Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)

North Carolina State University (lead institution)

Harnessing nanotechnology to improve global health by enabling correlation between personal health and personal environment and by empowering patients and doctors to manage wellness and improve quality of life

A National Science Foundation Engineering Research Center since 2012

Partner Institutions:

- ***Florida International University***
- ***Pennsylvania State University***
- ***University of Virginia***

Affiliate Institutions:

- ***University of Michigan***
- ***University of North Carolina, Chapel Hill***

The NSF Nanosystems Engineering Research Center (NERC) for Advanced Self-Powered Systems of Integrated Sensors and Technology (ASSIST) envisions a paradigm shift in health informatics enabled by wearable devices employing nanotechnologies that monitor individual health parameters and environmental exposures. Long-term sensing will enable patients, doctors, and scientists to make direct correlations between health and environmental toxins leading to chronic disease prediction, management, and treatment. Advances made by ASSIST will accelerate environmental health research and clinical trials as well as inform environmental policy. ASSIST's vision—propelled by innovative technologies and guided by industrial partners, environmental scientists, medical practitioners, and social scientists—will directly address the National Academy of Engineering's (NAE's) Grand Challenge in Engineering in Advanced Health Informatics.

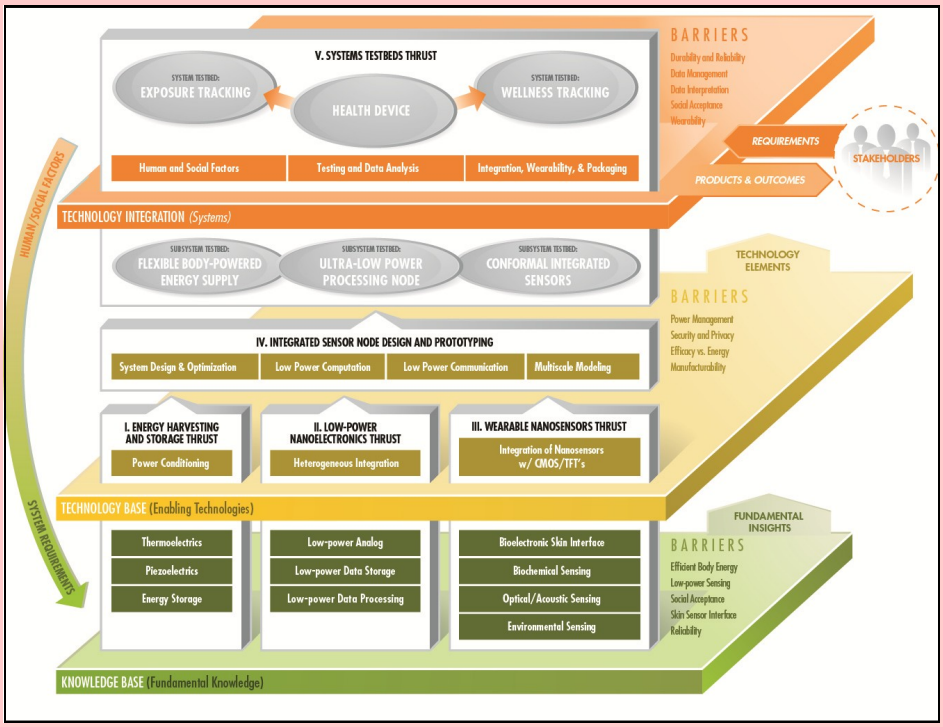
The mission of ASSIST is to transform the U.S. and global health informatics, electronics, and biomedical engineering industries through development and demonstration of fundamental and enabling nanotechnologies for energy harvesting, battery-free energy storage, and ultra-low power computation and communication—integrated with physiological and ambient nanosensors and biocompatible materials—to empower personal environmental health monitoring and emergency response. ASSIST will produce creative and innovative engineering graduates ready to address engineering challenges that cross national borders. Finally, these innovative technologies for self-powered systems can create new commercial markets in health and environmental monitoring, clinical trials, agriculture, military, food science, and electronics.

Research

ASSIST's research goals include the following:

- Advance discovery through fundamental knowledge and innovative solutions in energy harvesting from the human body and energy storage based on thermoelectrics, piezoelectrics, and supercapacitors to maximize available power.
- Leverage nanostructured materials and structures and intelligent power management strategies to improve energy efficiency at the system level by several orders of magnitude.

- Demonstrate low power non-invasive sensors for health and environment that are wearable and reliable and develop robust heterogeneous and hierarchical integration techniques to seamlessly integrate dissimilar technologies in highly functional ASSIST systems.
- Design intelligent power management strategies to enable sensing, computation, and communication in a battery-free operation.
- Develop systems integration requirements, incorporating research on human and social factors, and demonstrate "Exposure Tracking" and "Wellness Tracking" testbeds.
- Engage medical professionals, environmental scientists, social scientists, and innovation partners to realize the ASSIST vision.
- Create a culture of team-based research, education, and innovation, cultivating a diverse group of talented and well-prepared graduates excited about research, design, and the production of health informatics and biomedical engineering solutions for health and safety.
- Form partnerships with precollege institutions to strengthen the STEM pipeline by helping middle and high school students and teachers develop technical literacy and motivation to contribute to solving NAE Grand Challenges.



The three interacting levels of ASSIST's strategic research plan

- Stimulate entrepreneurship and form sustainable partnerships with small and large firms, health practitioners, and emergency responders to link ASSIST discoveries to innovation, accelerated commercialization, and job creation.

To achieve its vision, ASSIST will employ two testbeds: Exposure Tracking and Wellness Tracking. ASSIST activities will revolve around three synergistic programs: (1) systems-driven strategic research, (2) an innovation ecosystem designed to translate technologies to the marketplace, and (3) a pipeline of students that innovate and compete in the global economy of health care. These three programs will guide all efforts in the Center. In addition, the Center will seek a diverse population in all its ventures.

A prototypical ASSIST wearable health monitoring device

Education

ASSIST will develop adaptive and innovative graduate, undergraduate, and precollege students through an interactive community culture of engineering research and education integrating mentoring, rigorous coursework, an aggressive innovation ecosystem, professional development training, international collaboration, leadership experience, diversity, and high ethical standards. The specific education goals are as follows:

- The Center's precollege program will develop pre-college education teams to work with partner school principals, teachers, and students to stimulate student interest in engineering careers and increase the diversity of domestic students studying engineering at the college level.
- The Center will support 45 Research Experiences for Teachers (RET) slots over five years; provide teacher workshops, Young Scholar opportunities, engineering summer camps, school visits, nano clubs, campus NanoDays, and other activities to stimulate middle and high school students to consider engineering degrees and careers; and adopt best practices in formative and summative assessment. In addition, the NCSU College of Engineering has committed funds to support three Research Experiences for Undergraduates (REU) students every year for five years.
- The graduate program of ASSIST will support 31-38 grad students in each of Years 1-5 and will empower them with a new graduate certificate in nanosystems engineering at all partner schools. Each ERC-supported graduate student will have a customized portfolio of skills that range from technical to professional and translational and are expected to go beyond the skill-set proposed by NAE for the engineer of 2020.
- ASSIST will emphasize the importance of global connections through its international partners in the form of student exchange internships.
- ASSIST will provide its graduate students will various mentoring opportunities ranging from REUs and Young Scholars to precollege programs.
- Through a new minor at the undergraduate level, undergraduate research opportunities, and strategies to recruit from underrepresented minority groups, ASSIST expects to produce a diverse and uniquely qualified pool for recruiting potential grad students.
- ASSIST's education directors will also seek additional funding and collaborative opportunities to expand the REU and other programs to increase the diversity of the graduate population.

ASSIST's precollege programs will increase the number and diversity of students studying engineering.

Innovation Ecosystem

The Center's innovation ecosystem will create value by linking ASSIST transformational nanosystems engineering to social and commercial needs through a set of linkages that symbiotically engage industry with faculty, students, and entrepreneurs in all phases of the innovation process. The objectives are summarized below:

- The Center's success will be built upon partnerships with large and small companies, medical and environmental health research practitioners, and entrepreneurs.
- Translational research will team NERC faculty and students with start-up companies or other small firms who license ASSIST technologies.
- With various levels of membership available to industry, ASSIST will ensure that engagement with different types of industry throughout the entire value chain is achieved.
- ASSIST's Industry/Practitioner Program will involve technical staff from companies and government agencies in pursuing research, engaging with students and faculty to build testbeds, and constructing early-stage prototypes based on completed enabling- and systems-technology research. Practitioners will be integral to ASSIST strategic planning and will contribute to research and education programs by providing knowledge of markets, product design, manufacturing, and global innovation models.
- ASSIST will also engage local and state organizations including University technology transfer offices, local/state government offices, venture capital firms, and non-profit entrepreneurial assistance and economic development organizations.
- Graduate students will participate in the four credit-hour ASSIST-TEC boot camp, which is a customized version of the NCSU TEC course sequence. Students will bring ASSIST-generated technologies to the course and will work on cross-disciplinary teams (engineers and MBAs) to investigate and construct commercialization paths.

Facilities

ASSIST is headquartered at NCSU, with 20,000 sq. ft. of space in the Monteith Research Center (MRC) on NCSU's Centennial Campus dedicated to ASSIST staff, faculty, postdoc, and student offices, conference rooms, video-classroom, kitchen, and student "bullpen." A state-of-the-art conferencing system has been installed for the MRC 218 suite of ASSIST offices. ASSIST will be co-located with the NCSU Nanofabrication Facility and the Analytical Instrumentation Facility. Partner institutions also have an excellent combination of facilities and major equipment to support the ASSIST effort, including an NNIN (National Nanotechnology Infrastructure Network) node at partner Penn State University (PSU). The NERC will also utilize the NCN (Network for Computational Nanotechnology) NanoHUB's web-based resource for research, education, and collaboration in nanotechnology.

ASSIST is housed in NCSU's new Centennial Campus

Configuration and Leadership

The ASSIST research program involves an integrated, cross-disciplinary mix of faculty, postdocs, industry practitioners, grad students, and undergrad students in electrical and computer engineering, materials science, computer science, biomedical engineering, textiles, science education, social science, and business management. Faculty at NCSU, PSU, the University of Virginia, and Florida International University are among the recognized world leaders in many of the proposed research areas. Partnerships with foreign universities will be administered through memoranda of agreement governing exchange of students and researchers.

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