanics, and function being developed that will contribute to bending the curve.

EXOSKELETONS – to reduce wear and tear on the body, improve productivity, reduce health claims and reduce turnover; to enable disabled people to walk.



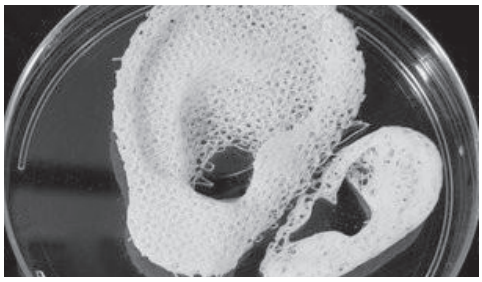
NEAR-EYE DISPLAYS – for use in augmented and virtual reality.

IN-EYE DISPLAYS – smart retinal implants.

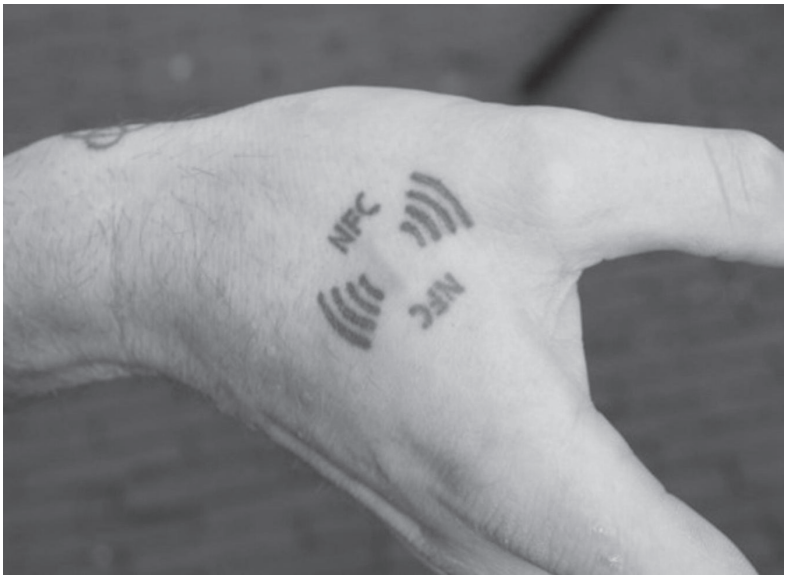
LIMB AUGMENTATION – through prosthetics.

COCHLEAR IMPLANTS – that could allow for language translation.

3D BIOPRINTING – ear and nose replacement, organ replacement, and lab-grown skin.



NEAR FIELD COMMUNICATION AND SMART HEALTH IMPLANTS – glucose monitors, seizure prevention, and treatment of depression.



FASHION – LED tattoos.

HUMAN ADAPTATIONS OCCURRING IN NATURE – less teeth, extra arteries in hands, and reduction in normal body temperature.

What are the consequences of these developments? According to Bartolf, consequences that will potentially exacerbate current challenges include impacts on hiring (with those who can afford augmentation having advantages), social justice implications if we can change who we are, a widening digital divide, and a growing wealth gap.

Provocation

SENSEMAKING IN AN AGE OF ACCELERATION

BOB PRIETO
CHAIRMAN & CEO STRATEGIC PROGRAM MANAGEMENT LLC

Bob Prieto began his provocation by describing the process of sensemaking, which he described as "the process by which people give meaning to their collective experiences." He stressed the importance of **Thinking Again** with respect to **Common Perceptions and Theories That Must Be Supported by Facts**. An example from the world of physics is the muon, a sub-atomic particle produced by the collision of cosmic rays with particles in the upper atmosphere. Standard theories of physics fail to predict the actual behavior of muons as they descend through the atmosphere. In the world of engineering, a similar phenomenon occurs with respect to the theory of projects, particularly technologically complex mega-projects. Two of three mega-projects planned using classical project planning theory are known to fail. Prieto stressed several shortcomings of classical theories.

- Lack of understanding about, and agreement to, what the project is trying to accomplish (strategic business objectives) among key project stakeholders.
- With respect to risk and risk modeling, large projects do not behave normally, and we tend to lose sight of the real drivers.
- Multiple stakeholders disrupt the normal flow of project activities.

He emphasized that even though current models are not working, we are still highly resistant to changing them.

Prieto described how a **Noble Purpose** can set the stage for transformational change and accomplishment for projects. He cited examples from the past when noble purpose or clear, shared strategic objectives played a role in the success of major projects – the Manhattan Project, the Atlas and Polaris Missile Systems, and the Man on the Moon project.

He then described the need for the engineering community to develop **New Focus**, **New Skills**, and **New Ways**.

1. **NEW FOCUS** includes shifting from management to governance, with permission from those being governed, and engagement with as opposed to management of stakeholders.

2. This new focus requires **NEW SKILLS**, including knowledge of the social sciences, willingness to recognize what we don't know, and strong communication skills that are based on listening to new voices.

3. **NEW WAYS** involves rethinking the position of the individual and our concept of community, particularly in our world of tribalism and artificial intelligence.

All these transformations are captured in the concept of **Radical Empathy**, through which the engineering community can build "trust that becomes the currency for action."

Prieto emphasized a theme common to much of the work of ECL-USA, the importance of systems thinking, a skill he described as mostly missing from engineering. Both he and Bruce Bartolf highlighted the need to return to the engineer's role of Master Builder as an important step to closing the technology gap. He stated that artificial intelligence will be the single largest driver of technology spending over the next five to ten years and that we are only at the beginning of the revolution of data monetization. He also believes that the convergence of multiple emerging technologies will drive the acceleration of technological capabilities. Examples of convergences includes the merging of the physical and biological worlds such as in the use of fungi to fill cracks in concrete. He challenged participants to think about a "post-human" view of creativity, such as a recent patent granted in South Africa for inter-locking food containers that was developed by an AI system, not by a human being.

Prieto summarized his presentation with four provocations (see exhibit).

PROVOCATIONS

P1 — **Today's engineer is not being trained for the potentials of tomorrow**

P2 — **The siloed nature of the industry makes systemic innovation improbable and has destroyed the value previously brought by the Master Builder.**

P3 — **The Theory of Projects fails at scale and a new System of Systems model is required with new and *expanded governance and engagement* models.**

P4 — **Risk appetite is a principal barrier to innovation and technology adoption. The industry is undercapitalized for long term survival and success.**

Forces of Acceleration & Change, Exploring the Gap – Group Exercise

In illustrating the "gap" that is growing as society experiences this age of acceleration, Eric Teller's adaptability diagram presents "human adaptability" as a straight line. We could observe, however, that different elements of society have varying capacities to adapt and change, making the discontinuities, disruptions, and problematic transitions we experience even more problematic. Institute participants explored this more complex view of the "gap" by comparing the "speed" that various elements of society are traveling compared to technology that is traveling at a speed of 100 mph (and accelerating). The consensus of participants is illustrated below.

	SPEED						
Sector	***0 - 10***	***10 - 30***	***30 - 50***	***50 - 70***	***70 - 90***	***90 - 99***	***100***
Business				X			
Government & Regulatory Agencies		X					
Non-Profits (NGO's)				X			
Low Income/Disadvantaged Individuals & Families		X					
Middle Class Individuals & Families				X			
Wealthy Individuals & Families					X		
Public Education (K-12)			X				
Legal Institutions (Law, Courts, etc.)		X					
Nature / Environment		X					

Participants then reflected on these observations and considered the following questions.

What types of discontinuities, disruptions, and problematic transitions being experienced by society are most concerning to you?

What do you observe about the adaptive capacity of humans and the institutions of our society?

What speed rating would you give …

- The Engineering Profession / Engineering Community
- Engineers
- Engineering Education (Colleges & Universities)

What concerns surface with those ratings for engineering?

Key points from the group discussion included the following.

- Distrust in science and technology impacts engineering and widens the gap.
- Rise in tribalism is a concern- facts are no longer facts.
- Lack of soft skills emphasis in engineering education.
- Overall importance of technology in everyday life creates dependencies and inequities related to age, economic status, etc.
- Engineering can help fill the information/communication gap and education related to risks of new technologies.
- We are "not all in this together"- e.g., disparities between different segments of the engineering community.
- Concern about our ability to interact in productive discourse.
- Risk aversion impacts adaptation- software engineers v. civil engineers.
- Human adaptability is held down by institutions.
- Users/clients of engineering impact adaptation.
- Just because we can do it doesn't mean we should- need for moral / ethical compass.
- How do we close gaps between segments of the engineering community?
- **We are part of the problem in technological adaptation, but there is potential for the engineering community to have a major role in solutions.**

Participants then turned to an exploration of organizational and personal resilience and adaptability by considering these questions.

1. ***Reflecting on the age of acceleration concept, assess both your personal capacity and the capacity of your organization to adapt and accelerate.***
2. ***How resilient are you and your organization in the face of the forces of change that come with our age of acceleration?***
3. ***Thinking about yourself and your organization, what are you most optimistic about? Where do you see the greatest potential?***
4. ***What most concerns you both personally and with respect to your organization?***

Group discussion of these individual reflections surfaced the following key points.

Change is inevitable, and we need to embrace change. COVID example - we will not go back to where we were before the pandemic.

There can be variances in regional challenges, e.g. coasts versus central plains.

Generational challenges exist, such as transferring technology adaptations to younger generations who still need coaching and mentoring and intergenerational collaboration.

Organizations need to foster curiosity, openness to learning, and a culture of entrepreneurship as discussed at ECL-USA Summits 6 and 12.

Organizations need agreed upon methods of managing change. Metrics are important as well as watching out for unintended consequences.

How do we help and care for people who suffer harm from falling behind?

- Multiple systems of communication.
- Empathy.
- Recognizing the consequences for society to influence decision-making.

Provocation

ENGINEERS AS AGENTS OF CHANGE & ADAPTATION

ALISON WOOD
ASSISTANT PROFESSOR OF ENVIRONMENTAL ENGINEERING OLIN COLLEGE OF ENGINEERING

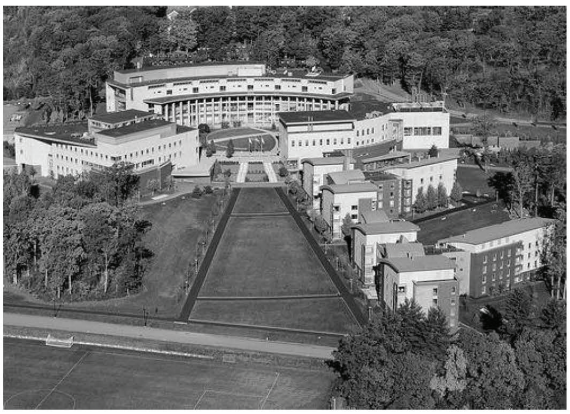
Alison Wood began her provocation by observing that "acceleration in technology and society speeds up engineering processes and spreads our work further and faster than ever before," and that going faster and faster results in breaking things. She described the philosophy at Olin College of Engineering that engineers are agents of adaptation and change and that the engineering community can choose how to design technologies and build with technologies, considering the impacts of our work on society and the environment. "**We have agency**." Olin is re-defining "good engineering" through a systems approach that encourages considering broader impacts on people and the environment, pushing the envelope of the box that often defines engineering practice.

Olin's approach to sustainability in engineering centers on inter- and intra-generational equity and justice that broadens the ethical definition of the "public" for whom we hold paramount health, safety, and welfare. They utilize the United Nations 2030 Agenda for Sustainable Development.

Olin seeks to make values a fundamental part of the work of engineering. Their overall focus is to "*prepare engineering students to do good in the world.*"

Olin College of Engineering

"Olin College prepares students to become exemplary engineering innovators who recognize needs, design solutions and engage in creative enterprises for the good of the world. Olin is dedicated to continual discovery and development of effective learning approaches and environments, and to co-developing educational transformation with collaborators around the globe."



Olin College of Engineering

Other key elements of Olin's approach include the following.

- Incorporating arts, humanities, and social sciences into engineering education.
- Fostering ethics in engineering modeling such as through a course titled "ModSim," the objectives of which are to teach critical thinking with respect to models, challenge assumptions, and evaluating whether a model should be used.
- Understanding social and hierarchical structures through a course in "Context and Consequences," that requires reflection and looking through different lenses.
- Requiring all students to take a course in entrepreneurship.
- Fostering a strong sense of community on campus.
- Focusing on diversity with a goal of 50% female students.
- Experiential, project-based learning that integrates fundamentals.
- Maintaining ABET accreditation but examining whether accreditation limits their ability to meet their vision.

As an example of the traits that Olin seeks to develop in its students, Wood cited Frances Haugen, a 2006 Olin graduate who was the whistleblower that revealed Facebook's practices that placed profit over ethics and safety.

Facebook Whistleblower Frances Haugen: The 60 Minutes Interview - YouTube

acebook data scientist Frances Haugen speaks during a hearing of the Senate Commerce, Science and
ation Subcommittee on Consumer Protection, Product Safety and Data Security on Capitol Hill on Tuesday.
on/AP

Bridging the Gap, Strategies for Engineering Leadership – Group Exercise

Institute participants explored the need to bridge the gap between the acceleration in technological development and human's capability to adapt to change through reflection on several questions.

As stewards of technology and nature on behalf of society, what could engineers do to help society …

- Bridge/close the "gap"?
- Deal with the discontinuities and disruptions that we are experiencing because of the "gap"?

What capacities will engineers either need to develop or bring forward (emphasize) to fulfill that role?

Key points from group discussion are included below.

- We need to be part of the disruption and push the limits. (Example cited was the move to multiple uses of public streets in New York City.)
- We should be leading in the push for better codes that deal with social and environmental externalities.
- There needs to be a greater focus on life cycle costs/impacts in standards.
- The engineering community should aggressively and ethically step up our public face in educating the public and politicians regarding the values and risks of technology to society, leveraging our trustworthiness.
- Engineering licensure and its primary focus on technical knowledge needs to be addressed.
- We must learn the perspective of clients and users.
- We want to be agents of change, but we may lack the tools.
- We need to shift to a mindset of "agency" rather than waiting for others.
- There is a need to engage the public sector in planning for the future of engineering through collaborative leadership.
- We can capitalize on the noble purpose concept in expanded ways related to our agency.

Bridging the Gap, Community & The Upswing – Presentation & Group Exercise

> *There is only one way to thrive now, and it's by finding and creating your own eye (of a hurricane). It draws energy from it, while creating a sanctuary of stability inside it. It is both dynamic and stable - and so must we be.*
>
> *The closest political analogue for the eye of a hurricane that I can think of is a healthy community.*
>
> From Thank You for Being Late by Thomas Friedman

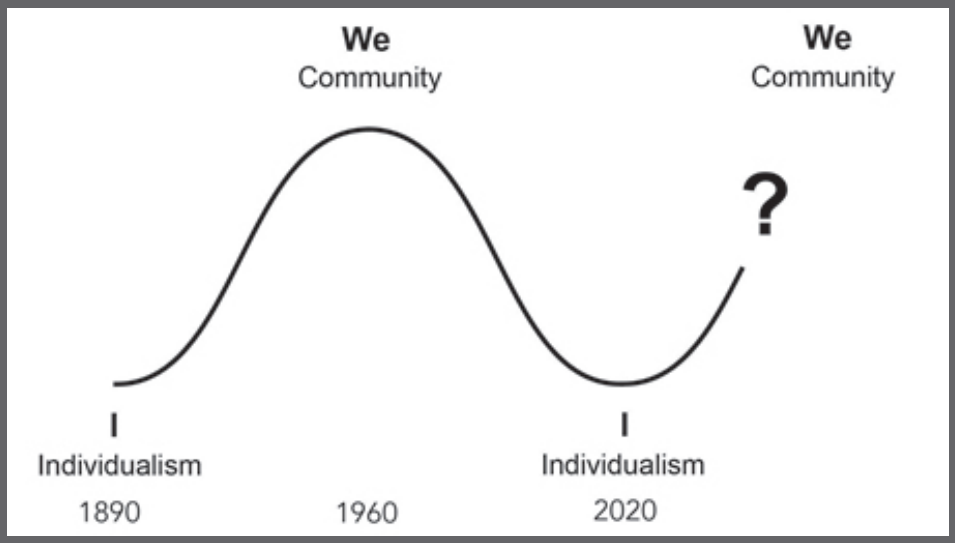
"The basic architecture of a resilient and prosperous twenty-first century society must be a network of healthy communities."

– Gidi Grinstein as quoted by Friedman

According to Thomas Friedman, the key to bridging the gap is to work toward strong and resilient communities. Friedman states that "when people are embedded in a community they feel "protected, respected, and connected" … which generates enormous trust. He also offers that "when people trust each other … people in the community can be much more adaptable and open … (and) more inclined to …"

- Think long term.
- Collaborate and experiment.
- Be open to others, to new ideas, and to novel approaches.
- Extend the Golden Rule to others.
- Feel free to fail … and learn.
- Take ownership of problems and practice stewardship.

Another of the readings for the Institute was the book, The Upswing: How America Came Together a Century Ago and How We Can Do It Again by Robert D. Putnam. The theme of the book is that "what's past is prologue; rediscovering the latent power and promise of we." Putnam documents the history of the last 130 years as characterized by two major swings, the swing from individualism to communitarianism from the 1890's to about 1960 and the swing back to individualism from 1960 to the present.



"We" – Commitment to common purposes and care for others

"I" – Emphasis on personal liberty and freedom

Putnam rejects "either-or" thinking with respect to the need to swing back to communitarianism in favor of a "both-and" approach. Putnam states "... the question we face today is not whether we can or should turn back the tide of history, but whether we can resurrect the earlier communitarian virtues in a way that does not reverse the progress we've made in terms of individual liberties. Both values are American, and we require a balance and integration of both."

In group discussion participants reflected on Friedman's and Putnam's premise regarding the importance of "community" as a prime strategy for coping with the disruptive forces of the age of acceleration. What role can engineers play in building / rebuilding communities and contributing to the "upswing"? How healthy is the "engineering community"? What could be done to improve the health, resilience, and adaptability of the engineering community?

Key takeaways from the discussion are listed below.

- Digital tools can create a false sense of community. What does real community look like in a digital world? Our digital life gets in the way of community.
- In our personal lives, we know a real community when we see it – churches, neighborhoods, etc. The characteristics of a real community include shared purpose and people supporting each other.
- Workplaces can be a community.
- Are on-line communities real?
- If the engineering community was a network of healthy communities, what would that look like?

Provocateur presentations are available on the ECL-USA website
(Summit Information | Engineering Change Lab – USA (ecl-usa.org).