“... making value requires an integrated system of activities—understanding customers, research, development, design, manufacturing, and services—that are all necessary to deliver value to customers. Making value requires that a holistic system of these activities be developed and optimized in the national interest.”

- Charles M. Vest
NSF ENG: Investing in engineering research and education to foster innovations for benefit to society
The Service Economy

• The U.S. service sector is responsible for:
  – Employing approximately 80% of workers
  – Creating approximately 80% of GDP

• Manufacturing (product) industries are increasingly incorporating value-added service components

• We need high-quality, low-cost, and highly personalized solutions in education, healthcare, manufacturing, transportation, and agriculture.
Productivity and Economic Growth

Chart 3: Percentage Contribution of Employment and Labor Productivity to Global Growth
Productivity remains a more important driver of economic growth than increases in employment.

Source: The Conference Board Total Economy Database™, January 2014

Chart 1
Output per Hour in the United States, Total Economy and Selected Sectors, 1948-2011
(average annual rate of change, per cent)

Source: Gordon, International Productivity Monitor, Spring 2013


Source: Kocher and Sahni, N Engl J Med, October 2011
“Manufacturing is performing a magnificent ballet on a shrinking stage.”

-Robert Gordon
Service System – A Working Definition

A cyber-physical-social system

A system for human interactions with physical and informational environments mediated by advanced technologies to add value
“In short, we’re at an inflection point—a point where the curve starts to bend a lot—because of computers. We are entering a second machine age.”
"The Internet of Things has already set in motion the idea of a fourth industrial revolution—a new wave of technological changes that will decentralize production control and trigger a paradigm shift in manufacturing."

-Markus Löffler, McKinsey

“But in most of the firms in which we carried out our research the traditional line between “manufacturing” and “services” has become so blurred that it no longer serves to distinguish separable and distinct activities or end products.”

-MIT PIE Report
Retail Revolution under Way

“Given the business evolution of Amazon from a bookstore to the store for everything, we had to reinvent automation, following the lean principle of “autonomation”: keep the humans for high-value, complex work and use machines to support those tasks.”
Imagine a (cyber-physical-social) future …
Research Challenges

- Increased complexity
- Range of scales – global scale to highly personalized
- Faster time scales – near real-time and/or rapid response
- Intelligent/learning system
- Human-centered
What fundamental knowledge is needed?

What research communities should be brought in?
A Thought Experiment

- Imagine designing a railway engine at the dawn of the 19th century
- No systematic mechanical engineering at that time
- Are we in an analogous situation in various service systems?
- What might we learn from the experience in the development of different engineering fields?
Models

• Models are fundamental building blocks in all engineering fields
• Leverage scientific knowledge in physics, chemistry, biology, and the power of mathematics
• What might constitute “models” as we think about engineering for service systems?
• What would be the role of social and behavioral sciences in this regard?
Analysis and Design Tools

• What analysis and design tools might be developed to systematize the process of engineering service systems?
• How do we leverage advances in cyber-physical systems and machine learning?
• What are cyber security implications and needs in this context?
• How do we put people in the center in framing design questions?
• What can we learn from early experiences in infrastructure and retail?
Example: Learning and Education

- Productivity of a teacher has not improved significantly in decades
- Major challenges in K-16 education
- Growing body of knowledge in learning science and education
- Modern information technology tools provide an unprecedented opportunity to transform education into just-in-time, personalized education
- Idea of a learning engineer

Plenary session presenters discussed advances in the fundamental science of learning—the underlying research base as to how individuals learn—and called for the development of a new applied discipline—termed learning engineering—which was intended to translate these fundamental insights into new learning environments and tools.

Advancing Technology-Enhanced Education: A Workshop Report, IDA STPI, December 2013
Example: Health Care

• Aging is one of the mega trends for the next many decades
• Cost, quality, access, and efficacy of health care are major societal issues of our time
• PCAST report on Systems Engineering for health care
• Health care engineers

REPORT TO THE PRESIDENT BETTER HEALTH CARE AND LOWER COSTS: ACCELERATING IMPROVEMENT THROUGH SYSTEMS ENGINEERING

Executive Office of the President
President’s Council of Advisors on Science and Technology

May 2014
Would a smart health care engineered systems enable such a learning health care system?
Relevant NSF Programs

- Service Enterprise Systems (SES)
- Engineering and System Design (ESD)
- Systems Science (SS)
- Communications, Circuits and Sensing Systems (CCSS)
- Cyber-Physical Systems (CPS)
- Smart and Connected Health
- National Robotic Initiative (NRI)
- Building Innovation Capacity (BIC)
- US Ignite
- Smart Cities DCL (NSF 15-015)
“According to our estimates, about 47 percent of total US employment is at risk.”

“Our model predicts that most workers in transportation and logistics occupations, together with the bulk of office and administrative support workers, and labour in production occupations, are at risk.”
Concluding Thoughts

• Is there an opportunity to lay the foundations of “X Engineering” where X would be transdisciplinary and represent some subset of the service sector?

• We would like to be bold and creative yet rigorous in our thought processes

• We welcome creative ideas, research agendas, and considered advice from the workshop participants
QUESTIONS?

IDEAS, THOUGHTS!

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