

**U.S Senate Committee on Commerce, Science and
Transportation**

Leveraging the U.S. Science and Technology Enterprise

**Expert Testimony by
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Good afternoon Mr. Chairman, Ranking Member, and members of the Committee. Thank you for inviting me to speak with you today about topics to help ensure American competitiveness and global leadership in innovation. I currently am the Dean of Engineering at the University of Michigan, Ann Arbor, and am a Professor in the Department of Electrical Engineering and Computer Science. I am also the co-founder of InstaRecon, a start-up that has developed and commercialized patented and patent-pending algorithms that reconstruct images from 2D and 3D tomographic, or CT, data 20 to 100 times faster than conventional methods for typical image sizes.

I would like to talk to you today about a range of topics critical to the higher education research enterprise. At its core, the U.S. investment in and commitment to research should be considered a strategic national asset and treasure.

First, I would like to start with the talent pipeline for STEM (Science, Technology, Engineering and Math). In order to continue to be the innovation leader that we are today, it is vital that our STEM population be sufficiently large and especially well educated. Both the size of the population and the quality of education should draw on the rich diversity of our nation. Talent knows no boundaries; there are exceptional people throughout all demographics in the country. We know that opportunity does not present itself to everyone in equal measure to all that are deserving and capable. We must continue to address this issue, and expand our efforts to engage the future scientists and engineers of our nation. Programs such as FIRST Robotics provide a vital link between fun and interesting engineering projects and the STEM

disciplines that K-12 students are studying in school. Expanding efforts in education to provide students with context and relevance opens doors and is critical to our future. The opportunity to grow a more diverse STEM population relies on our ability to provide a broader range of students with an answer to the “so what” question when participating in STEM classes – students need to better understand why they should care about success in STEM disciplines during their K-12 studies.

Today, there exists a huge range of discrete investments aimed at addressing this challenge. The scale of this problem, however, is immense. Discrete investments are helpful, but such a pressing national issue would benefit from a more coordinated approach. As a nation, we should contemplate unified programs that will enable the challenge to be tackled more broadly, leveraging best practices and creating integrated partnerships between government, industry, and academia. Everyone wins if our nation’s STEM pool is more robust and diverse. A national network, utilizing a

public/private partnership, could be contemplated to address this issue at scale. With such a network, federally funded programs that currently have discrete “pipeline development” and/or “workforce development” programs could integrate into an existing national infrastructure, with each program playing a well defined and coordinated role, thereby producing a broader impact and reach. This would build on elements of the current model where individual programs have created independent solutions with limited scope and no ability to scale.

In reflecting on the capability of programs to have measureable impact, I believe there is some consensus about what works, and on key indicators that can be measured to make sure that programs are on track. The missing elements in this equation are the ability to share best practices across the nation and to decide which organizations will tackle the big pieces and do so at scale. Of course, operating at scale will also require resources to assure the desired impact.

Demand for engineering and computer science graduates has greatly accelerated at the University of Michigan. I am hearing the same from peer institutions. Talent provides the ultimate competitive advantage. As the world becomes smaller and smaller through technology, and the labor cost differential between geographic regions narrows, talent will be *the* differentiating factor in economic competitiveness. Environments that can best develop their talent will have a significant competitive advantage in attracting and retaining cutting-edge industry.

American higher education still has no peer in the development of talent, although other nations are catching up in some ways. Our main competitive edge remains in the area of creativity and innovation. American society fosters an out-of-the-box, unencumbered spirit, where nearly anything is deemed to be possible. This is exactly the mentality that creates a robust STEM pipeline for the conduct of high-impact federally funded research.

And, in turn, Federal research dollars facilitate the education and training of an especially creative STEM workforce. Research, in many ways, is a creative process, with outcomes that are impossible to predict. Research has led us to a wide-range of stunning discoveries and inventions, whether it was the cure to a disease or the invention of the Internet. The Federal Government has and needs to continue to play the key role in enabling the creative research process through funding fundamental research.

That said, it is important to also have a suite of programs that create strong links to industry and federal customers (such as Department of Defense). These partners bring important research issues to academia in a variety of application areas. The National Network of Manufacturing Institutes (NNMI) is an excellent example of such a program, bringing a diverse group of institutions together to identify, research and then implement solutions which are critical to advancing a domain of national strategic importance - manufacturing.

Historically, it has been a challenge to reach a level of trust with industry research partners sufficient to permit sharing of proprietary ideas, which can enable progress on topics that really matter. “Trusted conversations” are essential to enabling research and allowing researchers to have impact. Engaging in these conversations requires striking a balance between openness and a collaborative spirit and assuring that competitive advantage is not compromised. The University of Michigan has been successful in managing this tradeoff by investing time and effort in creating strong links with industry partners that are outcome oriented.

Trust is an essential ingredient in these public-private partnerships as evidenced in the ongoing research program of the University of Michigan Mobility Transformation Center, which has a consortium of more than 60 companies that are supplementing Federal and State of Michigan research dollars in the area of connected and autonomous transportation.

Research impact is translated through the innovation ecosystem. This ecosystem is complex, requiring multiple partners to play a range of roles. The early phase of innovation is basic or fundamental research, a domain dominated by academic institutions and enabled by the resources and policies created primarily by the Federal Government. Moving to the applied realm, there is a wide playing field, where academia, industry and government must partner to support translational research with an eye toward desired outcomes. Again, at this stage, Federal resources and policies are important enablers, with industry and angel investors also key at this stage of the innovation cycle. The Federal SBIR program is a vitally important vehicle for supporting translational research. Moving into the “final” phase (development and deployment/implementation), the customer, be it industry or the Federal Government, is the lead player, sometimes with the support of venture capital. Also, the Federal Government often plays an important policy role, especially with intellectual property, in appropriately enabling innovations to move forward.

In thinking about the innovation ecosystem, programs such as the NSF ICorps, are having a tremendous impact. Similar to STEM pipeline programs, ICorps is an important enabler and eye-opener for faculty and (often) graduate students. On Day 1 of the ICorp program, start-up teams are confronted with the importance of the marketplace, when teams are required to contact dozens of possible customers and receive their feedback. From personal experience, I can report that the start-up process is grueling. The “ideal” technology with no market simply has no value. Fortunately, with positive role models and the encouragement and support of university and regional entrepreneurial ecosystems, the results can be amazing. The required passion and energy flows from the strong desire of our faculty and students to make a positive impact on the world. It is our job to enable and support their success through programs and policies.

Probably the greatest inefficiency in the Federal research system is caused by the low funding rates of many agencies. For example, at NSF fraction of research proposals funded has slipped to 20%.

This means that faculty members are spending a huge fraction of their time writing proposals and also reviewing proposals of their colleagues, with the high probability that these proposals will not be funded. It is my experience, from 37 years in academia, that about one out of three research proposals is truly excellent and easily merits funding. To provide a funding rate consistent with this statistic, one might assume that it would be necessary to increase the annual NSF budget by over 50% (to move from a funding rate of 20% to about 33%). However, a smaller, but still significant, increase might buy much more than is apparent. One reason the NSF and other government agencies receive so many proposals is because the probability of funding is so low. When a proposal is not funded, the faculty member typically reworks the proposal and then resubmits it, or else creates a proposal on a different topic. This proliferation of research proposals is bogging

down the system, causing a waste of time and resources, and is part of the reason for low funding rates. In a sense we are running the research system at an inefficient operating point. In my opinion, it would be far more effective to fund the research agencies at a somewhat higher level, driving down the number of research proposals that are written and reviewed, in which case funding rates would rise and researchers would spend far more of their time actually doing research.

The U.S. research enterprise has been and must continue to be a strategic national asset. As we look to the future, the nation will be well served by major research investments in selected areas supporting economic competitiveness and national security. The European Union has followed this path for years, sometimes taking a “moon-shot” approach. Likewise, the U.S. military has pursued an “offset strategy,” when appropriate. The NNMI program, which is a large targeted investment, may prove to be a good

example of a strategic innovation investment to foster U.S. competitiveness in the global economy.

In closing, today's engineering students and faculty share a heartfelt passion to make a difference. Our faculty provide students with a firm grounding in fundamentals, and also with the ability to learn, adapt and create as they move through their careers. We must provide our faculty and students with the resources needed to explore and innovate. The nation will be the beneficiary. Federal programs and policies are critical in this regard.

