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Chairman Rubio, Ranking Member Cardin, distinguished Committee Members—thank you for the opportunity to appear before you today to discuss issues of critical importance to American economic competitiveness: the Small Business Innovative Research (SBIR) program.

My name is Sridhar Kota, and I am the Founder and CEO of a small business, FlexSys Inc. founded 18 years ago in Ann Arbor, Michigan with an SBIR Phase II project. I am also the Herrick Professor of Engineering at the University of Michigan and a professor of mechanical engineering for over 31 yrs. For the past 4 years, I have served as the founding executive director of a national consortium (think and do tank) called MForesight: The Alliance for Manufacturing Foresight, with a singular focus on technology innovation to drive U.S. manufacturing competitiveness. I have been involved in technology policy at the national level for the past 10 years including a 3-year tenure at the White House as the Assistant Director for Advanced Manufacturing.

The SBIR program is one of the crown jewels of our federal investments in Science, Engineering and Technology. The SBIR program is often the first source of funds for an informed entrepreneur to demonstrate a working prototype and attract private investment. It helps mature Technology Readiness Levels beyond TRL-3 (basic research) and fuels entrepreneurship and growth.

My company, FlexSys Inc., has received multiple SBIR Phase I, II and III contracts from the Air Force, Army, NASA, and NSF. Through a Phase II and III Air Force SBIR, we developed the technology to morph the shape of an aircraft wing in flight, eliminating drag producing flaps, and successfully demonstrated significant fuel savings and noise reduction through 3-yrs of rigorous flight testing conducted in collaboration with the Air Force and NASA. The Air Force and NASA invested nearly $70 million on this project and we also received an SBIR Tibbetts award. We are currently working with the Air Force to retrofit military transport vehicles with our technology to yield hundreds of millions of dollars' worth of fuel savings per year on a single fleet alone.

My company's technology would not have been possible without SBIR funding and sustained investment by the Air Force. Once proven through flight testing, the private sector invested nearly $5 million in our shape-morphing technology and we have made important strides in other commercial applications. Since the goals of this project are well aligned with the broader goals of the Air Force, the agency was able to provide sustained funding on a path from research to development to demonstration to deployment.

Not all SBIR projects, even within my company, benefit from such sustained investment like the Air Force shape-morphing wing project. Although SBIR provides critical initial investment

needed to demonstrate the technology to make a working prototype, the follow-on funding to scale manufacturing is usually very difficult to attract in the U.S. Making a one-off prototype is not the same as manufacturing at-scale. Sustained investment is needed for process innovations to mature manufacturing readiness and sufficiently reduce the technical and market risk. The vast majority of venture capital funding in the U.S is devoted to software and biotech with less than 4% invested in hardware start-ups. Foreign investors at times are ready to provide the patient capital for promising technologies demonstrated through SBIR programs and invest in further development but commercial-scale production is done overseas.

This problem—commercial-scale production offshore of technology developed here—is significant and growing, and cannot be successfully addressed by SBIR programs alone. Through decades of offshoring manufacturing the nation has eroded our ability to manufacture new advanced technology products to create national wealth from our investments in R&D. As more and more production has moved offshore, companies have found that the necessary suppliers and, more importantly, the technical know-how to develop new products and processes has migrated, too, because it is best done where the factories are. The longstanding strategy of "Invent here, manufacture there" is fast becoming "invent there, manufacture there" – a dangerous trend for a developed country. Our taxpayer-funded R&D is essentially subsidizing foreign countries that are able to create jobs and wealth from American inventions.

Thanks to federal government investments in basic research, the United States still leads the world across a broad spectrum of discoveries including drug discoveries, publications and citations. Being the best in the world in science is important—but it's not sufficient to ensure success. Investments in basic research (science) generate knowledge – scientific discoveries and engineering inventions. Innovation, both technological and business, is about transforming a promising discovery or an invention, through world-class engineering, into a new product or process that meets societal needs. Investments in translational research (engineering) generate engineering methods and manufacturing know-how that are essential to create national wealth and security. Unless we make large and sustained investments in translational R&D, we will continue to offshore innovation and manufacturing. The SBIR program is one of the few programs that invests in translational R&D but it is not sufficient to capture or retain promising technologies to yield desired returns to the nation.

Market Failures in Translational R&D

Restoring U.S. manufacturing leadership and, perhaps more importantly, restoring the nation's ability to capture wealth from the national innovation system with a robust manufacturing base, is a challenge to both the private and public sectors. With its focus on short-term profit maximization, the private sector will continue to offshore manufacturing and R&D if it yields immediate private benefits – and it does. But in manufacturing, societal benefits in the form of national wealth, jobs, and national security far exceed private benefits and, therefore, government has a critical role to play. For instance, the manufacturing sector offers a wide range of job opportunities from blue-collar production workers and supervisors to white collar R&D, design and manufacturing engineers, accountants, business managers, etc. In 2017, the

average U.S. manufacturing worker earned $84,832 in pay and benefits, 27% more than the average worker in non-farm industries.

The United States is the only developed country without a strategy on how to leverage investments in basic research and the resulting scientific discoveries and engineering inventions to create jobs, wealth and national security. According to OECD 2016 data, of the U.S. federal R&D budget of $149 billion, only 0.052% ($773 million) was spent on "Industrial Production and Technology", whereas Germany spent $4.34 billion. That is six times the amount the U.S spends on translational R&D (Industrial Production and Technology); Japan and S. Korea spend three times and eight times more respectively.

Japan, Germany, and S. Korea have maintained trade surpluses in advanced manufacturing, are well ahead of the United States in their use of industrial robots, and have a greater share of high-technology production in their manufacturing sectors. These countries are not low-wage countries (wages in Germany are 40% higher than the U.S) and their energy costs and pollution abatement costs are higher. Yet, they are competing successfully in global markets. In 2017, the U.S had a $796 billion trade deficit in goods, whereas Germany, Japan and S, Korea had trade surpluses of $290 billion, $25 billion and $85 billion respectively.

America's private sector, driven by quarterly profit reporting and other short-term considerations, has little appetite for long-term investments in translational R&D needed to mature nascent but promising ideas resulting from taxpayer-funded basic research. Large companies, once reliable sources of corporate R&D to mature new products and processes in this country, no longer have large research budgets and increasingly do their new product development where their factories are—offshore. Most U.S. headquartered original equipment manufacturers (OEMs) derive well over 50% of their revenue from foreign sales – Apple (65%), HP (61.5%), GE (55%), IBM (53%), Caterpillar (54%). These companies employ more than half of their total work force outside the U.S. (J&J -73%, P&G - 73%) and have more than half of their corporate assets outside the U.S. Their corporate interests simply do not align with U.S. national interests to generate wealth and national security from taxpayer-funded R&D.

Start-ups and small and medium-sized manufacturers (SMMs) are the backbone of our manufacturing sector comprising nearly 98% of all manufacturing firms. These firms are often innovative but lack resources to invest in R&D. Unlike multi-national OEMs, these companies prefer to stay in this country. The Small Business Administration already plays a critical role to support these SMMs through SBIR and other programs to strengthen our manufacturing sector.

SBIR and National Innovation

The motivation for federal investment of taxpayer dollars in R&D is to benefit American taxpayers by creating jobs from new products manufactured and scaled in the United States. The return on investment could be realized in different forms – creation of national wealth, ensuring national security by giving our military a technological edge, enhancing health outcomes, or leading the world in energy production. Much of the approximately $150 billion

spent annually on science and technology (S&T) creates knowledge through much needed basic research. The SBIR share of 3.2% is one of the few investments the federal government makes to transition that knowledge into national wealth and/or security. Increasing the SBIR share from the initial 2.5% to 3.2% was a positive step in bridging the gap between creating knowledge and obtaining a return on investment.

We need a national strategy on how to nurture our best ideas domestically. The federal government has a critical role to play by investing in translational R&D to leverage promising results from basic research. This is especially true when societal benefits far exceed private sector benefits. Market forces alone will not bridge this gap in our innovation cycle.

To avoid giving away our best ideas and technologies to foreign competitors, we must bolster the SBIR program in three ways:

1. Agencies should target SBIR projects that are on their technology road-map with an eye towards tangible outcomes rather than a curiosity-driven research project. This ensures that if and when the Phase II project is successfully carried out, the agency will be motivated to take it to the next step rather than leaving the small business to find investors on its own.
2. A separate set of funds, DoD's Rapid Innovation Fund for example, should be identified for successful SBIR projects to mature manufacturing readiness and to further de-risk the technology.
3. The federal government should enact strict guidelines on intellectual property (IP) generated from SBIR projects to ensure that it is scaled only in the U.S. SBIR awardees should be allowed to license the technology to any firm, domestic or foreign, as long as the technology is manufactured at scale only in the U.S. This would not be a burdensome or unreasonable regulation since the taxpayers who funded the research are entitled to a return. Otherwise our taxpayer-funded R&D will continue to be an unintended subsidy for technology used and products produced in other countries. Currently, the SBIR program does an outstanding job in protecting the small business IP from large companies. But once the SBIR project is completed that protection disappears.

Finally, I would like to suggest a few minor changes to the program to make it even more effective.

1. SBIR contracts should allow patent expenses. Otherwise, it is very difficult for a starting entrepreneurial business to protect its IP.
2. Agencies should be granted flexibility to increase the size of the Phase I, II or III awards if the subject technology development merits the increase.
3. The Company Commercialization report instituted by the SBIR program as a score card is an important instrument to assess how effectively a small business contractor is leveraging SBIR funds to attract private investment. Consider establishing a similar score

card for the agencies to assess how effectively they are utilizing taxpayer dollars in shepherding promising technologies to scale domestically.

4. The contracting process for some agencies is very arduous and expensive. We need standardized "SBIR 1040EZ" forms and procedures across all participating agencies.
5. To help ensure long-term return on investment, small manufacturing recipients of SBIR funding should have preferred access to other SBA loans and investment funds. This would help to provide the patient capital needed to scale production in the U.S.
6. Phase II and Phase III contracts should have some flexibility to allow for mutually-agreed upon meaningful and effective changes to the Statement of Work after the contract is issued.
7. Mission-oriented agencies solicit proposals on topics specific to their mission. NSF, on the other hand, solicits proposals on any topic within a broader category of energy, health care, advanced materials etc. Such broader solicitations accommodate a wide range of discoveries and inventions resulting from nearly $150 billion invested annually in S&T. Additional funding for such SBIR solicitations could offer a pathway from research to ROI.
8. SBIR projects are usually managed by a technical program manager in most, if not all, mission-oriented agencies. However, NSF employed several experts with entrepreneurial and engineering expertise to guide its SBIR awardees on effective paths to reduce technical and market risk and to promote entrepreneurship. Other agencies could follow NSF's lead by employing a cadre of such experts to guide the awardees towards successful outcomes.

In conclusion, based on over two decades of my personal experience, I strongly believe that the SBIR program is critical to our national competitiveness and hope it continues to flourish far into the future.

Thank you for giving me this opportunity to share my thoughts.