Engineering Research Centers (ERC)

NSF EPSCoR Regional Outreach

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Outline

1. ERC Program: Background
2. Planning Grants
3. Overview of Gen-4 ERC
4. ERC Strategic Approaches
5. Important Changes for Gen-4 ERC
6. Questions

ERC Program: Background

Integrated ERC Program Goals

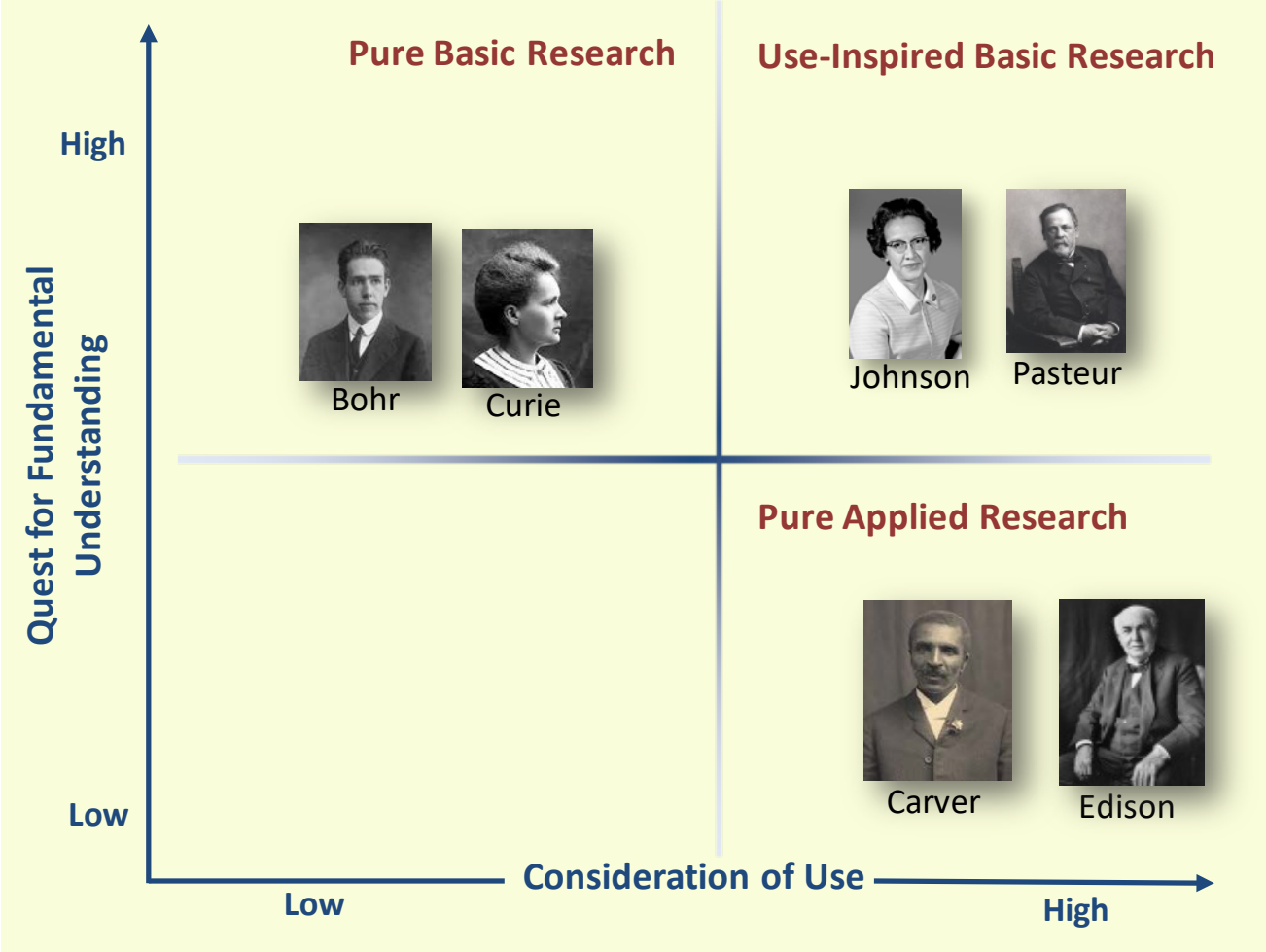
- Create an inclusive culture to integrate scientific discovery with technological innovation through <u>transformational engineered systems research and education</u>

- Build partnerships with industry and practitioners to strengthen the <u>innovative capacity</u> of the U.S. in a global context

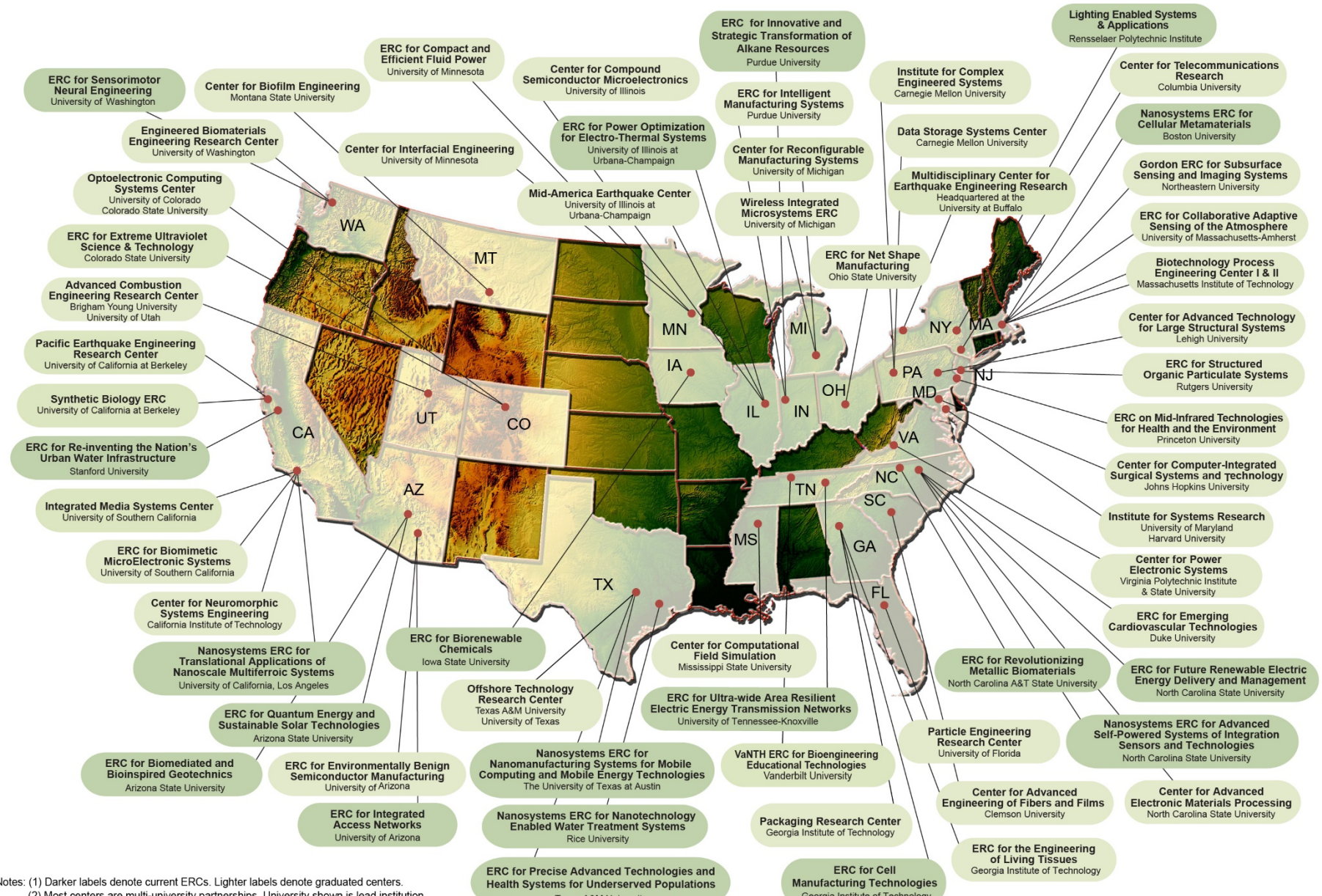
- Produce <u>diverse</u> engineering graduates who are creative innovators in a global economy

Pasteur's Quadrant: ERC=>Use-Inspired

- Use –Inspired: driven by a significant need
- System-driven: the overarching engineered system defines the overall research agenda

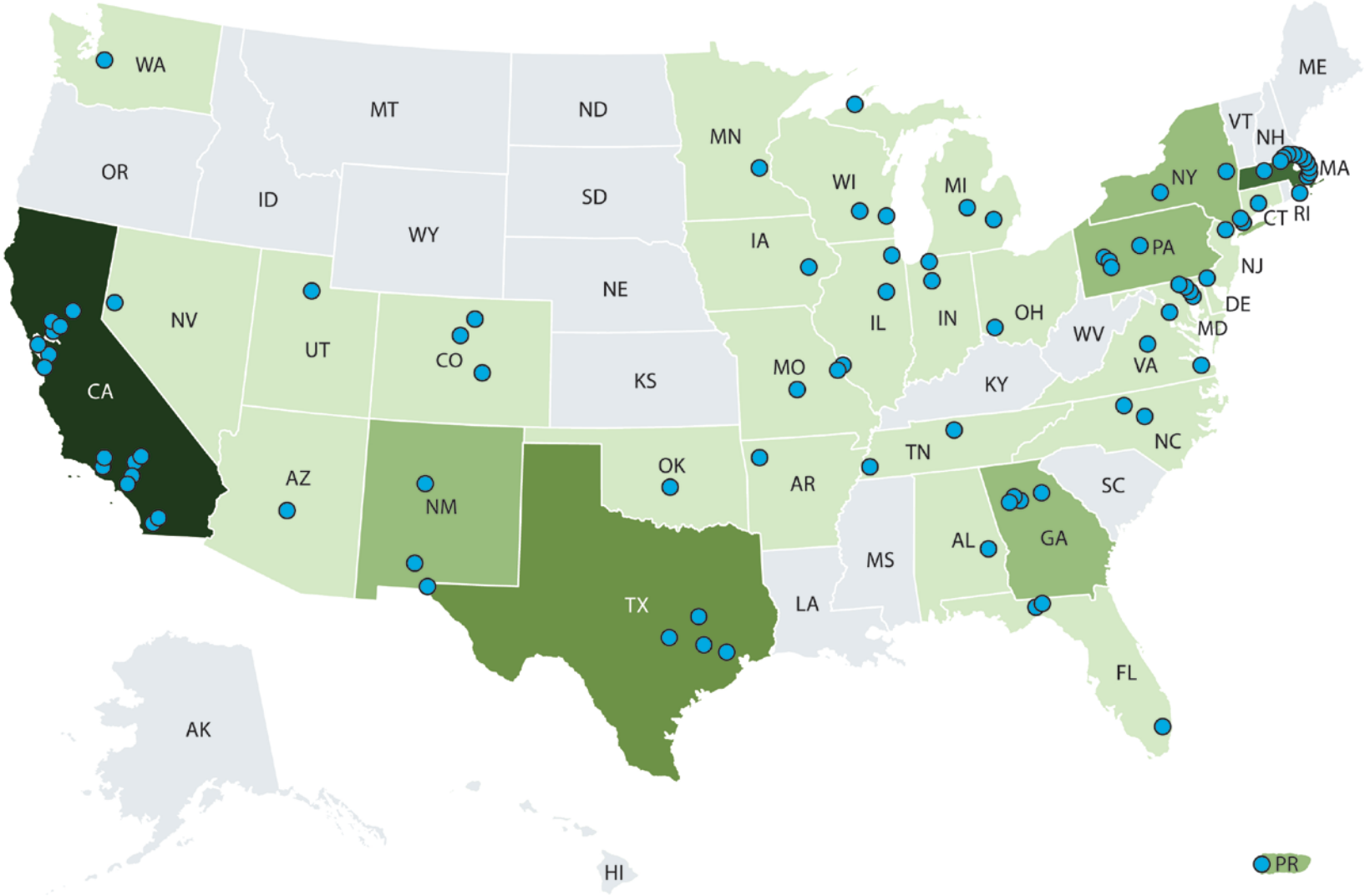


NSF Engineering Research Centers (ERCs) 1985–2019
Lead Institutions



Notes: (1) Darker labels denote current ERCs. Lighter labels denote graduated centers.
(2) Most centers are multi-university partnerships. University shown is lead institution.

NSF Engineering Research Centers (ERCs) 1985–2019
Core Partner Institutions



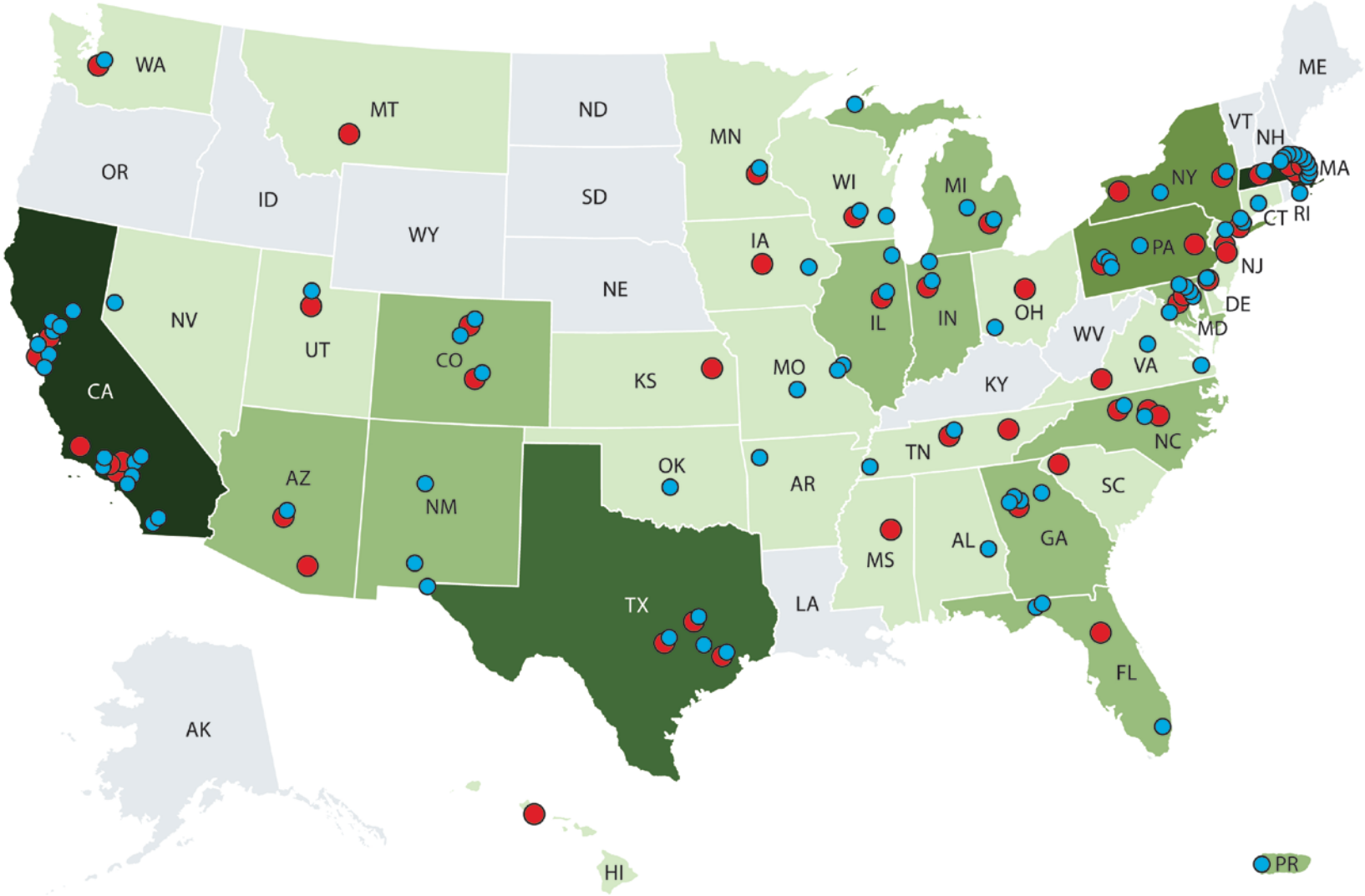
Note: Only one dot per institution; many institutions are/were part of more than one ERC

Core Partner institutions

Core Partner institutions, including multiple participations

0	1-5	6-10	11-15	16-20	21+

NSF Engineering Research Centers (ERCs) 1985–2019
Lead and Core Partner Institutions



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Lead institutions

Core Partner institutions

Lead + Core Partner institutions, including multiple participations

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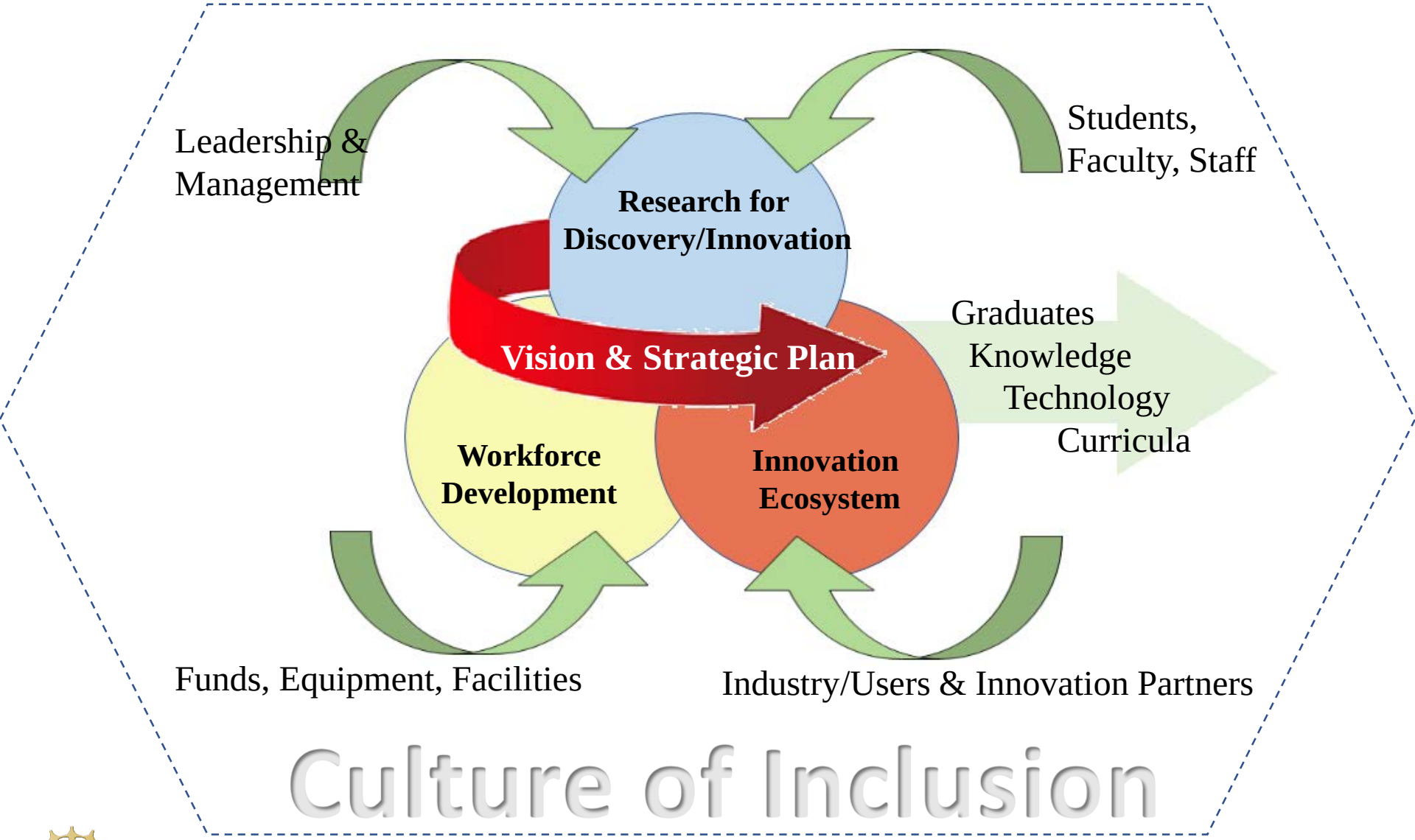
NSF ERC: A Complex, Interdependent System



Essential Elements of an ERC

Vision and Strategic Plan:

- **Vision**: *Guides discovery & technology to uniquely transform US prosperity, health, or security in 10 years* *What is the compelling new idea and how does it relate to national needs?*
- **Strategic Plan**: *Leverage recent breakthroughs to overcome key gaps/barriers that limit advances to state-of-the-art via clear research milestones. Both the focus and adaptability of plans are apparent.* *Why is a center necessary to tackle the idea?*

Research:

- **Research**: *Guided by envisioned proofs-of-concept for an engineered system, research is defined with synergistic (whole >Σ parts) partnerships and benchmarking vs. state-of-the-art to achieve scale-able results.*
- **Engineering System Scope**: *Clear path from research to demonstration of proofs-of-concept in engineered system testbeds.*

Engineering Workforce Development:

- *An inclusive, research- and evidence-based approach is used to develop both curriculum and professional skills training. These activities are refined via external assessment.*

Innovation Ecosystem:

- *Plans for strategic engagement of stakeholder community using innovation frameworks.*

Culture of Inclusion and Diversity:

- *Plans to recruit and retain diverse students, faculty and staff and plan for strategic engagement of all partner institutions in a Culture of Inclusion*

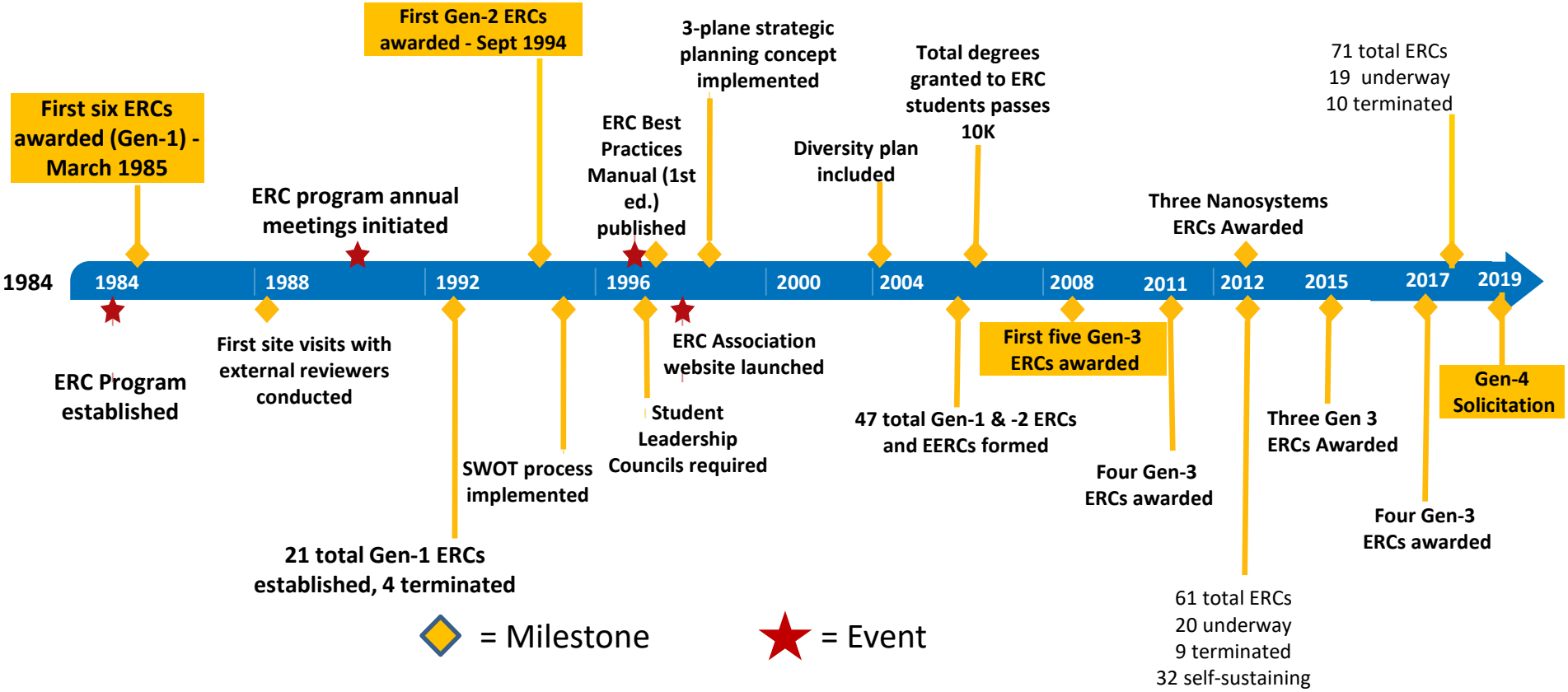
Infrastructure:

- **Leadership**: *Deep expertise required in Research, Workforce Development, Innovation and Diversity and Inclusion*

ERC Logic Model:

- *Does the logic model adequately illustrate the integration of the four pillars?*
- *Does the logic model provide effective guidance for designing the Center's assessment plan?*

ERC Evolution Timeline



Overview of Gen-4 ERC Competition

Gen-4 ERC Competition Goals

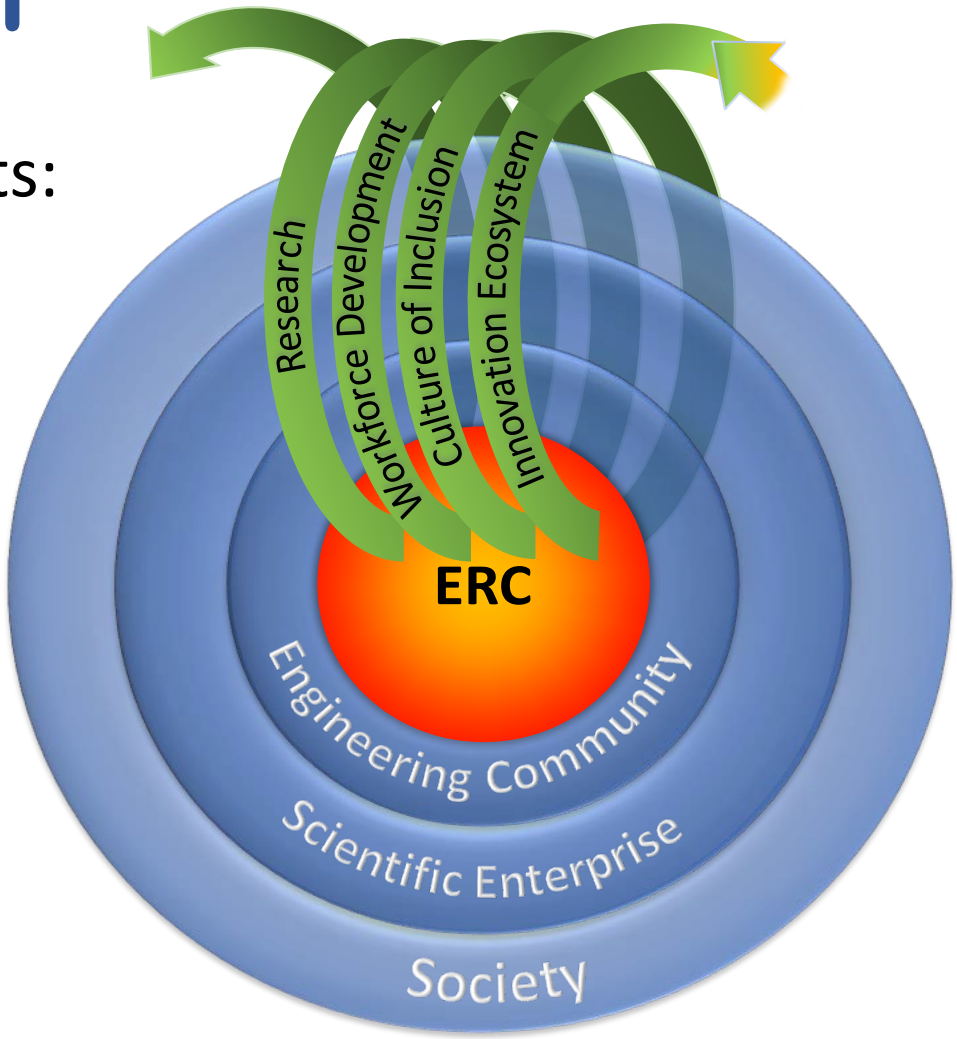
- This ERC Competition has been informed by a study from the *National Academies of Sciences, Engineering, and Medicine (NASEM)*.
- The program continues to focus on advancing an engineered system through inclusive **cross-disciplinary** and **cross-sector** partnerships, while placing greater emphasis on research that leads to **societal impact** through **convergent** approaches, engaging **stakeholder communities**, and strengthening **team formation**.
- ERCs should have strong synergies or value-added rationale that justify a center or institute-like approach.

Gen-4 ERC Particulars

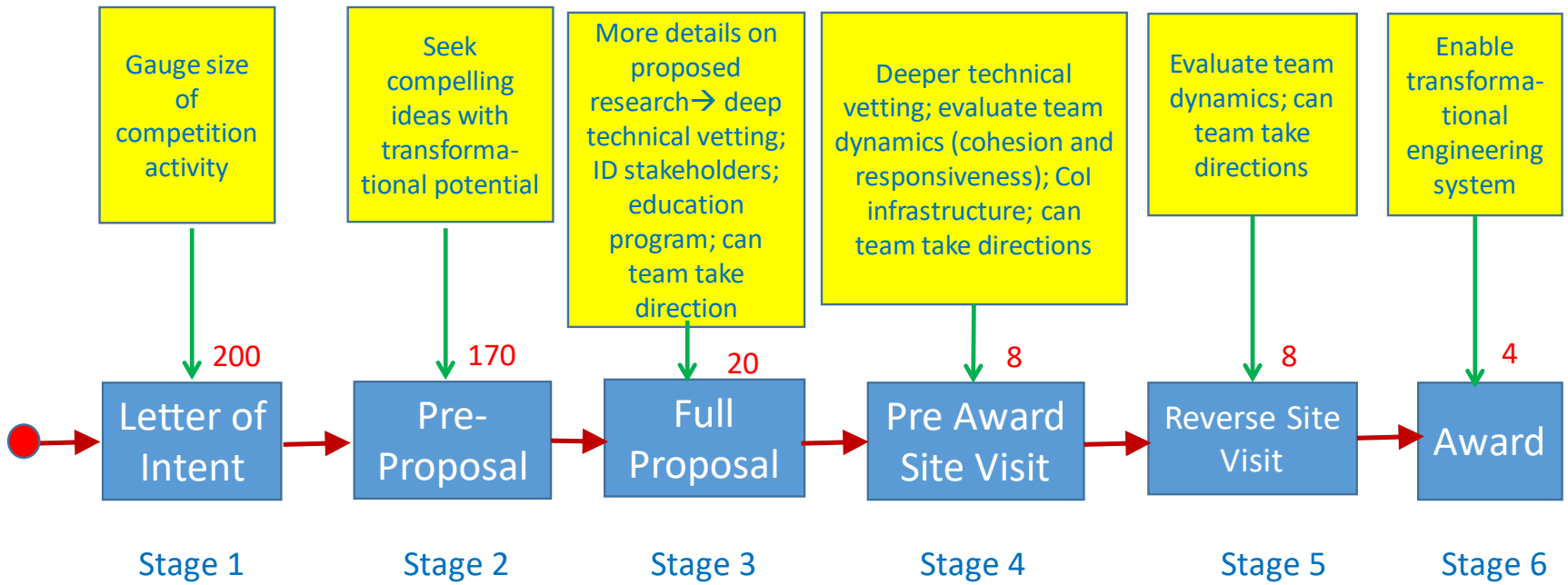
- Award mechanism: Cooperative agreements
- Multi-institutional requirement
- Budget: $6 million / year
- Up to 10 years of funding for successful ERCs

The ERC Model

- Foundational Components:
  - **Convergent** Research
  - **Engineering** Workforce Development
  - **Diversity** and Culture of Inclusion
  - **Innovation** Ecosystem
- Areas of Impact:
  - **Engineering** Community
  - **Scientific** Enterprise
  - **Society**



Functional Flow Chart of Generic ERC Competition



Planning Grants

Planning Grants

GOAL: *The Planning Grants for ERC solicitation is a mechanism to increase capacity across the engineering academic community to develop ideas, facilitate team formation, and foster stakeholder community networks.*

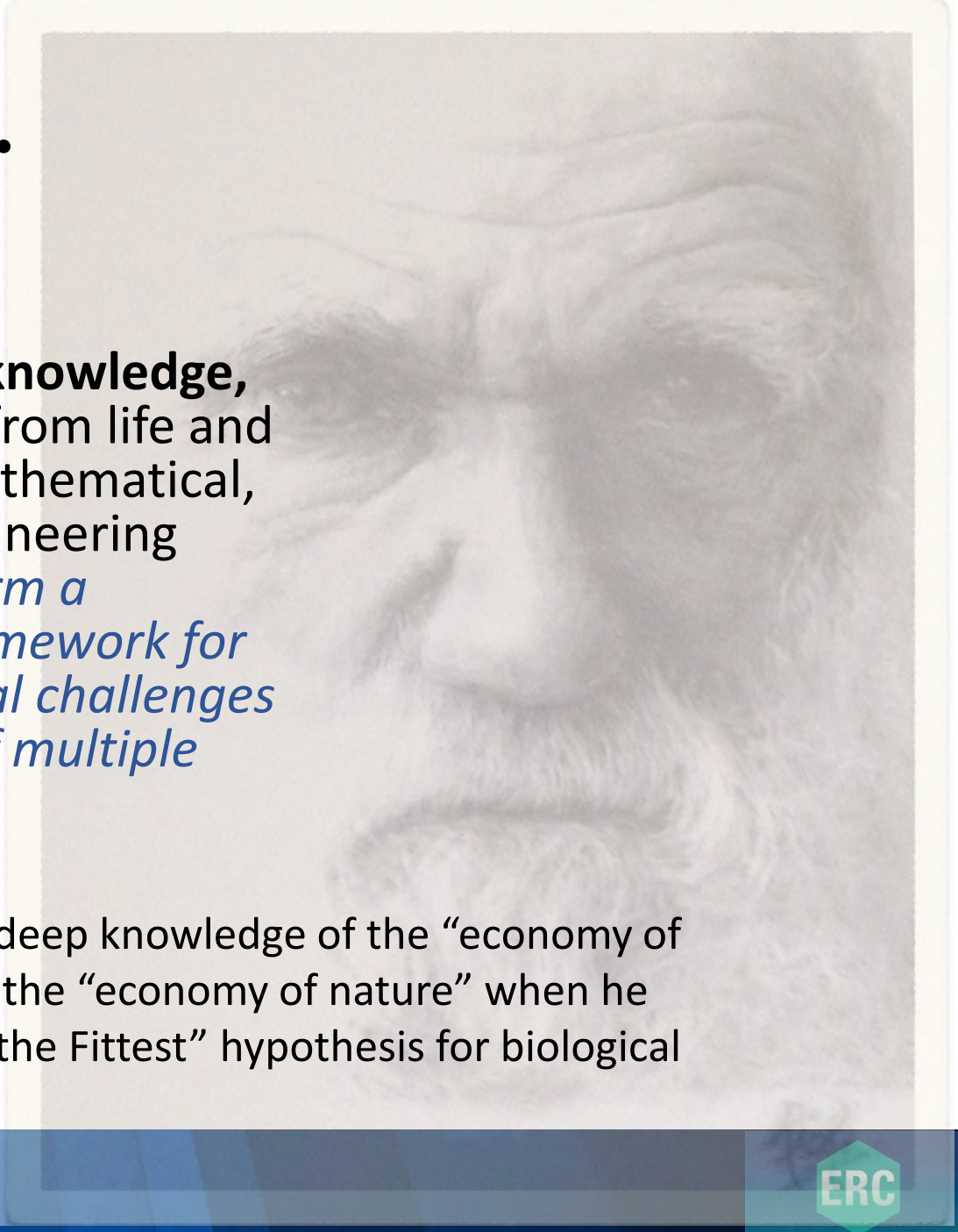
- Participation in the **Planning Grant** program should not be construed as an application submission for this ERC competition;
- To participate in this **ERC competition**, one is not required to have submitted a planning grant proposal nor to have received a planning grant.

ERC Strategic Approaches

Foundational Components: Convergent Research

- **Convergence** is an approach to problem-solving that cuts across disciplinary boundaries.
- **Convergent** engineering is a deeply collaborative, team-based engineering approach for defining and solving important and complex societal problems (NAE, 2017).
- **Convergent** research has the strong potential to lead to transformative solutions or new fields of study.
- https://www.nae.edu/113283.aspx

Convergence…



- …is the deep **integration** of **knowledge, tools, and ways of thinking** from life and health sciences, physical, mathematical, computational sciences, engineering disciplines and beyond to *form a comprehensive synthetic framework for tackling scientific and societal challenges that exist at the interfaces of multiple fields.*

Example: Darwin used his deep knowledge of the "economy of man" and applied them to the "economy of nature" when he developed his "Survival of the Fittest" hypothesis for biological systems.

Example: Tissue Engineering Meets 3D Printing

- 3D printing technology fuses
  - Geometric modeling
  - Additive manufacturing
- Tissue engineering combines
  - Clinical medicine, engineering, and science
- Additive manufacturing now enables printing of scaffolds for tissue engineering
  - Unanticipated convergence of two different research directions

Novogen MMX Bioprinter

Foundational Components:
Engineering Workforce Development

- **Human resource capacity development** aligned with the targeted engineered system; ERC engineering workforce development strengthens a robust spectrum of engineering education and pathways.
- **Workforce Development** occurs at all levels of the Center and provides opportunities for engagement by all ERC members including students, faculty, and external partners, as appropriate.

Foundational Components: Diversity and Culture of Inclusion

- The culture of the ERC and teams within the ERC demonstrate an environment in which **all members** feel valued and welcomed, creatively contribute, and gain mutual benefit from participating.
- Participation from members of groups traditionally **underrepresented** in engineering as well as **diverse scientific and other perspectives** is required.

Foundational Components: Innovation Ecosystem

- **Trusted** partners that work together to create and enhance the **capacity for innovation** and new ways for delivering value with positive societal impact.
- Include **effective translational efforts** from ideation to **implementation**, workforce development for the **enterprise**, and deliberate efforts to attract **funding** and **resources**.
- **Articulate plans** for strategic engagement of stakeholder communities while **including the legal frameworks** needed to protect the participants.

ERC Program Overview: Impact on Society

- **Societal Impact** represents opportunities and challenges that may be addressed through advances in engineering research and innovation for the benefit of society at large.
  - Potential **societal impact** should be relevant and complex, and not limited to any specific schema of grand challenges

ERC Program Overview:
Impact on the Scientific Enterprise

- **Scientific Enterprise:** ERCs should be exemplars of how cohesive, high-performing teams engage in convergent research and innovative approaches to create major impact that informs and inspires the scientific community, engineering and beyond.

ERC Program Overview:
Impact on the Engineering Community

- **Engineering Community:** ERCs directly impact the engineering community, preparing students and researchers by highlighting new engineering approaches and best practices for engineering workforce development, diversity and inclusion, and academic-industrial partnerships.

ERC Strategic Approaches: Team Formation

- **Team Formation** is the process by which all necessary disciplines, skills, perspectives, and capabilities are brought together.
- Successful teams are interdependent, multidisciplinary, and diverse; can work and communicate effectively even when geographically dispersed; and effectively overcome barriers to collaboration.
- Best practices: https://www.nap.edu/catalog/19007/enhancing-the-effectiveness-of-team-science

Effective Leadership/Management

- **Effective Leadership/Management** describes the skills needed by ERC leaders including intellectual vision and leadership, effective management of center activities, successful entrepreneurial experience, a track record of delivering results, and the ability to communicate clearly and effectively with diverse audiences, such as team members, sponsors, partners, host institutions, stakeholders, press and media, and the public.
- **Effective ERC leadership and management** teams may, for example:
  - Empower all team members to contribute regardless of status and power differences;
  - Establish a culture of deep collaboration and inclusion;
  - Build consensus around goals and problem definition;
  - Facilitate communication to ensure a common understanding;
  - Resolve conflicts and build trust.

ERC Strategic Approaches: Stakeholder Community

- **Stakeholder Community** includes all parties who may contribute to the ERC or may be impacted by the ERC.
- **Stakeholders** can include but are not limited to:
  - Relevant researchers across partner institutions with complementary research and education expertise;
  - Industry leaders who can guide the innovation effort;
  - Partners for innovation, education, workforce development, and diversity;
  - Beneficiaries of the ERC outcomes (community members, users, customers, patients, and policy-makers, et al.).

Examples of Stakeholders

- Researchers across Institutions
- Undergraduate Students
- Graduate Students
- Postdoctoral Researchers
- Partners for Innovation
- Partners for Outreach and Education

- Community Members
- End Users
- Customers
- Patients
- Watchdog Organizations
- Policy Makers
- International Partners

Important Changes for Gen-4 Competition

Changes in ERC Competition: Focus

- Societal Impact:
  - Enable society to have a better quality of life, and be more resilient, productive, and/or safe.
- Convergence:
  - The deep integration of knowledge, tools, and ways of thinking beyond engineering (for example, from the physical, mathematical, life/health sciences, computational sciences, and social sciences, among others).
- Team Formation:
  - Supporting convergence, the formation of diverse scientific teams.
- **Culture** of Inclusion and Diversity:
  - Both inclusion of underrepresented groups and inclusion of team members from different scientific disciplines.
- Review Criteria:
  - Additional Review Criteria reflect the changed focus areas.

Changes in ERC Competition: Flexibility in Eligibility

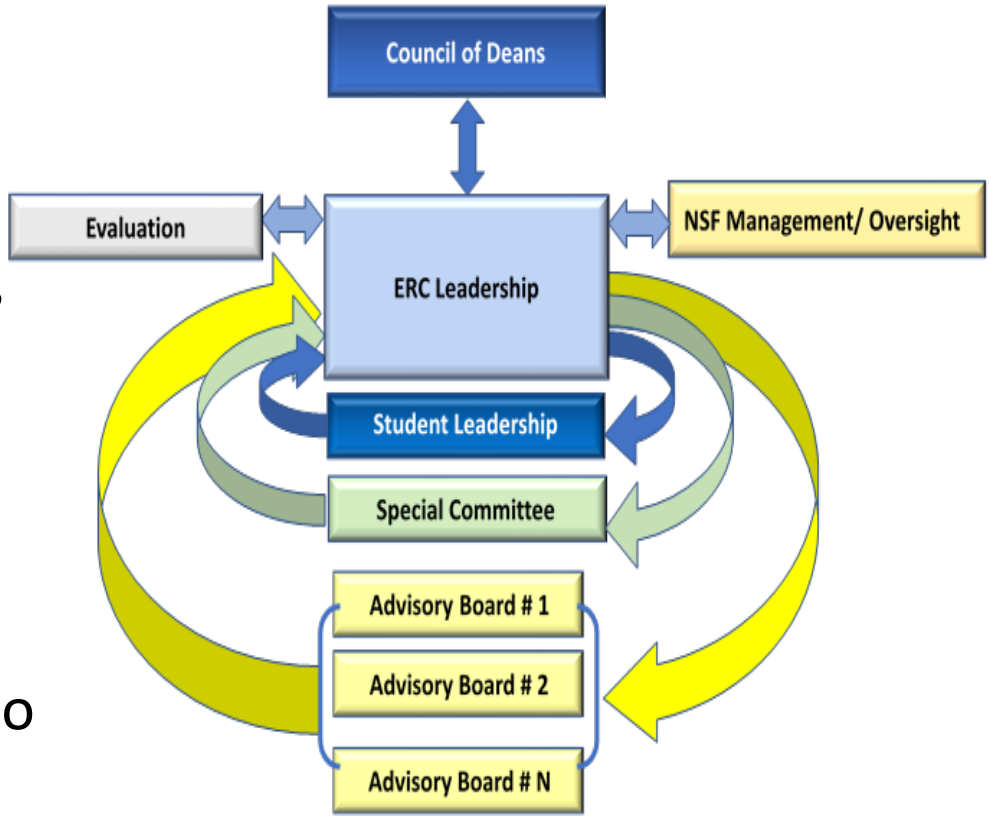
- Limit on Number of Letters of Intent and Preliminary Proposals:
  - Per Institution: None
  - Per PI or Co-PI: None
- The lead institution must have an Engineering Department/School, offering degrees at the Bachelors, Masters, and PhD level.
- A letter of support must be received from the Dean of Engineering at that institution.

Changes in ERC Competition: Flexibility in Personnel

- Principal Investigators:
  - The Lead PI must be a tenured faculty member at the Lead Institution; cannot change.
  - The Lead PI does not have to be from an Engineering Department.
  - The Lead PI and the ERC Director are not required to be the same person, but both must be from the Lead Institution.
  - Non-Lead PIs are the PIs listed on the Cover Sheet after the Lead PI and may be from institutions other than the lead university.
  - Non-Lead PIs do not need to be tenured; may change.
- Leadership Roles:
  - Opportunity for different models of leadership
  - Exception: ERC Administrative Director role is required.

Changes in Competition: Flexibility in Management

- Management Structure:
  - More freedom and creativity
  - Define the roles of various advisory boards/entities
- Explain the ERC's processes for
  - Team communication
  - Taking in and responding to advisory feedback



Resources

- Gen-4 ERC Program landing page: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505599
- ERC Association Website: http://erc-assoc.org/
- *A New Vision for Center-Based Engineering Research:* https://www.nap.edu/catalog/24767
- *Convergence*: https://www.nap.edu/catalog/18722
- *Enhancing the Effectiveness of Team Science*: https://www.nap.edu/catalog/19007

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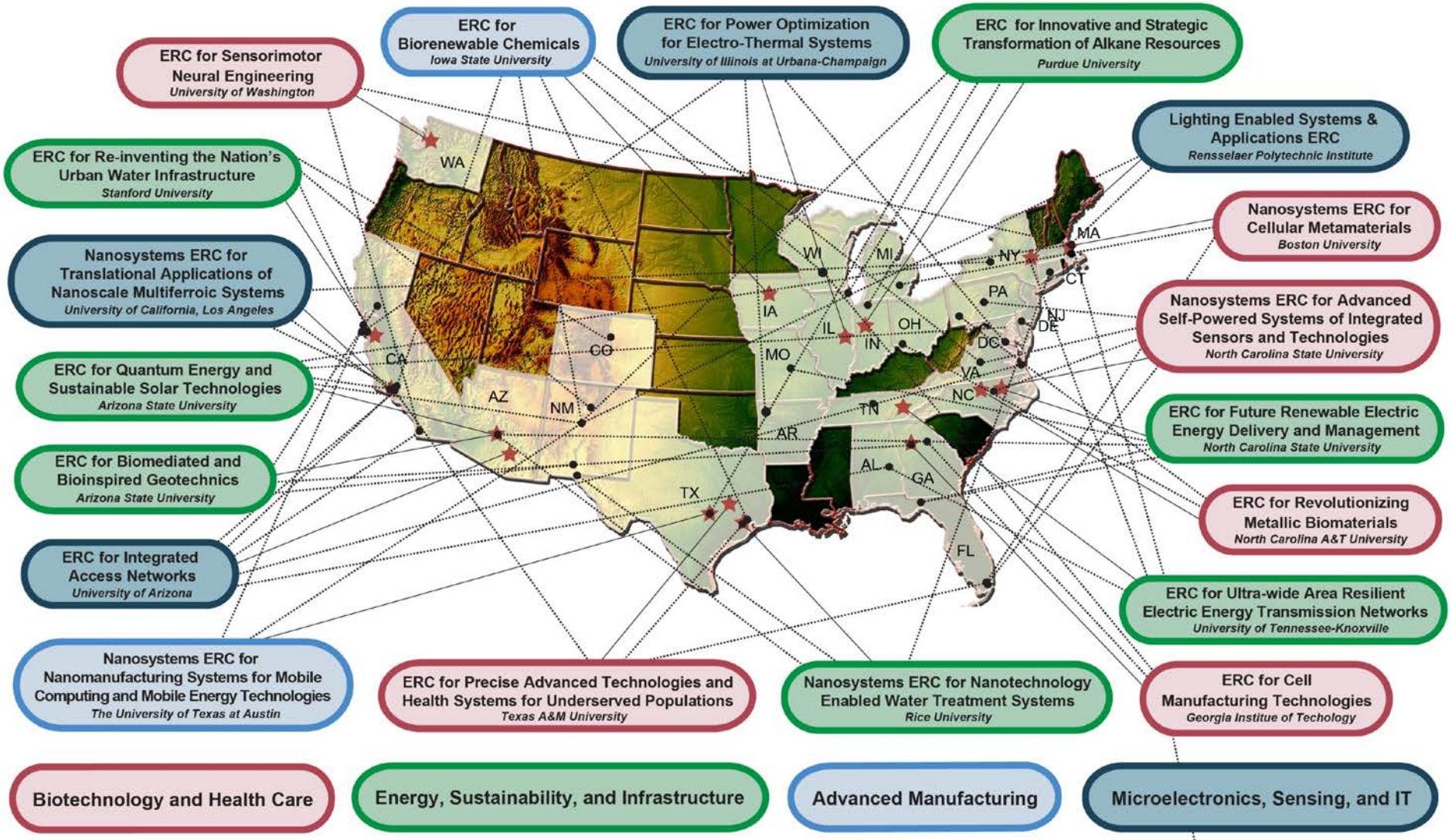
Questions?

2019 Location Map of ERC Lead and Core Partner Institutions



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