Vanderbilt University researchers are leaders in cyber-physical systems (CPS) research, extending the use of the internet to create a deeply connected world where humans, their machines, and the physical environment interact seamlessly, continuously, and without mistakes and breakdowns that could lead to safety issues. Designing these systems requires the ability to keep track of interactions between computers and machines (such as traffic lights or dishwashers) while ensuring the safety, security, and stability of those connections.

The Institute for Software Integrated Systems, led by director Janos Sztipanovits, is managing the Cyber-Physical Systems Virtual Organization for NSF, linking together all of the organizations working on the topic, archiving and disseminating documents produced by research, and offering collaboration and experimental platforms for thousands of CPS researchers. In 2015, Vanderbilt, with collaborators from other institutions, won a $3.2 million grant from NSF to support the project, with a commitment of an additional $2.4 million over the next two years. In 2017, the institute received an ambitious new international, interdisciplinary project to develop and test the concept of incorporating social norms, policies, and values into the basic architecture of these new generations of systems. Titled “Science of Design for Societal-Scale Cyber-Physical Systems,” the project has just received a $4 million, five-year grant from NSF to fund researchers at Vanderbilt and UC Berkeley, who will work with research teams at the Technical University of Munich and University of Oldenburg. (Photo: Institute for Software Integrated Systems brochure)

Recent CAREER awards at Vanderbilt

The Faculty Early Career Development (CAREER) Program is a foundation-wide activity that offers NSF’s most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of their organizations. The following are examples of research being conducted by CAREER award recipients.

- **Associate Professor of Education, Diversity and STEM Education Ebony McGee**’s CAREER Award studies “The Impact of Racialized Experiences on the Career Trajectories of Doctoral and Postdoctoral Underrepresented STEM Students of Color.” This essential research is examining ways to broaden participation in engineering and computing through a multi-tiered research design that studies how race-related bias and microaggressive acts affect the career trajectories of Black, Native American, and Latino/a doctoral students and postdoctoral researchers.

- **Assistant Professor of Computer Science, Computer Engineering, and Biomedical Informatics Yevgeniy Vorobyevich** won a CAREER Award for his approach using artificial intelligence and game theory to solve important social problems, including cybersecurity, privacy, public safety, and immunology. His research helps police and fire departments use limited resources to respond to urban incidents, and his work on secure machine learning algorithms results in more effective detection of fraud and cyber attacks. The goal of the research proposed in his CAREER Award is to develop a general framework for adversarial AI, with these applications in mind, building on insights from game theory, AI planning, and cybersecurity.

- **Assistant Professor of Chemical and Biomolecular Engineering John T. Wilson** won a CAREER award that is supporting the development of new synthetic materials for “encoding” immunological messages and tightly regulating their delivery to the organs, cells, and pathways of the immune system. His research will have ramifications for vaccine development, cancer immunotherapy, and treatment of autoimmune disorders.

- **Assistant Professor of Earth and Environmental Sciences Jessica Oster** won a CAREER award to study stalagmites in California caves to examine the cause of extended drought in the region during the late Pleistocene and early Holocene period, which could help climatologists determine whether changing atmospheric conditions caused by global warming are likely to increase the severity and duration of droughts.
Education programs funded by NSF

Fourteen Vanderbilt graduate students won prestigious NSF graduate research fellowships in 2017. The program is aimed at aiding individuals who have demonstrated notable potential early in their research careers and increasing the diversity of the science and engineering workforce. The fellowships provide three years of support within a five-year fellowship period. In all, 68 students at Vanderbilt are receiving NSF graduate fellowship support, out of 2,069 students nationwide.

Tennessee State University (TSU) and Vanderbilt are partnering to lead a “bridge to doctorate” program to increase the number of minority students who earn STEM Ph.D.’s. NSF awarded $987,000 to TSU to launch the program as an expansion of the Tennessee Louis Stokes Alliance for Minority Participation (TLSAMP), a NSF-funded collaborative effort by 10 Tennessee colleges and universities to increase and improve the retention of underrepresented minority students in STEM fields statewide. Vanderbilt is the inaugural host of the new program, which funds 12 students.

The TLSAMP program builds upon the success and lessons learned from the Fisk-Vanderbilt Master’s-to-Ph.D. Bridge Program. Launched in 2004 with NSF support, the Fisk-Vanderbilt two-year program has built a detailed, research-based toolkit to support underrepresented minority students on their path to earning Ph.D.’s and has made Vanderbilt the leading producer of underrepresented minority Ph.D.’s in astronomy, materials science, and physics in the United States. As of 2017, 120 students have participated in the Bridge Program. Of those 120, 30 have completed their Ph.D.’s, and all 30 have secured jobs in STEM fields.

Vanderbilt Institute for Nanoscale Science and Engineering (VINSE) has hosted a NSF-funded Department of Physics and Astronomy Research Experience for Undergraduates (REU) site program on campus since 2011. VINSE REU attracts undergraduates from across the country to Vanderbilt and also provides valuable supplementary enrichment and social activities to the participating students. In its seven years of operation, VINSE REU has provided opportunities to 77 students who have gone on to win numerous national awards, including eight NSF graduate research fellowships and five Goldwater Scholarships.

Vanderbilt has also received one of NSF’s inaugural INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) awards. INCLUDES aims to improve access to STEM education and career pathways at the national scale, making them more widely inclusive to underserved populations.

Expanded nanoscale research capabilities

An advanced tool to be housed at VINSE core facilities will allow researchers to deposit uniform, ultrathin films for microelectronics, energy conversion devices, and biomaterials. A $600,000 grant from NSF’s Major Instrumentation Program is acquiring an ALD - atomic layer deposition - system. The technology not only advances Vanderbilt’s nanoscale capabilities but also provides a much needed resource for researchers across Middle Tennessee. It will provide the ability to create electrical gates for optoelectronic devices, coatings for steerable surgical needles, and exotic materials for use in batteries and fuel cells, among other applications. The announcement comes as VINSE marked the grand opening of its new facilities, including an 8,000-square-foot, state-of-the-art cleanroom. (Photo: Vanderbilt University)

Smart underwear prevents back stress with just a tap

With the support of NSF, a team of Vanderbilt University engineers is changing the world of unproven, unworkable and just plain unattractive solutions for back pain with a design that combines the science of biomechanics and advances in wearable tech to create a smart, mechanized undergarment. The team’s testing proves that the smart clothing offloads stress on the low back. The device is designed so that users engage it only when they need it. A simple double tap to the shirt engages the straps. When the task is done, another double tap releases the straps so the user can sit down, and the device feels and behaves like normal clothes. The device also can be controlled by an app that the team created - users tap their phones to engage the smart clothing wirelessly via Bluetooth. (Photo: Vanderbilt University)