**My ERC Experiences**

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**Center for Subsurface Sensing and Imaging Systems**

In the mid-1990s a new Dean of Engineering, Al Soyster, arrived at Northeastern University with the goal of winning an ERC award. This dovetailed with my own ambition to achieve the same goal. At that time Northeastern was not known as a top research university. Aspiring to win an ERC award was thought by many at the university to be akin to tilting at windmills. Nevertheless, we submitted a pre-proposal in 1996 which made it to the full proposal stage but did not result in a site visit. The theme for this first proposal was high-resolution sensing and imaging systems. In retrospect there were three fatal flaws in that proposal. First, the theme was not crisp enough to convey to the reviewers the exact mission of the proposed ERC. Next, we only paid lip service to the ERC Program’s mission to focus ERCs on engineered systems. It did not really reflect the operational strategy and system-level goals needed for a successful Center, Finally, the effort was not a multi-university partnership. At the time it was allowed for a single university to propose a theme; however, Northeastern alone did not have the critical mass needed to succeed. As a result of this first experience, Northeastern had to decide whether to move forward on a new proposal. To the credit of the institution, the President and Dean decided to invest seed funding to encourage a more successful bid.

The second proposal addressed the fatal flaws of the first one as follows: The theme was sharpened to focus on **subsurface** sensing and imaging systems. The key there was the idea that a surface was simply a boundary that separated what one could “see” from what one couldn’t “see.” So a subsurface region could, for example, be inside the human body (i.e., cancer detection), under the water (i.e., coral reef health), under the ground (i.e., buried waste) or inside a cell (birth defects). This was a pivotal organizing principle which drove the development of the research, testbed, and system levels of the proposed Center. By this time, the ERC Program was requiring a 3-plane strategic research planning diagram and this forced a serious effort to design our 3-plane diagram, which culminated in the system-level theme of *“diverse problems–similar solutions.”* This theme meant that the proposed Center would be a process Center, not a product Center. The system deliverables would be tools and demonstrations of general versatility, to enable implementing the “next” application of subsurface sensing and imaging without having to reinvent the wheel. Finally, in order to achieve the goals of the proposed Center it was crucial to develop a multi-university collaboration—especially around the testbeds, which would demonstrate the versatility of the research methods.

The redesigned ERC proposal was named CenSSIS (Center for Subsurface Sensing and Imaging Systems). Northeastern University was the lead partner, with Boston University, Rensselaer Polytechnic Institute, and the University of Puerto Rico at Mayaguez as the other key partners. As a result of this redesign, CenSSIS was one of only two awards made in the year 2000. Winning the ERC was a major accomplishment for Northeastern and our partners. At the time of the award the university was not considered a serious research university. That image changed dramatically after winning the ERC award.

Once the euphoria of winning wore off, it became clear that a major challenge would be to maintain the award through the series of rigorous NSF site visits. In order to do so we used the 3-plane diagram as the blueprint for implementing our strategic plan. A key part of this method was a yearly retreat that was held several months prior to each site visit. During those retreats all of the partners participated, including the Engineering Deans of each academic partner. As a result of this strategy, CenSSIS never had any major problems in the 10 years of its operations. The retreats served to identify problems and solutions before instead of after the site visits. Throughout the 10 years of NSF funding, the 3-plane diagram evolved but always served as a true capsule of the Center as a whole.

After NSF funding ended, CenSSIS demonstrated the power of the mantra “diverse problems–similar solutions.” Specifically, three new Centers emerged from the CenSSIS platform. These were funded by the Department of Homeland Security (ALERT), the National Institute of Environmental Health Sciences (PROTECT), and the National Institute of Standards and Technology (VOTERS). Each Center had a specific subsurface application. For example, ALERT focuses on finding explosives-related threats inside luggage at airports.[[1]](#footnote-1) PROTECT explores the correlation between the high premature birth rate in Puerto Rico and the flow of underground contaminants. VOTERS images subsurface urban roads and bridges to determine civil infrastructure health. Of these three Centers, two are still in operation (ALERT and PROTECT), while VOTERS has morphed into a spinoff company.

Aside from these three byproducts of CenSSIS, the Center’s research has resulted in a significant advance in breast cancer diagnosis by developing algorithms that enabled the cost-effective use of tomosynthesis imaging systems used in 3-D mammography, as well as in the creation of cost-effective, autonomous underwater vehicles to explore regions of the ocean such as beneath the ice caps. In terms of education, a major accomplishment of CenSSIS was the engagement of diverse students from grades 6-12, community colleges, and undergraduates. One unique vehicle for this was the “High Tech Tools and Toys” modules which gave these students hands-on experiences that allowed them to engage in guided inquiry. These modules sparked the students’ interest in the CenSSIS disciplines and helped motivate them to further pursue ERC-related research. Another important ERC education effort was centered on the production of the textbook “Introduction to Subsurface Imaging.” That undergraduate/graduate level textbook lays out the key elements of the new discipline that was at the heart of the ERC.

In summary, my experiences in defining and directing CenSSIS (and now ALERT) have given me immense satisfaction. The ERC program was a key enabler for inspiring me to reach beyond the norm at my university and in my own professional life.

1. In April 2019, the DHS awarded ALERT $3.6M ($2.6M more than the expected) for new security-related research. [↑](#footnote-ref-1)