Accelerating Engineering Innovation Planning Meeting

A group of representatives from Sandia National Laboratories (SNL), industry and academia met on Wednesday, October 25, 2006 in Chicago. The meeting participants discussed recommendations made at SNL's *Accelerating Engineering Innovation Summit* (*Summit*), held in Albuquerque on May 31 - June 1, 2006 and next steps. This report summarizes the results of the October 25th meeting.

Background and Objectives

In June of 2006, a *Summit* meeting was called in response to the President's American Competitiveness Initiative (ACI) highlighted in the January 2006 State of the Union address. Goals of the ACI are to improve the pipeline of talent in the fields of science, technology, engineering and math (STEM); prepare a more diverse population of engineers with a range of technical and non-technical skills; and enhance the U.S.' ability to capitalize on business opportunities created from future scientific discovery utilizing a skilled workforce trained in interdisciplinary, collaborative research and product development.

Key findings from the *Summit* were:

- Engineers need to be better at quickly building successful partnerships.
- Partnering among U.S. institutions must be made simpler.
- Engineers need to be more broadly educated (depth is critical, but breadth is increasingly important).
- The advantages and needs for a multi-disciplinary approach to education are recognized, but the challenges to implementing this approach are great.
- There must be a concerted effort to attract, inspire, and retain qualified U.S. students – a "pipeline" of talent essential to future competitive success.
- Bright minds are attracted to engineering when they are given the opportunity to solve challenging problems of national importance, and provided access to state-of-the-art facilities.

The *Summit* meeting participants recommended that new approaches to accelerate and enhance partnerships between institutes are required to facilitate partnering, enhance educational experiences, and truly accelerate innovation for the nation. The concept of Discovery Science and Engineering Innovation Institutes (DSEII) was endorsed as an approach that would address the key challenges and Sandia was encouraged to take the lead in developing its prototype National Institute for Nano-Engineering (NINE) with industry and university partners.

Sandia then gathered a group of distinguished participants for a follow-on meeting in Chicago in October to address *Summit* recommendations. Goals and objectives of the meeting were to:

- Provide SNL and its partners with an opportunity to develop a framework for a DSEII based on shared vision, using Sandia's NINE as a model.
- Develop a foundation for a Memorandum of Understanding (MOU) based on a common vision for a DSEII.
- Establish a set of criteria to be used in a future national Request for Proposal (RFP) from DOE on establishing DSEIIs.

Meeting Structure and Goals

The ultimate goal for this planning meeting was to provide the initial basis for a new conceptual model of a DSEII. Information gleaned from the meeting would be used to populate a Memorandum of Understanding (MOU) that describes the common vision of the group, and inform a response to a future DOE Request for Proposal for DSEII's.

The meeting opened with presentations by SNL managers that outlined the day's goals, current governmental climate toward Discovery Institutes, and challenges that may face DSEIIs. The meeting was divided into morning and afternoon sessions. The purpose of the morning session was to answer the following questions:

1. What are the correct goals for DSEIIs?
2. What approach will be successful in accomplishing the DSEII goals?

This session was an open discussion of the structure, organization, and features required of a DSEII. Challenges that may be associated with developing new institutions were also discussed.

The second half of the meeting wrapped up key points from the morning session and gave several participants the chance to share examples of existing models for STEM education. The key question to be addressed for the afternoon session was:

> *In developing a prototype DSEII, what will be the framework for engaging the partners to develop curriculum, broad research terms and innovative solutions?*

Sandia's NINE model, with its hub and spoke structure, was described as a DSEII model that would meet educational and innovation objectives. The remainder of the discussion focused on identifying the best blend of features required to design a DSEII that would provide maximum value to all partners. Other topics, such as seed-funding and metrics for measuring outcomes and success, were also addressed.

Framing a DSEII Model

The initial discussions focused on defining the goals and approach of a DSEII that would create a new generation of engineers and scientists through a unique educational partnership. The following goals were outlined for a successful DSEII:

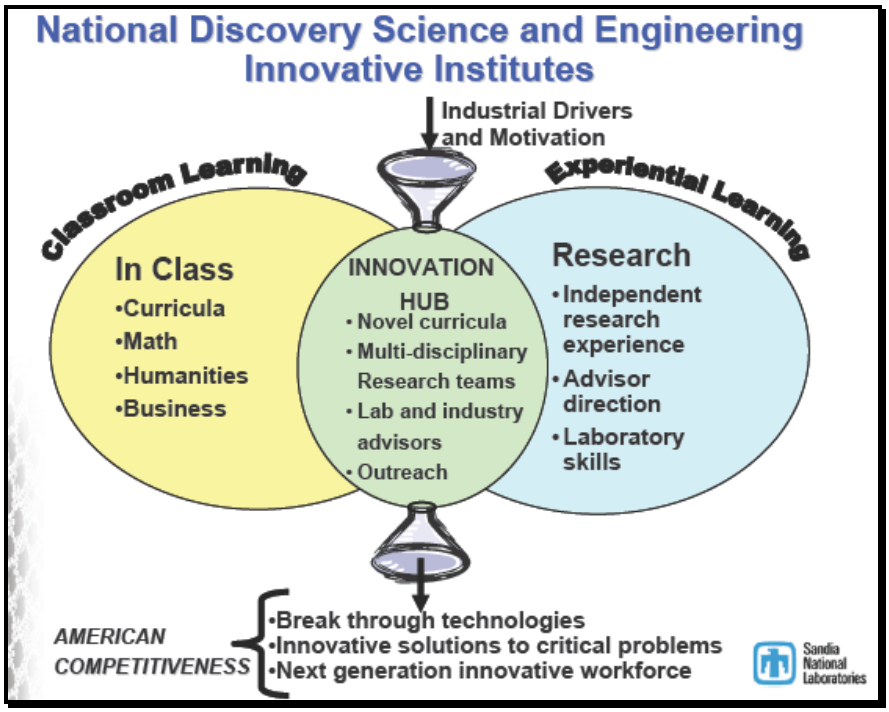
- Graduates educated with the breadth and depth to address critical national challenges and meet the needs of industry to drive innovation from concept to product,
- Graduates knowledgeable about teaming with scientists and engineers from other disciplines, and
- Increase the quantity and quality of innovative engineers and scientists working to solve nationally important challenges.

The approach recommended for accomplishing DSEII goals, included:

- New curriculum and novel learning opportunities through a national network,
- Access to unique, large national laboratory facilities through research staff advisors/mentors,

- Multidisciplinary, multi-institutional research programs that emphasize the latest engineering tools and collaborative environment approaches, and
- National outreach to stimulate interest and engagement in science, technology and engineering with teachers and students (K-12 focus).

The discussion centered on proposed goals for DSEII and how they would be realized through the NINE model. A visual of the DSEII concept is presented below, additional slides from the presentation that further describe NINE are provided in the Appendix to this document.



The NINE Model: The NINE model involves a hub-and-spoke structure, with the DSEII as the hub, and partner institutions serving as spokes. The hub represents a new paradigm committed to what will be a long-lived institution. An important feature of NINE is that the partner institutions share equally in the development and implementation of the concept. A series of inputs and outputs flow back and forth between the innovation hub and partner spokes.

Partners bring different inputs to the model. The national labs supply unique facilities and infrastructure, depth of expertise, and experience in applied R&D. Industry supplies technology drivers, technical experts, and expertise in commercialization. Universities supply faculty, students, and creativity.

NINE provides value to national labs through new strategic partnerships and increased development and innovations. It will address the national need to solve important problems and aid American competitiveness. Outputs received by industry are innovative solutions, experts and infrastructure, and a well-trained future workforce. Universities – and thereby faculty and students -- receive links to industry, infrastructure and expertise, increased innovations, unique educational experiences, partnerships in developing novel curriculum, and a unique student recruiting tool.

Overlap between the innovation hub and partner functions, such as classroom and experiential learning, is critical. The goal of NINE is to create a new complementary educational environment that focuses on national needs and involves multi-disciplinary teams. A differentiating factor of NINE is that is focused on theme areas – high-impact activities – designed to leverage and create nano-engineering approaches and capabilities.[1] Partners are all equally engaged in designing and mapping out theme areas and developing complementary curricula.

Additional partner roles – for both industry and universities – involve serving as advocates and drivers for NINE, serving as members of target teams, and contributing to the development and teaching of NINE curricula. The prototype concept could be based on no-cost participation by industry, but many industrial partners felt that industrial funding was essential to create the necessary commitment from partners. Block funding for university partners would provide support for curriculum development and distribution and would sponsor and support NINE students and faculty.

The model calls for students to spend significant time at NINE. Students may access the curriculum both on site and at partner institutions. Students from non-partner institutions could also have access to NINE through a national competitive fellowship process.

Other Partnership Models: The group agreed that the purpose of NINE is not to reinvent the wheel, but to develop a model using lessons learned from previous successful programs, that offers structure and provides substantial and differentiable benefits to both partners and student participants. Several other existing educational partnership models were identified during the planning meeting that may have relevance to framing NINE more thoroughly. Participants referred to elements of successful models at their own companies and institutions (ExxonMobil, SRC, Rensselaer Polytechnic Institute, Harvey Mudd College, Goodyear). They also recognized the positives of the Sematech model, but were careful to note that its initial funding was $100 million (which would be close to $400 million in current dollars).

Other models noted by planning meeting participants as particularly successful or worthy of further consideration and/or investigation are the National Science Foundation's Integrative Graduate Education and Research Traineeship Program (IGERT) and the Focus Center Research Program (FCRP). IGERT was noted at the planning meeting as a government-funded program that has "changed graduate education." FCRP is a not-for-profit managed by a subsidiary of the Semiconductor Research Corporation (SRV).

Challenges: Participants were quick to recognize challenges associated with developing a new educational model. A significant challenge noted by the group was receiving accreditation for a new program by the Accreditation Board of Engineering and Technology (ABET). ABET is responsible for specialized accreditation of educational programs in applied science, computing, engineering, and technology. Programs are audited for compliance with ABET standards. The question of ABET accreditation of NINE was brought up as an issue that merits further consideration. Another challenge was trying to maintain a four-year degree program while adding requirements to broaden the students without sacrificing technical depth.

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[1] SNL has capabilities and infrastructure in MEMS, parallel computing, and nano-engineering integration tools. NINE's goal is to motivate and retain students through theme areas that are inspiring to participants and that have high impact. These basic goals remain constant even if theme areas change.

Observations and Recommendations

The planning meeting generated several observations and recommendations regarding the development and structure of a DSEII. This section of the report summarizes key observations on DSEII goals that might translate into an MOU or RFP into general categories of what a DSEII *should* accomplish. The second section below describes consensus points achieved regarding potential goals for features and structure of a model DSEII.

Observations on Goals for DSEIIs:

- **DSEIIs need to create novel environments that attract, excite, inspire and engage participants.** DSEIIs will serve to rekindle an interest in and a passion for STEM. The DSEII needs to position itself as being a unique opportunity for students and for partners from the national laboratories, industry, and universities.

- **Focus on openness, the front-end process, pre-competitive research, and breakthrough technologies.** Accessibility and opportunities for students, beginning at the undergraduate level, to solve unique problems is important. Pre-competitive research is regarded as critical in order to minimize issues related to ownership of research later on in the pipeline.

- **Create a program driven by entrepreneurial personalities.** The goal of a DSEII is to generate leaders – not only the "best and brightest" but those who have the inherent leadership skills, motivation to succeed in new intellectual and technological arenas, and who are capable of reaching their fullest potential.

- **Ensure that value is perceived and received by <u>all partner institutions</u>.** The definition or scope of value may vary from partner to partner, but the group reached consensus that a DSEII cannot be successful unless each stakeholder – national laboratory, industry, and academia – realizes value from participation (*e.g.*, if it is only used as a recruiting program rather than a means of solving real problems, industry will not buy in).

- **Ensure that value is perceived and received by <u>students</u>.** Students need to realize specific benefits, whether they are in the form of a certificate of completion, course credit, or some other formal recognition. Students need to know that their time and efforts are valued as participants in the program, and that they will be acknowledged for their participation.

- **Ensure that students participate in the full chain of the research and innovation process.** The real value to students comes from actively participating in solving new problems and in taking those solutions to new environments. Without this value, a DSEII might be "well-intentioned but not so valuable."

- **Clearly define partnership roles for industry.** Roles of national laboratories and universities are clear but industry's role in the DSEII requires better definition. The role must be based on the value industry will receive by partnering in pre-competitive research with an added benefit of a pipeline of new potential employees.

- **The research (or the way it is conducted) must be novel and clearly differentiated.** New curricula need to be developed, which will require faculty acceptance. DSEIIs should differentiate themselves from, rather than duplicate, current models. Resources from partner institutions will be combined to create new research environments. (Specific approaches to how research would be conducted were not a priority in this discussion.)

- **Faculty involved in a DSEII must understand its dynamic.** Faculty that choose to participate in DSEII should have the same excitement and motivation to participate in the institute as the students do. The experiential, collaborative learning environment envisioned by DSEII is a far cry from the world of "publish or perish." Faculty solely focused on publishing may not be the most appropriate participants.

- **Clearly define the scope and milestones.** The ability to translate industry-scale problems to student-scale problems lies at the heart of DSEII. Defining the scope of a compelling problem, establishing milestones, and following a path to the solution of that problem comprise an educational process that DSEII seeks to teach.

- **Access to the DSEII by all students is key.** DSEII seeks to attract and retain the "best and brightest" as its scholars, so all students should have access to the Institute. Partner universities will supply bright, eager students. Students not at partner universities will gain access through a nationally competed NINE fellowships program.

Features of a DSEII Framework:

- **Activities at DSEIIs need to be distributed among all three partners**. The institute may be operated or managed by a central "hub" (see NINE model) leading to participant spokes, but each partner – national laboratory, industry, and university – must enter the arrangement as equals.

- **Connectivity between the partners is essential.** Flow of information between each partner is critical, as is continued exchange of information among student participants. (Gathering participants on a regular basis – even after program completion – was suggested.)

- **The model needs to be differentiated from other models.** The DSEII structure must consist of a unique educational environment that offers positive outcomes to all partners. Finding the right matches between mentors and students, solving different problems, serving unique populations are some of the factors associated with differentiation. In addition, an Institute needs to be able to clearly articulate its unique contributions and approach when justifying its federal funding to auditors.

- **The DSEII will serve both undergraduate and graduate students.** Planning meeting participants noted the retention problem in STEM fields at the undergraduate level: 2/3rds of students sign up for STEM as freshmen; after one year, 1/3rd remain in STEM; and at graduation only 10% are in STEM. Attracting and retaining strong STEM students early on in their careers is an integral element of a DSEII. If possible, outreach to the K-12 level should be included in the model.

- **Faculty need to buy into the concept.** Acceptance of change in engineering curriculum needs to be achieved, and university faculties are responsible for implementing these changes. Change must therefore be perceived as necessary and exciting, and should have a valuable outcome.

- **A multidisciplinary environment is key.** Non-technical skills are an element of DSEII education, and are valued in the work environment. Leadership and management skills should be emphasized in addition to science and engineering capabilities.

- **Scientific problems addressed must be compelling.** A model DSEII needs to bring compelling scientific problems to the table that in turn are likely to be supported by an interested sponsor. If problems are of national importance, then solving them will be satisfying and fulfilling to sponsors and researchers alike.

- **User agreements are necessary.** DSEIIs should operate under specific agreements between users. The “hub” stakeholder will likely provide the framework for those agreements, based on existing practices at DOE user facilities. [It was noted that SNL has existing user agreements developed for its Center for Integrated Nanotechnologies (CINT) which could be used as a model for NINE user agreements.]

- **Metrics will be instituted to track participation rates, retention and other factors associated with the Institute.** DSEII partners need to formulate metrics that will follow students throughout the process. Participation, retention, theme area selection, and opportunities are some of the areas that will be tracked once the DSEII is in place.

Conclusions and Next Steps Forward

The overall conclusion of the planning meeting was that if the group, with SNL as the organizational lead, could develop a truly unique educational institute that provides sufficient value to all partners and participants, then action should be pursued. The new model should incorporate the goals and features listed above to ensure success and to garner acceptance.

The next steps of the process, to be led by SNL, are to:

- Develop a more defined framework for NINE.
- Begin establishing relationships with potential partners in industry and academia.
- Crystallize the “nuggets” from the meeting into items that will populate an MOU.
- Start work on seed projects with key collaborators.
- Conduct a teaming meeting when the RFP for DSEIIs is released.

Participant List

Name	Organization	Title
Government		
Duane Dimos	Sandia National Laboratories	Director, Materials Science & Engineering
Robert (Bob) Hwang	Sandia National Laboratories	Senior Manager, Radiation & Nanosciences
Justine Johannes	Sandia National Laboratories	Senior Manager, Materials Synthesis & Processing
Carl (Ed) Oliver	Sandia National Laboratories	Senior Scientist, Technology & Research Foundation
Industry		
Bill Hopkins	Goodyear	Vice President, Technology & Strategic Initiatives
Greg Leeming	Intel	Manager for Radio Frequency ID Development
Andy Kaldor	ExxonMobil	Lab Director for Corporate Strategic Research
Ram Seetharam	ExxonMobil	Supervisor, Advanced Simulation and Reservoir Management Section, Reservoir Division
Joan Kane	Corning	Manager, External Collaborations Science & Technology Division
Kathleen Morris	Corning	Manager, Applied Process Research
University		
Joe Cecchi	University of New Mexico	Dean
Billy Sanders	University of California Davis	Assistant Dean
Daniel Goroff	Harvey Mudd College	Dean and Vice President of the Faculty
Peter Kogge	University of Notre Dame	Concurrent Professor, Electrical Engineering
Juan Sanchez	University of Texas at Austin	Vice President for Research
Paul Fleury	Yale University	Dean of Engineering and the Fredrick William Beinecke Professor of Engineering & Applied Physics
Gerald Kulcinski	University of Wisconsin	Professor and Associate Dean for Research
Jennifer Lewis	University of Illinois	Professor of Materials Science and Engineering
Joe Chow	Rensselaer Polytechnic Institute	Associate Dean
Government Support		
Richard Macklin	Perspectives	President
Barbara Schay	Perspectives	Sr. Research Analyst

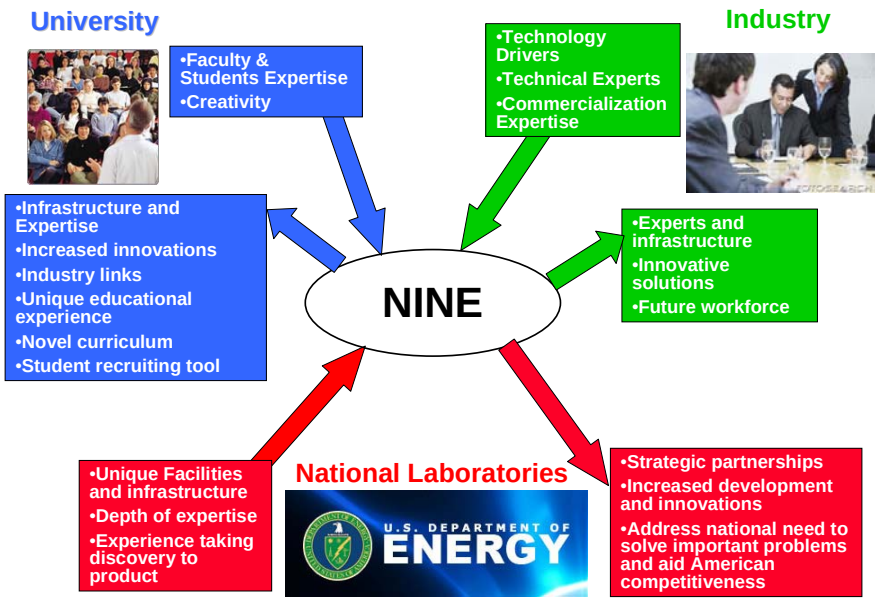
Appendix: The NINE Model

National Institute for Nano Engineering (NINE)

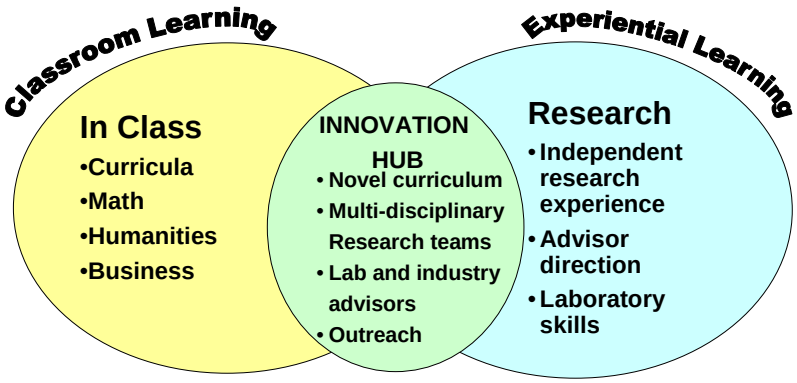
Concepts for Discovery Science and Engineering Innovation Institute

Sandia National Laboratories

Partnerships for Accelerating Innovation



Educational Environment to complement Universities & couple to Industry



NINE - Educational Environment to complement Universities & couple to Industry

- Learning to Innovate - Experience based education
  - Research teams formed around NINE Theme Areas
    - Focus on National needs
    - Multi-disciplinary Teams
      - University groups
      - Strong Industry drive & involvement
      - SNL staff and tools

NINE Theme Areas

- Theme Areas are high impact activities that are designed to leverage and create nano engineering approaches and capabilities
- Theme Areas will be the primary mechanism that brings together interdisciplinary teams from NL, Universities and Industry
- Theme Areas are designed through interactions of NINE partners

NINE - Educational Environment to complement Universities & couple to Industry

- Newly developed Theme Area courses
- Training
  - SNL training on state-of-art S&E tools
    - MEMS and µ-fabrication (MESA)
    - Parallel computing (Red Storm)
    - Nano engineering integration tools (CINT)
- Innovation Lecture Series
  - Entrepreneurial processes
  - Management
  - Financial engineering
  - Corporate models of product development
  - Start-ups and Venture Capital models
- Access to partner university courses - distance learning

NINE University Partners and Faculty

- NINE University Partners
  - Advocates and drivers for NINE
  - Members of Target Area teams
  - Contribute to development of & teaching of NINE curricula
  - Sponsor and support NINE students
  - Partners will be block-funded by NINE

NINE Industry Partners & Faculty

- NINE Industry Partners
  - Advocates and Drivers for NINE
  - Members of Target Area teams
  - Contribute to development of & teaching of NINE curricula
  - No cost participation

NINE Students

Students spend significant time at NINE
Access to NINE curriculum on site and at partner institutions
Upon completion of NINE curriculum to receive NINE certificate

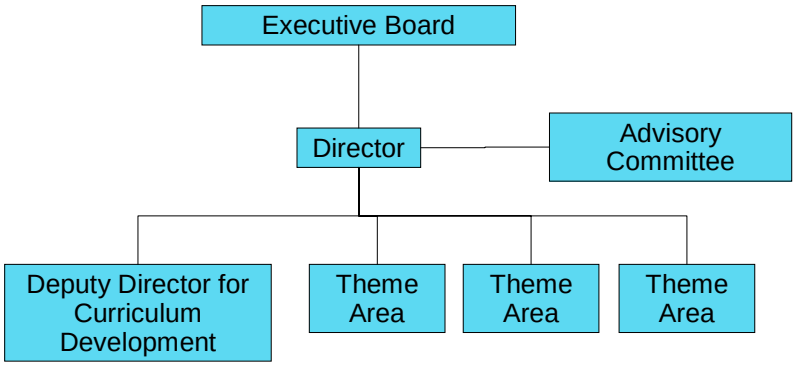
Partner Universities

- Hosted by NINE faculty & NINE Staff
- Supported either through NINE funding or DOE fellowship

Non-partner Institutions

- Application to NINE program with a NINE faculty/staff sponsor
- Support external to NINE

NINE - Operating Model



* Appropriate IP Model

Success Metrics

- Provide students with a foundational nano engineering education for innovation
  - State of the art tools
  - Collaborators and Mentors from range of institutions
  - "Hands-on" experience working in interdisciplinary teams focused on providing real solutions
  - Direct exposure to future career opportunities
- Provides Industry with a unique infrastructure and intellectual environment for innovation
  - Interdisciplinary teams focused on nano engineering solutions
  - Access to state of the art tools and expertise
  - Strong environment for employee training
  - World-class recruiting pool

Sandia National Laboratories

NINE Framework Discussions?

- **Is NINE an exciting concept that will be engaging to your institution?**
  - **Does this framework provide needed ingredients for university partners?**
  - **Does this framework provide needed ingredients for industrial partners?**
- **What have we missed?**
- **What are the next steps?**

Sandia National Laboratories

Next Steps

- Take initial framework to DOE
- Use goals/objective to develop a memorandum of understanding with potential partners
- Use preliminary seed money to develop strategic partnerships that will be critical for developing response to DSEII RFP
  - Who are your technical POCs for NINE?
  - What might the curricula development and research teams in theme areas look like?

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