# LESSONS LEARNED IN RANN

## A.Strategyand Challenges

As a forerunner of the ERC Program, it is worthwhile to explore the challenges the RANN Program faced in starting up new efforts in a culture largely hostile to research that would purposely address societal and economic impacts. This analysis will provide insights regarding how the RANN experience impacted the leaders of the ERC Program and can be useful to new research program managers in other agencies and countries as they develop and improve their programs designed to strengthen competitiveness and innovation.

RANN’s primary goal was to organize the research community in engineering and the natural and social sciences to bring their skills to bear to address important national problems. The strategy was to ensure that the research was motivated by the problem area, not just by the disciplinary interests of the investigators. This necessarily opened the way for a more interdisciplinary approach to research, as solutions to important problems or opportunities for new technologies cannot rest on the insights of only one discipline. RANN essentially supported “directed” research, which included basic and applied research motivated by the problem focus of the research project.

As a consequence of this focus, RANN gathered in many of the engineers from the NSF Division of Mathematics, Physics, and Engineering (MPE) and hired an interdisciplinary staff from government (primarily NASA), universities, research institutes, and industry with skills in engineering, materials science, chemistry, biology, environmental science, and the social sciences. Some areas important for society had been under development in the basic engineering science and atmospheric science programs at NSF, such as “weather modification, earthquake engineering, enzyme engineering, power systems engineering, and fire research” and these were transferred to RANN.[[1]](#footnote-1) RANN experimented with new ways to join academe with industry through small university/industry Research Development Incentives grants, the precursors to the Industry/University Cooperative Research Centers (I/UCRC) and Small Business Innovation Research (SBIR) programs, which remain in operation today.

The RANN divisions were organized to focus on technology applications, environmental systems and resources, intergovernmental science and public technology, social systems and human resources, and exploratory research and technology assessment. The programs focused on earthquake engineering, solar energy, wind energy, geothermal energy conversion, batteries, weather modification, robotic assisted manufacturing, enzyme engineering, environmental pollution and clean water, public service delivery system assessment, technology assessment, societal response to natural hazards, and exploratory research outside of current programs for generation of new fields.

Some of the program directors transferred from the basic science and engineering research programs of NSF were initially wary of this new role, but those recruited from outside of NSF and most of those from inside saw this as an important opportunity to make a positive impact on society through research.

Given its mission to support directed problem-driven or technology-driven research, as opposed to curiosity-driven research, during the start-up and operation of RANN the staff had to break new ground within NSF and in academe and industry in order to fulfill this mission. The normal mode of operation at NSF was to wait for proposals to be submitted by academic researchers and then send them out for individual peer review. Because RANN had a mission to support research to address national needs, it had to invent methods to let a broader-based research community, including industry, know of this opportunity, and new modes of peer review to deal with the cross-disciplinary nature of many of the proposals, as well as with the new, cross-sector partnerships needed to explore the full scope of the technology or policy opportunities. Making these organizational innovations did not always come naturally to the engineers in RANN. (RANN program officer Lynn Preston, an economist, recalls telling her fellow members of the RANN leadership team, “You engineers act like you have to sit at the back of the bus, when you designed and build the bus and should be driving it!”) In addressing these challenges, RANN established a new culture in NSF, one that played out to threaten the status quo—ultimately resulting in its demise—but that outlived its bureaucratic life to impact not only the ERC Program, but also more broadly in NSF over time and in academe and industry.

## B. Issues, Solutions, and Lessons Learned in RANN

The issues the RANN staff faced in fulfilling its mission and the methods they used resulted in some lasting lessons learned for the later leaders of the ERC Program and culture changes in NSF and beyond. These include:

1. Are there Principle Investigators (PIs) interested in carrying out research at the cusp of basic knowledge and applied concepts, leading to new technology and impacting policy?
* Yes, there was a lot of enthusiastic and at times passionate interest in carrying out engineering research that would extend to the proof-of-concept phase where technology or policy applications could be explored in partnership with industry or policy makers.
* However, there were challenges in forming long-lasting partnerships between faculty and industry at the time, since there was little trusted interaction; these were addressed by experimenting with industry/university projects and industry university cooperative research centers.
* Lessons learned:
	+ Truly integrating the knowledge of different disciplines was not easy in the disciplinary environment that prevailed in academe in the early 1970s; it required a commitment on the part of the PI to actively engage faculty from the appropriate disciplines needed to address the chosen problem or to explore and develop a technology.
	+ Time was needed to develop a truly integrated cross-disciplinary culture in universities.
1. How can RANN generate new research areas important for national needs and the advancement of technology?
* Advisory Boards were formed, comprised of academic and industrial personnel, to bring emerging national needs and technological opportunities to the staff.
	+ Renewable energy technology was an example, which included wind, solar, and geothermal energy.
* Program Announcements were issued calling for problem-focused research relevant to national needs.
	+ The Program Announcement was invented by RANN staff as a mechanism to let the research community know of these opportunities for funding.
* Lesson learned:
	+ Use outside input to gain a broader range of recommendations than is possible with staff input only.
1. What type of peer review would be needed to achieve RANN’s more applied and interdisciplinary goals?
* RANN staff initially used the traditional NSF method of mailing out proposals for individual peer review, but it quickly became obvious that an additional mode was needed for cross-disciplinary proposals; otherwise, it was the staff that made judgments about the efficacy of the interface of the disciplines proposed. To address this challenge, they developed panels of reviewers from different fields and encouraged cross-panel discussion until a consensus could be reached, if possible. The panel mode of peer review quickly spread throughout the Foundation.
* Lesson learned:
	+ Invent new modes of peer review to suit desired outcome goals.
1. How can we be sure that the PIs actually carry out the research proposed?
* Some programs asked for brief post-award progress reports. It often became apparent that PIs would propose what NSF was interested in but, upon receipt of the award, would continue with their own research interests and largely ignore their proposed goals. For example, Lynn Preston, one of the RANN Program Directors, was concerned about a project that purported to build decision models, using operations research methodologies, in collaboration with users to guide the allocation of public service delivery system resources, but that appeared to be too theoretical in operation, based on its report.
	+ She consulted with one of her program advisors, Dr. Alfred Blumstein , then Professor of Urban Systems and Operations Research at Carnegie Mellon University, who suggested a post-award site visit with an cross-disciplinary panel with expertise in modeling and service delivery.
	+ The outcome was a curtailment of funding because the promised involvement of public service delivery personnel in the project was not forthcoming and the models would not provide useful guidance.
* Lessons learned:
	+ Post-award oversight is valuable for complex projects with complex goals and outcomes that directly affect technology or service delivery.
	+ Project funding should be curtailed if proposal goals are ignored.
1. How far into the spectrum of the development of technology from fundamentals to prototypes and applications should NSF’s funding be used and should such projects be carried out in partnership with users?
* RANN projects that proposed to advance technology were supported through the proof-of-concept phase, i.e., exploring the development of the technology in a research context but not through the commercial prototype phase that would precede advanced development and commercialization. For example:
	+ In the solar technology area, Dr. Eggers envisioned supporting an array of solar collectors to be put on the roofs of public schools, understanding that government support for proof-of-concept technology at that scale would help bring the technology to use faster and bring down the costs. The project was approved in 1974 with an award to Georgia Institute of Technology and the Westinghouse Corporation. In execution through proof of concept the investigators found out that thermal materials had to be strengthened to meet the extreme thermal stress, which limited the use of the panels.[[2]](#footnote-2)
	+ Prototype wind turbines were constructed to test material strength and system functionality and high-powered water drills were used to explore new ways of tunneling through rock with hydraulic jets.
	+ The Earthquake Hazards Mitigation Program, which had been started in the engineering sciences programs in MPE; was transferred into the RANN Program in FY 1971 with an expanded technology mission to:
		- Develop economically feasible design and construction methods for building earthquake-resistant structures, among other goals[[3]](#footnote-3)
* Lesson learned:
	+ Proof-of-concept is a viable goal for academic research, but it lies at the edge of the comfort zone for academe, where the interface with industry is crucial for useful outcomes.
1. Can social scientists, engineers, and public policy makers be brought to bear collectively on the effectiveness of the delivery of public services and the societal response to natural hazards?
* To address the additional societal-response mission of the Earthquake Hazard Mitigation Program, in FY 1976 Dr. William Anderson was authorized to developed the Societal Response to Natural Hazards program. A part of that was an outstanding model that joined engineers, social scientists, and public policy makers in efforts to understand how people respond to hazards and to develop new policies that led to a more effective societal response. This program spawned a new generation of researchers dedicated to this field, which continues to be supported by NSF to this day.
* The Earthquake Program Hazard Mitigation funded the “Applied Technology Council (ACT) to develop revised seismic provisions for building codes, which eventually led to the ATC-3, published in 1978, that proposed major research results to practitioners”[[4]](#footnote-4), who serve as the facilitators for code development in the industry. The ATC-3 led to the formation of the Building Seismic Safety Council in 1979 to bring together the broad public and private interests that are needed to develop consensus on provisions that can be adopted in building codes.[[5]](#footnote-5)
* John Surmeier and Lynn Preston developed a program to support social scientists and operations researchers to devote their energies to developing methodologies to be used to assess the efficacy of public service delivery programs—which included, for example, a project that joined health service delivery researchers with health service provider organizations to explore regulation of the healthcare industry.
* Lesson learned:
	+ Engage public policy makers in projects where the goals are designed to impact public sector infrastructure, public service delivery systems, and public safety.
1. Will the support of joint research to advance technology by small businesses with academic researchers speed the development of new technology?
* In 1974, Roland Tibbits, a former entrepreneur, became a member of the RANN Program staff. He recognized the importance of small, high-tech firms to the economy and observed the fierce opposition they faced from other recipients when pursuing federal R&D funding. He believed these firms were instrumental in converting government R&D into public benefit through technological innovation and commercial applications, therefore stimulating aggregate economic growth. Senator Ted Kennedy recognized the potential for small firms to advance technology as well. These interests converged and the Small Business Innovation Research Program was initiated in 1976 at NSF. Its successes led to the establishment of the SBIR Program government-wide in the 1980. Tibbits is credited as the father of the SBIR Program. [[6]](#footnote-6)
* Lesson learned:
	+ Collaborative research between small firms and academic research can speed the advancement of technology and give needed technical support to firms undertaking high-risk, high payoff projects.
1. How can we develop a culture of collaborative relationships between industry and academe to better link to industry’s needs for technology?
* Understanding that there was a broad gulf between industry views of research in academe and academic views of research in industry, the RANN Program experimented with two new modes to begin to bridge that gap: centers and projects.[[7]](#footnote-7)
	+ RANN set up the Research and Development Incentives (RDI) Program to understand how best to develop productive and collaborative relationships with industry. Ten experimental centers, funded jointly by NSF and industry, were established and monitored. These included one focused on polymer processing at the Massachusetts Institute of Technology, led by Professor Nam Suh, and another focused on furniture manufacturing at North Carolina State. These centers provided a model for how collaborative relationships between industry personnel and faculty could be productive. Based on this experience, the Directorate for Applied Science and Research Applications (ASRA) established the Industry/University Cooperative Research Centers (I/UCRC) Program, which was subsumed by the Directorate for Engineering in 1985 and continues in operation today. One of the I/UCRCs funded by ASRA added an additional dimension to the model: it expanded the value to industry beyond collaborative research to include the research experience provided to students through these projects; industry wanted to continue to fund this center just to have access to the students. This center was funded at Rensselaer Polytechnic Institute under the leadership of Professor Mike Wozny and the focus was on computer-aided design and visualization, an exploratory direction for those years.
	+ RANN also experimented with smaller industry/university cooperative projects, which were largely funded by NSF. These projects were curtailed under the Reagan administration because they looked like transfer of funds to industry, or corporate welfare. There was similar pressure on the I/UCRC program, but industry demanded that the program continue and pledged to provide long-term joint support, something that did not happen with the projects program.
* Lessons learned:
	+ Start major new initiatives with models that are assessed for efficacy in meeting program goals and continuously improve through time.
	+ Be mindful of the changes that come with changes in political administrations; keep projects going with modifications to address the goals of new administrations and jettison those that are not supported by industry or the administration.

There was a high level of energy among the RANN staff and a strong *esprit de corps* that carried on through the staff who remained at NSF after the demise of RANN and through many of its awardees to this day. That *esprit de corps* derived partly from a sense of being constantly embattled within NSF. Bernie Chen, manager of RANN’s Robotics in Manufacturing program, sometimes remarked, as RANN became more and more embattled, “Time to get under the tables, everyone!” RANN program officers had to be careful not to “blow their horn” too loudly, and some were quite reticent. Nevertheless, RANN had a mission to support scientists and engineers so their research and findings would strengthen the economy, address ways to protect society from natural and man-made hazards, and strengthen our knowledge of how the society interacts with technology and how to use scientific knowledge and technology to strengthen public policy and government service delivery. Most notably, then, the *esprit de corps* derived from this sense of shared commitment to important goals.

The resistance inside NSF to the RANN approach to funding arose from strong concerns among the non-engineers that “if engineering linked with problem-solving, especially beyond its most fundamental aspects, won additional support and organizational latitude, could NSF’s basic-science mission be sustained?”[[8]](#footnote-8) Nevertheless, the program garnered enthusiastic support from F. Guyford Stever, the Director of NSF, who praised RANN in 1973 as “a pioneer in that big-picture ‘systems’ interrelationship between the activity of a human society and the ‘technological fix.’. It was important, he said, to “break down some of the separation that has existed between basic research, applied research, development, and the potential users of the knowledge and know-how research and development generates.”[[9]](#footnote-9) However, counter-pressures were mounting in Congress about the quality of some of the awards and an impatient request to see immediate results. Support was not fully forthcoming among members of the National Science Board because of a fear that applied research would become too “popular” on the Hill and subsume basic research. When Dr. Richard Atkinson was chosen to rise from the Deputy Director of the NSF to its Director in 1976 with the departure of Dr. Stever, he believed that applied research belonged in the mission agencies and internal support for RANN waned. Because of this increasingly evident lack of support for the program, Dr. Eggers left in 1977 and RANN was dissolved by 1978.[[10]](#footnote-10) It was replaced with the Directorate for Applied Science and Research Applications, which operated between 1978 and 1981, when the first Directorate for Engineering was established. The author of a history of the support of biology by NSF remarked:

*Nevertheless, after RANN, the acceptance of applied research at the NSF endured and remains today a strong and fundamental aspect of the structure and organization of the Foundation. Both IRRPOS and RANN together provided a number of years of what could be termed “experiential education” for the NSF in learning how best to support applied research and how best to design programs inviting research proposals that might be basic, applied, or both. RANN was also a harbinger of the Foundation’s effort, a decade later, to link academic basic research with industry to address the issue of the United States’ international competitiveness in STEM*.[[11]](#footnote-11)

1. Belanger, Dian Olson (1998). *Enabling American Innovation: Engineering and the National Science Foundation*. West Lafayette, Indiana: Purdue University Press, p. 98. [↑](#footnote-ref-1)
2. Ibid., p. 109 [↑](#footnote-ref-2)
3. SRI International Science and Technology (1999). History of the NSF Earthquake Hazard Mitigation Program. Draft report prepared for NSF, October 7, 1999, p. 14. [↑](#footnote-ref-3)
4. Ibid., p. 17 [↑](#footnote-ref-4)
5. Ibid., p. 25 [↑](#footnote-ref-5)
6. Small Business Administration (N.D.). Birth and History of the SBIR Program. Retrieved from <https://www.sbir.gov/birth-and-history-of-the-sbir-program>. [↑](#footnote-ref-6)
7. The following bullets are based on a conversation between Lynn Preston and Alex Schwarzkopf, August 7, 2017. Schwarzkopf was a program director in RANN who was responsible for the RDI Program and went on to lead the I/UCRC program for more than 30 years. [↑](#footnote-ref-7)
8. Belanger, op. cit., p. 58. [↑](#footnote-ref-8)
9. Ibid., p. 116. [↑](#footnote-ref-9)
10. Ibid., pp. 118-119. [↑](#footnote-ref-10)
11. McGraw, Donald (2009). *Millennial Biology: The National Science Foundation and the Biological Sciences, 1975–2005* (draft), p. 31. Archives of the National Science Foundation library. [↑](#footnote-ref-11)