**EVOLUTION OF ERC KEY FEATURES**

The following chronicles how each of the ERC key features evolved over time and when new ones were added or when others were deleted.

## Focus/Vison and Research

 Gen-1 ERCs: Classes of 1985–1990[[1]](#footnote-1)

* Focus on major technological concern of both industrial and national importance
	+ 1985 — Examples given (systems for data and communications, computer-integrated manufacturing, computer graphics design, biotechnology processing, materials processing, transportation, and construction)
	+ 1986 on — No Examples (thought to be constraining topic choice)
* Provide research opportunities to develop fundamental knowledge in areas critical to U.S. competitiveness in world markets
	+ Strategic plan and testbeds added in 1997 for all classes
* Emphasize the systems aspects of engineering and help educate and train students in synthesizing, integrating, and managing engineering systems
* Team effort of individual from various backgrounds – cross disciplinary
* Provide experimental capabilities not available to individual investigators because of large instrumentation acquisition costs, requirements for a large number of skilled technicians, or other maintenance and operating requirements.

Gen-2 ERCs: Classes of 1994/1995–2000[[2]](#footnote-2)

Emphasis was added during this period to make it clear that ERCs had a base in creating new knowledge as well as new technology and strategic research planning was required to be implemented through a 3-plane strategic plan chart develop by the ERC Program.

* Clear, coherent vision
* Fundamental research strategically focused on the synthesis, integration, and management of engineering systems, spanning work from knowledge creation through to experimentation in testbeds, and delivery new knowledge and technological advances:
	+ Proof-of-concept description of testbeds added in 1998
	+ Complex next-generation engineered systems added in 1998
	+ Strategic research plan to realize the vision, displayed on the ERC Program’s 3-plane chart added requirement for full proposals under NSF 98-246.
* Team effort possessing different engineering and scientific skills
* Major specialized experimental capabilities not available through single-investigator projects because of need for skilled technicians, or other maintenance and operating requirements.

Gen-2 ERCs: Classes of 2003–2006[[3]](#footnote-3)

Because the proposals for the Class of 2000 were largely focused on incremental improvements in engineered systems, only two awards were made, when up to seven might have been made. As a consequence, the NSF ERC team focused on new language to generate proposals that would focus on *transformational* engineered systems that could spawn new industries or service delivery or infrastructure systems, or transform current ones.

* Long-term, strategic vision for an emerging engineered system with the potential to spawn a new or transform a current industry, service delivery system, or infrastructural element
* Cross-disciplinary faculty team to integrate fundamental and technology research with proof-of-concept testbeds designed to test theory in functioning systems;
* Experimental, computational, and other equipment, facilities, and laboratory space required to perform the proposed research and enable a robust learning environment.

Gen-3 ERCs: Classes of 2008–2013**[[4]](#footnote-4)**

The ERC construct was updated to address the challenges of the 21st Century to create the Gen-3 ERCs.

* Guiding strategic vision for advances in an emerging and potentially revolutionary or transformational engineered system with the potential to significantly change current practices, establish wholly new industries or public sector services
* Strategic, discovery, and systems motivated cross-disciplinary research program, including small firms engaged in translational research
* Strategic research plan motivated by the systems vision and positioned to advance the state of the art, which is dynamic and evolving over time, displayed on the ERC Program’s 3-plane chart
* Testbeds enable proof-of concept inquiries of enabling and systems-level technologies to test new ideas/components and their relationship in an environment that simulates their intended application
	+ Testbeds demonstrated on an academic scale, but beyond typical bench or laboratory scale, and not expected to approach product or process realization stages found in industry
	+ As technology progresses from academic proof-of-concept scale, industry would be expected to support the scale-up
* Facilities and equipment to be used to form a collaborative team with shared resources.

## Industrial/Practitioner Collaboration and Technology Transfer

Industrial collaboration, later expanded to include practitioner collaboration to accommodate infrastructure and health care ERCs, was an initial key feature of the ERCs and remained so throughout this history. Experience proved that the features of this collaboration needed to be supported through membership agreements and industrial commitments for financial support needed to be monitored post-award. Pre-award financial commitments were difficult for firms to submit because an award was not yet made and corporate lawyers advised corporate staff not to include finances in letters of commitment.

Gen-1 ERCs: Classes of 1985–1990[[5]](#footnote-5)

* Include participation in planning and assessment of research and education of engineers and scientists from industrial organizations, and from State and local government agencies or government research laboratories may also participate
* Focus activities on current and projected industry needs and enhance education of students in systems aspects of engineering
* Develop new methods of timely transfer to industrial users
* 1986 on — Strong commitment from industry (money, equipment, and people)
* Include an Industrial Advisory Board and function with a membership agreement (specified in cooperative agreements).

Gen-2 ERCs: Classes of 1994/1995–2000[[6]](#footnote-6)

Same as above, plus

* Guide ERC activities toward long-term, generic needs of industry and to enhance the education of engineers
* Facilitate two-way flow of ideas
* Help industry create new wealth
* NSF PA 94-150 — Long-term commitment for financial support in full proposals.

Gen-2 ERCs: Classes of 2003–2006[[7]](#footnote-7)

The prevalence of multi-university ERCs after 2003, required guidance that industrial support and intellectual property policies were to be at the center- and not campus-level.

Same as above, plus

* Center-wide membership agreement for multi-university ERC, participating as member of the whole ERC not just as campus-level affiliates
* Proposed fees and terms of membership agreement and Intellectual Property policy summarized in the preliminary proposal and finalized and included in full proposal for invited finalists.

Gen-3 ERCs: Classes of 2008–2013**[[8]](#footnote-8)**

* Same as above, plus Gen-3 ERCs required to:
	+ Optimize innovation and speed commercialization/utilization of ERC advances
	+ Support translational research by engaging domestic small firms in transforming high-risk research into successful commercial products for the U.S. economy
	+ Form partnerships with state and local government agencies designed to develop entrepreneurs, support start-up firms, and speed the translation of academic knowledge into practice and products.
* NSF 11-537 — Translational research support with small firms clarified to read “IP derived from ERC program support and industry partner membership fees will first be offered to member firms for licensing before translational research partnerships can be supported.”
* 2009 — ERCs receive supplemental funds to stimulate the economy.

##  Education and Workforce Training

The educational role of ERCs required major shift for academic engineering through the development of a research culture that joined disciplines and included a systems perspective and the participation of industry and technology transfer. Education had usually been defined as course and curriculum development to improve classroom education but the ERC program broadened it to include research and technology development experience.

Gen-1 ERCs: Classes of 1985–1990[[9]](#footnote-9)

* Emphasize systems aspects of engineering and help educate and train students in synthesizing, integrating, and managing engineering systems
* Significant education component involving both undergraduate and graduate students in research
* Expose students to many aspects of engineering, systems, and industrial practice
* Codify new knowledge for university students and continuing education of practicing engineers
* Involve 10 percent of home institutions graduate students and masters and doctoral levels (later dropped as it generated proposals with too many faculty to be manageable).

Gen-2 ERCs: Classes of 1994/1995–2000[[10]](#footnote-10)

The 10 percent requirement was dropped, as it resulted in proposals that involved too many faculty to enable the support of those students. In addition, the ERCs began to experiment with involving pre-college students and teachers, which provided the ERC program with lessons on a new feature. Through this period, the ERCs themselves expanded this feature but it would not be required until 2004.

* Same as above
* Develop courses and curricula based on ERC’s research
* NSF 94-150 — Expose pre-college teachers and students to engineering and industry; not mentioned again after that until NSF 02-24.

Gen-2 ERCs: Classes of 2003–2006[[11]](#footnote-11)

* Same as above including involving pre-college students and teachers
* NSF 04-570 — Research Experiences for Undergraduates required
* NSF 04-570 — Pre-college activities for students and Research Experiences for Teachers required.

Gen-3 ERCs: Classes of 2008–2013**[[12]](#footnote-12)**

The Gen-3 educational features made explicit what was implicitly required earlier. In addition, because of the requirement for assessment new faculty with degrees in education or even engineering education entered into the ERC culture. The pre-college feature was strengthened by requiring long-term partnerships with a few pre-college institutions as there had been too many random associations in prior classes.

* Strategically focused education program designed to develop engineering graduates who are creative, can work across cultures, able to work in teams to define pathways to explore and realize innovation opportunities
* Long-term partnerships with pre-college educational institutions and their teachers and students to bring engineering concepts into the classroom with ERC faculty and student participation
* Young Scholars program for talented high school students
* Course and curriculum impacts derived from ERC’s research and innovation experiences
* Assessment plan to monitor and improve the program and assess long-term impacts
* Universities will reward faculty for educational and mentoring activities.

## Leadership Team

The leadership team requirements grew over time as the centers became more complex and there was a realization at NSF of the important role of ERC students as members of the leadership teams of their centers and not just as “workers.” The configuration of ERCs as multi-university organizations brought on the requirement for a Council of Deans to support the Dean at the lead university.

Gen-1 ERCs: Classes of 1985–1990[[13]](#footnote-13)

* Center Director, mention of staff, no specifics but by 1990 includes administrative and financial management, education, and industrial collaboration and technology transfer

Gen-2 ERCs: Classes of 1994/1995–2000[[14]](#footnote-14)

* Same as above until 1998 when deputy or associate director and research thrust leaders added
* In 2000 an educational outreach director was added

Gen-2 ERCs: Classes of 2003–2006[[15]](#footnote-15)

* Same as above, plus Student Leadership Council, Advisory Boards (outside advisory board, academic policy board, industrial advisory board {IAB required through cooperative agreement since the 1980s)

Gen-3 ERCs: Classes of 2008–2013**[[16]](#footnote-16)**

* Same as above, plus Diversity Director, Pre-college Education Director, and a Council of Deans.

## Diversity

Diversity was always expected in ERCs and data was collected from the start; however, the requirements became more structured through time and by 2004, at the request of the Deputy Director of NSF, ERCs were required to prepare strategic plans for diversity with their associated departments and deans. Noting the lower levels of diversity present in most of the lead and core partner universities, added features came in to create partnerships with universities that served groups predominantly underrepresented in engineering. The evolution of ERC diversity policy and key features is detailed at some length in Section 9-L, near the end of chapter 9.

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