Statement of
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Chairwoman Johnson, Ranking Member Lucas, and members of the committee — thank you for inviting me to address the topic of U.S. competitiveness with a focus on critical technologies and their economic and security implications from the vantage point of a research university.

As you just heard, I am the executive vice president for Research at Georgia Tech, one of the leading research universities in the world, and a public one at that. Prior to returning to Georgia Tech, I was provost, and for a brief period of time, president, of the University of New Mexico, another public research university. I stress the public mission of my current and previous institutions because of the significant role such institutions play in postsecondary education and in research and innovation — and the importance of federal and public investments in their mission. Public institutions educate 74% of college-age students in the U.S. and conduct about two-thirds of all university-based research, and are critical in educating and diversifying the future workforce.

Beyond being a proud public institution, Georgia Tech is unusual among research universities in one other aspect, namely the presence of the Georgia Tech Research Institute (GTRI), the Institute's applied research division. GTRI is comprised of more than 2,000 scientists, engineers, support professionals, and students who help solve the most difficult problems facing government and industry across the nation and around the world. Notably, GTRI is also an Army University Affiliated Research Center (UARC), through which we provide substantial advanced science and technology expertise in support of multiple national security customers across the federal enterprise.

Let me first quickly frame the history and current state of the U.S. research and development (R&D) enterprise in relation to other nations. Until recently, most observers would have agreed with past assessments that the U.S. was the "undisputed leader" in science and technology funding and applications. Instead, as reported in the National Science Board (NSB)'s "The State of U.S. Science and Engineering 2020" report released earlier this month, "increasingly the United States is seen globally as an important leader rather than the uncontested leader."

The modern U.S. research enterprise was born out of the foresight and wisdom of political and scientific leaders who called for direct government support for science, and made the case for the creation of a national research strategy and the National Science Foundation 70 years ago. The model they established has served us well, and has been emulated in other countries. It stresses the important role of the federal government in funding independent research at universities, and the responsibility of those universities to work on the problems that improve the well-being of the citizenry, as well as the human condition. Later policies such as the Bayh-Dole Act have entrusted universities with intellectual property funded by the taxpayers, and encouraged them to work with the private sector to bring such intellectual property to market. The federal dollar is usually the first dollar in the chain, and is converted by universities into basic knowledge and talent, feeding businesses and leading to solutions, technologies, and products that generate returns back into the federal treasury and benefits to society.

The federal government, through its unique network of national laboratories and agencies such as NSF, NIH, NASA, DARPA and others, has also maintained a complementary but key role in supporting and guiding long- and medium-term research. Industry and business investments in R&D continue to ebb and flow, but in 2000, they surpassed the amount invested by the federal government. It is however the mission alignment and cooperation of the three actors — the federal government, higher education institutions, and the private sector — that has historically made the U.S. research landscape the most productive and admired in the world.

As an example, investments by private entities such as Bell Laboratories laid the groundwork for the communication and electronics industries, and NSF's federal investments in basic research at universities led to the creation of many successful high-tech companies. The system continues to work well, and we are all beneficiaries of the policies and investments made by earlier generations of leaders and researchers. Moreover, the dynamism and long-term certainty as well as the openness of the U.S. research model has served as a powerful attractor for global talent, and a birthplace of innovative ideas and industries.

Today, however, the once undisputed power of our model is being challenged. While we remain leaders in most critical areas, various friends and foes, have quickly closed the gap. If current trends continue, some will pull ahead of us in the near future. In fields such as quantum information science and technology and artificial intelligence, countries other than the U.S. are already ahead. As the aforementioned NSB report also states, the U.S. continues to lead globally in R&D expenditures, in the production of science and technology (S&T) doctorates, and in producing highly cited research publications, but other nations, namely China, are rapidly increasing their investments and developing their own science and engineering capacity. In other words, while we currently remain at the head of the pack, leading indicators such as S&T first degrees (associate and bachelors) and number of patents paint a worrisome picture about our future position in many important areas.

These important areas include critical technologies such as artificial intelligence, cybersecurity, next generation wireless, quantum information systems, advanced manufacturing and materials, bioscience and engineering, and many others. It is important to keep in mind, however, that what is now a critical technology was once a basic science research idea, or likely fundamental research funded by the federal government at a research university. For example, quantum information systems are direct descendants of quantum mechanics theory while artificial intelligence algorithms and products were, until recently, theoretical mathematical results.

The key role such critical technologies play in our national security is clear. Achieving quantum supremacy, for example, will affect current encryption systems, and materials that may be designed using machine learning are needed in achieving hypersonic flight. As you know, the economic impact of falling behind in such areas is significant. I believe that it will manifest itself in the following ways:

1) **A reduction in our ability to create new industries and the resulting impact on our economic health and competitiveness.** As I mentioned earlier, many of our current businesses are trees that grew from the seeds of past federal investments, and most were not anticipated by their original creators. Knowledge is being created everywhere and is traveling ever faster and farther — and, unlike physical resources, knowledge is not depleted when used. The best job creation and economic development strategy remains an investment in creating such knowledge and the pipeline to transform that knowledge into complex products in critical technologies and beyond. In failing to do so, we risk becoming a country that imports more advanced finished products. This has already manifested itself in areas such as solar cells and various computer components. It has also lessened our competitiveness in future growth areas such as clean energy products.

2) **A costly game of playing catch-up.** The rate of knowledge acquisition and propagation keeps accelerating, and once we fall behind, catching up becomes costlier than keeping our lead. Today, China's annual R&D growth rate is 18%. By contrast, the growth rate in the U.S. is around 4%. If and when China does surpass the U.S., we would need to further accelerate our own spending in order to remain competitive. It is also notable that the quality and impact of research produced by China are increasing along with its quantity.

3) **A dwindling attractiveness to the best and brightest minds from around the world**. Ultimately, talent and creativity are very dynamic and movable. Witness, for example, how certain regions of our country have become hubs of innovation and are attracting the highest quality talent from around the nation and the world. The same phenomenon is happening at the global level, at much higher stakes for our national and economic security. If we do not remain at the forefront of innovation, our appeal to talent is lessened, which further compounds the negative consequences I've just described.

While there are many actions that our nation is taking and can take in order to reverse the trend, I believe the following four are the most impactful:

1) **A commitment to the long-term increase and certainty in federal investment.** The research enterprise, while used to foster big ideas and big bets, needs the certainty of long-term planning and funding. Our funding agencies already realize that and fund multiyear programs and large centers, but government shutdowns and sequesters — as well as the disruptions of predictable funding sources that result from abrupt policy reversals — can have a rippling effect for universities such as Georgia Tech. This is especially risky as long-term commitment to researchers and research infrastructure becomes uncertain.

   Federal investment must continue to flow steadily in order to continue priming the pumps of the research enterprise, and to maintain a predictable and increasing flow of talent and ideas. Federal funds often play multiple roles: They help recruit, educate, and retain top talent, support research facilities, and create intellectual property that leads to new markets and enterprises. At Georgia Tech, for example, we have leveraged federal research funds, along with state and industry support, to create a vibrant entrepreneurship culture and innovation centers. Such activities have served to attract students as well as a new generation of researchers and entrepreneurs. Increasing and maintaining funding to agencies such as NSF, NIST, NOAA, Office of Science, ARPA-E and others, also sends positive signals to the greater research enterprise, encouraging students to pursue S&T studies, and companies to invest in their own R&D.

2) **A reduction in bureaucratic burdens on conducting research.** I commend Dr. Kelvin Droegemeier, the director of the Office of Science and Technology Policy (OSTP) for making this issue one of his top priorities. While it is true that industry R&D expenditures currently exceed those of the federal government overall, it is also true that the second largest portion of the R&D funds expensed at universities comes from internal university resources. A large portion of those expenditures are required to safeguard the quality and integrity of research, but as indicated by the OSTP, some requirements are duplicative and need to be streamlined. Legitimate concerns around research rigor, integrity, replication, and data sharing are highlighted in the OSTP request for information on the American research environment. While the research administrative and security costs are increasing, policies that help align compliance requirements and reporting will redirect precious human and financial resources toward the actual research and critical safeguards.

3) **A commitment to cooperate where we should and compete where we must.** We must absolutely protect what must be protected, as evidenced by recent reports on undue foreign influence. Today's science is like today's problems — global — and our interconnectedness, both physical and virtual, has made us stronger yet interdependent. For example, the ability to share data allows us to inform each other of an upcoming natural or manmade disaster, but it also allows bad actors to remotely attack our infrastructure. Data collected and shared by businesses and governments is the fuel needed by artificial intelligence systems to make business decisions, or create personalized medical treatments.

   Sharing such data when appropriate increases its value and impact. It is vital that we collaborate to solve the big problems facing humanity, and to share our solutions as widely as possible when appropriate. Specifically, it is important that we increase our cooperation with allies who share our values in pursuit of technical and policy solutions to solve global problems, and to safeguard the resulting technologies. In light of the fact that other nations may actually be ahead in some critical scientific areas, cooperating with our allies has a multiplicative positive effect.

   On the other hand, we must become even more vigilant in protecting what must be protected. Recent reports such as the NSF-funded JASON report titled "Fundamental Research Security" highlighted a concerted effort to leverage our open research environment to gain an economic advantage. Leaders of other countries are copying our nation's economic development playbook, and the stakes of that competition have never been higher for the U.S. More countries are also attracting their own students back — and recruiting American graduates and researchers as well. This is evident, in part, by the emergence of a competitive Chinese science system. Recent guidance by federal agencies is helping universities define and clarify how to protect sensitive yet unclassified information, and universities are engaged in efforts to make sure that conflicts of interests and commitments, whenever they arise, are properly managed. These are especially important around critical technologies, where the underlying research may not only be sensitive, but where the application of basic research, or the interconnection between various fields may create a serious risk to our national and economic security. I believe that Congress and government agencies play the most critical role in helping us increase cooperation with our collaborators, and matching the efforts of our competitors.

4) **Increased efforts to attract and retain a more diverse population into STEM.** There are international and national aspects to this strategy. We must regain our role as the strongest magnet for talent and creativity from around the world. The benefits of such a policy have already manifested themselves in the notable impact of foreign-born scientists, engineers, and entrepreneurs. It also seems obvious that such individuals, many of whom, like myself, were initially educated under a different educational system and funded by the resources of another country, bring with them a different way of thinking, learning, and problem-solving. Those unique perspectives, when coupled with our open research system and our American values, lead to a dynamic and healthy R&D enterprise.

   The demographic trends of the U.S. are also conspiring to reduce the number of U.S.-born, college-age students and graduates, furthering the need to attract international students and researchers. There also exists, however, a national and moral imperative to attract more U.S. students into higher education and, more specifically, to attract women and underrepresented minorities into STEM. The benefits of their diverse backgrounds and experiences are already felt in laboratories and companies, and the growth opportunity in such populations is obvious. That rich and diverse pool of candidates must be increased, prepared, and nurtured in the K-12 system. The best opportunity and most enduring strategy for improving our S&T position is obviously to nurture and engage a larger number from untapped domestic populations, and to provide an academic environment for them to strive and succeed as students, faculty, and researchers. My colleague, the dean of the College of Computing at Georgia Tech, remarks that it is one thing to be in front of someone and not be seen, but quite another to not be in front of someone and to never have your absence noticed. The absence of large portions of our citizens within the S&T enterprise is definitely being noticed and felt.

As I noted earlier, the cooperation between our federal government, our universities, and industry, has created a vibrant research enterprise and made the U.S. safer, healthier, and wealthier. The economic and social benefits of that system, however, have not been evenly distributed. As described in a recent op-ed by the president of the National Academy of Sciences and the president of Arizona State University, current and future challenges will require the participation of all segments of our population. The special role of American research universities in helping to create and govern critical technologies, is leading them to become more proactive in recruiting and nurturing more diverse students. At Georgia Tech, for example, the "Focus" program is in its 26th year and has already encouraged more than 2,500 students from underrepresented populations to pursue graduate degrees, awarding fellowships to many of them and leading many of them to become university professors.

For most of their modern existence, universities have evolved steadily but slowly. The quickening pace of societal and technological change, however, also necessitates a re-examination of how universities are organized and how research is being conducted and rewarded. Universities must assume their own responsibility to be ready for the students they admit, as well as to admit college-ready students. We must continue to increase our efforts with K-12 schools to widen and diversify the pipeline of students and to embrace our role as economic engines. Universities that have better engaged with their communities, both in preparing their incoming students and in translating their research into practice, are also moving to measure and reward student success and economic development activities, in addition to the more traditional metrics of education and research. The complexity of current research challenges is also driving universities and funding agencies to knock down disciplinary boundaries and to move toward convergence research. Such research cries out for creative approaches, best achieved by assembling diverse and multidisciplinary teams. For example, at Georgia Tech, we organized our research efforts around interdisciplinary research institutes, and built educational programs across departments and colleges. We also established educational programs such as CREATE-X, Vertically Integrated Projects (VIP), and competitions such as the InVenture Prize to better prepare graduates for the fast pace of business.

I would like to end with a comment on the need for educating the whole person, rather than focusing solely on the very critical areas we discussed today. While I welcomed the opportunity to advocate for increasing support for critical technologies, we should not lose sight of the disruptive (mostly positive, but sometimes negative) effects such technologies can have on our society. We are keenly aware, for example, that AI technologies have ethical dimensions and employment implications for a large segment of our workforce. Such implications will affect the distribution of knowledge and wealth within and between countries, and must be accounted for by educators and policymakers alike.

Earlier this month, we celebrated the life of Martin Luther King Jr. In one of his writings, he discussed the purpose of education and wrote, "The purpose of education, therefore, is to teach one to think intensively and to think critically. But education which stops with efficiency may prove the greatest menace to society. The most dangerous criminal may be the man gifted with reason, but with no morals." A diverse workforce educated in civics and the humanities, in addition to STEM, will be best prepared to help create and manage future technologies. It is thus incumbent upon universities to provide an education that emphasizes the public purpose and implications of technology, a role that public and private universities have embraced. And as a nation, we must continue to make sure that as we invest in our critical technologies, that we also invest in ourselves.
