



Joseph Sussman: Tracing implications of the development of new technologies

Joseph Sussman arrived at MIT for graduate school to contribute to fundamental changes occurring in engineering: the application of computers to engineering methods. Since arriving in Cambridge in 1964, he has witnessed how the field of civil and environmental engineering has grown and evolved.

After earning his Ph.D. in CEE in 1967, he joined the CEE faculty and was an active member of the department over his 50-year career, including serving as Department Head for five years.

Specializing in transportation systems, Sussman served as the inaugural JR East Professor and fostered a strong relationship between the East Japan Railway Company (JR East) and MIT. In addition to his faculty tenure in CEE, Sussman

also served as a Core Professor in the Institute for Data, Systems, and Society (IDSS).

CEE Professor Nigel Wilson recalls meeting Sussman during his first semester of graduate school at MIT, when Sussman was serving as a teaching assistant for a graduate computer class. “He impressed me from the outset with his dedication to MIT and his love of teaching and mentoring students,” Wilson said.

During his time as graduate student, Sussman recognized what he considers to be a key component to successful research and ideas: identifying the institutional and social aspects of implementing and deploying new systems and technologies. The recognition is a thread that followed Sussman throughout his career in CEE,



Sussman stands with 2014 R/HSR master's students after commencement.

even as his research interests expanded and evolved.

Addressing broader implications that emerge alongside the development of new technologies

Sussman applied his systems expertise to various projects throughout his career, including freight rail, intelligent transportation systems and market selection processes. Reflecting on his tenure at MIT, Sussman stressed the vital need for academics and researchers to understand both the technological and social implications of

solutions.

As a graduate student, Sussman worked on a project called Integrated Civil Engineering Systems (ICES). ICES was the brainchild of the late Professor Emeritus Charles Miller, who was head of CEE at the time. Sussman explains that ICES was Miller's "Vision for a big mega-computer system that would be applied to a variety of civil engineering applications." Under Professor Emeritus Daniel Roos, Sussman's work on ICES became the topic of his doctoral dissertation. It was also one of the earliest signs of needing to consider the institutional and social implications of technological advances. "The idea that the software had to work was important, but we also had to realize that the profession had to change. People in civil engineering practice, who hadn't been used to and probably weren't convinced of the efficacy of computers, were going to have to be convinced that they made sense," Sussman said. "We worked just as hard on getting people to accept the idea as we did on the software itself." ICES is generally accepted as having a profound effect on the practice of engineering in the early days of the computer revolution.

Sussman developed an interest in transportation systems as he finished his graduate degree and began his tenure as CEE faculty in the late 1960s. His first project as a faculty member was related to freight transportation, the use of railroads to move goods around the country. Specifically, Sussman analyzed service reliability, which had a "tremendous impact on the viability of railroads as they competed with the trucking industry much as they do today," he explained. Throughout this project, Sussman and his research team again acknowledged the need for broader institutional changes.

"We did a lot of fundamental research on how you could improve service reliability, and I think that had a substantial impact. The reason we were able to have an impact is we spent a lot of time thinking about how the institutions of railroading had to change," Sussman said. For example, in



Sussman and the 2016 R/HSR Masters students with their signed theses.

order to address issues of service reliability, the railroad industry had to consider the implications of scheduling changes on service reliability and modify the way the industry measured service. This research had a major effect on the railroad industry and the way it performed and was managed in the 1970s.

Sussman specialized in freight transportation through the 1970s, shifting gears in the 1980s to explore Intelligent Transportation Systems (ITS), the use of advanced technology to make transportation networks operate efficiently. While serving as the first Distinguished University Scholar at the Intelligent Transportation Society of America in 1991, he was a member of a small team that developed the first National Strategic Plan for ITS in the United States. This plan shaped the development of ITS for more than a decade. The ITS studies demonstrated how new technology can "provide capacity on our nation's highways and do it in such a way that it might obviate the need for building more highways,"

Sussman said. Although this solution seems like a feasible opportunity, Sussman again highlighted the need to look at the broader implications of suggesting such changes.

“We have to understand there are a lot of state departments of highways out there with people who have made their careers by building infrastructure, and all of the sudden to say, ‘well here’s a new way of providing infrastructure capacity through advanced technology,’ may not be something they are excited about,” he said.

Sussman was later inducted into the Intelligent Transportation Society of America Hall of Fame.

Research interests come “Full circle”

In 1991, Sussman refocused his research on rail systems and was awarded the inaugural JR East Professorship, an endowed chair that enabled the establishment of a long-standing and productive partnership between the East Japan Railway Company and MIT. With his previous experience in railway research, Sussman was well-prepared to expand his research from freight rail into passenger rail.

On March 2, 2017 Sussman was honored at a ceremony held to recognize the 25th anniversary of the JR East – MIT partnership. “The greatest honor in my professional career has been to serve as the first JR East Professor and for 25 years of my career,” Sussman said at the event. “I served, before my retirement, as an MIT professor for 50 years, so exactly half of my stay on the faculty was as JR East Professor. It’s something in which I take terrific pride.”

It was the beginning of the MIT – JR East partnership that became the foundation of what would eventually come to be Sussman’s Regional Transportation Planning and High-Speed Rail Research Group (R/HSR), an interdisciplinary cohort of students and researchers focused on

regional transportation and in particular, high-speed rail.

“We didn’t officially name the group until later on, but the genesis of getting involved in high speed rail and understanding the economic impacts on regional development stemmed from the fact that I was named JR East Professor,” Sussman explained.

The MIT – JR East partnership has benefited both organizations. Over the past 25 years, the partnership has allowed researchers from JR East to study at MIT, and for MIT students to pursue internships with JR East. R/HSR in particular has worked with JR East on numerous projects, ranging from safety of high speed rail to market



Sussman addresses the crowd at the 25th anniversary of the JR East-MIT partnership in March 2017. Sussman served as the JR East Professor for 25 years. Photo Credit: David Sella

selection processes.

When JR East began considering the expansion of its services and expertise outside of Japan, Sussman and R/HSR developed mathematical approaches for JR East to use when considering market selection. Sussman again emphasized that in addition to the technological approach to market selection processes, the researchers needed to acknowledge the institutional changes that would need to take place at JR East to implement the market selection process. “The technology, in this case methods to consider different markets that

JR East could go into, had to be supplemented by how the institutions inside JR East would have to change in order to take advantage of this new methodology.”

In addition to market selection, the R/HSR group also looks at areas of safety, on-time performance, economic development



Current R/HSR graduate students and local R/HSR alumni joined in the celebration of the 25th anniversary of the JR East-MIT partnership. Photo Credit: David Sella

opportunities and the creation of urban terminals. Students and researchers in R/HSR apply these different topics to various locations. For example, the group has looked at what the economic development opportunities would be surrounding a high speed rail system between Las Vegas and Los Angeles. Other studies completed have looked at the Northeast Corridor and international rail systems.

The R/HSR group was also very active in Portugal as part of the MIT-Portugal Program (MPP). Sussman was the first director of the transportation sector of MPP that studied high speed rail, among other transport applications. Through his leadership of R/HSR and fostering the JR East – MIT relationship, Sussman has mentored hundreds of students over his career. Continuing the theme of interdisciplinary thinking and considering institutional challenges, Sussman has instilled in his mentees the value of

thinking beyond the technological solution and to look at the wider context.

“As their mentor I would generally try to give them a broad mandate to consider not only the narrow questions, be it narrow economic questions or narrow technology questions or narrow safety questions. I urge them to look more broadly at other aspects of the problem because that would generally lead to much richer kinds of solutions.” For Joanna Moody, a graduate student in R/HSR and mentee of Sussman, this interdisciplinary approach has proved valuable. “It really broadens your perspective and your problem solving skills in any context,” Moody said. “It pushes you to ask difficult questions and to think about how your research connects with research and practice in other domains.”

Over the past 15 years, Sussman also led multiple generations of graduate students in the development of Complex, Large-Scale, Integrated, Open, Socio-Technical (CLIOS) Systems and the CLIOS Process, a theoretical framework that can be applied to complex systems. R/HSR used the CLIOS Process in creating the JR East market selection process.

“When we have interesting applications, we try to use the CLIOS Process to understand deeply how those systems work,” Sussman said. The CLIOS process integrates methods and information from various domains to help researchers analyze complex systems. The CLIOS Process has also been applied to complex systems including Intelligent Transportation Systems, wind energy (Cape Wind), air defense and the introduction of broadband access in Kenya.

Sussman arrived at MIT to study systems and the application of computer systems on the civil and environmental engineering discipline. Although his research evolved from systems to transportation

systems, the CLIOS Process was a return to his original research interest. Sussman developed the CLIOS Process “to study all sorts of complex systems, and not just transportation systems,” which he describes as bringing his research evolution “full circle.”

Maintaining a “Deep commitment to students”

In addition to a rich history of research experience, Sussman has also been an active CEE community member. He cites Research Speed Dating, CEE’s annual research showcase, as his favorite community event to attend.

“It’s such a nice way of getting the community together, getting presentations by faculty and by students. It’s just a very nice event and it’s grown very nicely over the years,” he said. “Any event that has that kind of community flavor, with faculty, research staff and students, is going to be something I’m going to support.”

Sussman also served as Head of CEE from 1980 to 1985. Over this five-year period, Sussman applied his belief in the value of interdisciplinary approaches to solving major engineering issues to disciplines beyond transportation and systems, particularly through faculty hires.

“Joe has been a tremendous colleague and leader in CEE, and his career has inspired many students and faculty. The department has benefitted in many ways from Joe’s exceptional contributions in research, education and service, including his tenure as CEE Department Head in the 1980s” said Markus Buehler, CEE Department Head and McAfee Professor of Engineering.

“What I find most inspiring is Joe’s deep commitment to students, and he would rarely miss any department event that offers an opportunity to build the community and make us stronger together. I am deeply thankful for the opportunity

of having Joe as a mentor, and learned a lot from him.”

Sussman has also made a significant impression on his students. “Joe treats his students as intellectual equals and encourages them to come up with their own ideas and to think about things from different perspectives. He really cares about research and getting good results, but he also cares about each student individually and what they want to get out of their research and time at MIT,” Moody said. “He has high expectations, but he helps you to meet them. He’s always very encouraging.”

Sussman himself was motivated by his own teachers to get a PhD and pursue a career in



Tako Nishiyama, executive director of JR East, exchanges gifts with Professor Joseph Sussman at the 25th anniversary of the MIT – JR East partnership. Photo Credit: David Sella

academia. “I had such positive experiences in my own studies and was inspired by so many professors, I felt that this had to be a very fulfilling way of spending one’s career,” he said. “I wanted to advance knowledge and that implied doing research. I wanted to give back to the community by teaching young people what I knew, and how to think more broadly in an interdisciplinary way.”