

ASSIST *The Pulse*

NSF NANOSYSTEMS ENGINEERING RESEARCH CENTER FOR
ADVANCED SELF-POWERED SYSTEMS OF
INTEGRATED SENSORS AND TECHNOLOGIES



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On The Cover



ASSIST funded research from Penn State University wins "Best Paper" award at Institute of Electrical and Electronics Engineers (IEEE) International Symposium on High Performance Computer Architecture (HPCA)



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Message from the Center Director



I hope you will enjoy reading this third edition of the ASSIST newsletter. The Center continues to make great progress in all three pillars: research, education and innovation ecosystem. We are getting ready for our 3rd Annual Site Visit by NSF, which will be held at North Carolina State University on May 19 and 20th. The Center's two Testbeds, the Health and Environmental Tracker and the Self-powered Adaptive Platform, continue to drive the research in the Center. We have brought on Mr. Jason Strohmaier as ASSIST's new Chief Systems Engineer to provide full-time leadership in the Testbed arena. Students from all partner schools are working closely together to demonstrate ASSIST Testbed functionality for our annual site visit.

In the last several months, we have created a five-year strategic research plan for the Center and have engaged ASSIST's Industry Advisory Board (IAB) and Scientific, Medical and Military (SMM) advisory board for their input on the future directions for the Center. We held an onsite meeting with our SMM board members in March to discuss the strategic plan in detail. The strategic plan focuses on roadmaps for the Center Testbeds along with the enabling research needed to achieve the Testbed requirements.

The Center continues to make tremendous progress in both areas of the power problem. Listed here are a few examples of the research output of the Center in the last few months. In the area of energy harvesting, the Center has integrated thermoelectric legs in flexible platforms for improving system level performance. Nanocomposites of bismuth telluride have provided heat harvested power levels that are much higher than the commercially available counterparts. Details of these will be provided at the annual site visit. The Center has also made significant breakthroughs in supercapacitors with low leakage properties. Work on ultra-low power SoC continues to push the envelope in power consumption and recent work on ASSIST's new SoC was published in ISSCC 2015. This work demonstrates clear accomplishments towards the ASSIST vision and contains wireless energy harvesting and a multi-modal sensing platform. ASSIST researchers also won a best paper award for their work non-volatile processing as shown on the cover. Environmental gas sensing work has demonstrated an ultra-low power ozone sensor with room temperature operation with intrinsic selectivity characteristics. Progress towards a biochemical platform consists of demonstrating a zero-power osmotic pump for extracting sweat at rates faster than they are generated. This is a critical step towards sweat based, non-invasive biochemical sensing.

Our translational engineering skills program has developed more innovative modules for our graduate students. Course sharing among our partners is underway. Our undergraduate students are engaging in ASSIST centric research through numerous ASSIST sponsored senior design projects. Our engagement with industry continues to thrive with more partners and more sponsored research programs. In the coming months, we seek to have every core Center project mentored by an industry member in the Center. Our engagement with key stakeholders is also growing. ASSIST sponsored an "Engineering Solutions to Health Problems" workshop that was held at University of North Carolina between doctors and engineers.

Thanks for all your support and interest in ASSIST. I look forward to getting your feedback on our technical, educational and industry activities.

Dr. Veena Misra,
ASSIST Center Director

Industry Engagement Sparks Innovation



Spring is always an exciting time for ASSIST. We kicked off the 2015 year, per usual, at the Consumer Electronics Show where our students got to showcase ASSIST technologies amidst over 160,000 attendees. We got great media attention out of the event, along with making a number of new connections.

We have welcomed several partners to the Center over the past few months, including Mann+Hummel, Smashing Boxes and SAS. It's great to have their expertise and insights within the Center and they are already making an impact on improving our testbeds and educational activities. As an example, Smashing Boxes helped our ECG Shirt senior design team overcome coding challenges on their project. Last week, the team was awarded Best in Show at NC State Design Day.

To highlight student engagement: KCF Technologies near Penn State and Phononic and Mann+Hummel in Research Triangle have each engaged in the popular student luncheon series. This luncheon series provides an open forum for students within the Center to communicate with key industry board members on topics such as company goals and state of the industry. Additionally, with student and NSF encouragement, we have started a new initiative matching several company mentors to each Center research project to provide another vehicle for students to work with industry. Lastly, several of our partners took time to work with Kelly Mesa at FIU, as she explored the commercialization landscape for Cortisol monitoring through the NSF I-Corps program.

As the formal semester winds to a close, the final touches are being put on the ASSIST testbeds and preparation for our May site visit review. Rest assured, the opportunities for engagement and interaction with our students and researchers won't wane under the heat of the summer sun. Many of our students have signed up for internships this summer with our industry partners and with other companies in the ASSIST network. We will host a number of meetings with the IAB as we scope the year 4 RFP and continue to steer our research towards our company needs and student job opportunities.

Thanks for a great spring semester and I look forward to catching up in person at our site visit in May.

Thanks,
-Tom

For Media Coverage

To see a full list of media coverage, please visit <http://assist.ncsu.edu> or scan the QR code to the right.



ASSIST Partner Chills

with Senior Design Team

Porticos has been a beneficial member of the ASSIST community since joining in [January 2014](#). In addition to helping steer ASSIST research, Porticos has now partnered with Dr. Jesse Jur and his Senior Design Class (explained in "ASSIST Funds Undergraduate Enrichment", pg. 10.) Porticos is a local Raleigh, NC based mechanical engineering and product development firm. Established in 2003, the company has a long standing reputation to provide consumers and customers with mechanical design, analysis, research and development services with the utmost efficiency.

At the American Society of Safety Engineers conference in 2011, Porticos released an innovated vest entitled "Porticool." This vest is dubbed the worlds lightest untethered active cooling garment, sitting at a weight of under 1.8 pounds. Suited for a variety of needs, the Porticool vest is a viable option for cooling when other methods are unavailable, such as for use by fire fighters, HAZMAT suits, industrial and military applications. ¹

Partnering with NC State College of Textile's Department of Engineering, Chemistry and Science (TECS) Senior Design program, members of Porticos tasked seniors David Warren, PJ Burger and Brian Kieber with the design and

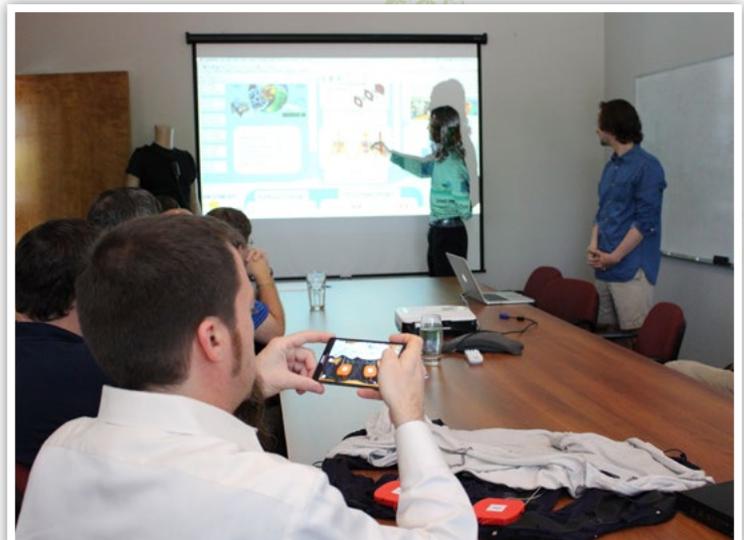
testing of improvements to their iconic vest. This design and testing was targeted toward improvements to conserve more cooling power while also exploring thermoelectric generators that could feed off of the vest's vast temperature differences. ²

While these students are not funded directly by ASSIST, it is worth noting that their research and partnership with Porticos has been highly interactive with the Center's technologies and staff. Industry Liaison Tom Snyder spent time with the team and Porticos working toward the goal of an improved technology that included thermoelectrics to harvest temperature difference from fire-fighters bodies and the cooling of the vest itself.

Warren, Burger and Kieber were able to improve upon the vest two-fold. With the inclusion of thermoelectric generators, these students were able to produce results showing wearers of the vest would be able to produce enough energy to power a small, online electronics system when heat is harvested from the shoulder region of the body. Additionally, with a goal of only a 30% increase in cooling power, the team produced outstanding results by doubling the cooling efficiency of the previous version of the Porticool vest.



(From left): Greg Patterson, Warren and Burger pose with original Porticool Vest mannequin. Photo Credit: Reify Media.



Tom Snyder inspects and photographs prototype while Warren and Burger present research findings at Porticos. Photo Credit: Reify Media.

1. Retrieved from: <http://www.porticos.net/porticool-vest-unveiled-at-asse-2011/>

2. Retrieved from: <http://www.porticos.net/porticos-supports-product-design-innovation-by-funding-senior-project-at-nc-state/>

ASSIST's Non-volatile Best Paper Award

The 21st annual Institute of Electrical and Electronics Engineers (IEEE) International Symposium on High Performance Computer Architecture (HPCA) held in early February 2015 brought thousands of individuals to the San Francisco, California area. Drawing scientists and engineers from around the world, the conference proceedings included talks from members of HP Labs, AMD Research, Penn State University, Georgia Institute of Technology and many more. This yearly conference allows an open forum for scientists and researchers to interact with one another while presenting innovative research in the areas of high performance computer architecture.



ASSIST research Kaisheng demoing non-volatile computer processor prototype.

ASSIST faculty member [Vijaykrishnan Narayanan](#) and student researcher [Kaisheng Ma](#) represented the Center and its forward-thinking research along with collaborators Yongpan Liu of Tsinghua University in China, Yuan Xie of University of California Santa Barbara, Yang Zheng, Shuangchen Li, Karthik Swaminathan, Xueqing Li, and Jack Sampson.

Over 220 research papers were submitted to this year's conference for consideration for the Best Paper award. Shining above the other 49 superb entrants, the ASSIST related research Architecture Exploration for Ambient Energy Harvesting Non-volatile Processors won the distinguished award.



Researchers Jack Sampson, Karthik Swaminathan, Schuangchen Li, Yuan Xie and Kaisheng Ma (from left) posing with award certificates from IEEE's HPCA Best Paper award.

ASSIST's goal of revolutionizing health care through wearable devices that can constantly monitor personal and environmental vitals of an individual is an innovative proposition. Technologies like those being developed at Penn State are essential to proper, long-term functionality of the testbed efforts within the Center. While energy harvesting has been a widely investigated source for providing power to ultra-low-power technologies, new-age forms of energy harvesting are still unreliable and dependent upon ambient environmental factors. The ability to power down and power on without a loss of data collection is crucial to long-term monitoring.

The nano-based research coming from Penn State has a focus on the exploration of a processor design that can retain its state and make forward computational progress even after the absence of power. While contradictory to current computing and mobile computing standards, the team out of Penn State, in conjunction with Yongpan Liu of Tsinghua University, is making great strides forward.

Researchers are developing and fabricating specialized systems that are able to tolerate power variation while

making forward progress on computational tasks. This research is increasingly becoming warranted in areas in and outside of wearable devices. Although non-volatile processors are not completely novel, the processor being developed and fabricated between Penn State University and Tsinghua University is a ground-breaking idea. In comparison to typical data storage back-up methodologies such as check pointing, this research lead by Kaisheng Ma is making novel advancements in low power, non-volatile computational progress in the absence of power.

Dr. Vijaykrishnan Narayanan states that future progression of research will allow for collaboration with additional ASSIST PIs Dr. Doug Werner, Dr. Susan Trolier-McKinstry, Dr. Suman Datta and Dr Theresa Mayer. These teams out of Penn State are working collaboratively together toward a low power, functional processor platform that has the ability to integrate gas sensors, 2-D nanoscale antennas and TFETS while holding true to the nano-enabled wearable testbed platforms of the ASSIST Center.

Assessing How Technologies

No matter how innovative or ground-breaking a technology may be, if consumers are unwilling to use newly formed tech, it will not succeed. Novel health technologies, like those created by ASSIST faculty and students, have vast potential to provide a user interface between clinicians and patients, and to improve patient health outcomes. Because of ASSIST's commitment to creating devices that people will ultimately use and find beneficial, we are engaging patients to understand what it will take to get them to use our technologies. Research shows that the most successful health tech communicates with users early on, conducting surveys with patients on their user preferences. Without such assessments, systems might become redundant and patients or clinicians may not use them.

ASSIST is continuously at the forefront of not only designing new technologies, but also designing ways to encourage their use. Growing research shows that medical sensor devices are only being accepted by patients when their social factors, attitudes and opinions are assessed throughout the design process (Bergmann 2011, Bergman 2012). To that end, Dr. Shedra Amy Snipes of Penn State design and conducted a special survey. Her research is expanding the ASSIST human social factor testing while integrating acquired behavior, preference and attitudinal data from potential consumers with a goal to support the ASSIST strategic initiatives through the establishment of critical parameters that will ultimately strengthen product design.



Matter for Asthma (AsThMA)

In a previous newsletter article, we called upon individuals to participate in Dr. Amy Snipes' survey to understand parent consumer preferences for wearable sensors for child asthma health. In partnership with industry partners RexHealth Express and RexPediatrics, as well as physicians at the Mt. Nittany Physicians Pediatrics in State College, PA and Penn State University Pediatrics, Snipes and her team of graduate student volunteer John Lee and Project Coordinator Sandra Gonzales de Del Pilar surveyed 150 parents of child asthma patients on what it would take to gain their acceptance of, and ultimately use of at-home asthma care. The overwhelming response has provided Dr. Snipes' and her group the ability to produce fruitful and interesting results that directly benefits each ASSIST research related thrust.

The online based survey gained information on acceptability, normative beliefs about technology, motivations and barriers to sensor wear in relation to technologies for child asthma patients. Positive preliminary findings indicated various modes that potential consumer patients would like to use ASSIST devices, such as by button, remote, touchscreen and automatic controls. In fact, automatic controls were rated higher on the ease of use scale than manual button control. Wireless control and through a smartphone or hand held device also showed favorable response to ease of use. As well, in line with the ASSIST mission and strategic goals, preliminary findings indicate that user acceptance of wearable placement on the arm or torso are viable locations for our technologies, and provide preferred alternative locations like the ankle should energy harvesting not prove feasible on those locations.

Perhaps most importantly, Snipes' team produced data that can provide an important and strategic view of patient perspectives among those who see nanotechnology as risky or "neither safe nor risky."

Thankfully, we have clues on what may overcome perceived risks among potential users. For example, parents of children who have been diagnosed at an early age, and are now between the ages of 7 - 13, are highly likely to state intended use of wearable technologies, as are parents who seek to reduce hospital visits. We also see interesting attitudes that may predict intended use. For example, parents who have tried other interventions and have a hard time with their children adhering to medical treatments would like to use automated wearables. Also, patients who want to work more closely with their doctors are likely to use nanotech devices. With this in mind, information on nanotechnologies and self-powered systems for use among asthma patients could easily be modified through careful marketing campaign.



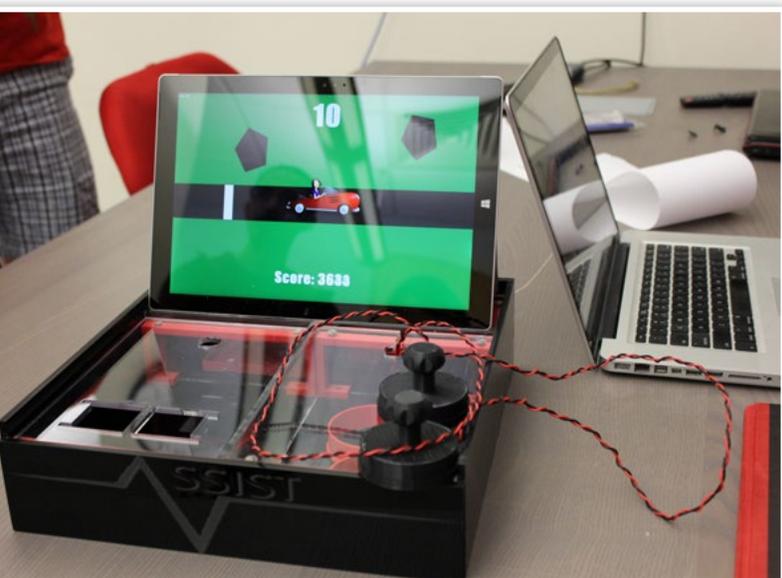
ASSIST Funds

Undergraduate Enrichment

“Working on this project has been extremely rewarding to see our ideas come to life.”



ASSIST graduate researcher Michael Lim testing senior design team's Energy Harvesting Demonstration final prototype.



ASSIST senior design team's final Energy Harvesting Demonstration prototype, including a game coded by group members themselves.

At the start of each academic year, the ASSIST Center's Industry Liaison Officer, Tom Snyder, partners with an enterprising program within NC State's College of Engineering. Dr. Rachana Gupta's year-long Electrical and Computer Engineering Senior Design class (ECE 484 & 485) pushes senior engineering students to plan, build and execute company sponsored design projects. Each semester, companies large and small speak to students and present (dynamic), approved design projects for students to undertake; each student is then paired with different individuals on projects in which they've expressed interest.

ASSIST partners on many of these sponsored projects each year. One of Snyder's groups in the 2014 - 2015 academic year is comprised of James Kieffer, Clayton Price, Aric Pope, Alex Yadon and Kelsey Mills. This dynamic group of graduating seniors has been tasked to produce an interactive demonstration of kinetic and thermal energy harvesting which utilizes the human body as an energy source.

“This project is intended to educate the public on the potential for wearable medical devices that are powered solely by the human body” states group member Kieffer. The team expressed gratitude, stating that “partnering with the ASSIST Center and Tom Snyder has been a wonderful opportunity to explore energy harvesting technologies and their application as it relates to wearable devices.”

Along with the participation of Snyder, the group has been highly interactive with Michael Lim, an ASSIST Ph.D. student who acts as a mentor to the 5 progressive undergraduates. Lim provided the group assistance in the ideation phase while providing recommendations on different technologies the group could utilize to improve the efficiency of their platform. While beneficial for each undergraduate group to be mentored by a graduate student, this experience allows graduate students an opportunity to learn mentoring tactics to lead program groups to project completion.

Dr. Gupta states that Snyder and the ASSIST Center have been beneficial partners to the program over the past year. She plans to take the model that Snyder uses for plan ideation and use those with new and existing company sponsors.

Making a Difference with the Pre-College Program

The Pre-College program has been in full swing this spring, sharing the innovative research of the ASSIST Center with schools and getting students involved in hands-on learning.

With a strong focus on the enrichment of K – 12 students through STEM outreach, ASSIST faculty and students have spent a great amount of time engaging with and advancing partner grade schools across the east coast. Staff and students recently judged engineering design challenge projects at a local North Carolina STEM Early College. As well, local middle school students from Centennial Middle School visited ASSIST to use virtual reality technology to learn about circuits. Marbles Kids Museum sponsored a special outreach education event for ASSIST graduate students following Marbles' NanoDays Expo at which graduate students put their new skills to the test. Graduate students have also visited Carroll Middle School to lead students in designing structures to scale.

With a fulfilling year of plans remaining, the month of April will bring together six teachers who participated in ASSIST's summer RET program; these individuals will be challenging their students to participate in an inter-school One Health competition. The challenge: design a wearable sensor to be used to detect or prevent Ebola in highly populated or highly infected areas, and create an advertising campaign targeted to the specific population where their device will be deployed. Also in April, ASSIST will be inviting nearly 400 middle and high school students onto campus for NCSU's NanoDays. Guests will tour ASSIST labs, speak to graduate students about their research projects and engage in fun, hands-on STEM activities. The school finalists from the One Health Competition will also be recognized at this event.



Four Wake County Public School System middle school students using the ASSIST senior design team's Energy Harvesting Demonstration at NanoDays.

Student Leadership Council

ASSIST Gets Active

From basketball to disc golf, 5k's and more, the ASSIST Student Leadership Council has begun a Center-wide initiative to Get Active! In light of the Center's goal for globally improved healthcare, the SLC started at ground zero, improving healthcare in ASSIST. Students, faculty, and industry members are all welcome to participate in the biweekly activities as a way to get involved in the ASSIST community and get active!

Industry Luncheons

The industry luncheon series is going strong! Students and industry members use this opportunity for one-on-one interaction and discussion on student research, professional experiences and challenges, and everything in between. ASSIST industry partners, Phononic and Mann+Hummel, have met with NCSU students and KCF Technologies took a group of Penn State students on a tour of their facilities. If you are interested in participating in an industry luncheon or tour, please contact the SLC!

Virtual Poster Session

The SLC organized the first ASSIST Virtual Poster Session hosted on the new student portal! Students across all ASSIST campuses submitted posters on their research to display on individual forums through the portal. Faculty, students, and industry members have access to view and comment on these posters to give valuable feedback to the students on their work within the Center. The poster session is still live so log on and see cutting-edge research from the Center students!

Graduation Announcements

Doctoral

Saad Arrabi, Ph.D. - UVA
Bin Zhu, Ph.D. - PSU
Kyle Craig, Ph.D. - NCSU
Huichu Liu, Ph.D. - PSU
Haojun Luo, Ph.D. - NCSU
Nathan Roberts, Ph.D. - U of M
Aatmesh Shrivastava, Ph.D. - NCSU
Charles Yeager, Ph.D. - PSU
Xiajua Zhong, Ph.D. - PSU

Graduate

Samuel Werner
Dan Aglione
Peter Beshay - UVA
Ben Boudaoud - UVA
Kelly Mesa - FIU
Tim Shay - NCSU

Undergraduate

Davis Blalock - UVA
Kristi Barnes - NCSU
Chia-Heng Chu - NCSU
Andres Felipe Dias Cruz - FIU
William Devine - UVA
Huangzhu Lin
Ankesh Maden - NCSU
Anish Simhal - UVA
Jianfeng Wang - PSU
Yuziang Wang - PSU



Amanda Myers



Dr. Veena Misra



Steven Mills



Francisco Suarez



Industry Member Spotlight

Rex Healthcare, a regional healthcare provider located within North Carolina, is a member of UNC Health Care; this private, not-for-profit health care system has more than 5,500 workers who care for 660 beds and nearly 34,00 inpatient patients each year. With dedicated centers for cancer, surgery, heart and vascular, post-acute rehabilitation and skilled nursing care, wellness and women's care plus dedicated services for bariatric, heartburn, pain management, sleep disorders, diabetes education, wound and emergency care, Rex's medical staff is very diverse and includes 1,100 physicians and 1,700 nurses. ¹

When speaking with primary contact and ASSIST Industry Advisory Board Chair, Anita Watkins, it is clear that the mutual partnership between ASSIST and Rex Healthcare has proven beneficial in many different ways. Watkins states that Rex, an ASSIST industry partner since the Center's inception in 2012, is aware that healthcare is an every changing, rapid industry, including changes in the ways that providers care for patients. With an understanding that ASSIST sits in the forefront of non-invasive healthcare wearables, Watkins expresses that "the ability to access real time patient health data will soon be a critical component of how we treat and care for our patients." Rex's partnership with the Center ensures that they and their patients "...will have access to the most cutting edge technologies for their care." ²

Watkins holds the Director position for the Rex Strategic Innovations (RSI) platform which has been an integral part of the Center and its research:

Rex Strategic Innovations (RSI) is a groundbreaking innovation platform created by Rex Healthcare to foster and nurture innovative technologies and companies in the healthcare sector. The RSI mission is to enable access to healthcare products and services that will allow for improved patient care. RSI is a Multi-Pronged Innovation Strategy. Rex Health Ventures supports the development of new treatments, tools, products and services that foster innovation and positively impacts the provision of healthcare. It also invests in companies to help bring their products and services into the marketplace. Rex Health Solutions pro-actively identifies healthcare delivery problems and partners with premier organizations and individuals to advance potential solutions. It also identifies cutting edge healthcare research underway in areas in need of a healthcare partner to advance research and ensure Rex at entry-point of innovation.

- Anita Watkins, Director RSI



Watkins also stated that Rex is very excited about the advances in the low and no power wearables industry, which ASSIST is diligently working within to create innovative and disruptive technologies. "Patient compliance is often one of the key factors associated with lack of recovery. Eliminating the need to charge wearable devices will remove one more major obstacle associated with compliance. Eliminating or reducing the need for charging or replacing batteries will also greatly expand the ways in which we deploy wearable technology."² Rex also sees benefit in the non-invasive biomarker sensing area in which the ASSIST Center graduate and faculty researchers are making headway. Watkins states that "not only will this improve quality of life for the patient, it will ensure that the clinicians receive the data they need without burdening the patient with invasive testing."²

As ASSIST's Industry Advisory Board Chair, Watkins says that she is learning the broad array of applications that the Center's research has across many diverse sets of industry. "Not only is [ASSIST's] research key to healthcare and improving patient outcomes, it has the potential to transform industries ranging from automobile manufacturing to fire and safety sensing to cosmetics. As a testament to the broad appeal of the work funded by NSF, the Center has over 26 members representing various different industries. Rex's membership on the IAB is one of the many partnerships we have with NC State University. Our partnership teams up two institutions committed to improving the lives of North Carolinians."

1. Abbreviated from text provided by Rex Healthcare Media Relations team.
2. Derived from e-mail interview with Anita Watkins, Director, RSI

For More Information

For more information about Rex Healthcare and the RSI program,
please contact:

Anita Watkins
Anita.Watkins@unchealth.unc.edu

<http://www.rexhealth.com>





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