

Exploring Innovation Frontiers Initiative

Stimulate.

Southern Regional Dialogue

Mays City Centre
Houston, TX
November 15, 2016



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Council on
Competitiveness

Stimulate.

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Table of Contents

Letter from the President	6
Participants	7
Agenda	9
Findings from the EIFI Southern Regional Dialogue	
Executive Summary	14
Innovation Keynote: Gregory Powers, Vice President of Technology, Halliburton	18
Panel Summary—Emerging Innovation Frontiers: Energy and Manufacturing	21
Panel Summary—Emerging Innovation Frontiers: Autonomy and Transportation	25
Panel Summary—Emerging Innovation Frontiers: Interdisciplinary Opportunities	28
Panel Summary—Emerging Innovation Frontiers: Engineered Healthcare	31
The Path Forward	34
About the Council on Competitiveness	35

EIFI SOUTHWEST REGIONAL DIALOGUE

Letter from the President

On behalf of the Council on Competitiveness (Council), I am pleased to release findings from the Southern Regional Dialogue of the Exploring Innovation Frontiers Initiative (EIFI), held on November 15, 2016 and hosted by the Texas A&M University System and Engineering at Texas A&M University at the Mays CityCentre in Houston, TX. The report, titled *Stimulate*, recognizes the primary directive of the event to understand the process of innovation in technologies supporting America's future competitiveness.

EIFI is a national, public-private effort to accelerate the over-the-horizon, transformative innovation models that will drive U.S. competitiveness in the coming decades. Sponsored by the National Science Foundation (NSF) Directorate of Engineering, Office of Emerging Frontiers of Research and Innovation (EFRI), EIFI is a qualitative analysis that will collect, synthesize and disseminate broadly the experiential knowledge of active innovation practitioners. This information will be used to provide academicians with direction for future research in innovation, business leaders and strategists with insights to inform future business models, and policymakers with knowledge to enact public policies that create a supportive environment for sustained innovation-driven growth.

I would like to extend a special thanks to Dr. M. Katherine Banks, Council Technology Leadership and Strategy Initiative member, Vice Chancellor for Engineering, Texas A&M University System and Dean of the College of Engineering at Texas A&M University for co-hosting and leading a deeply thoughtful conversation of business, academic and national laboratory technology innovators—laying the foundation for the coming decades of U.S. competitiveness.



Stimulate summarizes the conversations of the Southern Regional Dialogue, building upon elements of previous EIFI Regional Dialogues at the ARTSblock at the University of California, Riverside on November 23, 2015 and the launch and initial dialogue on Jun 9, 2015 at the Georgia Tech

Global Learning Center in Atlanta, GA. The lessons across dialogues have thus far been remarkably consistent: Innovation and future competitiveness benefit from students, researchers, and technologists' exposure to diverse experiences across disciplines.

The Council is honored to work with leaders across industry, academia, national laboratories and governments as we continue to illuminate insights and craft recommendations to leverage U.S. innovation and creativity to meet the goals of the Exploring Innovation Frontiers Initiative.

Sincerely,

A handwritten signature in black ink that reads "Deborah L. Wince-Smith". The signature is fluid and cursive, written over a light grey rectangular background.

The Honorable Deborah L. Wince-Smith
President & CEO
Council on Competitiveness

EIFI SOUTHWEST REGIONAL DIALOGUE

Participants

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Dr. M. Katherine Banks
Vice Chancellor for Engineering, Texas
A&M University System -and-
Dean of the College of Engineering at
Texas A&M University

The Honorable Deborah L.
Wince-Smith
President & CEO
Council on Competitiveness

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President & CEO
Research Valley Partnership

Todd McLemore
Vice President, Lubricant Sales
NanoMech Inc.

Rebecca McPherson
Assistant Professor of Human Resources
Texas A&M University-Central Texas

Rossana Madrid
Visiting Professor
Texas A&M Engineering

Ahmed Mahmoud
Chief Information Officer, Global
Purchasing and Supply Chain, Customer
Care and Aftersales & Quality IT
General Motors

Ajay Malshe
EVP, CTO & Founder
NanoMech, Inc.

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Vice President of Innovation
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Nichole Mercier
Managing Director, Office of Tech
Management
Washington University in St. Louis

Rustom Mody
Vice President—Technical Excellence—
Enterprise Technology
Baker Hughes

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Vice Chancellor for Research
Texas A&M University System

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Ocean Flow International

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Graduate Research Assistant
Texas A&M University

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Deputy Assistant Secretary for
Transportation
U.S. Department of Energy

Dean Schneider
Director of Operations, Gulf Coast
Regional Manufacturing Center
Texas A&M Energy Institute

Kunal Shah
Student
Texas A&M University

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FMC Technologies

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Director
UCI Applied Innovation

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Institute for Academic Medicine
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Sarah Westall
University Instructor, Business
Consultant, and Radio Host
University of Minnesota

EIFI SOUTHWEST REGIONAL DIALOGUE

Agenda

MORNING**8:00 Registration and Continental Breakfast****8:30 Welcome: Exploring Innovation Frontiers Initiative**

Dr. M. Katherine Banks
Vice Chancellor for Engineering, Texas A&M University System
Dean of the College of Engineering, Texas A&M University
[@TAMUEngineering](#)

The Honorable Deborah L. Wince-Smith
President & CEO
Council on Competitiveness
[@dwincesmith](#)

Dr. Richard Buckius
Chief Operating Officer
National Science Foundation
[@NSF](#)

8:55 Exploring Innovation Frontiers Initiative: Vision, Goals, and Objectives

Mr. Chad Evans
Executive Vice President
Council on Competitiveness
[@chadevans1019](#)

9:00 Keynote: Innovation in Oil & Gas

Dr. Greg Powers
Vice President of Technology
Halliburton
[@Halliburton](#)

9:30 Emerging Innovation Frontiers: Energy and Manufacturing

The future economic productivity and prosperity of the United States is inextricably tied to America's ability to build and create, as well as generate the power needed to do so. Panelists will explore the next frontier of energy and manufacturing technologies, powering America's future prosperity.

Moderator

The Honorable Deborah L. Wince-Smith
President & CEO
Council on Competitiveness
[@dwincesmith](#)

Panelists

Dr. Lloyd F. Colegrove
Data Services Director
Fundamental Problem Solving Director
Analytical Technology Center
The Dow Chemical Company
[@DowChemical](#)

Dr. Mark Johnson
Director, Advanced Manufacturing Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
[@ENERGY](#)

Mr. Rustom Mody
Vice President—Technical Excellence—Enterprise Technology
Baker Hughes
[@BHInc](#)

Mr. Alex Reed
CEO
Advanced Polymer Monitoring Technologies
[@alex_reed_](#)

10:20 Next Generation Innovator: Energy and Manufacturing

Presenter: Austin Rogers

Topic: Robotic Assessments of Energy

10:30 Coffee Break**10:45 Emerging Innovation Frontiers: Autonomy & Transportation**

Technology has reached a point where autonomous vehicles are no longer the domain of science fiction, with tremendous technological improvements coming to market just in the past few years thanks to Tesla's autopilot, Uber's test market in Pittsburgh with autonomous vehicles, and Local Motors' 3D-printed self-driving Olli. Panelists will reveal what is next in the autonomous system space, and how it will impact the movement of people and products.

Moderator

Mr. Reuben Sarkar

Deputy Assistant Secretary for Transportation
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

[@ENERGY](#)

Panelists

Dr. Dominic "Tony" Antonelli

Chief Technologist, Exploration Systems
Lockheed Martin Civil Space

[@LockheedMartin](#)

Dr. J. Karl Hedrick

Fellow, Texas A&M Institute for Advanced Study
James Marshall Wells Professor of Mechanical Engineering
University of California, Berkeley

[@UCBerkeley](#)

Mr. Ahmed Mahmoud

Chief Information Officer, Global Purchasing and Supply Chain,
Customer Care and Aftersales & Quality IT
General Motors

[@amm1_aus](#)

Dr. C. Michael Walton

Ernest H. Cockrell Centennial Chair in Engineering
University of Texas at Austin

[@UTAustin](#)

11:35 Next Generation Innovator: Autonomy and Transportation

Presenter: Gustavo Tapia

Topic: Additive Manufacturing—The Path from Tailored Geometry to Tailored Functionality

11:45 First Breakout Session

Parallel Session 1: Fostering Innovations in Energy and Manufacturing

Conversation Lead

Dr. Elizabeth Cantwell

Vice President
Arizona State University

[@BetsCantwell](#)

Facilitator

Mr. Chad Evans

Executive Vice President
Council on Competitiveness

[@chadevans1019](#)

Parallel Session 2: Fostering Innovations in Autonomy and Transportation

Conversation Lead

Dr. Steven W. Dellenback

Vice President R&D
Southwest Research Institute

[@SwRI](#)

Facilitator

Mr. Michael Bernstein

Senior Policy Director
Council on Competitiveness

[@mikebberstein](#)

AFTERNOON**12:30 Lunch and Fireside Chat**

Participants will explore how large and small companies are collaborating in new ways to open up and transform their long-term innovation capabilities and capacities.

Dr. Dimitris Lagoudas
Senior Associate Dean for Research
Texas A&M Engineering
🐦 @TAMUEngineering

Mr. Jim Phillips
Chairman & CEO
NanoMech, Inc
🐦 @NanoMechInc

Dr. Greg Powers
Vice President of Technology
Halliburton
🐦 @Halliburton

Dr. Gabriel Silva
Manager, Strategic Technologies Group
FMC Technologies
🐦 @FMC_Tech

The Honorable Deborah L. Wince-Smith
President & CEO
Council on Competitiveness
🐦 @dwincesmith

1:30 Emerging Innovation Frontiers: Engineered Healthcare

The potential for new forms of technology to create quickly and economically unique healthcare solutions, such as personalized medicine, is transforming the medical field in America and around the world. Panelists will dive into what engineered medicine and new healthcare technologies mean for the future of America's health, and how it impacts America's competitiveness prognosis.

Moderator

Ms. Sarah Westall
University Instructor, Business Consultant, and Radio Host
University of Minnesota
🐦 @westall_sarahw

Panelists

Dr. Gang Bao
Foyt Family Professor in Bioengineering
Director, Nanomedicine Center for Nucleoprotein Machines
CPRIT Scholar in Cancer Research
Rice University

Dr. Gerard L. Coté
Director, Center for Remote Health Technologies and Systems
Holder of the Charles H. and Bettye Barclay Professorship
Texas A&M University
🐦 @TEESresearch

Dr. Jon Mogford
Vice Chancellor for Research
The Texas A&M University System
🐦 @TAMUSystem

Mr. Tong Sun
Director, Central Operations
Institute for Academic Medicine
Houston Methodist

2:05 Next Generation Innovators: Engineered Healthcare

Presenters: Garrett Harmon and Kunal Shah


Topic: Additive Manufacturing—The Path from Tailored Geometry to Tailored Functionality

2:45 The Path Forward and Closing Remarks

Dr. M. Katherine Banks

Vice Chancellor for Engineering, Texas A&M University System

Dean of the College of Engineering, Texas A&M University

 @TAMUEngineering

Dr. Richard Buckius

Chief Operating Officer

National Science Foundation

 @NSF

The Honorable Deborah L. Wince-Smith

President & CEO

Council on Competitiveness

 @dwincesmith

3:00 Meeting Adjourned

Findings from the EIFI Southern Regional Dialogue

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

Executive Summary

A locus for technological innovation for industry and academia in the United States—especially the energy and manufacturing, autonomy and transportation, and engineered healthcare domains supporting America’s future competitiveness—Houston and the Texas A&M University were the model backdrop for the Southern Regional dialogue of the Exploring Innovation Frontiers Initiative (EIFI). On November 15th, Dr. M. Katherine Banks, Technology Leadership and Strategy Initiative (TLSI) member, Vice Chancellor for Engineering at Texas A&M University System and Dean of the College of Engineering at Texas A&M University hosted a robust and wide-ranging conversation of business, academic and government leaders.

The dialogue took place over the course of a single day, with panel discussions concentrating on new innovations and potential barriers to advancement for technology sectors poised to drive economic competitiveness for the United States in the coming decades, followed by student interventions working in these areas. These conversations were preceded by opening keynote remarks from Dr. Greg Powers, Vice President for Technology at Halliburton. The day was spent concentrating on innovation models for next-generation technology and laying the foundation for U.S. competitiveness in the coming decades.

Technology-based innovation is a critical component of America’s competitiveness. To maintain its global leadership, productivity and prosperity, the United States must continually innovate—and lead in an era in which the pace of innovation is accelerating, while a growing number of innovations across the economy unlock new opportunities for productivity. Capitalizing on these opportunities necessitates deep thought on innovation models to ensure they



Dr. M. Katherine Banks, Vice Chancellor for Engineering, Texas A&M University System, and Dean of the College of Engineering, Texas A&M University.

are primed to address an economy in a state of continual transformation. This thought reverberated throughout the day’s panel discussions, focused on energy and manufacturing, autonomy and transportation, interdisciplinary opportunities, and engineered healthcare. Each panel stressed the importance of incorporating cross-disciplinary educational and work models to stimulate new insights, inspire new collaborations across and within academia, industry and government, and acclimate new technology to legacy systems.

Panel Synopsis—Emerging Innovation Frontiers: Energy and Manufacturing

The day’s opening panel was meant to explore innovation models spanning the energy and manufacturing industries. These industries are rapidly changing, looking for new sources of innovation to enhance their productivity. **Participants forcefully declared innovations in energy and manufacturing had**



Mr. Jim Phillips, Chairman & CEO, NanoMech Inc.; Mr. Rustom Mody, Vice President–Technical Excellence–Enterprise Technology, Baker Hughes; and Dr. Gregory Powers, Vice President, Technology, Halliburton.

much to gain from interdisciplinary experience and incorporating innovation outside traditional research and development pathways. Discussion surfaced multiple examples of technologies from seemingly unrelated domains applied in novel ways in energy and manufacturing to dramatically increase productivity, through the collection of actionable data to uncover efficiencies.

The panelists were also quick to recognize that research and development does not need a clear end-state to be a valuable endeavor, strongly stating that innovation’s power is comes from the new and novel application of knowledge. Basic research reveals information that may not be well understood at the genesis of research projects, but manifest over time to enable groundbreaking advancements as scientists and engineers employ this information in their work. The value of basic research grows further as its usefulness grows across domains. What may have once

started out as a research project in one field may find significance in another, opening new tranches of innovation and productivity.

However, the unclear end-state for fundamental research can create obstacles to funding that are difficult to clear. Participants lamented that industry is hesitant to invest resources in either research or efforts to scale without a clear and high-probability return on investment. The investment community rightly has different criteria for investing across sectors, often exhibiting a preference for lower risk investments that are highly scalable leading to a higher tolerance of risk. By comparison, energy and manufacturing are inherently capital intensive and difficult to scale, involving greater risk for investors and fewer resources funding innovation in energy and manufacturing. This results in fewer incentives for researchers to undertake efforts that will move the industry beyond established technology as the uncertainty of investments in both research and the scaling of new technology makes resources more difficult to come by. **Panelists shared their concerns that while America is currently an innovation leader, failing to address investment in these areas threatens America’s future competitiveness.**

Panel Synopsis—Emerging Innovation Frontiers: Autonomy and Transportation

The second panel of the day delved into the future roles autonomy and transportation technology will play in the global economy, and considerations for new and augmented innovation models to drive U.S. competitiveness in this space. Conversation touched on a wide array of transportation systems in various

states of autonomy, highlighting the opportunities and potential hazards of automation in moving goods and people. Technology is advancing rapidly in this space, outpacing the ability of regulators to react to new technology and forcing technology leaders to challenge laws that are unable to accommodate innovations already in the marketplace. **Panelists agreed the inability of institutions and organizations to adopt new technologies is potentially the greatest inhibitor to innovation.**

The implications of hindered innovation are drastic and far reaching. Panelist discussion around this topic made clear the potential for new innovations to upend basic assumptions of transportation infrastructure, such as the extent of human input in any given mode of transportation, forcing significant change in the application of new technology both to the movers of goods and services and the infrastructure on which our transportation system relies.

Echoing themes appearing earlier in the day, this panel also highlighted the need for breaking down silos across industries and across teams within the same organization. The reason is two-fold: First, as a means to incorporate innovations across disciplines, and second, to include a greater diversity of expertise in solving problems that are increasingly multidisciplinary as the promise of transportation democratizes.

Panelists felt strongly that the path to greater cooperation and enabling teams to thrive lay in creating an environment where leaders within an organization had access to talent across the institution, rather than just within their domain.



Dr. Richard Buckius, Chief Operating Officer, National Science Foundation.

Panel Synopsis—Emerging Innovation Frontiers: Interdisciplinary Opportunities

The third panel explored means for companies of all sizes to collaborate in new ways to transform their long-term innovation capabilities and capacities. **Panelists representing a range of industry and academia quickly recognized partnerships expand innovation potential by making available as never before thought leadership and resources without needing to invest in building similar capacities in-house.** Successful partnerships broaden the range of outcomes achievable that many individual organizations would not be able to achieve otherwise in as timely a manner. Large organizations are able to access unique thinking; unconstrained by industry or organizational standards, small organizations have their technology validated in the market and are provided a path to scale; and

academic institutions gain access to industry practitioners and feedback on the skills most useful for students to succeed.

Notably, participants' conversation on drivers of innovation uncovered the difficulty of investing in invention and exponential innovation (as opposed to incremental innovations). Business units within an organization aim for stability in a thriving market, offering incremental productivity enhancements with a high probability of success. Alternately, investments in research and development are often cut in a down market. Organizations find themselves with little incentive to invest in high-risk, high-reward research. **This is driving firms to look to outside the firm for innovation, with panelists noting degrees of success in seeking technology outside their domain for solutions.**

Panelists agreed the pace of technological innovation can often make the application of technology sourced from a variety of disciplines a more cost-efficient and less risky means of incorporating innovation than building research capabilities in-house. It is therefore important for future innovation models to incorporate a rich interdisciplinary environment with opportunities to connect large organizations with small firms and academia to deploy innovations in the market. Doing so will increase the rate of U.S. productivity growth, further enhancing U.S. competitiveness.

Panel Synopsis—Emerging Innovation Frontiers: Engineered Healthcare

The final panel of the day focused on current innovations in engineered healthcare—advancing the diagnostic, delivery, and deployment of healthcare-related

technologies—and looked ahead to limits to innovation in this space. **A consensus was reached that technology will not be the limiting factor in the advancement of engineered healthcare innovation. Rather, the limiting factor will be the surrounding ethics.** Technology reaches ever deeper into the lives of the individual, collecting information, and offering bespoke healthcare and opportunities to augment biology. However, ability does not equal permissiveness, and panelists raised questions about responsibly applying innovations in this space.

Panelists noted that using ethics as a guide for innovation models introduces a level of nuance which is difficult to navigate. Participants surfaced evidence of ethical principles varying across countries, regions, cities and individuals, shaped by experiences and identity. This is especially problematic as research collaborations and resulting innovations are not limited by geography. Therefore, creating a common ethical boundary is challenging, but critical to avoiding a crisis of conscience during the advancement of technology. **The United States has an opportunity to compete and lead globally in this technology-based healthcare space if it can establish and encourage the adoption of ethics and standards.**

Assuming technology is developed that is not objectionable to society, it must still be useful and non-intrusive to the individual to be impactful. Ultimately, a technology that is not used is of limited benefit. Panelists suggested participatory community design collecting input from various stakeholders as means to incorporate multiple ethical concerns into the development process and build innovations more likely to succeed in the marketplace.

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

Innovation Keynote

Dr. Gregory Powers

Vice President of Technology
Halliburton

The cost of getting a barrel of oil from five miles underground to the surface is a big task; it's tricky. There are two elements we think about as an industry: The cost—how much is depreciation, how much is the equipment, etc.—and productivity. Cost is easy—lower cost from suppliers, change specs and change machinery. But the big lever in the oil world is productivity.

The industry is 100 years old, and much of the recent productivity comes from technology that had already been invented, but not invented to operate where the oil industry operates. We're running computers on drill-string tools five miles underground at 400 degrees Fahrenheit and 2500 PSI, possibly in an acidic environment. In the trip to get down to the bottom of the hole, they may experience 10-14Gs. Our computers have a 4,000 hour meantime before failure. How would your computer fare being dropped from the Empire State Building, approximating 10Gs or being left under the broiler in your oven for 6 months? That is what we're trying to do. You don't actually have to invent very much to do that.

In 1947, William Shockley of Bell Labs, along with John Bardeen and Walter Brattain, invented the transistor. This invention enabled modern society, but at the time it didn't really do much for us. When I was 16 many years ago, for Christmas I received a 16-transistor radio and that was hot stuff. Today we operate in billions of transistors. Unthought of density. In the oil and gas industry, we're trying to take what the Shockleys of the world have invented and make them work in the oil and gas environment. We



Dr. Gregory Powers, Vice President, Technology, Halliburton.

use technology as a generic term instead of “innovation” or “invention,” and fundamentally the prime mover for that is people. It's only people. We have nice facilities, but at the end of the day, it's global minds.

The millennial problem is how to use a population that is incredibly creative and well-connected, but have career expectations that don't mirror the realities of working in a large mature field that isn't historically known for its progressive views or rapid change. Additionally, we have a global enterprise, and we like global minds. You can't avoid a global discussion when you talk about U.S. competitiveness. We have 15 laboratories in 14 time zones around the world, which is a big advantage to us as we can move people around to expose them to new ideas and enrich our human capital. This is important because as the problems Halliburton tries to solve become more complex, we've had to turn more toward open innovation, meaning the solution can come from anyone anywhere, and not necessarily in oil and gas either.

We face a constant state of change. Where do solutions come from in a 100-year-old industry that isn't making many new things itself? In the oil and gas industry, we have a social compact that's required to have an equilibrium with society that allows us to practice. To maintain that compact, we have to go more and more to green chemistry and natural chemistry. There are many things that nature has perfected over the millennia that we know work in the environments we operate in. We've become strong believers that looking toward nature and research outside the oil and gas industry is the way of the future.

A prime example of how technologies pioneered in other fields have had a dramatic impact on oil and gas comes in the form of how Halliburton analyzes the materials in their wells. Doing so with laboratory efficiency down-well was thought to be impossible as typical analysis required a significant level of time, investment and education. Samples would have to be retrieved from the well, shipped to the lab where you would find out what was in the sample four months later, if it was not contaminated or lost during the collection process—a frequent occurrence). However, we found an optical sensor innovation from the food industry able to perform the analysis in real-time, dramatically reducing risk in and around the well. Now, with no electronic computational analysis, we can immediately understand the well's environment and dramatically improve productivity. This technology was originally invented to measure the impurities in dog food. With Halliburton, we were able to make their technology robust enough to work in the extreme and demanding environments we typically work in.

Here's another one, related to hydraulic fracturing. At some point during the process, you have to stop the flow of fluid, which is done using something called a "plug." The plug goes down the hole, and you force pressure on the fluid to force it to go into the rocks. That is essentially what hydraulic fracturing is. In the past, those plugs were made of a composite, so once the plug is in place, it is there until it is drilled out with the hope you don't actually drill a hole in the side of the pipe or the tool doesn't break or get stuck. We invented a plug that dissolves after extended exposure to certain constituent elements in the environment, such as salt water. This technology came from the electrochemical battery industry. Same chemistry, same mechanism, we just employed the technology in a very different way than it is traditionally used.

The last example is fiber optics. When you make a phone call, the information is transmitted over fiber optics, eventually, at some point in the world. Fiber optics started in telecom and made a leap to the defense industry at some point in the past as well. But it turns out fiber optics are more than just a data transmission device. It is also a recording device. It has properties by which you can measure back-scattered light and very small differences in length between a given point in time "A," where there's a backscattering particle, and if it stretches by temperature, pressure, or by an acoustic signature where it's wavering, it stretches the fiber. We can measure the difference in flight between an unperturbed and perturbed fiber. Therefore, the fiber becomes a microphone. We can measure temperature, pressure, and the acoustic signature. This generates a lot of information that can be used to understand what is happening in the well much better than we have been able to in the past.

In the past, we would go about hydraulic fracturing as a matter of procedure. Now, we are able to control what is happening down-well with a much higher level of precision, which enables us to be more productive, environmentally safe, and stop any process when any constituent piece of information tells us the process isn't working as intended and intervene in real time.

This also brings us to the question of big data. One well in one day produces two terabytes of noise. The real problem of big data in a well is what is the signal and what is the noise? When you filter out the noise from the audio from the well, you hear trucks going by, you hear earthquakes on the other side of the planet, you hear all sorts of things; the earth is a very noisy place. In response over the past few years, we've built a catalogue of sounds of the activities we're trying to induce—essentially a sound book of wells with fiber optics in them. This has turned out to be a revelation and changed the course of our decision-making so we can ensure we are actually doing what our customers ask us to do.

Lastly, I want to talk about nature. As I stated earlier, nature has been at this for millennia, and we've started looking at how we can take advantage of the properties of natural materials. We've found a lot of success with chitin, the protein that makes up shrimp shells. When you boil shrimp shells, it may turn red, but nothing really happens structurally. It is an incredibly robust material, as is wood pulp, which doesn't degrade quickly at all. We've started comparing the use of these polymeric mixtures of natural products to synthetic organic polymers. Synthetic organic polymers degrade rather quickly. If you are trying to make a permanent intervention in a well, it isn't going to last for very long, especially at high temperatures.

The natural products are far more capable in those environments. We're seeing very unusual properties in natural products we haven't encountered before. They have yield stress—if they are not being pumped, they act like a solid, but when pumped you can make them Newtonian or non-Newtonian so that they can sheer thin or thicken...to be able to control the fluid environment in the physical sense, not just the chemical sense.

At the end of the day, we're clearly in the business of taking in people and ideas from other industries. We have to get our information and new technologies from other industries. We're not as big of an invention industry as the many other industries that will be discussed today, but to be absolutely sure even at Halliburton, which is 100 years old (and) pretty conservative, people are now believers that open innovation and opening the doors to the inventions and developments from other industries is one of the main routes we're going to take going forward. We can use the success and creativity of other industries to make our industry more productive, more environmentally friendly and safer for the main energy source we are currently using.

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

Emerging Innovation Frontiers: Energy and Manufacturing



Speaking to participants: Mr. Alex Reed, CEO, Advanced Polymer Monitoring Technologies; Dr. Mark Johnson, Director, Advanced Manufacturing Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; Mr. Rustom Mody, Vice President—Technical Excellence—Enterprise Technology, Baker Hughes; Dr. Lloyd Colegrove, Data Services Director, Fundamental Problem Solving Director, Analytical Technology Center, The Dow Chemical Company; and the Honorable Deborah L. Wince-Smith, President & CEO, Council on Competitiveness.

Immediately following the morning keynote, this first panel of the day was organized to explore frontier technology in energy and manufacturing; the foundation upon which future prosperity will be built. The Honorable Deborah L. Wince-Smith led the panel, populated by Dr. Lloyd F. Colegrove, Data Services Director and Fundamental Problem Solving Director for the Analytical Technology Center at the Dow Chemical Company; Dr. Mark Johnson, Director, Advanced Manufacturing Office, Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy; Mr. Rustom Mody, Vice President—Technical Excellence—Enterprise Technology at Baker Hughes; and Mr. Alex Reed, CEO at Advanced Polymer Monitoring Technologies. The conversation tracked the uncharted path of investments in

energy and manufacturing research and development decades ago that led to technology available in the marketplace today, discussed issues that must be overcome for the next leap in productivity, and pointed solutions to those issues. Panelists were in agreement about the importance of investing in basic research for the sake of discovery rather than a particular end goal in sight, stressing the importance of knowledge creation and learning how to better scale innovations as well—a theme that continued into a post-panel breakout session with participation from attendees.

Pointed reflections from participants made clear that innovation is an iterative process, not a solution. Innovations create opportunities for further innova-

tions, where creative uses of new technology drive further innovation in ways unintended and unimagined directions. Similarly, investing in basic research and development as a source of innovation cannot be predictive, and often the full magnitude of such investments manifest long after the initial investment is made through the unique application of a given innovation. This understanding of innovation set the starting point for the conversation, with panelists acknowledging that productivity drivers in energy and manufacturing would not have been possible without investments in new technologies decades ago. Dr. Johnson and Mr. Mody highlighted research in diamonds as a prime example. In the 1970s, the U.S. Department of Energy Office of Fossil Energy conducted research around diamonds. **“Well,” according to Dr. Johnson, “the fossil energy folks had done studies that said if you make diamonds, you can make better drills; and if you make better drills, you can go down and make a drill turn a corner; and if you can make a drill turn a corner, now we can unleash a whole new wealth of energy.”** Mr. Mody continued that before diamond technology, drill bits would take 24-30 days to drill a horizontal well, and bits would be switched out to match the density and hardness of material. Now the same process takes 7 days, all using the same drill bit. This led to a dramatic productivity increase in the cultivation of energy resources. Like diamond research in the 1970s, new technologies making their first forays into the marketplace, such as additive manufacturing, are in the nascent stages of their capacity to drive productivity.

The long arc of innovation has shown us, however, that new innovations are often met with new problems to overcome. Our ability to collect and analyze

information unlike ever before is a powerful new tool to help overcome the new and unanticipated issues related to scaling innovations. That is, we must focus on training individuals in the innovation ecosystem to analyze collected data for actionable solutions.

“The next opportunity for us as a species is not inventing the next great thing, but increasing the data acuity of the people we are producing in our universities today,” observed Dr. Colgrove. Panelists expressed that to experience the most profound change in innovation, we must focus on the model for innovation, such as investing in basic research and development and education so the broader workforce will be able to analyze data already collected, rather than focusing efforts on the next innovation itself.

Challenges to innovation lay not only in discovery, but in scaling to reach the marketplace as well. **“When you see something useful and try to get it to scale and lower cost, it opens up a whole new manufacturing problem. A whole new range of science and technology is necessary,”** remarked Dr. Johnson, pointing to the existence of manufacturing hubs supported by Manufacturing USA for this purpose. **But, claimed Mr. Reed, “to innovate in an industrial environment requires a significant amount of de-risking.”** Panelists proclaimed this an especially difficult challenge as the tolerance for risk when financing scaling efforts varies widely. It seems, they observed, tolerance for risk is high when capital investment is low—such as scaling user capacity for software services hosted in the cloud—and tolerance for risk is low when capital investment is high—such as in manufacturing. This makes scaling manufacturing, especially for new innovations untested in the marketplace, very difficult. Those



Dr. Lloyd Colegrove, Data Services Director, Fundamental Problem Solving Director, Analytical Technology Center, The Dow Chemical Company.



Mr. Rustom Mody, Vice President—Technical Excellence—Enterprise Technology, Baker Hughes.

directing private investments require proof of an innovation's viability and pathways for investors to exist. **As Dr. Johnson describes, “nothing drives early stage investment than early exits—a way to get out and draws more capital to physical science problems.”** This is why panelists note that while silicon valley tolerates, even celebrates failure, in manufacturing failure is not an option. During the course of conversation, panelists agreed that what is important to cultivate is never fearing going after a big challenge and keep learning. **“We can’t fear taking on the big challenges,” Dr. Johnson proclaimed, “that is what the U.S. is and innovates that way.”**

Changes over the past several decades have led to further challenged sources of innovation and manufacturing supply chains, as well as companies transitioned away from a vertically integrated company structure to a series of suppliers across a distributed

value chain. As a result, single firms cannot make the investments in research development and appropriate the value of innovation across their supply chain as they have in the past. Suppliers are focused on their own portion of the supply chain rather than taking a systematic approach to the final product or putting the onus for innovation on the upstream producers. **Mr. Mody drove this point home, sharing “we rely on our operators to be interested in innovation and new technologies. We don’t own the wells.”** This is why **“change doesn’t happen unless the whole supply chain is excited about it,”** according to Dr. Colegrove. This fragmentation of industry means businesses must look for common shared infrastructure as a means to promote innovation. For many manufacturers, this means working with stakeholders, customers, suppliers, academia and perhaps even direct competitors on pre-competitive research.

“The question is,” as Dr. Johnson explained, “how do we do that, where we are bringing all those minds together?...And are they learning things that are complementary with each other, then stepping back and having them fight it out in the private sector.” Ultimately this may require innovation in business models as well, with **Mr. Reed affirming, “If you are really going to try to adopt technology quickly, and you have a specific way or specific culture of how you invest in assets, getting creative in how you deploy those new technologies in terms of how do you share the value with a vendor or supplier—how do you share along both sides to create new value faster—is going to have to happen.”**

In closing, panelists eschewed technology itself as the driver of next-generation innovation, instead focusing on talent and greater exposure to technology across domains applied in novel ways to create the next tranche of productivity. Dialogue attendees and panelists alike lamented the disparity between the education available to America’s talent pool and type of education sought by industry. Conversation suggested this may be a difference of incentives between academia and industry, but finding a source of alignment in funding sought by academia to fund research and capital from industry for committing to research. This may be the line through which communication on industry’s education needs are conveyed. Establishing a regular line of communication between these two sectors will be the key to future U.S. competitiveness. **Dr. Johnson echoed this sentiment in his closing remarks, stating, “The orgs that win and survive will figure out their workforce over the coming decades.”**

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

Emerging Innovation Frontiers: Automation and Transportation

This session explored existing technologies and potential innovations resulting from research and development in automation and transportation, identifying best practices for use in future innovation models and current concerns that may limit innovation in this space in the future. Led by Mr. Reuben Sarkar, Deputy Assistant Secretary for Transportation, Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy, the panel included Dr. Dominic “Tony” Antonelli, Acting Director, Advanced Programs, Civil Space, Space Systems Company at Lockheed Martin; Dr. J. Karl Hedrick, Fellow at the Texas A&M Institute for Advanced Study and James Marshall Wells Professor of Mechanical Engineering at the University of California, Berkeley; Mr. Ahmed Mahmoud, Chief Information Officer for Global Purchasing and Supply Chain, Customer Care and Aftersales & Quality IT at General Motors; and Dr. C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, University of Texas at Austin. The panelists recognized the breadth of this topic and depth of ongoing research into related domains means the movement of goods and people will be fundamentally transformed in the coming decades, collectively agreeing the future of autonomy and transportation will be as much a function of social ethics and organizational capacity as much as technological advancement.

Transportation technology has advanced dramatically in the last 100 years, with new innovations quickly adopted across the marketplace as new capabilities and modes of transportation come online. **As Mr. Sarkar notes, “Some are saying in the next five years, we’ll see more change than we’ve seen in the last 50, [while others] say in the next 10 years, we’ll see more change than we have in the last 100.”** Regardless, strong



Mr. Ahmed Mahmoud, Chief Information Officer, Global Purchasing and Supply Chain, Customer Care and Aftersales & Quality IT, General Motors; Dr. S. Karl Hedrick, James Marshall Wells Academic Chair & Professor, University of California, Berkeley, and TEES Distinguished Research Professor, Texas A&M Engineering; Dr. Tony Antonelli, Acting Director of Advanced Programs, Civil Space, Space Systems Company, Lockheed Martin; and Dr. C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, The University of Texas at Austin.

technology currents and a confluence of prevailing megatrends means transportation will see significant changes in the coming years. **“To put this into perspective, 100 years ago there was a predominance of horses over cars,”** observed Mr. Sarkar. The Wright Brothers made their first powered flight just over 100 years ago in 1903. Less than 60 years later, man first entered space, and within 10 years of that moment, man walked on the moon. Technological innovation in this space has not slowed. The integration of autonomy and connected technology, new lighter weight materials, new vehicle powertrains, deeper applications of big data, and faster processing speeds all coming in at lower costs shared across different economies means a transportation revolution is on the horizon.

While there was no disagreement that foundational changes lay on the horizon, there were differences in opinion behind the drivers and barriers to advancement in automation and transportation technology. **“The vehicle revolution will be in data,” predicted Dr. Walton.** As an individual driver, Dr. Walton argues, there is very little access to information regarding current or future congestion beyond listening to traffic on the radio or looking around at break lights. At issue are the sources of additional information and what the additional information would enable. Relating specifically to automobiles, Dr. Walton identifies vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-cloud information on current traffic conditions, estimated traffic conditions based on time of day and weather conditions, GPS, and crowdsourced conditions (a factor in current broadly available mapping applications). Mr. Mahmoud expanded the list to include vehicle-to-itself, noting that vehicles must be able to self-analyze and diagnose onboard systems to ensure the data sent to different systems within the vehicle are operating correctly. These systems can be applied to any mode of transport, and though humans alone may not be able to process all the information, an onboard computer can use these data to augment behavior for a given mode of transportation. The end result is greater efficiency and safety. **Dr. Hedrick cited a common argument that “95 percent of accidents are caused by humans, with the other 5 percent caused by things like flat tires and transmissions and so forth. However, when you take the human out of the vehicle, you have to put the robot in the vehicle. We have hundreds of millions of miles of data about what humans will do, but relatively little about what robots will do.”**

As technology enables greater autonomy of transportation, the role of the individual during transportation will change. The rate of accidents with human operators is known, and most people entertain the assumption that accident rates will drop as the share of autonomous transportation grows. The greatest concern is the period in-between, as autonomous modes of transport are mixed with human operators. **Mr. Sarkar explained the concern as “humans will act differently knowing there is a computer driving the car, either by bullying it on the road or walking in front of the car when you know it will stop and create other dangerous situations you may not take if you know a human is behind the wheel. Cars won’t creep up if there are humans around—it needs to learn some assertiveness.”** Taking humans out of the driver’s seat does not eliminate the problems, it just moves them to a different part of the chain.

There are transport systems that are already predominantly autonomous, but they have yet to be internalized by the general population, creating hesitancy to adoption in other forms of transportation, according to Dr. Antonelli, citing the ability for aircraft to take off and land hands-free. This hesitancy is but one barrier among many cited by panelists. Dr. Mahmoud cited technology issues such as cybersecurity concerns and the vulnerabilities of autonomous systems (ensuring data and sensors on board are not compromised), and the difficulty of bringing together cross-disciplinary groups for the purposes of advancing autonomous technology. This is an issue, states **Dr. Mahmoud “because it goes against the grain of the common methodology of departmentally solving problems,”** noting the automation group within GM is isolated to shield the innovation-focused

group from the departmentalization of the rest of the organization. **“Departments in corporations,” Dr. Mahmoud lamented, “are their own fiefdoms.”**

This separate automation group is not unique among automotive companies, claims Dr. Walton, with many companies establishing a small laboratory in Silicon Valley to attract computer scientists and AI experts. Yet they quickly find they are not equipped with the resources to compete for talent. **“It’s tough, culturally, to have someone in Silicon Valley making as much as the chief engineer at Ford,” quipped Dr. Walton.**

Though these barriers are significant, potentially the greatest inhibitor of adoption of new technology is the current innovation model—institutions and organizational systems currently in place. The systemic nature of this barrier was first raised by Dr. Walton, and was quickly supported by Mr. Sarkar, observing that many of the issues did not speak to technology per se, but the organizational design and talent. Institutions, private and government alike, drive technology as a showcase of what is possible but often rely on an entrenched and risk-averse operating structure. This limits their ability to accept and embrace change, limiting the adoption of new technology, and slows regulatory response to a rapidly changing technological landscape. On this note, the dialogue attendees opined if organizations and the public were cautious in their adoption of new technology because of how they have learned to tolerate risk. The public is more tolerant of automation where they have not been in direct control, such as air travel compared to automobiles. Though, at the same time tolerance for risk in uncommon activities, such as spaceflight, remains low. Yet, regulatory response

has not yet created an environment for automation in transportation to thrive. The result is a widening gap between the promise of technology and its realistic applications. Noting this challenge from his place in the U.S. Department of Energy, Mr. Sarkar observed the world is changing faster than institutions and models are or can accommodate.

The issue acting as the greatest barrier to advancement in automation and transportation technology then is one of political will, perceived **Dr. Antonelli, continuing that “Americans spend more on Halloween with decorations and candy than we do deep space human exploration.”** The United States has the resources maintain its leadership in automation and transportation, but it must be a priority for the public. American competitiveness hangs in the balance, and thus U.S. industry, government and the public need to be inspired to continue advancing and adopting automation and transportation technology.

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

Emerging Innovation Frontiers: Interdisciplinary Opportunities

Innovation is not limited to large organizations, and as stated throughout the day, large organizations often look to innovative smaller firms as sources of new perspectives and outside the box thinking. The problem then becomes how do small, innovative firms capture the attention of large firms to forge strategic partnerships. This panel explored how to establish such a relationship. Structured as a fireside chat among panelists, the conversation included Dr. Dimitris Lagoudas, Senior Associate Dean for Research at Texas A&M Engineering, Mr. Jim Phillips, Chairman and CEO of Nanomech, Inc.; Dr. Greg Powers, Vice President of Technology for Halliburton; Dr. Gabriel Silva, Manager for Strategic Technologies Group at FMC Technologies, and The Honorable Deborah L. Wince-Smith, President and CEO at the Council on Competitiveness. Though the backgrounds of participants varied, they quickly coalesced around a broad agreement that both large and small organizations stood to gain from partnering with each other, validating the technology of small organizations and providing an avenue for scale while also providing larger organizations outside-the-box solutions to pressing issues without the cost of building research and development capabilities in-house.

The conversation began by laying out a premise for the topic amid a slew of technology discussions taking place over the course of the day; that solutions to unique problems are not limited to its original domain. However, how do small firms who recognize they have solved a problem for a potential large scale customer, or large scale customers who believe they have found a solution in the technology of a small innovative firm, form a strategic partnership that adds value to both parties?



Dr. Gregory Powers, Vice President, Technology, Halliburton; Dr. Gabriel Silva, Manager, Strategic Technologies Group, FMC Technologies; Mr. Jim Phillips, Chairman & CEO, NanoMech Inc.; the Honorable Deborah L. Wince-Smith, President & CEO, Council on Competitiveness; and Dr. Dimitris Lagoudas, Senior Associate Dean for Research, Texas A&M Engineering.

Leading the conversation, Mr. Jim Phillips noted, “More will be invented in the next five years than in the history of all mankind. The reason is we are now exponentializing off the inventions of the last 30-40 years.” As large and small companies alike iterate and build off of new and existing innovations, they are likely to create a proliferation of new technologies capable of resolving industrial inefficiencies. The manifestation of these impacts is the continued acceleration of technology, as innovators build off the increased productivity for further advancements. This signifies the importance of creating an innovation model that supports creating partnerships between American companies and an ecosystem capable of quickly scaling new technologies. Participants noted the United States has a checkered past creating this environment, but that the biotech space has seen much success recently perhaps due to the perceived impact of breakthrough technologies.



Mr. Jim Phillips, Chairman & CEO, NanoMech Inc.



Dr. Steve Dellenback, Vice President R&D, Southwest Research Institute; Dr. Dean Schneider, Director of Operations, Gulf Coast Regional Manufacturing Center, Texas A&M Energy Institute; and Dr. M. Katherine Banks, Vice Chancellor for Engineering, Texas A&M University System, and Dean of the College of Engineering, Texas A&M University.

As more technologies are adopted in industries outside their original use, cross-disciplinary projects are seeing increased funding. **Dr. Dimitris Lagoudas noted that at Texas A&M he is seeing growing interest in translational projects and long-term investments. Research funding is flourishing in areas viewed as fundamental to society, such as basic research and development and infrastructure.**

Participants noted this may not be a persistent trend, however. Innovation has benefitted from a recently downcycle economy. **“It’s important to survey the field where you can leverage new technology at low cost and that is easily implemented,” according to Dr. Silva.** This is at odds with a common belief that during a downcycle companies would be less focused on R&D. **“Downcycle is when it is important to innovate fast. [You need to] ask innovators to be curious. With no curiosity, there**

is no innovation,” continued Dr. Silva. Dr. Powers articulated this position further, “If the price of oil had dropped from \$110/barrel to \$100/barrel, we wouldn’t be having this discussion. But it dropped from \$110/barrel to \$27/barrel. There is no space for incrementalism. You can’t increment yourself down to where what you do is one-third the price of what it was a year earlier.”

Though perhaps a dramatic example, this highlights the impetus for many American businesses to collaborate and partner outside their organization for fresh perspectives, especially as they see new and more useful innovations appearing in the marketplace. To this end, Dr. Powers noted that Halliburton’s outside portfolio of high-potential impact technologies and collaborations with customers, universities and entrepreneurs is richer than it has been at any point in the past, opening up an expanse of possibilities for future planning that was once unimaginable.



Dr. Dimitris Lagoudas, Senior Associate Dean for Research, Texas A&M Engineering.



Dr. Gabriel Silva, Manager, Strategic Technologies Group, FMC Technologies.

Another manifestation of these growing technology portfolios in search of valuable IP has been the merging of large organizations and a consolidation of smaller players (many small organizations are acquired by large organizations as well but are not as well publicized). While this may appear to be the result of lowered investment in internal research and development projects, there are other compelling reasons for this course of action beyond the cost savings of not needing to build, staff and fund a large business unit. A conventional argument for retaining institutional research and development programs would be the record of reliably turning research dollars into incremental productivity improvements. However, innovations in one research and development laboratory may threaten the work of another laboratory or business unit, creating internal battles to balance organizational priorities and research interests. Furthermore, because there are no guarantees in innovation, research efforts—especially long-term projects—are always fighting for funding.

Panel participants were clear the incremental approach is not sufficient considering the rapid and accelerating pace of change in technology. Rather, it is much easier for large organizations to use the innovation of an outside firm through acquisition or technology licensing. This is not to say such leaps in technology are not created in the laboratories of large research institutions—panelists noted they

often face less institutional resistance when intellectual property is available outside the organization rather than cultivating efforts within the organization. This conversation elucidated a change to innovation models that is already occurring. Industry traditionally made significant investments in internal research and development efforts, vertically integrating the end-to-end process of technology development within their field. However, as the proliferation of information has unleashed the capability and creativity of innovative students and entrepreneurs, industry has learned that especially in down markets it is in their financial interest to build strategic partnerships with small innovative firms that can bring a fresh, outside perspective to problems without the weight of legacy systems bearing down on them. Large organizations must find ways to engage creators of new technology and small firms must learn to apply their inventions to diverse fields so that both may prosper.

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

Emerging Innovation Frontiers: Engineered Healthcare

The final panel of the day was focused on the existing and future technologies' ability to change individual and institutional healthcare. The panel conversation was led by Ms. Sarah Westall, University Instructor, Business Consultant, and Radio Host at the University of Minnesota. Joining her was Dr. Gang Bao, Foyt Family Professor in Bioengineering, Director of the Nanomedicine Center for Nucleo-protein Machines, and CPRIT Scholar in Cancer Research at Rice University; Dr. Gerard L. Coté, Director for the Center for Remote Health Technologies and Systems, Holder of the Charles H. and Bettye Barclay Professorship at Texas A&M University; Dr. Jon Mogford, Vice Chancellor for Research for the Texas A&M University System; and Mr. Tong Sun, Director for Central Operations, Institute for Academic Medicine at Houston Methodist. Participants noted healthcare faces far more ethical and moral challenges than technical challenges, which will impact the growth direction of such technologies in different ways around the world. Healthcare is on the cusp of a revolution as the ability to exert greater control over people's environment deepens, but panelists agreed the innovation model must be set now to solidify self-imposed technological limitations that satisfy ethical and moral codes.

Ms. Westall opened the conversation with an assessment of current technology and research, projecting the capabilities of future innovations before laying bare the non-technical challenges technologists, ethicists, and policymakers must face as the technology continues to evolve. This change overtime has not only enabled greater capabilities, but changed how individuals receive care. **“Point of care technologies have changed dramatically over time,” Dr. Cote laid out, noting that “medicine started as doctors going to the patient. Then hospi-**



Ms. Sarah Westall, University Instructor, Business Consultant, and Radio Host, University of Minnesota.

tals were developed, and the patients came to the doctors. Now we are trending back toward returning to the patient, if not the doctors themselves then through technology.”

One of the most accessible and visible technologies today is the wearables market, part of a rapidly growing market segment that tracks biometric markers. This presents two issues according to panelists: appropriately capturing and disseminating information, and making effective use of the data collected. Mr. Sun stated that getting design right early is critical to getting innovations off the table and to the patient. The regulatory hurdles are such that industry and researchers cannot afford to continually invest their time and resources without bringing a product to market. This requires that designers ask participants what they are willing to wear and what information they are comfortable with being collected as part of this participatory design.



Dr. Gang Bao, Foyt Family Professor in Bioengineering, Director, Nanomedicine Center for Nucleoprotein Machines, CPRIT Scholar in Cancer Research, Rice University; Dr. Gerard L. Coté, Director, TEES Center for Remote Health Technologies and Systems, Texas A&M Engineering; Dr. Jon Mogford, Vice Chancellor for Research, Texas A&M University System; Mr. Tong Sun, Director, Central Operations, Institute for Academic Medicine, Houston Methodist; and Ms. Sarah Westall, University Instructor, Business Consultant, and Radio Host, University of Minnesota.

Mr. Sun articulated his point further, stating “engineers are great at designing things, but if no one wears it or uses it, then what is the point?” Dr. Cote pressed further that the benefit of this data is getting the right data to the right person at the right time. Healthcare providers must be provided the appropriate information to diagnose a patient. This point spans the current wearables market to a latent implantables market as well.

This highlights the second concern noted by participants, that patients must be consulted about the information they are willing to volunteer about themselves. The United States government has strict regulations in place regarding the electronic exchange, privacy and security of health information.¹ **Both Dr. Cote and Dr. Mogford reiterated that participatory design and community design working with social scientists will ensure ethics issues regarding data are averted and the experience is as seamless as possible, minimizing active inputs from the user.** Participants shared stories about new technologies rising from engineers work-

ing with physicians leading to new technology, but shared this model of design is not a one-way street. Perhaps, as participants suggested, make engineering part of a doctor's toolkit by incorporating it into their education as a means of bringing more technology into clinical practices and improve the co-design process as doctors are naturally closer to and more aware of patient concerns. Overall this improves the contextual awareness of stakeholders in the development of new wearable and implantable technology, leading to improved understanding of what people are willing to interact with, in regard to technology, as well as the information they are willing to share to the extent that the information sent to healthcare providers is relevant and actionable.

Concurrent to the development of wearable and implantable technology is research into dramatic advances in understanding of the human genome, which will allow people to inflect more change within their bodies at the most foundational level. New technologies such as CRISPR and nanotechnology have the potential to change the world, and new pharmaceuticals can be crafted for bespoke medication tailored to the patient. As these technologies are refined and more is learned about human physiology and pathology, the capacity for remedial and preventative care increases. Dr. Mogford posits that the United States is on the cusp of a wave of innovation reaching the marketplace. Manufacturing pharmaceuticals in the house on an as needed basis will be in front of the FDA in 18 months, and technology to identify illness contracted before expressing any symptoms is doable now but is expected to mature in four to five years. **“These aren’t biology problems, they’re math problems,” according to Dr. Mogford. “It is more an issue of finding the signal through the noise.”**

The impacts of these technologies are felt far beyond just the individual patient. For example, the moment of exposure when testing for illnesses at home before symptoms appear is unknown. If expo-

¹ *Summary of the HIPAA Privacy Rule.* U.S. Department of Health and Human Services. <https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/>.

sure is Day 0 and symptoms appear on day 5, by day 3 these tests can identify illnesses with a predictive value of 90 percent. Similarly, future technological advancements in electroceuticals—using the neurological system as a distributed communication system—may transform the world for physical therapy rehabilitation or paraplegics who desire to live alone. From an engineered healthcare perspective, these advances are incredibly valuable. The ability to run such a test from home reduces the “worried well” who now do not need to travel to the doctor’s office, freeing healthcare provider resources and limiting exposure to other pathogens. Extrapolated broadly, these advances in technology can reduce the cost of healthcare for the United States, which per capita in the United States is already higher than any other country in the world,² occupies a significant portion of the U.S. budget,³ and will ultimately impact overall U.S. competitiveness.

Panelists agreed that engineered healthcare is about the ability to control one’s environment, but as innovations advance, the frontier of knowledge faces new ethical questions about the limits of applying these technologies. **As Dr. Mogford noted, “These questions are no longer theoretical.”** Should these innovations serve to maintain human health or broaden the natural abilities in humans? **Mr. Bao reflected that “if we make a mistake [in genomics], we can permanently change the human genome.”** Every new technology has risks. **“The need,” Mr. Sun identified, “is to balance risk and make progress. When we push the boundary of technology forward, we will always encounter these questions.”** Inherent in this question is how different cultures set ethics and moralities. Beyond this question is who enforces limits? Healthcare providers have the Hippocratic Oath and are assumed to act benevolently, but what happens if ethics clash or worse, some with access to these technologies have malicious intent? How the public is engaged will set

the tone of conversation in this space. **Dr. Cote laid out the problem, stating “ethics are very different across the world. Countries hold different entities responsible to different levels, such as the America’s public institutions are set to one standard, but private companies have relative freedom. But there is a very different expectation in Europe, such as in Germany, which is particularly sensitive after experiences during WWII.”** This is a debate that remains unresolved, and will require continued deep thought by the healthcare industry with stronger participation from social sciences and ethicists globally to ensure the value created in this field is not limited to those with the lowest common moral denominator.

2 *Per Capita Healthcare Costs—International Comparison*. Peter G. Peterson Foundation. October 17, 2016. http://www.pgpf.org/chart-archive/0006_health-care-oecd.

3 *The Federal Budget in 2016*. Congressional Budget Office. <https://www.cbo.gov/>.

FINDINGS FROM THE EIFI SOUTHERN REGIONAL DIALOGUE

The Path Forward

The Council on Competitiveness will conclude the EIFI dialogue series on June 6, 2017 together with Chancellor Mark S. Wrighton of the Washington University in St. Louis. The Washington University in St. Louis is a complementary setting for the next dialogue, locating a conversation on innovation and entrepreneurship in a region known nationally for its backing of young businesses as well as resources in and around the university supporting aspiring entrepreneurs. Identifying the traits of successful entrepreneurs and learning how best to train and cultivate future generations to bring their innovations to market is critical to the success of the Exploring Innovation Frontiers Initiative.

About the Council on Competitiveness

Who We Are

The Council on Competitiveness is a nonpartisan leadership group of CEOs, university presidents, labor leaders and national lab directors working to ensure U.S. prosperity. Together, we advance a pro-growth policy agenda and promote public-private partnerships in the emerging “innovation ecosystem” where new technologies are born.

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- Forging public-private partnerships to drive consensus.
- Galvanizing stakeholders to translate policy into action and change.

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