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Senate Committee on Agriculture, Nutrition, and Forestry

June 15, 2017

Good morning Chairman Roberts, Ranking Member Debbie Stabenow, and members of the committee. My name is Gary McMurray and I am the Division Chief for the Food Processing Technology Division of the Georgia Tech Research Institute (GTRI) in Atlanta, Georgia. I am honored to lead a team of 28 full-time research professionals, 14 academic professors, and 40 students working in the areas of perception and sensing (food quality and food safety), robotics and automation, energy, and environmental engineering in support of the agriculture and food processing industries. I am also the Associate Director for the Institute for Robotics and Intelligent Machines (IRIM) at Georgia Tech. IRIM serves as an umbrella organization that brings together over 75 roboticists to create new and exciting opportunities for faculty collaboration; educate the next generation of robotics experts, entrepreneurs, and academic leaders; and partner with industry and government to pursue truly transformative robotics research. In addition, I am a member of the Advisory Council for Food Waste and Loss for the Foundation for Food and Agriculture Research. Thank you for the invitation to discuss the importance of agricultural research and innovation as you prepare the next Farm Bill.

Investing in agricultural research is critical and necessary to address the future food production needs of the United States and the world. The need for an additional 75 percent more food by 2050 is well documented and the focus of a great deal of research. The USDA has made significant investments that have produced incredible improvements in yield per acre and reduced the inputs required to achieve that yield. However, to make even greater strides in this area, transformative innovation is needed. Transformative innovation moves beyond just improving existing methods and processes to totally re-thinking systems development by creating entirely new systems.

At Georgia Tech, we are very focused on the technology required to make the next quantum leap in food production systems. Georgia Tech is consistently ranked in the top 5 engineering schools in the United States and has received significant research dollars from other federal agencies such as National Science Foundation, Department of Energy, Defense Advanced Research Projects Agency, and the Department of Defense. GTRI has been a leading research institute for more than 80 years and prides itself with developing technologies that help industry and government solve complex problems. Robotics and sensors, in conjunction with machine learning, have been the key technologies behind our agricultural research endeavors. In conjunction with our colleagues at the University of Georgia (UGA), we are currently focused on two main areas that we believe can benefit from new technology.

Crop monitoring for biotic yield-reducing factors (pest organisms such as insects, plant pathogens, and weeds) and abiotic stresses (such as inadequate moisture and nutrient levels) are pivotal components of integrated crop and pest management systems, but manual crop scouting by growers or crop consultants is often time- and cost-prohibitive. In the state of Georgia alone, yield losses due to these factors exceed a billion dollars a year. Multi- and hyper-spectral satellite imagery has been studied for years as a method to monitor crop health, and unmanned aerial vehicles (UAVs) are currently garnering considerable attention as a method of remote crop monitoring. Although such systems can detect plant stresses, they are not capable of autonomously collecting samples for identification and verification of the cause of the stress symptom. In this area, we are working on autonomous systems for improved field scouting and sampling for peanuts. These systems are instrumental in providing earlier detection of pests as well as abiotic yield-reducing factors, thereby preventing crop loss and improving the efficacy of agrichemical applications.

We are also developing advanced sensing capabilities for unmanned ground vehicles (UGVs) that work in conjunction with unmanned aerial vehicles (UAVs) to autonomously map presymptomatic (plants that show no visible symptoms of disease) and infected plants using real-time volatile organic compounds (VOC) emissions data and ground images of leaves, fruits, and the stem. This technology will enable earlier detection of infected bell pepper plants or peach trees and identify the source of plant stress for timelier and more targeted intervention spraying, thereby preventing crop losses and improving the efficacy of agrichemical applications. This is a significant problem on the farm as growers currently lose over 12 percent of their crops to disease. This work integrates collaboration between aerial and ground robotic systems, advanced perception to build 4D models of individual plants, novel micro-electromechanical sensors for measurement of volatile organic compounds from plants, and sensors to measure root mass in the soil. We are using advanced machine learning techniques to synthesize the different sensor data into a decision. This is especially important in forestry, orchards, and groves as trees can be presymptomatic for up to 10 years with some diseases while they are producing the bacteria to infect other trees the entire time.

What is important about these problems is they were not something that Georgia Tech or UGA was even aware of as being problems. It was only through intentional and consistent interaction with UGA plant scientists and extension experts that the problems were identified as critical and ones that Georgia Tech had technologies and experts that could contribute to a solution. This type of interdisciplinary work involving engineers, computer scientists, plant scientists, and extension personnel is critical to making the next leap in innovating food production systems. Much like the biomedical revolution, it is the integration of multiple disciplines into a single project that allows for the transformative innovation that provides improved products for the consumer and builds new industries in the United States. The amazing new biomedical devices ranging from robotic surgery, new sensing systems, and disease diagnosis using artificial intelligence never would have occurred without significant investment by NSF and NIH in multidisciplinary projects.

There are many examples of federally funded large, multidisciplinary projects that often result in transformative innovations. Examples include the NSF Engineering Research Centers and Science and Technology Centers and the National Network Manufacturing Innovation (supported by various federal agencies). The Department of Defense's DARPA and the Department of Energy Advanced Research Projects Agency – Energy fund high risk, high reward projects that drive transformative innovation. A recent example is DARPA's Insect Allies program that is focused on using targeted gene therapy and viral manipulation to spread disease-resistant genes to plants via insects so that mature plants are protected

from disease in a single growing season. The current structure of USDA is well suited for funding the basic science work that has had a tremendous impact on all of our lives, but it is not suited to funding this type of multidisciplinary research.

I would respectfully propose that the next Farm Bill include the creation of an Advanced Research Projects Agency – Ag (ARPA-AG) to create the next generation of transformative research in agriculture by bringing together multidisciplinary university-based research teams. The agency would bring together experts in nutrition, soil sciences, plant pathology, plant physiology, and other fields of sciences with technology experts in robotics, sensors, artificial intelligence, materials, supply chain logistics, and energy systems to solve the most complex problems in agriculture. Examples of these large, multidisciplinary projects include areas such as efficient, high-throughput phenotyping; individual plant management to optimize yield; and efficient, dynamic supply chains to minimize food waste and loss. These are examples of the types of projects that are necessary to take the next leap in innovation, but they do not fit within USDA's current research structure. Only through the creation of an ARPA-AG can we provide the necessary resources required for multidisciplinary teams to solve these complex problems.

Finally, the next Farm Bill must address the issue of overhead restrictions. Today's leading engineering universities are major partners in driving innovation in every economic sector other than agriculture. These universities will be deterred from participating in USDA opportunities until the overhead issue and cost-matching requirements are revisited because most of them are not land-grant universities. The overhead rate at USDA must be on par to what other federal agencies like NSF and NIH pay to attract the best minds to solve these critical problems. A partnership between engineering universities with their systems approach and technology focus and land-grant universities with their agriculture expertise would be a powerful team to bring the types of transformative innovation that the agricultural community needs to keep our growers profitable and the world fed.

The entire Georgia Tech community looks forward to working with USDA and NIFA to solve the problems that face our agricultural community. We know that these problems are critical to maintaining one of the most important industries to our nation and our world. The challenges are large, but I am confident that through a systems approach coupled with integrated, multidisciplinary teams, we can begin to solve these problems in a cost-effective manner that will maintain the public's confidence in our ability to produce safe and affordable food while allowing the growers and the affiliated industries a profit. I look forward to working with the USDA, the academic community, and the industry to achieve these goals.

I would be happy to respond to any questions that the members may have.