Event Log: Service Systems Engineering in the Human-Centered AI Era

Online Event: October 17, 2022, 11am-5:00pm ET

Purpose of this document: This document is an event log (the cleaned-up transcript). Next step, is for all speakers to first review their sections, then modify their sections (if they would like), and finally sign-off on it. In this document, (1) formal references to speakers are used instead of first names, (2) speakers' comments have been summarized and broken up into paragraphs, (3) most paragraphs have been given opening topic phrases. Speakers can also modify their slides in the compiled presentation if they would like to do so. The final version of this document and the slides will be (1) shared with everyone who registered for the event, and (2) be used as input to create a final concise summary report for this event. All speakers and those who registered for this NAE event will also receive a copy of the final concise summary report and be invited to future NAE events on the topic of service systems.

Useful links:

NAE Event Link (Public): https://www.nae.edu/281715/Service-Systems-Engineering-in-the-Era-of-HumanCentered-AI
Event Agenda (Public): https://www.nae.edu/File.aspx?id=281720&v=d8f00309
ISSIP Blog Post with additional links (Public): https://issip.org/service-systems-engineering-in-the-era-of-human-centered-ai/
Event Log Presentation (Public):
https://docs.google.com/presentation/d/1pmUN4BdiePqV4GXy2b1ABjjg9Wk_nBrP/edit?usp=sharing&ouid=105937985217136001453&rtpof=true&sd=true
Speakers' link to Google Drive Folder (Private): https://drive.google.com/drive/u/0/folders/1_DSsuN3HYeDwOP79nmntTEQc1QEc2JTC

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Framing Remarks
Guru Madhavan

Welcome: Welcome everyone to today's NAE virtual forum entitled "Service Systems Engineering in the Human-Centered AI Era." I am Dr. Guru Madhavan, the Norman R. Augustine Senior Scholar and Senior Director of Programs, National Academy of Engineering. Over the next six hours, we will have a keynote and four panels to begin exploring this topic. To wrap up the day, we have an open mic session that will present various perspectives and points of views gathered in a survey, as well as give participants a chance to share their thoughts and point of view directly.

NAE Leadership in Systems Engineering: This event will build on the interlinked themes of people, systems, and culture that guide NAE programs. The NAE FOCUS (Forum on Complex Unifiable Systems) program is new and evolving, and our goal is to explore approaches to better engage with complex systems and the surprises they produce. Examples of these complex systems surprises abound. For example, the Japan electric grid failure, caused by 50Hz and 60Hz component incompatibilities during the Fukushima trifecta of earthquake, tsunami, and nuclear plant, which had ripple effects of impacting US exports and supply chain disruptions. Other example, include Scotland contaminated food and there are many more examples. Each incident gives rise to complexity tactics and the need for deeper understanding of complex systems and emergence. Effects can happen over many time horizons, more quickly in some technology areas, and more slowly in some cultural areas, but there are always surprises, phase transitions, disparate impacts, and changes to the state of the system.

Service Systems Engineering in the Human-Center AI Era: As advancing artificial intelligence (AI) capabilities are advanced and increasingly positioned to improve productivity and quality in the data-intensive, human-centered service sector – including healthcare, education, government, finance, retail, hospitality, transportation, green energy, and more—
We need more systems engineering approaches to unifiably serve the well-being of people and planet. We will explore such possibilities in this meeting and what does it mean to inculcate a cultural engineering mindset. After the keynote, we have four expert panels to address (1) service science, (2) artificial intelligence, (3) future engineer, and (4) social implications, followed by an "open-mic" session to get additional ideas and position statements. Now, I would like to turn things over to Dr. Nicholas Donofrio, IBM Fellow and NAE Member, who will provide the opening keynote for today.

Keynote: Service Science, Management, and Engineering (SSME): If Nothing Changes, Nothing Changes.

Nicholas Donofrio

The Goal of Bringing Communities Together To Better Deal With Growing Complexity: When we started SSME (Service Science, Management and Engineering), it was about bringing communities together as the main goal. At IBM, we needed to find a way to bring all communities together - not just for better integrated hardware, software, and service systems, but also for better alignment for our technology, business, and people strategies. Now we are increasingly in an AI-driven world, and we haven't seen anything yet. Increasing AI capabilities will bring with it more nuanced and more challenging science, engineering, and management issues. For example, a basic question about what is real, what is true, and what is fabricated. Virtual reality will make truth screen even harder.

Systems and System Failures: Dr. Madhavan has already given some examples of complex systems and system failures. On September 11, the Bank of NY stopped banking, the stock market stopped stock marketing, and Federal Reserve stopped Federal Reserving. Why? They thought they had backups systems because they were using two carriers, but the two switches were side by side in the towers that collapsed.

The Challenge – We Have To Do A Better Job of Building Complex Systems Together, Inclusively: We have to do a better job of building together, inclusively. DEI – Diversity Equity and Inclusion – for all of us, and diversity of thought matters as well. Being open and collaborative matters as well. We need better leading indicators. Lagging indicators tell us about where we have been. Lagging indicators don't do us much good. We need better leading indicators. Leading indicators tell us about where we might be going.

Service-Driven Economy: We live in a service-driven economy. We want to generate value faster by improving productivity of service systems. However, we are just building a house of cards if we don't have better systems. Scientists will be blamed for the mistakes, so we must take responsibility for both value created (benefits)(, and value destroyed (harms). Everything we touch, we create, consequences known and unknown, real and imagined, we need to better understand and take responsibility for what we build and put into the world. Technology is there in these systems, and it will get better. Technology is on exponential improvement curves with no end in sight. However, lot of bumps in road, more will always be there. We must do a better job of harnessing technology for good humanity

T-Shaped People: In my new autobiography titled "if nothing changed, nothing changes," I write about the importance of T-shaped people. Bringing communities together requires T-shaped people who have an ability to talk to each other in a common language, and who are

also deep in their own specific area of knowledge, be that engineering, management, social or whatever.

Why This is Important: To compete in tomorrow's world we need to find a way to bring all communities together. We need to deal with all aspects of challenges, not just technology, not just people, but also culture. In a fast paced and fast changing world, a nation's culture must value what is real and what is true, to successfully innovate and compete. Going forward this is what worries me the most. How can we screen for what is fake when each year the fake's get more sophisticated? We must find a way to be on the right side of history and focus on what is true – even as the AI and VR world advancing makes it harder. And again, we need to have better leading indicators, real predictors. DEI (Diversity, Equity, and Inclusion), open, collaborative all matter when we are looking for better leading indicators to innovate.

Concluding Remarks: Look; what matters is the work you did, the work you are doing, and the work you will do. It matters to our country and the world. Everything we touch, we create, consequences known and unknown, real and imagined – we should raise up the floor on service delivery in our increasingly AI-powered service-driven world. That is where the rubber meets the road. There are lots of bumps on the road, more will always be there, but this work is about harnessing knowledge from all disciplines for the good of humanity. I look forward to the proceedings of today's event.

Panel 1: Engineering Considers for Service Systems
Moderator: Paul Maglio
Panelists: Richard Larson, Kelly Lyons, John McDermid

Guru Madhavan
Thank you Dr. Donofrio. Now, I would like to turn things over to Dr. Maglio, and the first set of panelists.

Paul Maglio
Thank you Dr. Madhavan, and thank you Dr. Donofrio for that wonderful talk to kick off this event. I am Dr. Paul Maglio of the University of California Merced, and prior to that I was with IBM Research where I worked with Dr. Donofrio and Dr. Spohrer others more than twenty years ago on launching IBM's Service Science, Management, and Engineering (or SSME) initiative. It's my pleasure to moderate this first panel on *engineering considerations for service systems*. I have a few opening remarks, and then we have three distinguished panelists who will also make short presentations, Dr. Richard Larson (MIT), Dr. Kelly Lyons (U Toronto), and Dr. John McDermid (U Cambridge, UK). There should be plenty of time for discussion and questions at the end.

Service Science: Let me begin by expanding the aperture beyond engineering considerations for service systems by providing a bit of context and definition for the area of "service science". In the Springer *Handbook of Service Science* (published in 2010), we defined service as "value cocreation, which is useful change resulting from the purposeful interaction of entities," and we defined service science as "the systematic search for principles and methods that can help us understand and improve all kinds of value cocreation." As Dr. Donofrio mentioned, our goal was to bring diverse communities together to think about improving service innovation and service delivery. Traditionally, service businesses are labor-intensive businesses, and as IBM was making a big push into services – IT services, business services, outsourcing service – we quickly realized that we could not just keep throwing people at the problem. We needed a better understanding of how to scale service and how to make service better over time, across all industries, such as transportation, retail, etc. We wanted to find out what was common across them all and put them on the same innovation footing. We compiled some of those early thoughts and results in the 2010 Handbook, which looked mainly at service from a variety of perspectives and existing disciplines, such as marketing, operations, economics, computing, design, engineering, management, etc.). In 2019, we published a second volume, the *Handbook of Service Science Volume II*, which began to demonstrate some integration across disciplines, including in the contexts of digital transformation and smart service systems.

Complex Service Systems: Along the way, I was also editor of the INFORMS journal, *Service Science*, as we worked to build the service science community to study the complex web of systems that cocreate value by sharing capabilities to create mutual benefit. The study of

complex systems as service systems, service ecosystems, service ecologies, and the notion of entities sharing capabilities has gradually been confirming our intuition that service science is less like the science of Newton, and more like the science of Darwin.

Service and AI: To provide a simpler introduction to service science, we recently published a short book, *Service in the AI Era: Science, Logic, and Architecture Perspectives* – where science deals with models of the world, logic deal with models in people, and architectures deals with models of organizations – all evolving alongside increasingly capable AI models for packaging and sharing capabilities among entities that work together for mutual benefit.

Service Science Principles: Over time, Jim Spohrer and I developed some principles of service science, what I think of as the basics or fundamentals of service and service thinking:

- Service system entities dynamically configure four types of resources, people, information, organizations, and technologies.
- Service system entities compute value from multiple stakeholder perspectives.
- The access rights associated with resources are reconfigured by mutually agreed-to value propositions.
- Service system entities compute and coordinate actions with others through symbolic processes of valuing and of communicating.

In the present context, I thought it might be interesting to take an *engineering* perspective on these principles:

- *Design for human interaction*, as people are the key resource.
- *Simultaneous optimization of multiple functions* is needed to satisfy multiple stakeholders
- *Define clear interfaces for systems and subsystems* to access resources effectively.
- *Predictive modeling at multiple scales* enables entities to determine possible future value (and possible partners)

Discussion questions: Now, I invite the panelists to touch on topics related to the following questions, which came out of a National Science Foundation (NSF) sponsored workshop focused on building a research agenda for *human-centered service system innovation*:

- How can educators ensure the steady flow of skills for industry career paths as job roles change due to service innovations?
- How can educators identify the emerging knowledge and skills gaps, and close them as quickly as possible to help ensure industry growth?
- How can educators prepare the next generation of citizens, innovators, and entrepreneurs?

- What roles for government, academia, and industry collaborations exist? How best can human-center service system knowledge be disseminated, and which disciplines with capture and maintain this knowledge?

Now, Dr. Larson will share his thoughts with us.

Richard Larson
Thank you Dr. Maglio. Now I don't want to throw Newton out just yet. I want to give a plug for Newton's 3rd law, every action has an equal and opposite reaction. Change has consequences.

Engineering Considerations for Service Systems: To start, I want to highlight a chapter of mine from the book *Service Systems Implementation*. I make the point that service is often defined by subtraction – by subtracting out economic activities such as manufacturing, agriculture, and mining that focus on physical goods, and saying what is left is service. Positive examples of service are when a service provider helps a beneficiary – consider economic activities such as healthcare and education. So by definition, service systems are human-centered. They evolve over time – self-service technologies replace or augment human labor. For example, telephone operators practically don't exist anymore, because you are your own operator, you have been augmented to perform the activity yourself. Other examples include: ATMs replacing human bank tellers, transponder systems in vehicles to assess roadway tolls, and self-service replacing attendants in retail sales (super markets, gasoline stations, etc.). Today, AI capabilities are increasing what technology can do, further augmenting people, such as, complex medical diagnoses, automated voice robots, self-driving cars, etc.

The Definition of Engineering Needs to be Revised: Wikipedia says, "Engineering is the use of scientific principles to design and build machines, structures, and other items, including bridges, tunnels, roads, vehicles, and buildings." But we know service systems are human-centered systems. Human-centered systems, service systems, also need scientifically-informed design, as can be offered by broadly educated engineers.

Considerations: I propose these as the priority considerations for this revised view of engineering:

- Humans, not technology, are at the core of the system.
- Human abilities, preferences, and behaviors vary in limitless ways.
- Any closed-form "engineering solution" based on technology alone, including AI, will – with probability 1.0 – run into problems, some severe (like loss of life).
- We need to create technology-supported open systems that can put people back in control when the algorithms near their boundaries of applicability: consider driverless cars only slowly making progress as more and more edge cases are discovered – because we are dealing with open systems and not closed systems.

Related Topics: When looking at human-centered systems, topics like coordination and disciplines like management are also important. Engineers must understand the learning behavior of people in these systems. One should always be skeptical about asserting that we understand the people in systems. In fact, I have written a book that will be coming out soon by INFORMS press, about model thinking for everyday life. The book is full of examples of model-based thinking and is written to help people build better models of the world. Much learning takes place these days on computers, but people can confuse learning with doing a Google search on a topic. *Plug and chug learning*. This creates a serious problem of shallow learning. Instead, the book suggests people sharpen their pencils and get a blank sheet of paper and that sets the stage for thinking and designing better models. Always question the model of the system. Explore how things work using models.

Paul Maglio
Thank you Dr. Larson. Now we will hear from Dr. Lyons.

Kelly Lyons
Thank you Dr. Maglio. I appreciate the opportunity to be with you all today and discuss these important topics related to service science, human-centered service systems, and engineering considerations around service systems in the human-centered AI era. I would also like to acknowledge that I am from Canada and working in a land first settled by the indigenous people whose heritage is part of human-centered service systems then and now.

iSchools and Service Science: My perspective on all the topics we have heard about so far comes from an iSchool – or Information School – perspective. iSchools bring a multidisciplinary approach to study information, people, and technology as equally interacting entities, and with an interest in the relationship among these types of entities. We work to bring all the perspectives together and study both intended and unintended consequences that result from interaction and change.

To summarize my view of the relationship between iSchool and service science perspectives:

- iSchools focus on the relationship among information, people, and technology; service science studies service systems, which are made up of information, people, technology, and organizations; both require a multidisciplinary approach
- iSchools work with industry to shape research directions; service science works to bring academia, industry, and government together
- ISchools start from the use and users of information, information technologies, applications; service science incorporates people and organizations, technology and business domains

- iSchools argue that depth in one area, such as information, technology, or people, is not sufficient to understand connections and interactions among entities; service science promotes the notion of *T-shaped adaptive innovators*, with depth in one or more areas and breadth to communicate across the complexities of others.

All of this brings us to a first engineering consideration: *Engineering systems in an era of human centred AI requires bringing multiple perspectives together*, centered *not only on humans but interactions among humans, data, information, and technology*.

Courses: For example, the UC Berkeley iSchool's *Service Science* course suggested the sequence: describe, model, analyze, optimize, innovate – all in a rather data centric-way. In my school, I created *Introduction to Service Science*, which con siders the following questions: How can we properly describe service systems? How can we represent (model) service systems? How do we use our descriptions and representations to enable analysis, optimization, and innovation in service systems? It is also worth noting the range of undergraduate and graduate students that took these iSchool-based service science courses include students from the humanities, social sciences, as well as engineering and technology majors.

Publications: Some example publications that bring multiple perspectives together include: Tracy and Lyons (2012) focuses on service science and the social enterprise, which helps students use a service science framework to better analyze social enterprises and understand a community of stakeholders; in the *Handbook of Service Science Volume II*, the chapter by Blair Frost, Cheng, and Lyons (2019), deals with the broader ecosystem and providing a multi-layer analysis framework for service ecosystems; in the *International Journal of Information Management*, an article by Lim et al (2018) provides a framework to go from data to value using a service system analysis approach.

Other Considerations: I have two more human-centered considerations for engineering service systems: First, *Human Centered Data Science* (Aragon et al., 2022) suggests data-science should shift from a focus on what models make the best predictions to models that give people the best outcomes. This is a human-centered data-science shift that is an important consideration for engineers teaming with others to design, deploy, and deliver service systems. Second, Attard-Frost's work uses a service systems lens to study AI governance systems, specifically for understanding "disservice", where some stakeholders experience benefits while other stakeholders experience harms.

Ongoing Evolution: Consider the two handbooks of service science, which were published about a decade apart. Dr. Maglio already mentioned that the first handbook had sections for different disciplinary perspectives, and the second was less about separate disciplines and more about areas of integration. When we look at the two intersecting word clouds – thanks to my students Noel, Brisson, and Liu – we see that the terms "manufacturing " and "revenue" stand out in the first handbook, while "ecosystem, data, and healthcare" stand out in the second. The

intersection of both handbooks shows the "service" and "systems", as well as "customer" and "innovation" remained important throughout. The point is that there is an ongoing and healthy evolution of topics and areas of focus in the service science community.

The Problem with "Data is the New Oil": This idea that "data is the new oil" – with variations in quotes from Tesco's Humby, IBM's Rometty, Siemen's Kaeser, as well as the Economist's articles picture showing Google and other oil rig like business platforms pumping data – is misleading. The problem with this view is nicely highlighted in the quote by my colleague Lisa Austin, a Law Professor at the University of Toronto: "This is a 20th-century approach to 21st-century topics. A better framing recognizes that data is not a natural resource but a new informational dimension to individual and community life." We know from service science and service-dominant logic (S-D logic) that viewing value in "things" – be it oil or data – is a goods-dominant perspective. As engineers look to better understand human-centered approaches, engineering disciplines would do well to overcome 20th century, goods-dominant thinking and instead embrace a 21st century, S-D logic perspective on data that is more human-centered. Both the iSchool and service science communities have been pioneering this more human-centered perspective for two decades. I am optimistic that working together across disciplines that we can equip policy-makers and industry leaders with this perspective to guide decision-making and shape outcomes that benefit all.

Summary: Service science can contribute to a multidisciplinary, cross-institutional, cross-border research agenda that:

- Pursues world-changing data-science research
- Increases productivity, efficiency, and inclusiveness across industries
- Furthers the transformation of existing operational systems with advanced data-science capabilities
- Delivers transparency, explainability, fairness, and ethics in all aspects of data-science deployment
- Equips policy makers and industry leaders with tools for predicting, managing, and surviving the pending disruption and economic and social consequences of adopting data-science at scale.

Unintended consequences are more likely to be recognized quickly if we can ensure diversity of perspectives as service systems are designed, deployed, and delivered.

Paul Maglio
Thank you Dr. Lyons. Now we will hear from Dr. McDermid.

John McDermid

Safe, Ethical, Sustainable: The three considerations for engineering service systems that I will present today are: safe, ethical, and sustainable. All three are human-centered engineering considerations, and engineering service systems is hard, for many reasons, including the wide range of stakeholder considerations.

Safety Engineering: Safety engineering is about preventing harm. One of my early contributions to safety engineering was the development of the *Goal Structuring Notation* for graphical arguments, which has since become the basis for safety cases (starting with products and now thinking more about service offerings) and which has achieved wide recognition, including national standards and awards. My current focus is on the levels of autonomy of systems that use AI/ML, which requires considering not just safety, but also ethical and sustainability perspectives.

Ethical Assurance: I have four principles plus one, adapted from biomedical ethics:

- Beneficence – do some good
- Non-maleficence – avoid harm
- Personal autonomy – freedom to make meaningful choice
- Justice – fairness in distribution of benefit and harm
- These four can be supported by transparency, which provides for human-centered visibility of AI/ML behavior.

Trade-offs and Challenges: Systems engineering is about trade-offs. The question is how to choose the best design when properties of interest, such as safety and human autonomy, are incommensurable. Engineers can "reject" designs that do not satisfy key criteria, for example, when the set of beneficiaries are disjoint from those at risk of harm. Engineers can compare remaining designs in terms of justice or fairness. But typically, there is no Pareto optimal/dominant solution. Engineers can use a process of reflective equilibrium to produce the argument. How this gets done shares some similarities with the notion of critical thinking – but for groups working together, not just individual judgments.

Mobility as a Service: Consider an electric autonomous vehicle that is part of a mobility as a service offering and part of an urban transportation service system. In a safety case analysis, four types of electric autonomous vehicles are considered (2 seat, 4 seat, shuttles, and buses) and four types of stakeholders (adult occupant, child occupant, other road users, and safety assistants on the road – including police, ambulances, etc.). The safety case analysis can compare fleets of different vehicle mixes and look at a range of outcomes, including carbon emissions as part of sustainability considerations.

Acceptability vs Optimality: Although there is typically no Pareto optimal solution in these types of human-centered service system analyses, such analyses can provide a baseline to improve

acceptability over time. The goal is to work out the "least worse solution". From a moral philosophy perspective, that means looking for a reflective equilibrium that is most acceptable, though not optimal.

Concluding Remarks: Safe, ethical, sustainable are three important considerations for engineering service systems. These examples help to illustrate that designing safe, ethical, and sustainable service systems is hard. Nevertheless, I believe that an argument-based approach helps to illuminate the issues. An argument-based approach can also be a powerful tool for finding a basis for reaching consensus on a most acceptable solution. This short presentation has sketched a promising approach. Some of the concepts and building blocks have been published, but more needs to be done. This approach can be reflected in engineering education. In conclusion, remember the mantra – *safe, ethical, sustainable*. Those are three important considerations for engineering service systems.

Paul Maglio
Thank you Dr. McDermid for that concise and clear introduction to safe, ethical, sustainable human-centered service systems engineering considerations.

To recap before we move to the discussion: So far, we heard from Dr. Madhavan and Dr. Donofrio about when systems fail, often it I after someone had issued a warning that was not acted upon in time. We heard in this panel from myself, Dr. Larson, Dr. Lyons, and Dr. McDermid that a range of disciplines are continuing to evolve with new principles and approaches to improve our understanding of service systems, including how to improve and innovate them more systematically, considering both benefits and harms, and looking for the most acceptable, rather than optimal solutions.

Dr. Donofrio spoke about the design of things that people use as well as the design of systems with people in them. How do we design better systems to create value with and for the people in them?

John McDermid
We need to do safety analysis recognizing that there is shared control and shared responsibility between the human and the technology in the systems that we design, engineer, and manage.

Kelly Lyons
Dr. Madhavan spoke about the need to change the culture of engineering itself. The engineering field is not as diverse as it could be. For example, I recall a Wired Magazine article from around 2017, that mentioned only 12% of leading AI researchers are women, and for Computer Science, women made up only about 20% of the leaders in the field. Many different groups are underrepresented.

Richard Larson
The definition of engineering from Wikipedia is instructive – and too narrow. "Engineering is use of the scientific principles to design and build machine structures and other items, including bridges, tunnels, roads, vehicles, and buildings." I think engineering is much broader than that. Operations research has dealt with service systems for decades.

Paul Maglio
Agreed. We have to be careful not to stereotype or over-simplify engineering. For example, human factors engineers analyze and design systems with people in mind. How do we think about engineering in the context of service systems? What kinds of skills are needed in future engineers?

John McDermid
The world still needs some specialists (I-shapes), but even with specialists, continuous learning is necessary. Being T-shaped or even pi-shaped (deep in two disciplines) has advantages, but again requires continuous learning to stay up to date in a fast changing world. For autonomous vehicle safety, engineers must discuss human-factors with psychologists to draw out the issues properly. Being attracted to other disciplines helps with continually learning.

Kelly Lyons
We call those people "the center of the table people" because they are good translators between different perspectives. I have noticed teaching students in the faculty of the I-School that the students without technical backgrounds are more fearful at first. When people come from a technical background, they too can be fearful of learning about the social, psychological, and human-side of things. Of course, this happens in real-world consulting practices too. Day one of a new service engagement should be boots on the ground, everyone fans out and has conversations with key actors in a service system to understand their priorities, understand their fears, and understand their responsibilities.

Panel 2: Artificial Intelligence, Prospects and Challenges
Moderator: Jim Spohrer
Panelists: Hila Lifshitz-Assaf, Kartik Ramani, Shaun West

Guru Madhavan
Thank-you all, and now we will transition to the second panel with a focus on human-centered AI.

Jim Spohrer
Recap – Imperatives Including Voices Sounding Warnings: We have heard from Dr. Madhavan, Dr. Donofrio, and Dr. Maglio and his panelists, that when systems fail, and they do fail and cause harms, that there was one or more voices, probably at least one stakeholder, who warned everyone. However, people either did not listen or did not take action. How can we better design these complex service systems with people and technologies? There has to be a way to be more inclusive of the voices sounding the warnings and suggesting system changes at all stages - design, engineering, management, maintenance, and governance**.**

System Failures and the Transdisciplinarity Trend: Regarding system failures, business and society depends on an enormous variety of complex product-service systems that people have to design, engineer, manage, maintain, and govern, there is a sense that technology – the most highly engineered parts of all these systems - is changing rapidly, and yet we have to make it more humanity-centered (as Don Norman says in his upcoming 2023 book) to avoid harming people, not just customers, but a wide-range of stakeholders, including future generations as well as chronically under-served populations. All disciplines are evolving to take this into account, and so all disciplines are on a transdisciplinary journey, including I-Schools, safety engineering, systems engineering, behavioral sciences, and more. Dr. Donofrio made this point in his keynote – we started SSME to bring people together from all disciplines, industries, and cultures – because people live and work in service systems – but they often don't know it.

Feedback Request Reminder: We ask that all participants put comments in the zoom chat, and in closing session lead by Prof. Vittal Prabhu (PSU) – he may call on you. He has the hard job of summarizing the feedback we have already received via the survey.

Panelist Introductions: The panelists for this AI session include Prof. Hila Lifshitz-Assaf (University of Warwick, UK, also affiliated with Harvard), Prof. Kartik Romani (Purdue), and Shaun West (U Lucerne, Switzerland). Before turning things over to each of them, I will make a few opening remarks about the need for people in service systems to upskill with AI. This is both an enormous challenge and opportunity for nations today.

From I-Shaped Professionals to T-Shaped Professionals: Systems are increasingly complex, so there is a need for T-Shaped Professionals, as Dr. Donofrio mentioned. The notion of a T-

Shaped Professional continues to evolve. Teams of T-Shaped Professionals can communicate with each other across disciplinary, industry, cultural and other boundaries better than teams of I-Shaped professionals. Teams of T-Shaped Professionals also have deep expertise across what ISSIP has labeled six realms of expertise: disciplines, industry sectors, cultures, advanced technology, work practices, and mindsets (ISSIP's six realms of expertise).

The Complex Systems Language Problem: Part of the challenge for dealing with future complex systems is language-related, the complex systems language problem. The future engineer and professionals who design, use, engineer, maintain, manage, change, and govern complex business and societal systems need to have a larger vocabulary that spans multiple realms of expertise. Future professionals need to communicate with better language and models of future complex systems. As Don Norman describes in his new book, humanity-centered challenges cannot be solved by one discipline alone, and he positions design as a good choice for a bridging discipline with a good balance between human and technology aspects of complex, interconnected socio-technical systems with multiple stakeholders.

Pi-Shaped Professionals and X-Shaped Professionals: Dr. McDermid spoke of Pi-Shaped Professionals who go beyond T-Shaped Professionals with depth in two areas, perhaps engineering and management or engineering and law or engineering and behavioral sciences. As we enter the AI era, there is the idea of X-Shaped Professionals augmented with AI tools and assistants helping professionals to communicate and solve complex systems challenges of increasing complexity. The slides will be made available along with references for those who want to read more about the major transitions from I-Shaped to T-Shaped to X-Shaped Professionals.

Learning Today's AI Tools: Which AI Tools should T-Shaped Professionals be learning about? Here is my list for today of AI tools to learn, and take note that this list is changing rapidly. Every week there are new tools from AI tools that turn text descriptions into pictures to AI tools that answer questions based on facts in a repository of 10,000 books to AI tools that complete simple writing tasks when give shorts prompts about what to do and how to do it. This slide shares a list of ten online AI tools that are free and easy to try today in just a few hours. This slide also shares the warning that "Service providers will not be replaced by AI, but service providers who do not use AI tools will be replaced by those who do. And all people, all of us, we are all service providers if we have a role in an organization." People who work in agriculture, manufacturing are service providers – not just people in what economist call the service sector. We are all service providers, and we must all learn to give and get better service with the help of AI tools. Or risk being replaced in that role by someone who is using AI tools to give and get better service.

Building Tomorrow's Digital Twins: As AI capabilities advance, each of us will eventually have smartphones with the equivalent of 100 digital workers working for us. We will also have

digital twins of ourselves that can help us give and get better service. Even while we are sleeping our digital twin can be answering routine emails, and performing other tasks on our behalf or generating possible responses for use to read and approve before they are sent. Dr Rouse and I published a roadmap for intelligence augmentation a few years ago, and that citation is also on this slide.

Improving the Service Science and Service Systems Glossary: As Dr. Maglio already mentioned the IBM-Cambridge SSME Report, I want to point out that that report which is online has a pretty good initial glossary for service science and service systems. Dr. Maglio also mentioned our new book with Dr. Vargo and Dr. Warg called "Service in the AI Era: Science, Logic, and Architecture Perspectives." The index of that book is a good start point for improving the service science and service systems glossary for the AI era. Improved glossaries that are mastered by X-Shaped Professionals can begin to address "The Complex Systems Language Problem." We can even use AI Tools (such as ChatGPT) to help us build the needed glossary across the six realms of expertise that ISSIP has identified in ongoing efforts to better understand the future of expertise.

Service Systems Benefits and Harms Exploration: To wrap up my introduction to this panel that will focus on AI, and before turning the discussion over to our three panelists to share their perspectives, I just want to share some important rethinking that is happening in the service research community about benefits and harms of service systems. When Dr. Maglio and I started working on service science, and the notion of service as value cocreation – our focus was largely on the benefits from improved interaction and change processes. However, what is beneficial interaction and beneficial change for some, can be harmful to other stakeholders. The growing awareness of concepts of service systems failures and both unintentional and intentional value codestruction by some stakeholders is especially important to explore in the AI era. Dr. Ray Fisk has established ServCollab to galvanize action research and grow the service research community to better serve humanity and address both reducing harms and increasing benefits of future complex service systems.

With that we are now ready to move on to the other panelists. Dr. Lifshitz-Assaf is our first panelist and can provide perspective on the benefits and harms associated with changing innovation processes in organization, including AI adoption and other types of changes. Dr. Lifshitz-Assaf has studied innovation process change in a variety of service system context from medical diagnosis to new product design. As mentioned earlier, after reading one of her papers, I found the work so interesting, I immediately had to read more about her and her collaborators fascinating experiments and case studies. Here is Dr. Lifshitz-Assaf.

Hila Lifshitz-Assaf

Thank you for the wonderful introduction. When someone slaves over writing a paper, it is a big compliment when someone else then reads that paper and wants to read more of my papers.

Understanding Future Innovation Processes: We have a lab that is dedicated to the study of the science of innovation. The faculty span business school, information systems, technology management, and more. We ask ourselves what is the future of the innovation process? As innovation processes change, some stakeholder groups may see the changes as positive, and other stakeholder groups may see the changes as negative. If we start with a historical perspective on innovation processes, clearly technologies have changed a lot since the industrial revolution – so the tools used in innovation processes are changing over time. The dynamics of innovation processes also change when large numbers of people can work together in cities and regions or with online web tools together searching for solutions to problems. And now the question is how will AI change innovation processes? We have to be cautious about the hype around AI augmented or automated innovation processes, just as we had to dig through hype around open innovation, open source, and crowdsourced innovation processes in the past. We need to better understand the reality to see beyond the hype. I am seeing the same situation with AI that happened with crowdsourcing.

In-Depth Longitudinal Case Study of NASA Engineers and Scientists: The good news is that a very hard, long-standing NASA problem was solved by a semi-retired radio engineer. So one lesson to learn is that organizations can describe their hard, unsolved problems in ways that can be understood and engage people with unique perspectives on possible solutions outside their organizations. The bad news is the innovation process can create a lot of tension and resistance. An organizational scholar can guess what happened next. When NASA management began to embrace the new innovation process and asked for groups to volunteer their own problems, management met resistance. Research teams worried the new process would replace the current process, and some domain experts felt threatened.

The Human-Centered AI Debate: Now when we come to AI, I see the AI debate shifting from automating versus augmenting to instead focus on builders and users working together. As Dr. Macdermid mentioned users do not want blackbox AI. I have studied critical decision-making in medical diagnosis for cancer and seen this first hand. As Dr. Donofrio mentioned in his opening keynote, it is time to shift from studying the systems to shaping the systems. We are doing experiments that bring the builders and the users of AI systems together, both working together with researchers to change the decision-making and innovation processes.

Additional Experiments and Case Studies: We are experimenting with the builders of AI image generators and product design engineers working together with researchers. Also, as Dr. Larson mentioned Google search is not learning, so we are also doing experiments with the

builders and users of design search algorithms to better understand design algorithms for exploratory thinking, divergent thinking, and analogical innovation processes.

Jim Spohrer
Question: Are you mostly working with AI systems or crowdsourcing systems these days? Or do you see them blending along the builder and user collaboration dimensions you discussed?

Hila Lifshitz-Assaf:
How To Decontextualize Problems: Right now the crowdsourcing area, which I have studied for decades, is still of great interest. I am also interested in the combinations between crowdsourcing and AI, and ability to decontextualize problems, for people from other domains to solve them. The role of AI and other technologies including VR and AR, for boosting creativity in innovation processes and new knowledge creation for scientific discoveries are also of interest. I have heard that companies like Boeing may be working on that combination of technologies.

Jim Spohrer
Thank-you Dr. Lifshitz-Assaf, and your comments about AI/AR/VR are a perfect setup for our next panelist. Now, Dr. Kartik Ramani from Purdue will present. Dr. Ramani clearly sees a possible future transformation of the education service system using AI and XR (Extended Reality). Let's hear from Dr. Ramani now.

Kartik Ramani
Spatial Intelligence Augmentation and Closing Skills/Hiring/Productivity Gaps: Thank-you Dr. Spohrer and Dr. Lifshitz-Assaf. My talk is about AI and XR (eXtended Reality) in the context of spatial intelligence augmentation for education service systems and real-world jobs that require pre, up, and reskilling of workers. As technologies change, the need for workers to gain new skills has created a larger and larger gap in the US economy between job openings and hirings. These types of hiring gaps persist until the demand for workers with high-tech skills can be met. Closing the skills and hiring gap is important because that is what leads to more productivity. The NSF-funded human-centered research that my collaborators and I have been developing has a focus on using new technologies to help people design and build AI-powered robots – specifically innovative robot toys - as part of Purdue's Mechanical Engineering degree programs. This is a highly multidisciplinary degree program, and we produce Q-Shaped, T-Shaped, and Pi-Shaped graduates. We have been doing toy design for 25 years, and it is one of the most popular courses with 160 students per semester, and 320 students per year.

From Toy Design to the Human Augmentation Age: For the past 25 years, the toy design context has been a fantastic experimental ground for me and the students because they get to build cool things. Students use the latest technologies, including 3D printers, and they also learn about software algorithms as well. Pushing forward with new technologies like AI and XR

(eXtended Reality, combining both VR – virtual reality and AR – augmented reality), we are entering the human augmentation era. The idea of augmented human intelligence is not new. For example, one of Dr. Spohrer's mentors, Douglas Engelbart who invented the computer mouse, gave a demo in 1968 that showed off a range of human intelligence augmentation technologies. That demo is now famously called "The Mother of All Demos." What is new is the way we can conceptualize and represent the human interaction with machines and robots mediated in part using a physical-reality simulation. It's the first time in human history that a machine will share our viewpoint and our specific context moment to moment. This change in perspective is very useful. The economist Tyler Cohen and others refer to these types of changes as key components of the human augmentation age. Large companies are investing in the human augmentation age because of the economic growth potential of people actually cognitively working in a spatial sense with their hands and eyes, bodies and minds in new ways that accelerate learning. Not just in one location, but the people and the machines in physical space can be distributed in many places, but all connected via the physical-reality simulation in virtual space.

Authoring Spatial Intelligence Augmentation Applications: In modern industry, human workers, as the most flexible part in the production process, need to rapidly master different machine tasks. When workers need to learn to use new equipment, a human expert instructor can demonstrate how to do the job and then coach the worker as they try. For example, we are working with a local truck welding company – and demand for skilled workers who can use the latest welding equipment is high. Now imagine what it would be like if the worker could learn to do the job using an AI/XR system. One of the challenges is authoring these types of spatial intelligence augmentation applications. With funding from NSF and DARPA we have developed a prototype authoring environment for spatial intelligence augmentation applications, useable by workers learning to master machines tasks such as welding and other types of operating equipment. In the future, we can envision augmented perception of all service systems around us, and this can feed into a virtuous cycle, to create the next generation of hands-on systems thinkers. I'll stop here to see if there are any questions.

Jim Spohrer

Question: Thank-you Dr. Ramani. One quick question thinking back to Dr. Donofrio's points about the competitiveness of the US economy, and I know your son wrote a nice piece in the "Economist" magazine about AI progress in China and the US (which everyone should read), but I would just like your opinion on when this AI/XR capabilities will be real and widely deployed. Since around 2012, deep learning has made the AI of speech recognition and image recognition real, and increasingly widely deployed. However, when will the AI/XR moment happen in your opinion? This decade? Next decade? Your vision for the impact it could have on closing the skills/hiring gap and boost economic productivity is compelling, but when will it be real?

Kartik Ramani

Answer: It is getting more real as we speak, and the level of investing is substantial. We have seen some of the core technologies being embedded in smartphones. In addition to hardware changes, we also have social comfort and acceptance levels – human organizational hurdles to overcome as Dr. Lifshitz-Assaf mentioned. Apple, Microsoft, Meta/Facebook and others are making big investments. I think in another 5 years there will be visible successes, and then 10-15 for wide scale adoption.

Jim Spohrer
Thank-you Dr. Ramani; your work advancing the integration of AI and XR shows clear potential to generate a next generation of systems thinkers better able to understand service systems. Our next panelist Dr. West is a leading expert on smart service systems based in Switzerland, and he recently completed a guidebook on service design featuring the role of digital twins for smart service systems with multiple industry case studies.

Shaun West
Field Service and AI - Smart Service Systems, Digital Twins, and Field Service: Thank-you Dr. Spohrer. I have been working in the area of smart service system design, digital twins, and field service for many years. My talk will explore current approaches to field service and new opportunities in the human-centered AI era. Upfront, one big challenge is the aging work force of field service professionals, and many are not the first to adopt new technologies and methods. Change can be scary for these workers. We need a life cycle perspective and a human-centered perspective together to make progress. The term "advance analytics" is a lot less scary than "AI."

Where do we have opportunities for field service and AI?

Field services and AI within the world of people, processes, and things this is a complicated environments on one that we need to take time to understand. It's one with complicated systems, many actors, and many jobs to be done. Figure 1 describes the life cycle of a typical industrial asset from being developed to manufactured, installed, commissioned, operated, maintained, upgraded, and at some point, decommissioned. The figure shows the beginning of life, middle of life, and end of life; these are important phases and the assets life. During its life, many people interact with it each other I'm within this, we have filled service supporting the safe, reliable operation and maintenance of the asset. How can AI help, where can it help, in effect, "*what can it do for me*" over the lifecycle and whenever there are field service interactions with the equipment or the people? We see through service innovation that AI can support field services and bring them additional resources over this complicated life cycle. AI can even support the delivery of remote field services by supporting the operator or the maintainer and allowing them to provide field services that may have been done in the past by the supplier.

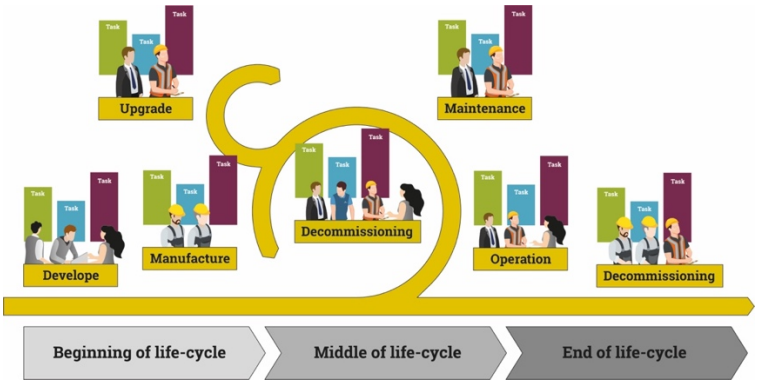

Figure 1 We have opportunities along the whole lifecycle to use AI to support field service

Field service an AI on one level seems scary, and instead, I think of AI as empowering field services to get more done and do better. The advanced analytics we have today can support field service technicians to make better decisions, allowing them to do more than possible in the past. Basic and advanced analytics help create new insights which can be fed back to improve the equipment's operation, the equipment's maintenance, and the equipment's design. AI can also empower the field service to do things better, routing visits or automatically creating reports based on dictation direct from the field service technician. This can empower the field service technician to do more, do it better, and remove jobs they're not good at doing or jobs they don't like doing.

Where do we have opportunities to use AI?

Drilling down a bit deeper, we can see a traditional environment with many actors within an operational environment (Figure 2). Each of the actors performs different jobs. Each actor has different roles and situations and, therefore, various problems. So the first thing we need to do is to map out the problem space to discover where AI could support field services and how AI could support field services. This is a change management activity where we need to engage with all of the actors here to understand better their problems, challenges, and the outcomes that are important to them. If we do this from the top down, it never works; we end up talking about how to get the users to comply with the new process rather than trying to understand the problems and how we can help the people to do their jobs better.

Figure 2 The business system today has many actors fulfilling different roles.

Using AI to improve '*customer support*'

AI can support customer support, although not directly deliver field services; there is a tight relationship between customer support and field service. Here we see a printer that needs toner to produce the prints; sometimes, the printer breaks the printer needs maintenance. The printer can talk to us, which is why we use the avatar map here. In many respects, the printer is as important as a person; when we can get the machine and the people to talk, we can improve things. In this example, toner reordering was automated using AI; this resulted in less help this stress, better customer experience, and lower inventories a fantastic win on something which seemed relatively trivial yet was very important because, without toner, you can't print.

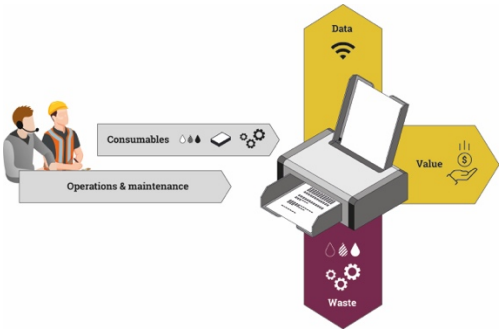

Figure 3 The aviator model of a printer showing the inputs and the outputs

Use AI to support the (field) service team

Field service and operational support are essential activities. Here we see a field service technician repairing a motor and checking the data above. The field service technician is the journey map of everything that needs to be done to get this job done; suddenly, we can see how AI can support us in getting our job done. AI can ensure that we have the replacement spares necessary to repair the equipment and allows us to schedule the inspection. AI may also help us work with problem-solving; it can help us with report capturing and assisting the technician in getting to the location on time to do the field service work. This all seems relatively trivial, but it is necessary to get the job done, and with AI, we can automate this to

help field service technicians do their job. There's nothing more frustrating for field service technicians than waiting for their spares to be heard while standing by their machine waiting to repair it.

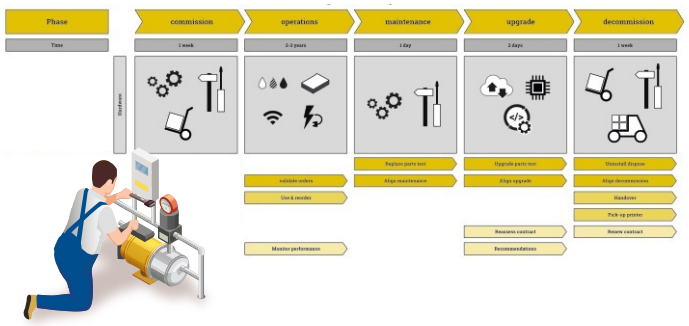

Figure 4 The journey map for a field service technician

So how do we use AI to support the field service team or the broader service team? We need to capture the data we need to shape the data into information and build knowledge - here, lessons from interactive design can help us better understand the processes. But before doing that, we need to know how data is used and how information is valued in the organizational context. From that, we may be able to build new knowledge and perhaps wisdom. AI can help us learn and improve, and AI is not about compliance but improved performance. Improved performance can be measured in many ways, from customer satisfaction to employee retention and reduced inventories. In more of these use cases, AI will help us to identify new insights and allow us to build new models of the world.

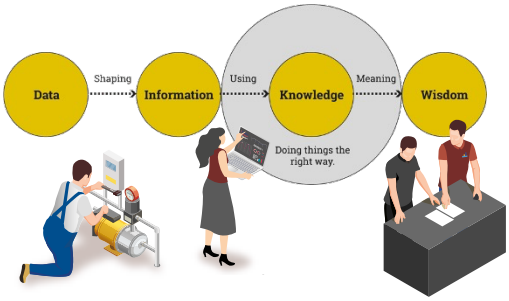

Figure 5 Firms needs to use data with context and insights to help them build new knowledge

Closing

In closing, we can see how AI can support field services to become more efficient and effective, helping us do our jobs better and in different ways. So, I'm left with two questions, one on the matter level and one on a practical level. We need to learn to answer both questions to enable field services to be far more effective and far more efficient through applying AI. The questions are:

- Meta level: How do we integrate AI into field services so that they enable 'us' to get the job done rather than control 'us'?
- Practical level: Is field service the '*last mile'* of many supply chains?

Jim Spohrer
Question: Thank-you Dr. West. How many different industries have you developed case studies for?

Shaun West
Answer: In the recent smart service system design guidebook, we highlight 5 different industries, but we have published elsewhere about 20 industry cases studies. We highlight organizational functions like supply chain and logistics, field service and maintenance, staff scheduling and other service-related topics across industries including shipping, railroad, tunneling, printing and copying technologies, finance, as well as others, and use a variety of methodologies and perspectives, including service-dominant logic. Our work on smart service system design highlights cases across organizational functions, industries, and methodologies. And we are also starting an executive program on the growing role of digital twins. As Dr. Ramani highlighted in his framework the part of the triangle called the "Physical-Reality Simulator" can be thought of as advancing along with digital twin technologies and methodologies in smart service system design.

Jim Spohrer
Question: Thank-you Dr. West. We have just 2 minutes before we all take a 15 minute break, so I would like to ask the three panelist for just 1-2 sentence quick response to one question. Dr. Maglio wanted to see what the commonalities were between systems across industries. Could each of you say just a little bit about the challenges of working across industries? Let's start with Dr. Lifshitz-Assaf, then Dr. Ramani, and then Dr. West.

Hila Lifshitz-Assaf
The biggest challenge of working across industries is the learning curve. Each new industry takes a least a year of learning new terminology and creating new relationships with industry professionals. The hope is that the technologies cut across industries to make it easier to identify common problems in the processes that the industry professionals are going through. For instance, around a specific AI issue for drug discovery, life sciences, material discovery and associated innovation processes.

Kartik Ramani
Humans and skills are pervasive across industries. Worker training and learning costs are substantial in money and time. If the US wants to be competitive on the global stage, we need to continue to increase productivity of our workers. For example, in aerospace, both big

companies and little companies need help to boost worker productivity through new technologies and new skills. Whether you're a welder, a plumber, a surgeon, or a field service maintenance worker as we just heard about from Dr. West, change is hard and sometimes scary. Instruction sounds simple, but it is not, and anything we can do to find the sweet spot to upskill workers faster and better to boost economic productivity will continue to be an investment priority.

Shaun West
Each industry has workers with tacit knowledge that is hard to write down tacit knowledge, so having some common language – in fiction the universal translator has been called the "bugle fish" that you put in your ear to understand what the hell their about. When you look at a problem from multiple disciplinary perspectives, and write a journal article that includes four ways of talking about the problem, it is hard to get it past the narrow filters of the reviewers. It's frustrating, and a big challenge working across disciplines, industries, and cultures to model complex service systems better.

Jim Spohrer
Let's thank our three panelist now and then take a short break and be back in 11 minutes for the start of the next panel.

Guru Madhavan

Thank-you Dr. Spohrer and AI topic panelists. The next mammoth topic is how to evolve engineering education based on what we heard about service systems and AI from the two distinguished panels earlier today. Dr. Bill Rouse is the moderator of the next panel.

Now we will take on how to evolve engineering education based on what we have heard this morning from two distinguished panels. And for this task we have one of the co-organizers of this forum. He is a research professor and senior fellow in the McCourt School of Public Policy at Georgetown University and formerly a professor and chair of the School of Industrial and Systems Engineering, a George Tech. Bill is a member of NAE.

Bill Rouse

Engineering Education as a Service System: I have been coming to terms with Engineering Education as a Service System: Let me tell you how I got to this topic. I have done a lot of work on complex organizational systems in terms of new product planning, technology strategy, and most recently healthcare. As a university faculty teaching engineering education, the obvious questions is why don't you apply your techniques to yourself? Engineering education is a service system that is and will continue to be digitally transformed by human-centered AI and other technologies. The pandemic as well as recent AI capability advances have certainly accelerated the digital transformation of higher education, including engineering education. However, I have been avoiding this until a few years ago. In 2016, I came out with a book about universities as complex enterprises. I partnered with John Lombardi, who has been president, chancellor, or provost at 5 universities and he's a historian who could bring a totally different perspective from my own. Well, today I am going to talk about engineering education as a service system, and then make some projections – you may find this very ambitious, but I think it is pretty intriguing as well. Let's begin.

Pervasively Computational: Engineering education is becoming increasingly computational for physical phenomena. I project in the future it will be pervasively computational across physical, economic, behavioral, social phenomena.

Core Competence - Modeling Tools: The core competence of engineering students is becoming increasingly tied to their skills using commercial modeling tools. I project in the future advanced modeling tools, like we heard about in Dr. Ramani's presentation, will be standard across universities and industries.

Digital Engineering Environments: Data, models, artefacts, designs are increasingly digitally represented. I project in the future the principles and methods for composing

multiple digital representations will be standardized. How do you take two different models (perhaps from two disciplinary perspectives of the same system) and plug them together meaningfully?

So that is a summary of the future of engineering education, but now let's look at educational service systems at the university level in general, including viewing them as economic enterprises with standardized work process, and understand the status quo and projections.

Mixed Mode: Within any individual course today, it is either largely in-person or online. I project in the future all courses across the full university curriculum will be mixed mode, available both in-person and online.

Knowledge Management: Today, knowledge is captured and managed at the level of individual courses with individual experts in charge. I project in the future that knowledge management will be at the whole curriculum level – across all disciplines and the whole university with collaborative teams of experts in charge.

Faculty Role: Today, it is largely sage on the stage. I project in the future the role of faculty will be as mentors ("guide at the side"). Every student should benefit from the best lecturers, Richard Feynman for physics, and Paul Samuelson for economics. However, fields advance, and the new edge topics need an active mentor. Every student should have a faculty mentor to help them on their learning and career journey.

So that is a summary of the education as a service system, but now let's look at AI role in this education service system.

Digital Twin: Today there is little personalization because the models of individual students are impoverished. I project in the future that all students will have AI-enabled digital twins of themselves that support their lifelong learning goals. The digital twin will have a digital representation of what you learned in elementary school, high school, in college and/or on-the-job.

Support Systems: Today faculty and TAs often cannot know individual students well enough to provide a support system for the students. I project in the future that all students will have AI-enabled support systems.

Tailored Pathways: Today university education cannot be tailored to individual students interests and capabilities very well, in general. I project in the future that all students will have AI-enabled tailored pathways to follow and develop their interests across the whole university curriculum regardless of disciplinary boundaries more readily.

So that is the summary of the role of AI in the education service system of tomorrow, enabling the whole curriculum as well as all the faculty and students to truly become a learning system. However, to make this future happen will require better models provide support in three key areas.

Models: Models to support models means we need to be able to develop principles that enable composing multiple models. Composing economic, behavioral, social and physical models together. We will need to understand in the work processes associated with modeling because we're going to try to support that work using ai type technology.

Pedagogy: Models to support pedagogy means we are going to need models to support pedagogy principles and practices of mixed mode pedagogy and understanding how to put things together in different ways. Your digital twin is helping you. Your faculty advisor is helping you. Other people are helping you, and the tools to relate measured individual outcomes to change the pedagogy. So this sounds kind of ironic, but basically we are going to convert the whole educational structure into a learning system that continues to learn and to improve itself over time with a better model of itself.

Lifelong Learning: Models to support lifelong learning means learning about students, learning about outcomes, learning about what works and what doesn't work and what types of students it works for it, learning about students and workers, because the students are going to become workers at some point. This support is going to continue out their whole lifetime. We are going to have digital twins of individuals both as students and subsequently as workers. This will require developing principles and practices for knowledge management across disciplines in time, the whole curriculum. So I'm really thinking of a pervasive redesign of higher education. All of this is of course still a work in progress.

So those are my wild predictions. Next up is our panelists…. We will hear from Mr. Wladawsky-Berger who helped IBM launch its service science initiative along with Dr. Maglio and Dr. Spohrer two decades ago, and then Dr. Madni who has been pioneering a transdisciplinary approach to systems engineering, and the final panelist of this session is Dr. Medina-Borja of NSF who established the smart service systems program and more recently programs related to the challenge of human-AI collaboration. Mr. Wladawsky-Berger it is your turn now.

First Irving Wladawsky-Berger is going to give us his perspective on the service systems initiative, where he has been intimately involved as an IBM executive and with his ongoing efforts.

Azad Madni and I were graduate students together 50 years ago when I was at MIT and he was at UCLA. We went to the same conferences when we were students and have continued to interact ever since.

Alexandra Medina-Borja will the talk about her leadership activities in service science at the National Science Foundation and her background that led her to these endeavors.

Irving Wladawsky-Berger

Thank-you Dr. Rouse. Service Science Management and Engineering, or SSME, as we call it at IBM in the early 2000, has been an initiative to establish an interdisciplinary academic discipline to apply science, technology and innovation to the service sector.

On October 17, the National Academy of Engineering (NAE) conducted an online forum on Service Systems Engineering in the Era of Human-Centered AI. "With AI advances poised to drive service system productivity and quality - similar to the way previous generations of technology revolutionized agriculture and manufacturing productivity and quality - it is time to take stock for industry-academic-and-government stakeholders on this important topic," wrote the NAE in its website.

The agenda included an opening keynote by retired IBM executive Nick Donofrio. It was followed by four panels on various aspects of service systems, and concluded with an open discussion of the way forward. I was a member of the panel on Evolving Engineering Education. In my prepared remarks, I reflected on the current state of service science and related sociotechnical systems. Let me share my remarks, slightly edited for clarity.

Service Science, Management and Engineering (SSME) is an initiative launched in IBM's Almaden Research Lab in the early 2000s in partnership with a number of universities as an interdisciplinary field of study aimed at applying science, technology and innovation to the service sector of the economy. The service sector is the largest in most economies around the world. At the time, services already accounted for over 70% of GDP and jobs in advanced economies, as well as an increasing portion of the revenues of many companies, including close to 60% of IBM's revenues.

Over the next decade, I worked closely with service science leaders, both in IBM and in the wider research community to help define this emerging discipline. I tried to explain what service science was about in seminars to academic and business audiences, and I've written a number of entries on the topic in my blog.

My remarks at the NAE Forum were focused on a few key questions: Why is service science such a nebulous, hard to describe topic?; what progress have we made in the twenty years since service science was first launched?; and, what are some of the major future challenges?

Despite being such a large portion of GDP and jobs around the world, the intrinsic nature of services remains vague, - hidden from view in plain sight as if they were a kind of dark matter. It's easier to define the services sector by what it doesn't include: it's not agriculture or fishing, and it's not manufacturing, construction or mining. Just about every other job is in services.

What is a service? "A service is anything sold in trade that cannot be dropped on your foot," is one of the most succinct definitions I've seen, attributed to The Economist. I particularly like the practical definition of services by INSEAD professor James Teboul in his 2006 book Service is Front Stage: We're All in Services … More or Less:

Every organization consists of front stage and back stage activities. Services deal with the front stage interactions while manufacturing and production deal with back stage operations. High quality and competitive costs are the key objectives of back stage activities, achieved through specialization, standardization and automation. People are prominent in front stage activities. Achieving a superior customer experience is one of the top objectives of such people-oriented activities, often as a collaboration between the providers and consumers of services.

I often explained what services are about by contrasting the key difference between innovation in the industrial economy of the 19th and 20th centuries and innovation in the emerging 21st century service economy.

R&D in the industrial economy was mostly focused on natural and engineered physical objects. Thanks to major advances in science and engineering over the past two centuries, we can now build highly complex physical objects like airplanes, bridges and microprocessors. While continuing to advance such work, our next challenge is to now apply R&D to market-facing, human-based organizational systems, such as companies, industries, economies, governments, and cities.

Complex physical objects consist of huge numbers of physical component that behave as designed unless something is wrong. That makes it possible to predict the overall behavior of the complex object under widely varying conditions. On the other hand, people, their assorted interactions, and the services they perform for each other are the key components of complex organizational systems. People and services exhibit a high degree of variance that makes such systems intrinsically unpredictable, and thus require new approaches to their design and operation.

Furthermore, the bulk of the R&D in the industrial sector of the economy takes place in labs and factories, and there is a significant time lag between the development of new technologies and products and their subsequent deployment in the marketplace.

Not so with services. The bulk of the innovation in services takes place in the marketplace, in a time and place much closer to where the services are deployed. It's hard to envision an environment where new ideas for services are developed far from the actual marketplace and the individuals and organizations who consume them.

Sometime in 2016 I had an interesting conversation with analysts from an IT research organization who were preparing a report on the state of service science. They noted that we were hearing quite a bit less about service science in those days compared to 5 or 10 years earlier. Was it because we had become tired of the subject and moved on to other areas of innovation?

I told them that, in my opinion, the applications of science and engineering to services were so well accepted by now that they were no longer a topic of debate. The battle had been won. The technologies, methods and concepts once pioneered in service science were now part of a number of mainstream academic disciplines. Services were now front and center in some of the most prominent areas in computer science and IT, including AI, cloud computing, and design thinking.

For example, in their recent book Service in the AI Era, Jim Spohrer, Paul Maglio, Stephen Vargo, and Marcus Warg wrote that "Service is quickly becoming the central concept of our time, as service offerings become infused with advanced technologies like artificial intelligence (AI) and scale to new levels of quality, productivity, compliance, and sustainable innovation.

Throughout history, scientific revolutions have been launched when new tools make possible new measurements and observations, e.g., the telescope, the microscope, spectrometers, DNA sequencers. Our new big data tools have now been ushering an information-based scientific revolution, helping us extract insights from the huge amounts of data we've been collecting by applying tried-and-true scientific methods, that is, empirical and measurable evidence subject to testable explanations and predictions.

We've long been applying scientific methods in the natural sciences and engineering. But given our newfound ability to gather valuable data on almost any area of interest, we can now bring out tried-and-true scientific methods to people-centric disciplines, like the social sciences and the humanities. We can now better understand and make predictions in complex, service-oriented systems like healthcare, business organizations, government agencies and cities.

Cloud computing is another prominent example. I think of cloud computing as being essentially the Internet of Services. Data centers have now become the production plants of cloud-based services, requiring major advances in productivity and quality to be able to support the explosive demand for mass customized information and services

of all kinds. Software and applications are increasingly delivered as industrial-scale online services, while the internet and wireless networks connect more and more devices to such offerings.

Finally, given that services are all about people-oriented interactions, service technologies play a major role in design thinking. It's much easier to appreciate the role of design when it comes to physical objects: cars, bridges, buildings, dresses, shoes, jewelry, smartphones, laptops, and so on. But, it's considerably harder to appreciate its importance when it comes to more abstract entities like services, systems, information and organizations. Yet, such service-based systems account for the bulk of the growing complexity in our daily lives. Design thinking aims to make our interactions with complex products and institutions as intuitive and appealing as possible.

Let's conclude by remembering that we've been applying science, technology, and innovation to the agriculture and industrial sectors of the economy for over two hundred years, - ever since the advent of the Industrial Revolution, - while service science is just a couple of decades old. We still have much to learn on how to best apply science, technology, and innovation to our fast growing service-oriented economy.

Bill Rouse

Thank-you Dr. Wladawsky-Berger. We will have time for questions time at the end of this panel. Now, Dr. Madni it is your turn.

Azad Madni

Thank-you Dr. Rouse. Taking off from your opening statement, I will talk about engineering education from a service systems perspective. I am a professor of the last 14 years at the University of Southern California, and earlier this year I was appointed University professor of astronautical, aerospace and mechanical engineering. I am also the founder and CEO of Intelligent Systems Technology.

Prior to that I went to a startup, rose to the position of EVP for R&D and CTO of the company,and was part of the executive team that was successful in taking the company public. Prior to that, I was a GN&C engineer at Rockwell International on NASA's Space Shuttle Program. ,. My work experience is both in i industry and academia. I was asked to be a panelist today, in part because of the relevance of my book "Transdisciplinary Systems Engineering," in which I focus on the subject of exploiting convergence among disciplines and convergence of engineering and technology in a hyperconnected world. Norman Augustine, former Chairman and CEO of Lockheed Martin wrote the foreword to this book.

The key point of my book “Transdisciplinary Systems Engineering” is that engineering, when combined with some other discipline (x) or some technology (x) can make that more efficient. Similarly, technology or discipline (x) can make engineering more powerful. An example would be leveraging the concept of financial options from economics into engineering in the form of real options. Disciplines can combine with engineering to create new disciplines that did not exist before, solving problems that previously appeared intractable. That is the backdrop for thinking about AI in the context of service systems – making a service more efficient or improving it in some way with AI. Combining technologies like AI with social networks can lead to the creation of a new service. In other words, the combination of technologies can potentially create a solution to a previous service problem that heretofore had not been satisfactory.

Now let’s consider pursuing a solution within a discipline and thinking about it more broadly. If you look at a traffic problem and address it with traditional optimization, you may see an improvement on the order of 5%. However, if you treat this as a transdisciplinary problem, looking beyond the world of optimization, and into the world of technology – harnessing the control of the traffic lights with AI and connected through wireless 5G, you may see a greater improvement perhaps 30% to 40%.

Some people are working on trying to put interfaces on neural networks in the area of explainable AI – explanation generation. In deep neural networks, which are multi-layered neural networks, there is the need to explain the output and make it more transparent. Others believe that because deep neural networks do not have a semantic structure, or the important property called composability that an explanation is not possible. Some claim they have solved the problem of explainable AI. This is one example of questions related to AI technology and engineering improved service that needs further investigation.

In my book, I defineTransdisciplinary systems engineering as a meta-discipline that calls for a new mindset to exploit the convergence of engineering with other disciplines to address problems that appear intractable when viewed solely through an engineering lens. In my research, I have combined concepts such as reinforcement learning from artificial intelligence and machine learning with systems modeling – essentially taking an open-loop system modeling technology and making it closed-loop through reinforcement learning. Also, leveraging the concepts of preference, utility, and value from decision analysis to personalize products and services, along with leveraging concepts of crowdsourcing through social networks to enhance traditional approaches to collaboration by enabling expertise on demand – this capability is especially useful for startups. Another example is leveraging the concept of storytelling and animation from entertainment and cinematic arts in collaborative systems engineering thereby increasing the participation and contributions of people who are not technical and not familiar with system modeling languages such as SysML.

Transdisciplinary Systems Engineering Education (TRASEE™) is the educational paradigm underlying USC's Systems Architecting and Engineering (SAE) Program. It is based on my book and addresses the needs of 21st century systems engineering workforce and the proclivities of 21st century learners. Its transdisciplinary pillars are: 21st Century Mindset, System Modeling with Partial Initial Information, Storytelling as a Pedagogical Strategy, Hands-On Learning with Digital Twins, Diversity in Project-based Learning, and Dynamic and Actionable Assessment. This approach to engineering education is specifically designed to break down siloed thinking and foster leadership skills and creation of connected knowledge instead of islands of knowledge you get with siloed courses. The key idea here is to have enough contact with the synergistic disciplines to prevent the formation of disconnected islands of knowledge. Students learn to exploit the synergy of engineering with other disciplines to address complex problems, particularly in problem framing and formulation. In this way, methods and concepts from other disciplines can be used to complement and enhance systems engineering approaches.

Coming back to AI, I don't believe AI can replace humans yet for rapid decision-making in a novel situation. Today's AI systems operate well in normal scenarios without outliers. However, in the real world you are going to constantly run into outliers. So, you need human involvement because AI systems have difficulty adapting to changing context and uncertain environments. Also, AI systems are neither ethics- aware nor do they address legal considerations and trust satisfactorily. It is fair to state that human imagination and creativity are beyond what AI and machine learning are capable of today. This is why I'm in favor of augmented intelligence as a promising paradigm to address these problems. To engineer systems, we have to look at the strengths and weakness of AI capabilities and the strengths and weaknesses of human capabilities. Machines can do very rapid computations for search and pattern matching, and humans are extremely strong at contextualization and common-sense reasoning. Dealing with outliers and ambiguity is the hallmark of leadership in business and on the battlefield. Machines have limitations and difficulty with outliers, contextualization, and out-of-the-box type of reasoning capabilities. Humans have weaknesses too. Humans get distracted, experience loss of vigilance, fatigue, have fallible recall, limited memory capacity, and limited computating power.

Augmented intelligence is about capturing the best of both worlds. My 2020 paper in INCOSE Insight calls for exploiting augmented intelligence for systems engineering and engineering systems, including service systems. The key diagram in that paper shows six regimes:. both the human and machines are poor at and should be avoided.. . areas where both humans and machine are good at; machines are better than humans; humans are better than machines, humans excel at, and machines excel at.. Therefore, engineers should take these considerations into account when determining how work gets assigned to humans, to machines, and to both working together. Remember, some regimes are well-suited for machines, some for humans, some for both together.

Where human availability and fatigue figure into the equation, that is the area where augmented intelligence can thrive and excel, and I think this is the area for AI to improve service systems. For example, many years ago I worked on shared perception. Consider the situation where an enemy tank is hiding behind a hilly region, and the friendly tank is trying to locate it. In this case, the machine is great at pattern matching while the human is better at contextualization. . So, the combination of human and machine working together is clearly superiotr to the AI-enabled machine. Specifically, the human can guide the machine where to look for the hidden target, while the machine can figure out what the target is even if the target is partially obscured from view. is way better than the human could do alone. Situations like this can arise in a variety of contexts where e the combination of the human and machine working together will outperform either working alone.

Coming back to the subject of engineering education as a service system and human-centered AI… an important goal is to accelerate learning in humans to make service systems more productive and profitable. This is where AI can be harnessed to close the skills and hiring gap as mentioned previously by Dr. Ramani. However, it is not just AI, but other complementary technologies like social networks, extended reality, and digital twins that can be exploited in service systems.. Another relevant concept for service systems is the “zero latency enterprise.” Gartner defines “Zero Latency Enterprise” as a strategy that exploits the immediate exchange of information across technical and organizational boundaries to achieve business outcomes and benefits. In the educational context, this implies a rapid cost-effective reconfiguration of resources to help students accelerate learning. Context-awareness, flexibility, and spontaneous collaboration are all enabled by AI in the educational service domain. If your context aware, then you can have pre-positioning of information and physical assets through intelligent information and physical logistics. Flexibility allows the students to follow either a formal work, plan associated with the degree, or a flexible non-degree for workman to suit their job needs. Collaboration as opposed to merely interaction for the instructor, the teaching assistant, and the student to co-create value. Contextualization to achieve economic and social benefits for all the participants in this team.

So now let's consider some specifics of a student-centered engineering education service. We could have something like a pedagogical digital twin, which could be an intelligent version of the electronic training jacket that the US Navy has used for a good couple of decades. Instead of just maintaining student history, this particular intelligent twin would also recommend courses to take, based on prerequisite constraints and course availability, so it would have a preductive component to it, and not just a descriptive component in terms of serving as an online resume. The notion of intelligent information logistics is the ability to pre-fetch education materials before the learning begins. The next concept to integrate is dynamic context management because that's the basis for context-specific value creation, which is what a service organization does.

The next concept to integrate is dynamic education service reconfiguration, in which you decide about classroom or online based on student mix. The next capability enabled by AI is dynamic scheduling of resources. For example, the service based on predicted demand so you don't have servers with idle time and unused resources. . The next is prefilling or partially filling student work plan based on students' profiles and histories. The next is automating repetitive workflows based on the work plan. And finally to provide a context-aware dashboard for monitoring the status of student service parameters, both for the students and instructor in terms of the course status, the homework status etc..

Some of the key implementation technologies include a collaboration platform with cloud storage, shared repositories, context-aware dashboards and links to social networks, to work on collaborative projects. Thank-you for the opportunity to present on the panel today. Back to you Dr. Rouse.

Bill Rouse

Thank-you Dr. Madni. Now, Dr. Medina-Borja will present, and we will have questions at the end.

Alexandra Medina-Borja

Thank-you Dr. Rouse. I am an industrial and system engineer with a focus on human-centered service systems research. At NSF as a program director in engineering for some time, then a stint in the office of integrated activities, now in the division of undergraduate education in the engineering cluster, I have worn many hats, but the one that is most related to this conversation today is that I am co-chair of the future of work at the human technology frontier program.

The big question for me is how can we prepare engineers for the future of work and what research do we need to fund? Around 2017, my focus was to create a vision for the future of education. In 2020, the pandemic hit, and we released the report on the Future of Education and then funded the National Academies to start a national conversation on the topic, with a focus on undergraduate STEM (Science, Technology, Engineering, and Mathematics) education. The conclusion of the report was many pages, so I will just focus on the things relevant to this conversation. The report says that in the future there would be a demand for humans to do work that machines cannot do. So it is basically as the previous speaker Dr. Madni mentioned understanding what machines cannot do as well as humans can, such as think critically, to have creativity, to reason probabilistically, to exercise logical discernment, judgment, and the education system needs to harness cognitive and emotional mechanisms of these students to instill self-motivation and actualization for lifelong learning.

In addition because technologies are changing constantly, the education system can play a role in ensuring workers know how to use modern technologies. For engineers who innovate new technologies, the most important thing is to really consider the effects of whatever we design on society – the societal effects. Therefore, when talk about the engineering curriculum, we have to make space for other disciplines. We need to have the conversation about what is the foundational knowledge that all students need.

All engineers need to have an understanding of the foundations of their discipline, but it's probably not exactly what we were taught as engineers. It is a difficult conversation, because traditionally we think that we should have 4 calculus, 3 physics, differential equations, and so forth to be a good engineer. Traditional thinking says we cannot accommodate all this material in a four or even five year undergraduate engineering curriculum. So we need the exercise of crafting and design education curriculum in a different way. We have all heard very interesting ideas today from previous speakers. Shifting the emphasis from memorization to understanding concepts in context, and using available computational power to accomplish tasks.

Understanding what we are doing in context is key – advancing knowledge and technologies have consequences, and so contextual thinking is required. For graduate education that means instead of being absolutely narrow in just one silo, that creatively thinking about how an advance in knowledge might change the whole system is needed – both benefits and harms. With contextual thinking, graduate students can start solving really meaningful and complex problems. Knowing context requires knowledge of other disciplines and modern technologies, as we already said, and working across disciplinary boundaries and to collaborate with diverse, global teams. What does contextual thinking mean for the design of service systems, and what we need to instill in undergraduate and graduate students? Computational thinking, probabilistic thinking, and knowledge of modern technologies, certainly those 3 things, but what else?

To exercise local, discerning judgment, be creative, and understand modern complex service systems and their complex dynamics requires making connections across disciplines – interdisciplinary knowledge. To apply knowledge so that service systems impact and help solve real world problems requires including the social and behavioral sciences. However, two often a quote, unquote "interdisciplinary" proposal sent to the NSF for funding includes an electrical engineer with a mechanical engineer. Yes, those are different disciplines, but we are really talking about the issue of impact of this design and the impact of the solution, and for that you need to understand the human. You need to understand organizational entities. You need to understand the impact on sustainability and many other things. For assessing that kind of impact you need to expand to other disciplines and bring in that knowledge. Besides academic discipline diversity, there is also cultural diversity – African America and Hispanic students are under-represented in most STEM professions. So how does the proposal for funding make that kind of impact? So across industries where work happens, across disciplines,

across cultures, and across modern technologies – we are looking to fund impactful research on the future of work and the future of education. We are also talking about teaching your students to work on impactful problems with others at a global scale.

Three lessons we have learned form studying successful future learning environments is that they are student-centered, project-based, and personalized. For the purpose of improving equity and inclusion, we have to get in the habit of asking every time we give an assignment – who are we excluding? Who are we leaving out? Perhaps someone with math phobia. What innovations and innovators are we excluding when we arrange the education system the way we do? Do we really have to scare students with calculus in the first year? Too often the quality of education in the US depends on your zip code, and how much money your parents are making. So how do we fix the education system? And then there was the pandemics impact on the education system.

The NSF program on the future of work at the human-technology frontier is accepting preproposal that have a clear focus on the future worker, the future technology, and the future work – the human, the technology, and the organizational aspects of the research must be clear. Work happens in integrated systems, service systems.

In closing, a few final reflections on the engineering curriculum. We need to think about which parts of the curriculum, what parts of systems engineering, what parts of the learning environments, etc. help students work on the most important real-world problems. Can we create a record of the emerging cross-disciplinary concepts? Are there successful examples of self-directed curriculums, personalized curriculums or plans of study? And how do we handle differences in foundational knowledge so we can be really inclusive?

Bill Rouse

I would like to thank all three panelists for great presentations that were very stimulating, but I think we are going to have to wait until later for questions, because we are behind schedule. Dr. Madhavan, do you want to take over?

Panel 4: Socially Conscious Service Systems Design
Moderator: Carlotta Arthur
Panelists: Cora Marrett, Clarence Wardell III, Ben Shneiderman

Guru Madhavan
Thank-you Dr. Rouse and thanks to all the panelists. Let's move to the next panel and use the reflections and open discussion period to entertain questions and comments. Our next big topic will be moderated by Dr. Carlotta Arthur one of my newest distinguished colleagues at the National Academy. Dr. Arthur is the executive director of the academy's division on behaviorial and social sciences, and education. Her panel will address the big topic of socially conscious service systems design. Dr. Arthur welcome and thank-you for leading this next panel.

Carlotta Arthur
Thank-you Dr. Madhavan, I appreciate the invitation. It is a pleasure to be here today and to have this opportunity to discuss our topic: Socially Conscious Service System Design. I will share an overview of the conversation that we are planning on having today with our three panelists. We are joined today by Cora Merritt of the University of Wisconsin, Clarence Wardell III of the White House Domestic Policy Council, and Ben Schneiderman, of the University of Maryland. We will circle back and give everyone the opportunity to introduce themselves, tell us more about themselves, their work, and also their connection to, and perspectives on, today's topic. My role at the National Academies is leading work in the behavioral and social sciences, and on their application to policy and practice. We aim to center people, and diversity, equity, inclusion is core to much of our work. DBASSE (Division of Behavioral and Social Sciences and Education) is home to 9 units, including the Board on Human Systems Integration which works quite often not only with the National Academy of Engineering, but also with the division of engineering and physical sciences at the Academies. We are home to the Board on Science Education which fairly recently produced the Science and Engineering in Preschool through Elementary Grades report. We are also home to the Board on Behavioral, Cognitive, and Sensory Sciences which, among other reports, produced an important report on how people learn. This was a follow-up to an earlier study that's important in thinking about education, learning, and also about cultural contexts of education and learning.

<u>Ecological Systems Model:</u> I want to mention that it's very tempting to talk about people as individuals who exist in isolation, but it's important to remember that people are embedded in and navigate complex systems. So, this [PowerPoint image of Bronfenbrenner Ecological Theory model] is just one example of what's known as an ecological systems model. This model is actually more than 40 years old, and it centers the individual within multiple systems. For example, those systems consist of families, peers, schools, workplaces, religious organizations, and those systems interact with other systems. For example, they interact with industry, social services, national neighbors, mass media, politics, and all of those exist within the attitudes and

ideologies of the culture. When you add the dimension of time, the complexities of thinking about how people interact with systems and change over time is more readily apparent.

Socially conscious service systems design topics: I wanted to share that model as sort of a grounding for the conversation that we are going to have on the concept of socially conscious service systems design. The next topic of our conversation will be definitions to try to get a better sense of what is meant by socially conscious service systems design. Then we will talk about the benefits and pitfalls or challenges to socially conscious service systems design. If we have time, we will talk a bit about best practices, and then hopefully, we will have a time for a conversation around what is next for socially conscious service systems design. Going back now to introductions, it would be great if each panelist could please introduce themself and just tell us something about your connection to this work. I am going to start with Dr. Marrett, then Dr. Wardell, and Dr. Shneiderman.

Cora Marrett
Hello, I'm Cora Marrett and I am retired from the Department of Sociology at University of Wisconsin. But I should also note that I served for a number of years on the Advisory Committee for the Division of Behavioral and Social Sciences and Education. I did so part of that time with Dr. Rouse which helps explain why I am here today. I am pleased to be here.

Clarence Wardell III
Thank-you Dr. Arthur, and thanks everyone for having me. I am Clarence Wardell in a couple of roles with the White House, two of which are fairly relevant to today's conversation. I am senior advisor for policy implementation and delivery, as a member of the domestic policy council work team, across a range of issues, including the President's mandate to advance equity and equitable outcomes for underserved communities and individuals. I have also collaborated closely with colleagues from the office of science and technology policy, around work related to AI and equity. Some of you may have seen the report released about two weeks ago of a blueprint for AI development that lays out some principles and provides a framework for the use and deployment of automated technologies and tools. So happy to have a conversation on that topic as well. Another possibly relevant role, I have dual hats on the American rescue plan implementation team as our chief data and equity officer. I think about service delivery from a government perspective – and how to advance equity and equitable outcomes. Thank-you for having me here today.

Ben Shneiderman
Thank-you Dr. Arthur, I am pleased to join this panel. Thank-you Dr. Madhavan and Dr. Rouse for organizing this event and inviting me. I am a professor from the University of Maryland in the Department of Computer Science with a long history of work on human-computer interaction (HCI) and human-centered artificial intelligence (HAI). So that focus clearly brings me to the point about the design aspects of socially conscious service systems design. I am

pleased that this panel session is socially conscious service systems design, which allows thinking about the diversity of users who are out there, who may be disabled, and with diverse literacies and diverse cultural backgrounds. So those are places we are going to need to investigate where HCI brings its value in understanding user experience, user interface design, and user experience design. Thank-you.

Carlotta Arthur

Question - Definition: Thank you Dr. Shneiderman. In fact, you began to touch on our first question for the panel, which is "what is socially conscious service systems design?" Is there a single definition? It would be great if each of the panelists could share their perspective on what it means to have "socially conscious service systems design." In our preliminary conversations preparing for this panel, we realized that there wasn't a single definition. So, it'll be great to have some conversation around the varying perspectives on what socially conscious service systems design is. As a starting point, Dr. Shneiderman, perhaps you can elaborate on what you just said.

Ben Shneiderman:

Defining Socially Conscious Service Systems Design: Thank-you Dr. Arthur. I appreciate that there is no one definition. We are exploring an emerging topic, and I am really happy the word design gets included. We have heard a lot about systems, and specifically the need for service systems science and safety (Dr. Maglio's panel), service systems technologies - artificial intelligence, extended reality, digital twins (Dr. Spohrer's panel) and service systems engineering education (Dr. Rouse's panel). I want to raise the profile of service systems design (this panel, Dr. Arthur's panel). In fact, we have a National Academy of Science and a National Academy of Engineering. It's time to begin to think about the 50 year process required to create a National Academy of Design. Our complex social world is shaped and designed by people's behaviors interacting and changing over time. Design considers the diversity of users (including customers and other stakeholders participating in and impacted by service systems). So "socially conscious" means that we think about the differences of people, different kinds of people, different kinds of users, different kinds of customers, different kinds of stakeholders. "Socially conscious" also includes the environment for people. We are dealing with climate change issues, inequality and economic issues, and the struggles with misinformation and disinformation. So there are a lot of broader challenges. Thinking about service systems science and engineering is important. However, thinking about "socially conscious service systems design" brings us straight up to the challenges, the threats, the things that can go wrong. Therefore, we have to be especially proactive in understanding how we can build those better systems. We have models of success stories. We know that it can be done, but we also have many places where we see the challenges. So the definition of socially conscious design is, I would say, making the world a better place. That's a general definition, but it's about making the world a better place by amplifying, augmenting, empowering, and enhancing human abilities. It's also about introducing the kind of check points that will deal with the problems

that arise. It's about making sure that we limit the frequency that those problems reoccur. That's really our challenge. Also, it's the challenge of dealing with malicious actors, with AI bias and with the threats that come from technology that is excessively automated. So just one more closing comment. You know, I believe in people. I believe in the expertise of people, and I think we want to provide automated systems to support human capabilities rather than autonomous systems that replace or take away socially-conscious control from people. Thank you.

Carlotta Arthur
Thank you, Dr. Shneiderman. Dr. Wardell, I'll go to you next, please.

Clarence Wardell
Defining Socially Conscious Service Systems Design: Sure. I am excited to be on this panel and appreciate Ben's comments. I agree the design piece is important. The modifier often heard is "human centered design" and here today we are working on a definition of "socially conscious service system design." On the one hand, if you are doing quality human centered design, then you should be doing all the things that are implied by the socially conscious piece. However, I do think it's important that "socially conscious" is included as a a reminder of the types of people, experiences and communities that we should be centering on in this work. For example, in the work that we do in the administration, thinking about equity, how do you operationalize equity within the context of design, deployment and delivery? Do you consider designing a new program or redesigning an existing program. Do we need more or different modifiers, like "equity" and "human centered" and "socially conscious?" I know we often need these reminders, and we need a certain ser of design principles. these reminders, and that there are a certain set of principles that are implied by that "socially conscious" modified. A set of principles for "socially conscious service system design" should account for what people, what communities are at the table. As we are thinking about design, whose experiences are we representing? Have we developed the full set of personas that we would design a system around or towards? It is highly important to think about here today. I would just add that one more piece about design – beyond the idea of a set of design principles that addresses including the specific people and communities at the table. We should not think about design as a "one time, upfront process." One of the things that we've learned, particularly in the context of delivering the American rescue plan, our world is a very complex, constantly changing environment, and so requires iterative discovery and feedback. Understanding how to extract experiences and put the needed redesigns back into the system is an important piece here as well. So, I echo what what's been said so far. We need to make sure that we're not leaving anybody out of the picture here. We need to think about the service systems and the types of resources and outcomes that we are trying to design, deploy, and deliver through these systems.

Carlotta Arthur

Thank you, Dr. Wardell. And now Dr. Marrett.

Cora Marrett

Defining Socially Conscious Service Systems Design: There is very little that I can add to what's been said already, except I would draw on what Dr. Spohrer has reminded us of. He's indicated that if we take the term service it has several meanings. One of the meanings is, of course, the service sector that has to do with the non-manufacturing part of the economy. However, I am going to read the quote from him on what else service can mean, and he says that it covers "intangibles of selfless acts of loyalty, courage or ethical convictions about what is right and good in human society," and I think that comes closer to what we are talking about. Now, when we talk about socially conscious service design, it's true seeking to have designs that are concerned by with broad-based social cultural and related effects. those effects. That is, Dr. Arthur, you had indicated are very broad across the society and so they're not just the individual kinds of outcomes, or they're not just customer centered, but they're much broader than that. And they're designed to have these larger kinds of societal benefits. I believe this simply repeats what all 3 of you have said already.

Ben Shneiderman

Human values: Can I jump in here and invite Dr. Wardell to tell us a little more about the AI Bill of Rights? Because when we talk about socially conscious design, we are talking about the high-level issues of human values, of human rights, of social justice, of individual dignity. These involve individual goals as well as community goals. These individual goals include self-efficacy, creativity, responsibility, social connectedness; all are central to design. And then the community goals of building reliable, safe, and trustworthy systems throughout organizations and throughout large industries. The AI Bill of Rights that was recently put out takes a big step forward by enumerating these issues and setting us at the start of the path of how we implement them. That's the challenge, I think. All of us in this group understand and are aware that the ethical principles and the philosophical points we're making are valid concerns. They're important, but now it's time to turn to the practical aspects of implementing the aspects of governance. Maybe Dr. Wardell could tell us about how the AI Bill of Rights has been working as an initiator and as a trigger for those practical implementations by government agencies as well as large corporations?

Clarence Wardell III

AI Bill of Rights: Thank-you Dr. Shneiderman. I happy to do so. The administration just released the AI Bill of Rights about 2 weeks ago. So it is newly released out into the world. We are at the front end of what it will ultimately become. The Federal government has a huge role to play in some cases, not just in terms of potential laws, but in terms of a unifying framework to reduce disparity across agencies. Some are way out in front and have their own principles. Some are starting to operationalize the use of automated technologies and implement some

guard rails, while others weren't quite as far along. So what we wanted to do, at the very least, was create a ground floor across the Federal government that is in some ways still aspirational. Where we set the bar in the Federal government is important. Then understanding where we are and are not meeting the bar today is important. We realize that all the tools should be on the table for regulatory guidance, but also procurement power and grant making and especially areas where the Federal government can set guidelines. The AI Bill of Rights is not only for the Federal government, but is also a call to action, to private sector companies and civil society as well to be partners in this work. There is not one actor in the system that will alone change outcomes. Different folks along the way design and then redesign. You will see that today it isn't principally a design document. We are asking how do you build the needed relationships? And how do you include others in the dialogue early in the process? And where should the bar be set? What should the threshold be? Both now and over time? How are these automated tools are deployed today and how should be deployed in the future as AI capabilities advance.

Carlotta Arthur

Exploring the Divisions in Society: To your point Dr. Wardell about starting to generate some real actions from the document, from the work, and from design examples you see, I am very curious to learn from all three of you more about the implications, differences, and divisions in society.

Cora Marrett

We can talk abstractly about community interest, but Dr. Wardell had just mentioned the agencies differed, and whether you can bring them all together or not. The differences represent a challenge because they're not just different because of past experiences, they differ philosophically as well. There are other kinds of experiences that lead them to contrasts in the way in which people interpret ethical and other sorts of issues. So, I'm just curious from Dr. Arthur, Dr. Wardell, and Dr. Shneiderman, how each of you see these existing divisions in our society as potential contributors to or impediments on, the pursuit of these kinds of shared socially conscious, or socially responsible kinds of events, documents and design work.

Ben Shneiderman

Diversity as Strength: Well, I would take the optimistic view that the diversity is one of the strengths. The fact is that the Department of Agriculture may take a different approach to the design of AI systems from the Department of Interior, or from the Department of Defense. We do see these different perspectives. The ways you can sort the differences out, and even how you raise the topic of differences, it all matters.

Dimensions of AI Systems: The thing that troubles me in the discussion of AI is that it seems like a large unity of a current concept. We don't really look closely enough and break it down. There are several dimensions we can look t, but let's take the simple example of lightweight AI

recommendation systems, which are fun, even when they often make mistakes. It really doesn't matter. It may be fun to get a different movie recommendation or a restaurant recommendation. However, then we have the consequential kinds of AI for legal, for financial decisions, and then we have the life critical ones in medical, military and transportation. So, as we move up the scale of the consequentiality, on the life criticalness of the applications, we have to take an ever-sterner view, and a more careful one about applying AI.

Service Systems with AI Incident Reporting Databases: One of the things I like to see, and maybe this can become part of the concept of what service systems are, is that there's always feedback systems, such as an AI incident reporting system. The Food and Drug Administration has an adverse drug event reporting system. FAA and NASA have an aviation safety incident reporting system. Every AI system that's seriously put out there in the world needs to have an AI incident reporting system. Sean McGregor, founder of the Responsible AI Collaborative, has created such a generic AI incident database. It already has 1,600 reports of the problems from AI system deployments. If we could repeat that notion in the different fields of application that would be doing a lot to provide the feedback. That way, we are aware more rapidly when problems arise and therefore, we can work to reduce them.

Diversity as Strength: To go back to your question, I think we have to break down the concept of AI. AI in general is too vague. AI is a large technology and application area with a wide range of specific applications and dimensions. One of the dimensions is consequentialness. Another dimension is the speed of reaction. So of course, we need automation for pacemakers, for airbag deployment. But we also need slower moving systems, often for medical decisions, and so the speed of reaction becomes a second dimension. There are other ways we can separate out the different kinds of AI systems that we will use. Therefore, the design of these systems is a longer discussion, including showing some of the screens of the examples of AI systems that are explainable, that are comprehensible, and that are user controlled. For example, the digital camera that we so often use is a remarkable blend of AI that does color balance, sets the shutter, the focus. it even reduces hand jitter. These are wonderful contributions of AI. On the other hand, it's still the user in control who sets the picture who determines the zoom and clicks for their decisive moment. It's their photo. They can edit it they can change it they can share. They can be socially connected. It provides excellent service to them and gives them control at the same time. while putting in a large amount of AI to serve their needs.

Carlotta Arthur

Inclusive Design From The Very Start, Including Behavioral and Social Science Experts: Thank-you Dr. Shneiderman for the examples, and your point about the varying levels of consequence, and dimensions of AI in service systems. Beyond talking about the people as users, I have another colleague who suggests that people need to be involved not just at the end of the process as users, but at the beginning of the process, when systems are being designed so that we don't run into some thorny AI issues. Having certain people at the table earlier can avoid

some of these issues. When I say people, I mean people like behavioral and social scientists, for example, who are experts in people and in human behavior. Hopefully, we could avoid some of the issues around ethics and equity because you'll have those experts that are in tune with many of the challenges that individuals face in under-served communities, who understand ways in which people are embedded in systems, involved in design so their contributions are made earlier in the process versus after the work has been done. Too often, only after the work is done, people are brought into the process as a user towards the end. That's an interesting segue into our next question, which is: What are some of the benefits of socially conscious service system design? What do we gain by doing the work this way? Perhaps Dr. Wardell can start this time around.

Clarence Wardell III

The Benefits of SCSSD As 100% Enrollment of Eligible People: When we talk about these systems and service system design, at the end we are delivering from the Federal Government perspective. We work to deliver a set of benefits, programs, resources to individuals or communities. We don't have the luxury of not thinking about the edge cases. The Federal government is here to serve all, regardless of profitability. The user or customer is set by the context of the program and the policy. The design, or the socially conscious design, or the human centered design, happens up front – because we go back to who are the communities? Who are the individuals that are not at the table? We can help bring their perspectives as we're designing, deploying, and delivering resources and services. The benefits from my perspective are that we miss less people. I intentionally phrase it that way, because there is almost never a program at least that I am aware of that has 100% enrollment and participation of eligible populations. It's been a challenge. Unless you can automate enrolling all the people. Can we get that number down, of folks who are missing? For example, this year, the American rescue plan extended eligibility for the child tax credit and made it fully refundable. That was a monthly payment such that it was money and checks in people's pockets on a monthly basis. We have spent an inordinate amount of time trying to design a process that captures, reaches as many of those folks as possible by bringing awareness and by really building on top of an existing system. We are trying to build a more equitable way of delivering that program. That's where I come to this from those are real resources to help people. Folks are entitled to it, and we are able to get it out to them. Taking this perspective allows us to think about more options or mechanisms for deploying those resources. How do we build a system that is continually evolving along the way to serve 100% of those eligible better? That's where I come to from a benefits standpoint.

Cora Marrett

The Benefits of SCSSD As Greater Social Cohension: What's being suggested has profound implications for government. It suggests that a key benefit could be the enhancement of social cohesion, and thus reducing the likelihood of conflict. If that's the case then what do we say about the benefits beyond the governmental sector, since socially conscious design is being

touted as something that should be appropriate for businesses as well as for any number of other kinds of actors. Some benefits might be economic. Some benefits might be of other forces. However, how do we talk collectively and in general, about the benefits that might not be readily seen? Perhaps the benefits might be limited to a given sector and I see Dr. Schneiderman has been thinking a lot about this, and so he's going to respond.

Ben Shneiderman

Benefit of SCSSD As Competitive Advantage: Design has to become a competitive advantage. Socially conscious service system design is not something we do because we want to, it is something we do because we really need to do it, it's in our own interest. Every consumer and every designer and every politician needs to know that technologies need to serve human needs to serve the human values and social justice, and that we all need to do our part. What's the advantage of it? Well, once we begin to think in these new socially conscious ways, and, as you suggested, bringing the diverse participants and participatory design notion and additional expertise, especially human computer interaction, design becomes elevated. The disability community long ago made the point. Nothing about us without us, and that became a theme for indigenous communities and others. We need to be inclusive at the earliest stages. Inclusivity makes the design better for everyone. That's the magic and the examples are very clear. If you design curbs to allow people in wheelchairs to get across the streets, you make it better for people with baby carriages, and you make it better for people with roller bags who are traveling. You make it better for delivery people who are rolling heavy loads, and so the benefits accrue to many others, more than the ones we originally thought. Similarly, the closed caption designed for deaf people abd those who have hearing difficulties becomes a generator for sports bars, and an advantage in airport lounges and it's something that we then have a transcript from which we can include searches. Design for the diversity of users improves the design for all and create new opportunities. Maybe not all, but for many, many different communities, so that's the second advantage.

Carlotta Arthur

Question - Transition to Potential Pitfalls: Thank you all for those comments. Those are important advantages to highlight. Of course, the flip side of advantages is what are the potential pitfalls of not taking a socially conscious approach to design? What do we lose? We have seen some examples of that already in society, but I would love to hear your comments on this topic. Perhaps Dr. Marrett could start this time.

Cora Marrett

Level of Engagement: Earlier when we were talking about the system design, Dr. Arthur said let's include social scientists. I have a great deal of interest in ensuring the participation of social behavioral scientist. If we're talking broadly about the benefits accruing to a larger population isn't there a need for making sure that there is at least some level of engagement? Without authentic engagement, disadvantages could accrue. Let me give you the example of

what's come up in the world of medical systems. Think of the medical device suppliers and hospitals, and something that may or may not benefit the average person. Expensive equipment only available in urban areas creates potential benefits for some, and potential disadvantage for others. Level of engagement makes a big difference when we talk about who should be at the table and who should be involved in the discussion. I don't think that that what we were trying to indicate suggested that there should be a great deal of limit placed on whose voices can be heard, and how those voices would be brought into the process. Those are some preliminary comments.

Carlotta Arthur

Question - Pitfalls – Increased Disparities. Thank you, Dr. Marrett. Your remarks are an excellent lead into what I wanted to share. We have seen some of the examples of what happens when design is not socially conscious. We see an exacerbation, for example, of health disparities. We see AI contributing to increased incarceration of people who are already discriminated against in our society. We see the kinds of negative impacts that happen when systems don't incorporate our knowledge base about people. There may be bias in the data. Having a social behavioral scientist as part of the design team, that person will come with a body of evidence-based knowledge about the social and behavioral sciences, some of which may have been co-created with communities. So, it's not just having a person who happens to have a behavioral or social science degree. It's bringing in someone who can leverage the many decades of research on what we know about people and behavior, experts who are engaged in the communities. For example, DBASSE, just celebrated the sixtieth anniversary of the social and behavioral sciences at the National Academies. So, bringing in someone, for example, with that background might bring in 60 years or more of evidence-based knowledge, an individual who can contribute their opinion, and come in with a scientific basis for what they would contribute to that conversation.

Ben Shneiderman

The Pitfall of Exclusion: We have talked about threats and dangers here. Every technology that's powerful and that's widely used can be dangerous. One danger is excluding certain people.

Cora Marrett

The Pitfalls of Privacy Invasion, Bias, Unfairness: Pitfalls include the danger of invasion to privacy and bias, and so unfairness. Those are really important issues.

Ben Shneiderman

The Pitfalls of Privacy Invasion, Bias, Unfairness: Privacy invasion, bias, and unfairness have gotten a great deal of attention, which is good news. We are seeing the AI community stepping up and fairness accountability, transparency movement has moved forward. It's a great deal of discussion ethical principles. There's some good work on design and algorithms. So we are

seeing some progress there. I am still. worried about the dangers and so I'm looking for the feedback systems incident reporting systems. The flight data recorders for every robot, if you will. Civil aviation is made safe because of flight data recorders and cockpit voice recorders. We need the same kind of trackers for consequential and life critical systems. So that when things go wrong, as they inevitably will, we can do the retrospective analysis that does the forensic investigation. As we understand what went wrong, we can put teeth into the movements the ways in which we will make it better. The National Transportation Safety Board is a good model, with its influential and respected reports. They have teeth. They have impact. They require change to improve safety. At an earlier time. I proposed a general notion of a National Algorithms Safety Board. Which would have a similar kind of impact. That was meant to a provocative discussion, and we need to have those much more tuned to specific industries. The Federal agencies and the AI Bill of Rights are pushing forward the idea of their there being a safety board that would investigate the problems in each of the areas of application. Each area is quite different and needs specialized treatment, as Dr. Marret has mentioned. Also we need to have people who are experts. in that, and we need to kind of independent oversight. That's the essential thing when the large companies say "We're doing great we're very careful in our design of technologies." That's fine. but we know that the Securities and Exchange Commission requires every publicly listed company to have an internal audit and an independent external audit for their finances. The idea of an independent external audit for AIi systems is, has validity, and I hope will gain currency.

Cora Marrett

People with Beliefs and Disciplines with Fundamental Knowledge: Many disciplines , bodies of fundamental knowledge, are required for socially conscious service system design. Certainly, one can argue for a continued emphasis on science, the fundamental knowledge that's based on evidence and not just on a set of assumptions and views. In the area of design, how one designs, it should be just as much related to evidence data as anything else. That has profound implications for what Dr. Wardell is dealing with, because it is so easy within the governmental sector for people to show up saying, "this is what I believe." This is the way it should be, in the absence of having fundamental knowledge that's there. This as a theme that's coming through – design informed by fundamental knowledge from disciplines as well as the explicit, not tacit, beliefs of communities of people and individuals. Some beliefs can be appropriate hypotheses for disciplines to put to the test. What this group might do is to place a great deal of emphasis on getting information and being sure we have more than just sets of assumptions and views about issues.

Carlotta Arthur

Thank-you Dr. Marrett. Dr. Wardell would you like to weigh in on this topic?

Clarence Wardell III

I don't know that I have more to add to what you all have already said, except that when you pick the domain, there are cases and case studies – that type of information as well. These cases sometimes include the success models that Dr. Shneiderman referred to earlier. Unfortunately, examples of success cases are more likely to be documented rather than unsuccessful cases – so the pitfalls of approaches may be less well documented. the talk about, you know, and layout very clearly what the pitfalls are when you don't take these types of approaches. If you look at the AI Bill of Rights, it is an initial rights preserving framework. Not denying opportunities, and really a civil rights framework. From this perspective of trying to protect against those pitfalls – correct? It aims to set a floor at a minimum. If you were deploying these AI technologies in service system, then that should not be done in a way that degrades someone's access to opportunity broadly conceived, as mentioned in Dr. Shneiderman's remarks. How you do that design and then deploy and deliver service systems, can be very specific, depending on the on the domain.

Ben Shneiderman

Independent Oversight and Diversity of Opinions: We want the AI Bill of Rights to both raise and set that floor for how we think about the design and deployment of AI in service systems across government agencies and across business and society. I want to support that effort. The AI Bill of Rights is an important document which has gotten a lot of attention already but needs to continue. John McDermott in the chat here reminds us all of that. Also, we should be looking at European models which are good efforts, along with the OECD. Their efforts are quite instructive as well. I'm not an expert on these but at the times I've looked at the Chinese and the Saudi Arabian Bill of Rights issues or versions of their rights documents for ethical AI, and there is something to be learned there as well. The diversity of opinions is important. The AI Bill of Rights is 73 pages and a bit of a daunting to read, and it does make the points about reviewing the use of AI and the oversight of AI. Maybe I am picky, but I would I prefer the term "independent oversight." The idea that you have different perspectives coming in and the comments are not coming from the same place brings a lot of value.

Carlotta Arthur

Question - Transition SCSSD Best Practices: Thank-you Dr. Shneiderman. Now for the last question for our panel on socially conscious service system design: what are some of the best practices? Dr. Wardell I am going to ask you to start given that, you've already laid out what we can anticipate from the recently created AI Bill of Rights. We have already heard about "nothing for us, without us" and "build with, not for" in the context of digital service when the technology community works on civic projects.

Clarence Wardell III

Priorities and Resources: Perhaps inclusive cocreation will become a North Star for socially conscious service system design. For best practices, where do we start from? What kind of first principles make sense for any type of design? Who is at the table? Design, deploy, and deliver

all should be socially conscious for a large variety of programs with trillions of dollars of funding for AI infused service system coming. How are we creating feedback looks for design, deploy, and delivery? We are not going to get it right the first, second, third, fourth, or fifth time – most likely. How do we continue to be iterative in our processes? How do we resource this work – in government, corporate America, and civil society? All the things that we're talking about require resources. It requires time. It requires keeping records of the failures along the way. When it's not prioritized, it's not given resources and so we end up with suboptimal systems.

Carlotta Arthur
Thank-you Dr. Wardell. You make a good point about the importance of resources.

Cora Marrett
Resources: We are not talking exclusively about the financial resources. The resources that exist among people – their expertise and skills are also very important. The question of what are some of the best practices that can be identified? The principles I know. We've already put a lot of responsibility on the shoulders of those who are going to write up the results of today's discussion. But I think it would be extremely useful to draw together to have a lot of the people who've talked already today reflect on exactly how principles, best practices have emerged, or what we know from the experiences that have been gained. There are other groups and bodies that could be drawn into the conversation. I assume that the National Academy of Engineering is going to remain very much focused on this topic. Where else might it draw? For example, another activity from the Academy is called the New Voices. They are a group of young younger scholars who've been very much interested in the question of the advances in science and engineering for the benefit of the larger society. They are looking at education and engineering education. We need to grow the community and the knowledge resources that can be important for the building of these socially conscious service systems.

Carlotta Arthur
Thank-you Dr. Marrett. There's been a lot of conversation today about the importance of learning more about the social behavioral sciences by engineers. I would also suggest that there's the opportunity to partner with people who have deep expertise in the behavioral and social sciences and not having to learn another discipline on top of the one that you already have. Working together does require taking some time to figure out a common language. For example, DBASSE does a lot of partnering across the Academies, and so it makes sense to use that model to address some of these issues. I am going to turn it over to Dr. Shneiderman to wrap up our panel.

Ben Shneiderman
Concluding Remarks: What will the future be like if we focus on a socially conscious approach to it? I am heartened by what I hear from the whole workshop that we've been attending and the

many voices. However, I do remind everyone that there's a lot of work to be done. While the communities we know about may share some of these principles and beliefs there's a very large circles and larger circles of places where we still have to make these messages central. We have to move past a technology centered approach to innovation. We have to embrace what is human and user needs. We want to make the world better for people. We want to support human values social justice, and individual dignity. That's where we're going. This movement is fundamental to cocreating a better future. But there's a lot of work to be done.

Carlotta Arthur
Thank-you Dr. Shneiderman, Dr. Marrett, and Dr. Wardell, and I hope that everyone will take something away from this panel discussion today. I am going to turn it back over to Dr. Madhavan now.

Reflections, survey summary, and open discussion on the way forward
Discussant: Vittal Prabhu
Others: Jim Spohrer, Bill Rouse, Kartik Ramani, Carlotta Arthur, Olef Pavlov, Louis Freund, Irving Wladawsky-Berger

Guru Madhavan
Thank-you Dr. Arthur and panelists. Socially conscious service system design is a weighty topic. Thank-you also for being "time conscious" and bringing us back on track. We are going to get into reflection mode shortly, but first Dr. Vittal Prabhu will get us started with some of his own reflection and the analysis of the survey results. Dr. Prabhu holds the Schneider Faculty Char in Service Enterprise Engineering at Penn State University. His work has long focused on manufacturing and service enterprises, with an emphasis on the developing unified mathematical and computational frameworks that enable better engineering of distributed control systems. Dr. Prabhu, please take over and looking forward to this conversation. I will be back later with Dr. Rouse to help you with the reflections and synthesis conversation as well.

Vittal Prabhu
Three Levels of Service Systems Engineering Education – Advancement, Academics, and Advocacy: Thank-you Dr. Madhavan. I will share a little bit about the kind of work we've been doing on the education front trying to dial up curriculum around service systems engineering. I will provide a very brief summary of what we have done over the last few years, and then summarize the survey feedback that we have received through the position statement. To everyone on the zoom now, the survey is still open, so please respond to it if you get a chance. What we have heard today is an excellent set of perspectives in terms of how we can go forward with educating engineers on service systems in the human centric Ai era. To me that is the 30,000 foot-view of gathering ideas from multiple experts, next the 3,000 foot academic perspective brings it to action in terms of academic offerings, credentials, teaching and learning materials, and the 300 foot advocacy perspective which is closer to ground level in business and society requires addressing the important awareness question – How can we raise awareness among the students and society at large?

Advocacy and Raising Awareness - Service Systems Engineering as a Profession: It's quite interesting if you search for "service engineer." You'll typically find maintenance type jobs, and operations and contractors. When college students look for opportunities in service system engineering that is probably what they are going to see in their searches. Not even the US Department of Labor recognizes it as an employment function or separate occupation. We have some challenges there in terms of raising awareness. I will share some of the things that we have learnt. The lowest hanging fruit is to raise awareness for opportunities, especially among our own students and society at large, by sharing stories about the kinds of engineering techniques that can be readily applied to services. To raise awareness of opportunities for engineering service systems among students and society, we have news stories and short

videos on social media, we have student competitions and prizes through professional societies, such as the Institute of Industrial and Systems Engineers Outstanding Innovation In Service Systems Engineering Award, INFORMS Service Science Conference Student Paper Award, and IFIP APMS SIG and Panels. This is our advocacy effort to make people aware of opportunities for engineering services, and there are lots of other low-hanging fruits to build awareness among students.

Academics – Textbooks and Case Studies: Many years ago, when we started to get more interested and active in trying to include services within the industrial engineering curriculum, we realized that we didn't have good textbooks. We invested in capacity building, to help faculty teach courses on service systems engineering and management. My colleague, Paul Griffin and his co-authors wrote a textbook on healthcare systems engineering. We also wrote a textbook on Services Systems Engineering and Management. We developed a wide range of case studies that we can use in our courses in service as well as statistics type courses, so that we can support educating engineers in this.

Academics – T-Shaped Service Systems Engineers at both Undergraduate and Graduate Levels: One of the things that has influenced me in this activity is the literature that many of you who spoke of today and contributed to coming up with this idea of T-Shaped Engineers. So what does it mean to develop T-Shaped Service Systems Engineers? Localized to the context of Penn State and Penn State industrial engineering in particular, we happen to be the very first academic program that awarded in industrial engineering degrees back in 1908. We trained a lot of engineers who went on to have stellar careers in manufacturing industry. More recently many of our alums came back and said, "Hey, we got a great education, but our careers are in services, and there is a lot of low-hanging fruits that can help industry to improve productivity and improve customer service. If you expose students and train students to apply engineering techniques to these service system problems." So earlier today we heard Dr. Larson talk about how he had a consulting company for 40 years. That was in various industry and societal sectors. So how can we scale it up through one of the channels we have, which is education at undergraduate and graduate level. All of you are very familiar with the constraints we face when try to change any curriculum. Typically, about 50% of undergraduate credits, which is about 130 credits, is common for all engineering majors. This covers breadth which includes arts, humanities, social sciences, communication (written and spoken), mathematics, sciences and some entry level engineering courses. The other 50% is in the depth for a specific engineering major. So that's roughly 2 years out of the 4 years that students spend with us in which we could infuse service systems coursework suitable for industrial engineering students. This depth includes several courses that we feel are most needed for someone in services but cannot be incorporated in existing required courses: service commerce, which is logistics, supply, chain, retail, e-commerce, and such, and healthcare systems, such as hospitals and eldercare centers. So can we train our students more intentionally at the undergraduate level to have at some training in health systems and human systems.

Tuning: Can we actually make industrial engineering degrees a little more tuned to services? In the last couple hours, we have had some great discussion around this topic, and as an IE department at Penn State, we offer operations research and data analytics courses for service systems. We can start to shape the depth that we offer to help students be more successful and quickly impact the industry that they go on to work upon their graduation. They can earn additional credit and augment the training through other opportunities like a minor in service enterprises. They can learn more about the service industries, such as hospitality, online commerce, health policy and social services. They can learn something that is not necessarily directly related to engineering, such as leadership and entrepreneurship. However, this is extra cost in terms of extra credits. If they have to earn more of these, then that is potentially extra time that they have to spend in the university.

Upskilling: Can we develop digital badges or stack credentials that are open to public? That way working professionals or students in other schools can take this fairly low barrier to entry approach. Maybe learners who want to upskill on service systems engineering can take one of the case studies as they develop new skills and convert that into a badge. They can learn something more that will help them in their present job. At the undergraduate level as you can imagine, we have several constraints around accreditation, as well as overall college level constraints So it doesn't really give us too much room to maneuver to do everything that we might want to be able to at the undergraduate level.

Graduate Degree: What we are working on now, as we speak, is can we create a T-shaped graduate service systems engineering degree? For working professionals, a graduate level degree in service systems engineering can contribute to their careers. For example, in modeling service systems could be descriptive models, mathematical models, computational models. So with an engineering degree, you would expect students to have this level of service systems modeling skills and competences. To begin with, we have a good dual degree program in operations research, so that might be an obvious model to offer our students. We are in the process of inviting faculty from across the campus to join us in this effort, certainly from industrial engineering, which is our home department, but also operations research, statistics, hospitality, health policy, transportation, so on, so forth. One of the interesting things might be to see if we can actually tackle Baumol's cost disease by better engineering service systems. In our own experience, this is quite possible, simply by tackling some of the service systems engineering problem applying existing techniques. Earlier, Dr. West referred to this - we're just collecting some data and then applying undergraduate or entry level graduate level techniques, engineering techniques to this. We can boost productivity 20%, 30%, and sometimes 50%. There is lots of opportunity here for engineers to learn about applying data analytics before we go to the level of tackling more advanced AI, which requires slightly more challenging infrastructure. To couple with this, we are hoping to start a multidisciplinary research center

on service systems engineering, where we hope that faculty from across the campus will join us and collaborate in doing research, but also delivering the course work in this effort.

Talent Supply Chain Statistics for Service System Engineers: Here are some statistics again very localized to our Penn State experiences. From my perspective, this is what the service systems engineering talent supply chain looks like. Students come in through the university, go on to have careers in industry. We did a survey of our current students that are in engineering and recent graduates. and we said, "Hey, if we were to offer you an entirely new degree in services systems engineering, would you be interested in this?" So roughly about 20-25% said yes, that they would be interested. This is not entirely surprising. Most of the students who responded positively to this, where in industrial engineering students and the next, a distance second, was mechanical engineering. Here's the interesting perspective on this: Over 60% of our students in industrial engineering start their careers in service industries, and probably that number is much larger after they work for a few years. Furthermore, we talked to industry, and asked them if they would like to hire T-shaped service systems engineers. We spoke with hiring managers in the service sector. We got very strong support, which is not surprising at all. We also established an industry advisory board, based on this strong industry support for hiring T-shaped service systems engineers. While all these curriculum and degree changes are nowhere near final approval at this point, we wanted to run this for sanity purposes like somebody said, How can we work with you? We're trying to figure out what are the talent needs that the industry would really look for in hiring graduates that have some training in service systems, especially from IEOR disciplines. You can make a similar argument for students graduating from a computational science perspective, or from marketing perspective, or business school and management.

Summary of Survey Results - Gathering Additional Points of View: So that was one perspective on service system engineering, based on our experiences at Penn State. Now, I would like to share with you a summary of other position statements, based on what we have received via the online survey as of late last evening. Our plan is to share the summary with the public at large in a future publication as well.

Survey Question 1 – Topics Should Be Improved: Existing degree programs (e.g., systems engineering, etc.) should be improved to ensure that graduates can continue to innovate safe, ethical, sustainable service systems in the AI era? As of last nigher we had 49 responses, and this is what it looked like – 52% strongly agreed, and 30% agreed. On the other side of the scale 14% strongly disagreed – and I am hoping during the discussion time we can hear more from some of them. We did collect some additional comments in the survey that we can share as well. This is not entirely surprising, based on what we have heard so far. However, for the engineers in us, this is sort of comforting to put some numbers to opinions.

Survey Question 2 – Topics Most Prepared For: From the perspective of your primary undergraduate discipline, what characteristics of human-centered, data-intensive service systems in the coming decade are graduates best prepared to address? This item was especially interesting for me and insightful. Not entirely surprising the top was technology, and I took the liberty of summarizing the text – so the that would be different if someone else did the summary. People generally seem to feel that our graduates would do a pretty good job in terms of technology that includes AI, ML, Big Data, Networks, Human-Centric. Regarding system - graduates would do well modeling, design, engineering control across different verticals, such as education, healthcare, financial, circular economy, and so forth. Other areas of confidence some growing levels of confidence include graduates' knowledge of climate issues, psychology, marketing, customer value formation, as well as gamified human assistance and cognitive assistants. Technology and systems were the two big ones, and the third one was scope. This is an interesting one. Some felt that current students are pretty good at dealing with multi-dimensional problems, and some felt that they'll be especially good at tackling narrow linear deterministic problem and also dealing with the user experience and customer experience in terms of human center design. We also had some feedback in terms of service quality, specifically called out were that students will have a good understanding of customer behavior, experience, and how automation might influence these. The bottom two where ethics - how can we build save accountable and transparent system?... and absolute bottom, was sustainability. We will come back to these slides, but let me just go through the next couple, and then we'll go through these summary responses and trying to call on people to share their opinions.

Survey Question 3 – Topics Least Prepared For: From the perspective of your primary undergraduate discipline, what characteristics of human-centered, data-intensive service systems in the coming decade are graduates least prepared to address? The strongest message I got going through each one of these is the human dimension, and thanks to the last panel led by Dr. Arthur for the excellent job of summarizing it. I just quickly paraphrase what I learn from the feedback, and that is, how would the human dimension impact the service quality? And how do we design, the entire interaction, the cognitive engineering aspect of it, and especially because the interest is in AI and human centered service systems? What were augmented cognition to, and what are the complementarities between AI and human decision? Some of the other things that came up. and more than one feedback is that how do we tackle the emotional satisfaction and the needs of the stakeholder? Can we actually look at empathy and the best practices and how it's incorporated in services? That was my takeaway from that comment. And one thing that was really thought provoking is that if we do not design it right, you might essentially end up undermining the human experience. Those are intriguing comments right there, and we saw some discussion earlier on bad actors and such. The other topic is demographic bias through data, if we do not have good representative sample in terms of the data that we use to train AI. The issues include bias when the data consistently removes certain stakeholders from the service needs, and with the recent experiences that all of us have

had what would be the role of AI in remote work, especially when it includes multiple cultures. My takeaway from this is that the human dimension is going to be a big challenge, and our students might be leased prepared to address these. (From slide: Human dimension: service quality, interaction design, cognitive engineering, augmented cognition, complementarity between AI and human decision makers, emotional satisfaction and needs of stakeholders, empathy-based best practices, undermining the human experience, demographic bias through data, AI in remote work across multiple cultures). The next item to summarize is the scope of the system that they tackle. (From slide: Scope: multi-disciplinary (including traditional engineering and law), multilateral, and cross-functional services, that have integrated processes; their control and change management; weakest at mid-range). AI policy will play an important role when it comes to regulating or governing AI. Can we incorporate law right from the get-go in engineered systems? The next up on this scope issue was how can students be trained or educated to learn how to tackle integrated processes that may span lots of organizational networks of service providers that are cocreating value, and the control and change management issues. Since these organizations are adapting at the pace of the market, as we heard earlier this morning, one interesting comment is that students may be good at very high level, at least generationally speaking. The current crop of students seems to be better cut-out to deal with very high-level issues rather than earlier generations and find great issues that typical engineering curricula maybe not so strong in tackling. At the midrange, there were comments on ethics. (From slide: Ethics: harmful effects of AI; unethical design leading to data privacy/security issues; critical thinking to find ethical paths; most difficult). This is also a big topic in terms of what are the harmful effects of AI. We heard several examples already today. unethical design that leads to data, privacy, and security issues, especially with a lot of bad actors lurking. What can we do to fix this problem from the get-go? Critical thinking to find ethical parts when there are conflicting issues? I personally liked this comment. there are going to be conflicting issues that arise. Can we help educate students in the critical thinking facilities to navigate their way through these complicated problems that find an ethical path rather than find the quickest solution that'll hit the market? And one person summarized it, as essentially, this is the most difficult challenge. Finally, we come back to technology. What would be the shape of AI human interactions? What will be the shape of digital physical integration? How best can we leverage technology to build new knowledge? We heard about digital twins earlier today from Dr. Spohrer, Dr. West, and others, where the digital twins of our person, what we know today can serve as a proxy for us or help us learn other disciplines quickly rather than spend you all trying to grapple with all the disciplines that we need to interact with. This is a verbatim quote “Students should not be seduced by easy data. Students are illegitimate to deal with systems, especially their dynamics.” And last, but not the least, organizationally, if we were to create new educational curriculum, how can we best identify methods and tools? if there is this service science, how can we practically work on a set off curriculum needs in terms of service systems engineering, I think that's what the was person saying,

Survey Question 4 – Feedback: I have selected just three specific feedback items from the 49 to share on these last couple slides. The questions was: Are there any other thoughts you would like to share regarding innovating future complex business and societal systems that serve people better and/or preparing graduates for the opportunities and challenges ahead? I just picked 3 that really hit me hard, and I've highlighted what I thought was the most a compelling part of these feedback.

From Slides:

> "If we are to build human-centered AI, *we will need to know a good deal more about humans*, which means that engineering and business will need to bridge to the cognitive sciences in a much deeper way, and the cognitive science must change their research to address those concerns. We need to consider the structure of organizations such as universities and research institutes to support this."

> "The application of AI is so problematic in the service area because when *digital footprints are primarily created by higher income consumers*, because they have the money to buy more things and (for example) those living in higher income neighborhoods will be given priority because of the higher possibility of "higher spend" .... then automated service will exclude and upset people, who will not use it, and the concentration of good services for high income people in high income neighborhoods will create increasing social unrest. Disparities will not just be in terms of treatment by other people, it will be increasingly unfair due to the way AI's are trained, and the priorities put on higher spending in a market economy."

> "We often separate people and technology, as if they are opposites. Technology is what makes us human, just as we as humans make technology. We also tend to separate the arts/humanities from the sciences (and definitely separate the social from the business). Those separations have value at a basic level but not in complex systems. So it seems like *now we need to fight the natural separation of disciplines and specialties in the other direction in order to survive. HOW to do that is the hard part*."

We heard the human dimension that came through very loud and clearly to me, in terms of what our students might be least equipped to tackle. And this feedback said, Hey, we need to know a good deal more about humans, especially where we are in the process of engineering. I thought was a great suggestion. The second one that I liked a lot deals with the issue of the application of AI and why it is so problematic. Engineers and others end up having digital footprints primarily created by higher income customers. So there is this potential risk of

perpetuating inequalities through these new systems that might be unchallenged in our future. The next items is something that also came in the previous panel that Dr. Arthur led, and we ought to pay attention to this. The last one that I selected as a conversation starter for us and for the rest of this particular session is, we heard different versions of this, using different terminology all through today, is how people and technology may be separated as if they were opposite, and arts and humanities are distinctly separated from sciences. So now, how do we, fight the natural separation of disciplines and specialties in the other direction? This person quoted said that how to do this reunification is going to be the hardest part. What I would like to do next is go up here to this slide and see if we have among the 27 or so in attendance now, somebody who would like to champion the thought on why they would strongly disagree that there is a need to design or evolve new educational programs.

Jim Spohrer
Thank-you Dr. Prabhu, and now we want to invite others into the conversation. I will mention that when we looked at the responses to the first item that were "strongly disagree" – they were feeling like simply improving current topics was not enough – that fixing or improving existing disciplines would not be enough. They were using their "strongly disagree" response to say something more radically different was needed. However, I am just curious, along with Dr. Prabhu, is anyone who did make that strongly disagree feedback, would you like to share your thoughts? The floor is open to others now to speak up and be heard. Thank-you Dr. Prabhu, and in a few minutes, we'll get back with Dr. Madhavan and Dr. Rouse for a summary of the day and next steps.

Vittal Prabhu
The microphone is open. So one point that I'd like to offer, as probably a statement to stimulate some discussion at the end of the day is, we got almost diametric feedback, the opposite feedback, saying that technology is the strongest, both most prepared and least prepared to address in current students. That was pretty interesting to me if anybody wants to comment.

Bill Rouse
<u>Human Factors and Ergonomics is Not Enough:</u> I would like to make an observation: I don't think taking a human factors course, and you know what causes eye strain, you know whether people can deal better with uppercase or lowercase letters or whatever, I don't think that helps you to really understand people. The kind of things that Dr. Shneiderman was advocating were different, where you basically you need to interact with the users. You need to find out about their core values and concerns, as well as what their perceptions of the interactions are. What we can do is to teach our engineers how to interact with people, with other humans. As opposed to thinking that we can just package all the information about humans and give it to them. These are two different models. At Georgia Tech, when students complete their senior design project, that is a huge effort. Our alums report that it's one of the most positive

experiences of their whole undergraduate career. For their senior design projects, they interact with the with the sponsors of their projects. From advising several senior design teams, it's an unbelievable learning experience to try to figure out what customers really want, and what customers really know, and what kind of things they find acceptable and what kind of things they are willing to perhaps try. My experience with these teams is they just had never really thought about this stuff. However, at the same time, especially when they're done and they do their great presentations, they're so proud of themselves that they actually figured it out. This ability to interact with end users, not only end users, but also customers, the people who are going to write the check even though they're not going to use it, those are just great experiences. However, it's hard to codify into like a handbook of people. It just doesn't work that way. My colleague Paul Griffin summarizing this, he said, Hey, we try to reduce humans to a probabilistic distribution or mean and variance. That's what we do right now, and we need to be more precise.

Kartik Ramani

Experiential Learning and Abstraction Across Disciplines: To your point, the students need to have a context in which they are designing and creating something real and to actually test it on people. If this experience happens earlier, in their own experiences, then they also realize that lot of real-world problems today require multidisciplinary approaches. Nobody is going to tell them a simple way to accomplish this – do this here, do that there. A good example is, if you take different fields within mechanical engineering, they all use second order partial differential equations (PDEs) for heat transfer for fluids, for the thermal analysis. However, the taxonomies and the countless ways in which they are presented in these individual classes themselves are different, and don't allow students to abstract their user. I completely agree that this experiential learning is important, but also the need to abstract out from it and see that it's applicable elsewhere. It becomes crucial for them to appreciate what they don't know and what they know.

Bill Rouse

Experiential Learning – Complexity Matters: One of my experiences was advising senior design teams in health applications for the local hospitals., One team after a few weeks revolted and they said, you know this isn't fair - our friends they're in a team, and they're figuring out the optimal order of packing coke boxes in a truck. The problem we have is enormously complex. For out hospital project, there are all these different stakeholders and doctors and the nurses and even theses administrators and we're trying to figure this all out and they're figuring out where to put the coke in in a tray in the truck. However, at the end of the semester, the hospital team of students did a great job. The students were so proud of themselves that they managed to figure out how to help people in this complex messy system. I don't know that what happened with the students who were optimizing the coke boxes. I don't think they learned a lot about people. I remember one of the other ones. We were in a hospital that was having various problems We were working on 2 different teams, and the doctors finally said to

us. You know you don't really have to give us advice about medicine We are actually pretty good at that. The problem we need help with is that we have no idea of what the economic consequences were. Can you help us with that? The students were totally prepared to do that. The students had to realize you're not going to become a guru on medicine in order to figure out how to economically model these processes. There are a lot of other examples. Some of the things you presented earlier Dr. Ramani are also a good example of "just get your hands dirty, and to get in there." For example, another one dealt with the monthly average delay time in the emergency department had gone up by an hour, and he didn't know why. The students developed a simulation of the emergency department and its relation to radiology because that was important. They basically identify a particular human factors problem that was causing that hour delay for the staff. Not for this patient. We presented the results, including the representation of the emergency department. The staff then got in an argument with each other because they actually didn't agree among themselves about the way the place worked. So our portraying the way the place functioned was a huge benefit to the staff, which we had never anticipated. The students were kind of tickled with that, because they knew how the place worked better than some of the staff did, because they paid attention to do it.

Jim Spohrer

<u>All Disciplines Are On A Transdisciplinary Journey As Soon As They Try To Give Students a Real-World Problem for Experiential Learning in a Complex Context:</u> Thank-you Dr. Rouse. I too agree with Dr. Shneiderman about design – and that design is like a contact sport. I will just jump in with one comment, since over the weekend Dr. Don Norman filled out the survey and sent me a draft copy of his upcoming book, saying he wanted to put more in the box than the survey allowed. In his new book, Dr. Norman expands the traditional 4 principle of human-centered design to 5 principles of humanity-centered design – and humanity-centered design expands the number of stakeholders to better address the equity issue that Dr. Arthur's panel addressed. Even as we make systems better for some, there's a huge mass of under-service and that is causing a lot of social unrest. I totally agree with you Dr. Rouse that it is not enough to have an abstract model of people, the distilled information about people. That is an uncomfortable thing that we have to face on the transdisciplinary journey that all disciplines are on. All disciplines are on this journey – each discipline with a method for solving a little piece of the problem. However, we realize that piece of the problem connects into this bigger problem that we have not yet solved over here, and perhaps the local solution makes the other problem worse in some ways – so there is a trade-off. From the very beginning with service science and SSME+DAPP (Service Science Management Engineering and Design Arts and Public Policy), we have been trying to increase awareness that somehow, we have to get a lot better at transdisciplinary approaches to win-win service system improvements, both locally and globally. T-shaped skills in people is like an approximation to what we need, Pi-shaped is even a better approximation. I liked the diagram that Dr. Lyons showed about the progress in service science from the first to the second Handbook of Service Science after about ten years. Many service science conferences over the two decade, we had great technology attendance, we

have had great business attendance, but the social scientists have so much to offer, and they're not there in great numbers yet. How do we do a better job to invite them? Have we not made enough space for them in these discussions? I'm not sure but that that's my summary.

Bill Rouse
Objective Function – Minimize Under-Served: I thought it was interesting, Dr. Wardell's comment about his objective function is minimize the number of people who miss a service that they deserve. I've not heard that expressed that way before. I see Dr. Arthur's hand up.

Carlotta Arthur
Communicate Better Between Disciplines: I wanted to mention that when Dr. Prabhu showed his slides there was the one slide where I believe it was 39% of people had chosen a human aspect as being the most challenging. I am surprised that it's not higher. Part of that is because humans are extremely complex - I know that I took 6 years to earn my doctorate in psychology. The average time is longer than that and I'm only a specialist primarily in psychology. There may not be a full appreciation for the fact that these are whole disciplines in and of themselves. These are large science disciplines in and of themselves and it's not realistic to expect an engineering student to learn that on top of engineering. It's not possible. However, what can be done in engineering training, and should be done more in the social sciences, is to focus on how we can do more to identify ways to communicate better between disciplines, so that we can have these multidisciplinary, interdisciplinary, and transdisciplinary teams work together better to address socially conscious service system design challenges. The challenges that we face are not single disciplinary. There's no way that an individual can be expected to have all the expertise needed to address the challenges. We've got to learn to partner and work with each other and no one should be expected to think that they can learn the social behavioral sciences on the side, or by taking a few courses. There are people who are experts in in those fields and we've got to learn to work together. Personally, I would like more invitations to this kind of meeting, so that I can share this perspective more broadly.

Bill Rouse
DBASSE Challenge Events Proposal: Thank-you Dr. Arthur. Here is an idea. Why don't we have a DBASSE challenge event? It is because of National Academy meetings and events like these that I met you, Dr. Marrett, and others. Someone comes in with a problem that is laced with behavioral science issues, and they present it to the DBASSE Advisory Committee. They basically ask, what should I do? And the collective wisdom of these 20 or so people, they don't, give them the answer to the question, they don't solve the problem, but they say you need to look at X, and then look at Y and speak with Z, and here's some key references. That would be a really fun and informative event.

Carlotta Arthur

Working Together From The Start: Thank-you Dr. Rouse. The DBASSE challenge event that you propose would be fun, but it wouldn't be enough. What I would suggest is that you not just come to us with that challenge, and then you invite us to partner with you to address it. That would be too much like getting a social behavioral science person as an add on after the problems already been defined and identified. Asking that person to help solve a challenge, it's often too late from my perspective. Bring them in at the beginning. From the time the very first conversations are being had about what the problem is or what the design challenge is – that is what I would recommend. You'll have a much better result.

Bill Rouse,
Thank-you Dr. Arthur. I agree. There definitely needs to be more presence at the table, but not so much in an advisory capacity, but as a partner in the work.

Vittal Prabhu
Prevention Science: I recall when I first met my colleagues in prevention science. I didn't know what that meant. To make a long story short, It took us about 6 months to create and learn a shared vocabulary. They're all social scientists with psychology training. That was a fantastic experience. We got some really good use cases for three projects in industrial engineering. So yes, it's a tough challenge.

Bill Rouse,
The 6 Month Rule – Building a Common Language: Thank-you Dr. Prabhu. Your data point is interesting. We've worked with about 10 major health centers. We have a rule of thumb. It takes 6 months before you're really communicating.

Jim Spohrer
Dr. Pavlov and Dr. Freund have their hands up.

Oleg Pavlov
Motivating Technology Students to be Interested in the Social Sciences: I want to thank you for an interesting discussion and the opportunity to be here. I'm an economist who is in a social science department at a technological university, Worcester Polytechnic Institute. I am surrounded by scientists and engineers of all sorts. When I teach economics classes, I have to convince students in technical and science majors who are not interested in the social sciences that they're not wasting their time in my economics classes. I spend a considerable amount of time on this. And so this is a topic that I would like to hear more about from all of you – How can we motivate technology students to be more interested in the social sciences?

Bill Rouse

Social Science and Engineering Faculty Cocreating Courses Together: Maybe some advice how to actually collaborate with engineers, how to convince them that we need to maybe sit down and create a course together.

Oleg Pavlov

Cocreated Course Challenges and Issues: A few years ago, engineering faculty at my university needed to incorporate modeling and systems elements in the curriculum as required by ABET. They created their own graduate-level systems courses, even though there was a group of system dynamics people in the social sciences department teaching graduate and undergraduate courses. Cocreation of courses by faculty in different departments is not easy.

Bill Rouse

Important Questions to Ask Engineering Students: Thank-you Dr. Pavlov. Those are important challenges. I taught an engineering economics course at Stevens, when I was there for a few years. I had 3,000 students come through my course, and they're all a variety of mechanical, civil, electrical, and other types of engineers. What I found really worked is this, I would come in and say Okay, imagine you just graduated and left Stevens. You got this great job, right? Now your boss just asked you the following question: How are you going to answer it? And the question was always laced with economics. Suddenly I got them in the position where they were the focal point and their boss wanted them to answer it so now they're interested in me telling them approaches to answer the question. Okay here's, how you can answer that question because you know when you're an undergraduate, and you're in civil or mechanical electrical, whatever you're not thinking about the economics of the organization or the marketplace. But i'm telling them you have to or you can't answer the bosses question, and here's how to do it. That really worked well for me. I see Dr. Freund has his hand up next.

Louis Freund

Service Systems Engineering Required Course at SJSU and HSSE Conference: Thank-you Dr. Rouse. I am Dr. Louis Freund, and I'm a professor of industrial engineering at San Jose State University. I instituted a course in service systems engineering into our industrial engineering curriculum in 2002, some twenty years ago, which is now a required course in our curriculum. I also wanted to mention that in 2012, about ten years ago, I started on a conference called the Human Side of Service Engineering, within the AHFE (Association of Human-Factors Engineers) umbrella conference. That conference is still going every year now, and it's an interdisciplinary conference which invites people from all fields related to service systems design and engineering and management to come in and talk about issues like the ones we've been talking about today. For example, issues that have to do with improving impact of service systems in our in our society and improving the quality-of-service at the same time. That conference is generally held in the July timeframe. Dr. Spohrer knows how to get in touch with the people there and get you information about the program – so look for the Human-Side of Service Engineering conference when you have a chance. We have had architects there, we

have people in social sciences, people from industry like Disney, IBM, and others, as well as industrial engineers, human-factors engineers, and service science people. Dr. Medina-Borja has attended several times and provided an NSF perspective on smart service systems. I wanted to bring that forward for those wondering about how this conversation on the human-side of service engineering could go forward in another context.

Vittal Prabhu
Thank-you Dr. Freund. It's also important to remember on the human-side about privacy and the gigantic about of big data that is being collected in service systems today.

Irving Wladalsky-Berger
The Increasing Availability of Big Data Relevant to the Social Sciences is One of the Big Change in the Last Decade: It is important to remember the big data from the marketplace about the behavior of people about organizations, and so on, that we didn't have before. if we went to a high energy physicist, we there is this new discipline, big data, analyze data, data science. They would know what we're talking about because they've been doing that for a long time. Same way with astronomy, same with genomics. The quote-unquote Hard Sciences have long been all about doing experiments. Get data, analyze the data, then generate a new hypothesis and do more experiments. We can now do that in the social sciences, in even in the humanities. The key change is for engineers to realize that this big change has happened. Now the big revolution is that they can now analyze what's going on in the marketplace with their ideas. If they have an idea for a better system, how do you figure out? If it works by gathering data and analyzing it, then whether it's modeling or doing experiments, it is important for socially conscious service systems design.

Bill Rouse
Big Data is the New Reality: That is the new reality – big data. However, it has not made its way into courses that much yet.

Irving Wladalsky-Berger
Big Data is the Big Change: That is the big change that we're having now. Maybe there is a better way for us to articulate its importance for socially conscious service system design.

Jim Spohrer
Big Data and the Social Sciences: Dr. Wladalsky-Berger is making a good point. Dr. Arthur, can you share your perspective on this? How are the social and behavioral scientists and researchers looking at big data for the behavioral and social sciences?

Carlotta Arthur
Big Data – New Opportunities and Old Challenges: As mentioned before. we just celebrated 60 years of behavioral and social sciences at the National Academies. There's a very deep and

strong evidence space in the social and behavioral sciences upon which people who are looking to partner with us can connect and build together. Unfortunately, I wasn't able to share my slides earlier, but even within the division of behavior on social sciences and education, my division we have a board on human systems integration that partners regularly across the academies. We have the board on science education. We have the board on behavioral and cognitive sensory sciences that also does work in this space. We are doing intradisciplinary work already and have been for at least 60 years. The challenge for us has been to be taken seriously by those in the quote-unquote hard sciences. Nevertheless, I've heard it from a Nobel laureate in physics, who called the social and behavioral sciences the quote-unquote harder sciences, because of the complexity of working with people who cannot be modeled easily. A challenge is still to gain the respect of people who are very steeped in their own sciences, and who think that behavioral and social sciences are just sort of common sense that you can kind of work out after you've done the real work. Simply by sharing and developing that common language after the fact is not enough to be able to bridge the gap between what we do is social and behavioral sciences, and what people in engineering. For example, one thing that we can all do a better job of is if we're thinking about training students, then we can do a better job with training students to speak that interdisciplinary language. We can't teach them all about the other discipline, so hopefully we can do a better job of teaching them to be potential interdisciplinary team members. Then, hopefully, it won't take 6 months when people from engineering or from the economic sciences or behavioral sciences come together to kind of figure out that common terminology and ways of speaking to each other. They will have learned that earlier on, and we'll be ready to begin to do the work together, because social and behavioral sciences are ready. We have been struggling with some of these issues that I just shared – getting a seat at the table from the outset, and better training in shared language and working together from the start, so that is not done over and over again taking six months each time two teams try to work together.

Bill Rouse

Transition – Summary of Seat at the Table Issue: Thank-you Dr. Arthur. That's interesting. It seems to me that to some extent you're saying we should teach people to know what they don't know, and know where to get the knowledge they need. To acknowledge that there are people who know the kinds of things that they're not trying to do, and that there's something there, in those other disciplines that can contribute to the work. Again, not as an add-on, but as partners in the work from the outset.

Irving Wladalsky-Berger

Building Engineering Student Interest in Human Behavior and Social Phenomena - Focus on the Marketplace: Engineering has been a discipline for what? 150 years or more. Chemistry much, much longer. In the sciences, one of the most important things you need to know about is how to design an experiment - so you can get the data. Then you need to know how to analyze the data – those two things are important for any science. For socially conscious service system

design, human-centered service engineering, and service science, in a very real sense, we are trying to develop a new application that's supposed to be in the marketplace, you need to figure out how to get there and how to talk to each other. Let's figure out together how it's going to work in the marketplace. This gets back to why the engineering students have to know about the economics. Economics just happens to reflect the marketplace, and they have to know about people's behavior because that's in the marketplace. By the time people get to graduate school they are more mature in their own thinking about the marketplace, but it is not just commonsense – design, engineering, and scientists of many varieties have to work together and focus on the marketplace and marketplace success.

Bill Rouse
Building Engineering Student Interest in Human Behavior and Social Phenomena - Age and Readiness: There are quite a few programs like that.

Irving Wladawsky-Berger
Building Engineering Student Interest in Human Behavior and Social Phenomena - Age and Readiness: As undergraduates, maybe they are too immature. Remember the same way you cannot get an MBA if you are 20, because you have less experience on what a business is, or how it works. Perhaps the same goes for Dr. Arthur's point about a young 20 year old engineering student and telling them about how people behave.

Bill Rouse
Building Engineering Student Interest in Human Behavior and Social Phenomena - Age and Readiness: Maybe you have to wait until they have more life experiences? Another possibility is that there's been no lack of interest in behavior and social phenomena.

Irving Wladawsky-Berger
Building Engineering Student Interest in Human Behavior and Social Phenomena: We see this with John Stewart Mill, for example. Students have an interest in social justice.

Bill Rouse
Building Engineering Student Interest in Human Behavior and Social Phenomena: Okay, but it wasn't an empirical approach. That's what has changed. Earlier they didn't have an evidence-based perspective. Earlier it was just what they happened to write and what they thought at the moment.

Irving Wladawsky-Berger
Building Engineering Student Interest in Human Behavior and Social Phenomena: John Maynard Keynes is the same way. Today, we have now the possibility of an evidence-based approach to social sciences to get students interested. It's not that these older scholars from decades and centuries back don't have perspectives of interest to students – the question is,

what does the data support? That's the revolution. I was asking Dr. Larson at MIT, and there was quite a bit going on at the graduate level in this area. The big data in the social sciences, and some of these courses that depend on that at the undergraduate level are pretty new. Service science is pretty new. Right, Dr. Spohrer?

Jim Spohrer
Timescales of Change in Undergraduate Education: Service science and SSME community courses are 20 years old. It took computer science about 30 years to be recognized by the National Science Foundation. In 1945, Columbia University had a computer science course that IBM helped to start. These things take time.

Irving Wladawsky-Berger
Timescales of Change in Undergraduate Education: Now granted, things do move faster now. As Dr. Arthur said the social sciences are the hardest sciences – people are the most complex systems. They don't stay put, they change their minds, and they interact. Studying an individual person is not like studying an individual electron. Group behavior is different than individual behavior. Dr. Sandy Pentland at MIT wrote the "Social Physics" – related to this point of big data coming to the social and behavioral sciences.

Vittal Prabhu
Timescales of Change in Undergraduate Education: These are new and complex concepts. We have to keep pushing forward with more big data in the social and behavioral sciences. As Dr. Arthur has said we need to build on the foundations and partnerships already established but take it to the next level. The next level includes giving the social and behavioral science experts a seat at the table from outset of tackling challenges together. Including building together courses that are exciting to all students so as they specialize later in their educations, the students have a common or shared language to communicate, and that does not take 6 months to achieve on the job when they join the workforce.

Jim Spohrer
Closing Remarks - Next Steps Summarizing the Discussion Today: Thank-you all. We should let Dr. Rouse and Dr. Madhavan wrap up now in the few minutes left. Thank-you Dr. Arthur for making the point about working together from the start, and not trying to put all of the social and behavioral sciences knowledge in a young engineer's head – since that won't work. Thank-you to all the speakers and participants. This has been an amazingly rich day, actually for me it was an amazingly rich experience designing the day as well. The question of how to summarize all this discussion and make sense of it is next. There is no magic bullet, but a wonderful set of considerations to keep in mind, and it's across several dimensions. One dimension is how do the disciplines interact? How does engineering interact with social science and management science?

Bill Rouse

Closing Remarks – Overcoming Academy Silos: Another dimension, and Dr. Arthur been commenting on this – How does the Academy interact across our silos? We've got depths. We got many extremely competent and highly motivated people. However, maybe we need to re-engineer our dialogues, and Dr. Arthur is the perfect person to lead this. Given her undergraduate degree in engineering and her doctoral degree in the social and behavioral sciences. Making progress on socially conscious service system design and service systems engineering in the human-centered AI era requires a different dialogue than we have been having – and I appreciate the roots of all this from Dr. Spohrer and Dr. Maglio. When we started, I didn't know where we would end up, and I'm not sure you did either. However, it's been really amazing - the insights that have come out from today's initial discussion. It also strikes me that what we've heard from people are lots of opportunities. We haven't leveraged the opportunities because we didn't realize the pervasiveness of service systems. However, everyone agrees service systems are pervasive. I'm really looking forward to a chance to sit back with Drs. Spohrer, Maglio, and Madhavan, and whoever else is involved., How do we digest all this? And how do we propose what happens next? Dr. Madhavan supported this whole idea from the start, and so what closure do you want to propose today?

Closing Remarks
Guru Madhavan

Thanking Colleagues: Thanks Dr. Rouse. I just have a couple of points, but before I go further since we were talking about dealing with people interacting with people engaging with people, and we all know what a frustrating business that can sometime be, I want to thank and deeply acknowledge my colleague Durel West who has interacted with almost all of you while getting this day set up.

Complex Unifiable Systems: We created this program on complex, unifiable systems as a small project. Given the nature of my responsibilities, I go to a lot of meetings, and try to keep myself abreast of all the work that's happening across the National Academies. I have noticed complexity and fragmentation. For example, even if you take one of the most reductionists formulas - the standard cost benefit analysis and how it's pursued across the national academies, whether it's water planning or nuclear waste disposal or urban infrastructure planning, there are 50 different ways to do even cost benefit analysis. That is the degree of fragmentation that we face. That observation gave us the initial stimulus for me to propose to the council that we need a program such as this that brings together groups and works to integrate their approaches better. As I mentioned this morning, at least bring them together in an adjacent quarter, so we can make better sense off that diversity of pproaches to challenges of complex systems. That is why we started this journey. As some of you have even privately communicated through chats throughout the day, and it was a very meaningful day for me where I don't have any other commitments, and I'm sitting and learning from the insights you all provide. Also, I hope it was clear that we are taking a stronger approach than ever before linking engineering to the social sciences. Linking engineering only to technology and not sociology, is like saying that evolution is only gene based and not related to culture, or that economics is entirely about rationality and has nothing to do with behavior. I've written with Dr. John Anderson, NAE president, my boss, that engineering's past was a grounded in the industrial revolution, but engineering's future must be able to be a more inclusive evolution. So this is what's really guiding our approach. I am glad that we have collaborators and partners, and to use Dr. Marrett's words that we have Dr. Arthur as a partner at the NAE.

Societal Transitions: As a final meta-point, since we have all collectively been through COVID, I have been reading some medical history books. I came across a truly profound 1975 article, by Jonas Salk, who provided a visual metaphor to describe societal transitions. It's basically an s-shaped curve with two phases – Epoch A and Epoch B. The Epoch A beginning is where humans are more individualistic, independent, opportunistic, with a focus on short-term rewards. So, it's like an alternating sine wave the rising part of the curve. In Epoch B, humans are more collaborative, they're engaged, and they recognize the need for more interdependent pro social design and long-range thinking that is rooted in system support and systems engineering. Epoch A shows a great pension for efficiency. Epoch B is where resilience is favored. Epoch A is

just in time. Epoch B is just in case. To dodge disasters in Epoch B, we need to be proactive to prevent catastrophes. So you can see, and I believe that the service systems engineering as we have articulated, is right between Epoch A and Epoch B. Epoch b is in our hands. We must be ready to help the professional thinking around the subject because it is so crucial.

Next Steps: The next step includes creating a summary of what we have discussed here, and of course that's going to come up with a large list of things to do. But importantly, what this forum has done is preemptively solidify the relationship that the NAE will have with DBASSE. We have internal units that have long respected each other, with a long collaborative history, but now it's time to take an even strong approach going forward. There are many details to be discussed internally, of course, but as a kind of a public first step we could certainly publish a vision statement or a kind of a call for action and call to practice based on what we have discussed today and see what could be done. Perhaps there is a continued engagement opportunity within the National Academies. We have the new concept of action. collaborative where committees don't come, get together, go into a room and outcomes a report, and then nothing happens. After that, whereas an action collaborative approaches where meaningful participants meaningfully engage in these discussions and debates over period of time, let's say, over 3 year period have or team engagement on the subject that gives you the longevity and focus on a subject rather than a one-off kind of a task order based that contract driven project that one often sees in Washington, DC. There could be a joint program with DBASSE, and again I'm publicly thinking about this since we are in a collegial environment here. Those are possibilities that we could certainly construct within the academies. I will leave it at that, and I don't want to anything more without consulting my council, and so forth. What I'm suggesting is something that I am confident about, and these are doable pathways here. Again, thanks to every speaker who put in time and effort to participate in this in this forum today. Giving us many ideas, and the very few opportunities that exist for me to just sit and listen, and just jot down ideas and think and reflect. I appreciate this opportunity. and importantly for your time and expertise. We'll close out on that point.

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