Department of Engineering Science & Mechanics: 2021–2025 Strategic Plan

Strategic Plan Committee

- Andrea Arguelles
- Charles Bakis
- Francesco Costanzo (chair)
- Saptarshi Das
- Melik Demirel
- Bruce Gluckman
- Reginald Hamilton
- Jian Hsu
- Michael Lanagan
- Matthew Lear
- Parisa Shokouhi

Mission

The Penn State Engineering Science and Mechanics Department is a recognized world leader in interdisciplinary teaching and learning, research, and service to the University, the profession and society.

We promote a culture of equity and inclusion, wherein everyone is welcome, everyone is respected, everyone's opinion and contributions are valued; and everyone strives for excellence in themselves, in their colleagues and in the institution. We provide a welcoming space that inspires our faculty, staff, and students to achieve excellence and build a community where everyone can thrive.

Through excellence in science, we form world-class engineers ready to remain at the cutting edge of their interdisciplinary fields and able to impact society by answering complex challenges in industry, academia, and public service. We uphold our tradition of excellence as the honors undergraduate program in the Penn State College of Engineering.

Where science and engineering meet, we create new technologies and impactful solutions to society's challenges.

In disseminating our work, we forge local and global collaborations, we promote entrepreneurship in education, research, and industry, and we contribute to the betterment of society.

Visions

The Penn State Engineering Science and Mechanics Department will be a nationally and internationally recognized welcoming community where science becomes engineering through excellence in interdisciplinary education and research, innovations and solutions, and the promotion of an engineering science-based culture in confronting society's challenges.

Goals

The Department of Engineering Science and Mechanics will design, implement, audit, and continuously improve programs to achieve each of these following goals by the end of 2025 through the underlying objectives.

Goal 1: Enhance the integration of our institutional values into our educational, research, service, and administrative life to strongly support our mission.

Goal 2: Provide our undergraduate and graduate students with a well-rounded multi-disciplinary engineering science and mechanics education while enhancing skills in ethics, sustainability, statistics, and computing.

Goal 3: Strengthen and expand our multidisciplinary and collaborative research activities to pioneer innovative engineering solutions to society’s complex challenges.

Goal 4: Augment the visibility of our program through increased outreach to international institutions, alumni, current and potential industry partners, and through increased targeted recruiting of undergraduate and graduate students.

Objectives, Actions, Key Performance Indicators and Metrics

Goal 1: Enhance the integration of our institutional values into our educational, research, service, and administrative life to strongly support our mission.

Note: The Engineering Science and Mechanics (ESM) Department aspires to continually improve in providing an environment of inclusivity that effectively nurtures the careers of faculty and staff, and educates students in understanding the role of the workplace in each person's career. We want to promote a growing understanding and inclusion of all constituents in the overall operations of the department. ESM also wants to be a place that rewards the efforts of its members in contributing to efficient and sustainable operations, cognizant that individual efforts are best supported by a sense of safety and manageable workloads. The goal is aligned with the values and priorities of both the University and the College of Engineering (COE). Some of the proposed objectives are defined to improve the sustainability of our operations and free resources to expand outreach activities. Some other objectives stem from current nation-wide events that have clearly demonstrated the societal effects of systemic discrimination. Strategic efforts are needed in STEM disciplines to promote and foster equity, inclusivity, diversity, and anti-racism for the sake of advancing STEM education and training nationwide.

Objective 1.1: Among ESM staff, students, and faculty, cultivate a strong, positive culture that values and promotes inclusivity, diversity and thus a sense of belonging.

Note: Discussions at the department and university levels brought to the forefront that deliberate and active efforts must be pursued to foster belonging in STEM, specifically for marginalized Black and Brown citizens. The ESM department currently offers limited professional development or community-building type activities that would address this concern. ESM will focus on cultivating and promoting equitable practices, guidelines, and approaches to recruiting, hiring, support, and professional development, and thus will actively demonstrate the value placed on diversity, inclusion, and anti-racism.

Key Performance Indicator: Degree of engagement of faculty, staff, and students in the College Equity Action Plan. Annual climate surveys to assess the satisfaction among faculty, staff, and students with their sense of community and with ESM's efforts to build inclusivity and diversity. Feedback will be sought from professionals and community stakeholders to continuously improve ESM's efforts.

Objective 1.1 mapping:

- Foundation:
  - F3: Engaging Principles of Inclusion Equity, and Diversity
- Thematic Priorities:
  - TE3: Transforming Education — Support and empower our outstanding faculty and staff
- Supporting Elements:
  - IS1: Infrastructure & Support: Prioritize investment in our people

Objective 1.1 — Actions

Action 1.1.1: **Create a Community Building Committee: this committee is envisioned as a standing committee of the ESM Department whose purpose is to coordinate community-building operations as well as monitor the satisfaction of the various constituencies of the department with such activities.**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Department Head/Associate Head and Community Building Committee representative of ESM community; faculty, staff, and students.

Action 1.1.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Creation of a Community Building Committee along with its charge.	7/2021–9/2021	Committee formation with precise charge.

Assess the PSU climate survey and report to all constituencies of the department. Then fill the holes if needed.	9/2021 – 1/2022	Overview of PSU survey at Spring Faculty Retreat
Assess the need for an ESM climate survey	1/2022 – 5/2022	Produce survey
If needed, conduct the climate survey	5/2022–8/2022	Conduct the survey and report the results to the department head/associate head
Continually assess with inclusivity within ESM	6/2025	

Action 1.1.2: Connect with the COE's Equity Action Plan and take advantage of the activities promoted by the University Office of Educational Equity to engage faculty, staff, and students on issues pertinent to diversity, inclusion, equity, and anti-racism. Create opportunities for faculty, staff, and students to describe their activities and roles in the department.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Community Building Committee.

Action 1.1.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Collaborate with University/College resources/professionals to educate, provide best practices and develop implementation plan for faculty semiannual retreats, ESM undergrad event, grad seminar and faculty meetings with feedback mechanisms.	1. Review COE Equity Action Plan 10/2021 2. Propose meaningful activities to enact the EAP for ESM 1/2022 9/2021-6/2025	Summarize EAP for ESM Best practices and implementation plan with initiatives
Organize a forum open to faculty, staff, and students to discuss University and COE priorities with regard to Diversity, Equity, and Inclusion, as well as publicize resources available through the Penn State Office of Educational Equity.	3/2022	Forum
Collaborate with COE to educate faculty and staff about career-related rewards to advance Diversity, Equity, and Inclusion.	9/2021-6/2025	Presentations at Faculty Meetings, Departmental Retreats, and Informational Sessions with Staff.

Provide opportunities for staff and students to be involved in departmental governance.	9/2021-6/2025	Evidence of participation on committees.

Action 1.1.3: Engage with the COE to contribute to the creation of a diverse and inclusive community.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Community Building Committee.

Action 1.1.3 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Collaborate with University/College resources/professionals to provide best practices and develop implementation plan to attract an inclusive candidate pool for diverse faculty recruitment and retention	9/2021–6/2025	Best practices and implementation plan with initiatives
Collaborate with University/College resources/professionals to provide best practices and develop implementation plan to attract an inclusive and diverse undergraduate pool	9/2021–6/2025	Best practices and implementation plan with initiatives
Collaborate with University/College resources/professionals to provide best practices and develop implementation plan to attract an inclusive applicant pool for diverse graduate student recruitment and retention	9/2021–6/2025	Best practices and implementation plan with initiatives
Build a database of funding opportunities specifically addressing recruitment of minority faculty, post-docs and grad/undergrad students.	9/2021–6/2025	Database
Educate faculty on how to include broader impacts and training opportunities for minority faculty and students.	9/2021–6/2025	Best practices repository and presentation to faculty
Explore and take advantage of opportunities to hire and support postdocs and faculty from minority and under-	9/2021–6/2025	Pursue joint funding opportunities that target minority faculty and students (2-3 over the 5-year period?)

represented groups through outreach throughout the PSU community.		

Objective 1.2: Pursue sustainability in administrative operations: balance workload, reward performance, and improve engagement in and efficiency of the governance of the department.

Note: A reorganization of administrative operations requires a reassessment of current needs. The creation of new committees as envisioned by this strategic plan cannot happens unless the current service load is rebalanced. In addition, there is a need to increase representation in the governance of the department in terms of staff and student participation as well as participation from affiliate graduate faculty and adjunct faculty.

Key performance indicator: Satisfaction with the workload and purpose of committee responsibilities and leadership of the department.

Objective 1.2 mapping:

- Foundations:
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - TE3: Transforming Education — Support and empower our outstanding faculty and staff
- Supporting Elements
  - OP2: Organization Processes — Establish processes for continual institutional assessment, improvement, and innovation, including more systematic review of administrative and academic organizational performance and financial stewardship.
  - IS1: Infrastructure & Support — Prioritize investment in our people

Objective 1.2 — Actions

Action 1.2.1: **Form a governance committee and review and assess the department's staffing and governance needs.**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Department Head with assistance from faculty and staff.

Action 1.2.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
The department head forms a Governance Committee consisting of representatives from all constituencies and defines its charge. In addition, the committee creates an assessment survey to measure satisfaction with the workload.	Spring 2021	Committee formation with charge.
Committee reviews the number, charge, performance of departmental committees.	Fall 2021	Report to the faculty with recommendations for

		reduction/addition of committees.
The committee becomes a standing committee with an updated charge to annually review the needs of the department and survey the department's constituencies on their satisfaction.	Fall 2023	Annual Reviews
Engage adjunct and ARL faculty in departmental governance	Fall 2021	Provide guidelines for ARL faculty to get engaged in the governance of the department. Seek engagement in qualifying exams.

Action 1.2.2: Assess the need for staff positions, promote rewards and retention of staff.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Department Head with Associate Department Head in consultation with the Staff.

Action 1.2.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Survey the current staffing in the main office and in every center in the department	Spring 2021	Report to the faculty concerning staffing.
Work with parent unit and HR to create career advancement opportunities for staff without having to leave the current unit.	Fall 2021–2023	Provide guidelines to the staff to achieve advancement without transfer to another unit.
Create a dedicated position for Departmental Communications and Public Relations.	Fall 2021	Fill the position.

Objective 1.3: ESM will pursue sustainability in our teaching, research, service, and operation practices.

Note: The concept of sustainability encompasses all aspects of the operation of a unit. It pertains to the use of all types of resources including energy, fuel, environmental, health, economic and human resources, among others. The concept of sustainability goes hand in hand with the objective to have an inclusive workplace. A sustainable workplace is one in which all feel safe, and can work at their best, with the maximum efficiency. The experience of working remotely during the COVID-19 pandemic has taught us various invaluable lessons: while we wish to come back to our familiar workplace, we can do so deliberately and with added flexibility.

Key performance indicator: satisfaction with resource usage at the office and in the classroom, as well as satisfaction with the feeling of safety and well-being in the workplace.

Objective 1.3 mapping:

- Foundations:
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - TE3: Transforming Education — Support and empower our outstanding faculty and staff
- Supporting Elements
  - IS1: Infrastructure & Support — Prioritize investment in our people
  - IS2: Infrastructure & Support — Invest in resources creatively and systematically.

Objective 1.3 — Actions

Action 1.3.1: **Create a Sustainable Operations Committee charged with reviewing best practices for reducing waste and streamline processes, as well as interface with the COE's Sustainability Council.**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Department Head/Associate Head and ESM community; faculty, staff, and students.

Action 1.3.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Creation of a Sustainable Operations Committee that includes faculty, staff, and student representatives.	7/2021–9/2021	Committee formation with precise charge.
Survey faculty, staff, and students on how resources are used. Beyond usage of electricity, water, paper, etc., this includes identification of inefficient processes, inefficient	9/2021–12/2021	Report to Department with recommendations.

or limited use of class management software, etc.		

Action 1.3.2: Adopt best practices for reducing waste and streamline processes.

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible Party: Sustainable Operations Committee in consultation with Faculty, Staff, and Students.

Action 1.3.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Adoption of streamlined processes in the office.	2022–2023	Updated procedures
Consult with IT staff and implement digital solutions where applicable	2022–2023	Use of digital solutions.
Guide faculty in best taking advantage of Canvas and Office 365 in their teaching and research.	2022–2023	Presentation at Faculty Retreat
In consultation with the COE and HR, pursue opportunities for work from home, for staff and faculty.	2023–2024	Guidelines on work from home.

Action 1.3.3: Survey and adopt best practices for promoting sustainability, health, and wellness in the workplace.

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible Party: Sustainable Operations Committee along with available faculty, staff, and students.

Action 1.3.3 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Survey faculty, staff, and students to identify improvements needed for their work spaces.	2022-2023	Recommendations for Improvements
Involve students in a competition to offer decorative items in the labs and office (something “artsy” related to their studies/research, reflecting the values of the university, promoting diversity and inclusivity), possibly as part of ESM Today.	2022-2023	Creation of Art Installations
In consultation with the COE, explore ways to encourage	2022-2023	Procurement guidelines.

selecting sustainability-conscious procurement procedures that would favor sustainability-supporting vendors.		
Create reporting/suggestion opportunities dealing with safety/improvement of the workplace.	2022-2023	Guidelines
Include in departmental retreats a discussion of the principles of sustainability and its facets.	2022-2023	Presentations

Goal 2: Provide our undergraduate and graduate students with a well-rounded multi-disciplinary engineering science education while enhancing skills in ethics, sustainability, statistics, and computing.

Note: The Engineering Science and Mechanics (ESM) Department aspires to continually improve in providing world-class engineering education that remains current as professional and societal needs evolve. The goal is aligned with the values and priorities of both the University and the College of Engineering (COE). The Foundations of the University's strategic plan include

> *Advancing Inclusion, Equity, and Diversity, Enhancing Global Engagement, Driving Economic Development, and Ensuring a Sustainable Future*

The fact that engineering education must incorporate training in DEI, ethics, and sustainability is also clearly spelled out in ABET's principles. For example, at https://www.abet.org/about-abet/diversity-equity-and-inclusion/ one finds:

> *We believe that understanding and experiencing diversity and inclusion in higher education are critical to competitiveness, innovation, and our social and economic futures. Further, we expect our accredited programs to support this vision.*

Current ABET's Student Outcomes criteria include (https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/)

> *An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors*.

and

> *An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.*

These principles provide a strong motivation for our strategic plan objectives in relation to education. An additional motivation for the proposed objectives is the ever-increasing reliance of almost every technology on computing and various forms of artificial intelligence. This trend is captured by one of the University's thematic priorities, namely, *Empowering through Digital Innovation*.

Objective 2.1: Transform undergraduate and graduate education by integrating ethics and policy making.

Note: Ethical considerations in engineering and science research broadly fall into three overlapping categories (1) procedural ethics, which includes guidelines and rules for responsible conduct of research; (2) intrinsic ethics, which addresses the values embedded in the research (e.g., the rationale behind a particular research agenda); and (3) extrinsic ethics, the broader ethical and social implications, intended or unintended, of the research (Schienke et al., 2009).[1]

Competence with ethics is increasingly recognized as a core outcome of education. In the newly revised 2019-2020 Accreditation Board for Engineering and Technology (ABET) criteria, facility in ethics is one of the core student outcomes for all engineering programs:

> *"General Criterion 3: Student Outcomes: Item 4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts."*

The ESM faculty is highly diverse, with training in a wide range of science and engineering disciplines. Our research projects combine multiple knowledge domains and leverage extensive, wide-ranging collaborations among our faculty and across Penn State as a whole. There is a critical need to model ethical considerations and decision-making processing beyond procedural ethics in this interdisciplinary context.

In 2019/2020, ESM secured a position for an ethics co-hire with the Rock Ethics Institute (REI), which has been filled by Dr. Laura Cabrera. Over the coming years, Dr. Cabrera will spearhead our department-wide effort to transform education by extending integration of all aspects of ethics awareness beyond procedural ethics, with a focus on neuroethics.

Key Performance Indicator: Expansion of ethics integration will be evaluated through assessment of quality of ethics writing in undergraduate theses and through enrollment and grade point average in the newly established undergraduate and graduate courses and envisioned dual-degree Bioethics/ESMCH program.

Objective 2.1 mapping:

- Foundations:
  - F1: Enabling Access to Education
  - F3: Engaging Principles of Diversity, Equity, and Inclusion

[1] Schienke, E. W., Tuana, N., Brown, D. A., Davis, K. J., Keller, K., Shortle, J. S., Stickler, M. and S. D. Baum (2009). The role of the NSF broader impacts criterion in enhancing research ethics pedagogy. *Social Epistemology*, **23**(3–4), pp. 317–336.

  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
- Supporting Elements:
  - OP2: Organizational Processes — Establish processes for continual institutional assessment, improvement, and innovation, including more systematic review of administrative and academic organizational performance and financial stewardship communication

Objective 2.1 — Actions

Action 2.1.1: Improve ethics and policy making components in the ESM undergraduate curriculum

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM Ethics Education Sub-Committee as part of ESM Undergraduate Curriculum Committee.

Action 2.1.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Develop and implement performance assessments based on undergraduate thesis elements and exit interviews for undergraduate seniors. Collect baseline assessments.	F2021-S2022	Assessment tool Baseline data
Assess current curriculum and identify places where ethics is currently or could be integrated. Develop implementation plan for improving and unifying sophistication of discussions to include procedural, intrinsic, and extrinsic ethics.	F2021-S2023	Implementation plan
Execute Plan. Continue Assessments	F2023-S2026	Catalog of implemented ethics components Yearly Assessments
Review Improvements, Revise Plan	F2025-S2026	Revised Implementation Plan

Action 2.1.2: Improve ethics and policy making components in graduate engineering science and mechanics program.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM Faculty

Action 2.1.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Develop graduate course in NeuroEthics and offer as ESC 597	F2021	Course plan

Revise NeuroEthics course, submit course proposal	S2022	Course proposal submitted
Design and propose NeuroEthics dual-degree graduate program between ESMCH and Bioethics	S2023	Dual-Degree Program Proposed
Recruit and enroll graduate students to dual-degree program	F2023-F2025	Enrolled Grad Students

Action 2.1.3: Develop new 400-level Honors course on ethics in engineering sciences

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM faculty

Action 2.1.3 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Design and advertise ESC 497H course	F2022	Course plan
First course offering	S2023	Course delivery, measure enrollment
Submit permanent course proposal	S2024	Permanent course established
Review course for inclusion in ESC program as required course or technical elective	F2025	Integrated course in degree plan

Objective 2.2: Enhance student awareness of sustainability.

Note: In recent years, Abet has emphasized the importance of sustainability in engineering and its associated need for preparing students in higher education to actively contribute to sustainable engineering solution (https://www.abet.org/wp-content/uploads/2018/11/ABET_Sustainable-Engineering_Issue-Brief.pdf). This focus is significantly reinforced by the National Science Foundation through the Environmental Engineering and Sustainability Cluster (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505483; part of the Division of Chemical, Bioengineering, Environmental and Transport Systems — CBET). This cluster consists of three programs: Environmental Engineering, Environmental Sustainability, and Nanoscale Interactions which, quoting from https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505692&org=NSF, support research in

1. *Building a future without pollution or waste: Investigation of innovative biogeochemical processes that prevent or minimize the production of waste; waste valorization and other research that will lead to new technologies to extract resources from waste streams to close the resource loop.*

2. *Sustainable supply and protection of water: Investigation of innovative biogeochemical processes that remove, biologically or chemically transform, and/or prevent the release of contaminants in surface and groundwater; innovative processes for recovery of water, nutrients, and other resources from wastewater, saline water, or brines; innovative approaches to smart and adaptive management of surface water, groundwater, and urban watersheds and storm water to maintain/improve quality and prevent downstream impacts from nutrients and other water constituents.*

3. *Environmental chemistry, fate, and transport of nutrients and contaminants of emerging concern in air, water, soils, and sediments: Investigation of transport and biogeochemical reactivity in the environment; environmental forensics to identify sources and reaction pathways; field- and laboratory scale experimental research that bridges gaps between data and predictions from molecular, continuum, and field-scale modeling.*

4. *Environmental engineering of the built environment: Research to understand the biogeochemical reactivity of the built environment with the goal of enhancing and improving human and ecological health; research that will lead to new technologies to improve outdoor and indoor air quality; research to understand how drinking water and wastewater chemical characteristics and microbial community structure impact or are affected by water quality and human health.*

These research thrusts are relevant to the mission of the ESM department. ABET and the NSF are simply of examples of the increasing importance that sustainable engineering has been gaining. Penn State commitment to sustainable engineering is evidenced by the creation of the Penn State Sustainability Institute (https://sustainability.psu.edu). These considerations point to the fact that sustainability must become integral part of engineering education. The present Objective is meant to address the strong need to incorporate sustainability into our program.

Key Performance Indicator: Expansion of sustainability integration will be evaluated through assessment of quality of sustainability writing in

undergraduate theses and assessment of sustainability content across the curriculum.

Objective 2.2 mapping:

- Foundations:
  - F1: Enabling Access to Education
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
- Supporting Elements:
  - OP2: Organizational Processes — Establish processes for continual institutional assessment, improvement, and innovation, including more systematic review of administrative and academic organizational performance and financial stewardship communication.

Objective 2.2 — Actions

Action 2.2.1: Evaluate current offerings of sustainability topics in ESM courses and assess what courses are amenable to integration

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM Undergraduate Curriculum Committee will aggregate data collected from ESM Faculty at large.

Action 2.2.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Establish list of ESC and EMCH courses with current sustainability topics and % of course hours	Months 1–6	Final list of current offerings per course
Establish list of ESC and EMCH courses in which sustainability topics are not currently included but are amenable to sustainability content (e.g., courses concerning materials for various engineering applications)	Months 6-12	Final list of potential courses for implementation
Assess whether to proceed to Action 2.2.2	Months 12	Final decision

Action 2.2.2: Implement new sustainability topics in ESC and EMCH courses (OPTIONAL)

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM Faculty.

Action 2.2.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Faculty education on how to implement topics into their courses (e.g., guest speakers at faculty meetings)	Once per year	Educational materials/resources

Update inventory of ESC and EMCH courses with sustainability content	at end of months 24, 36, 48	Updated inventory

Objective 2.3: Improve the integration of modeling and computation in the undergraduate curriculum to drive digital innovation.

Note: Exit interviews and student performance in upper-level programming courses has demonstrated a need to improve the lower level, introductory courses in computer programming. Furthermore, incorporating basic knowledge on algorithms for deep learning, neural networks, and machine learning would give our graduating students a competitive advantage when entering the work force and/or graduate school. Lastly, we desire to provide a more in-depth understanding of algorithms used for statistics and stochastic processes, which are framed under the big umbrella of computer methods.

Key Performance Indicator: student enrollment, grade point average in courses, survey of student's familiarity with relevant computing vocabulary and general knowledge

Objective 2.3 mapping:

- Foundations:
  - F1: Enabling Access to Education
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
- Supporting Elements:
  - OP2: Organizational Processes — Establish processes for continual institutional assessment, improvement, and innovation, including more systematic review of administrative and academic organizational performance and financial stewardship communication.

Objective 2.3 — Actions

Action 2.3.1: Evaluate current offerings of modeling, computation, and statistics topics in ESM courses and assess which courses are amenable to integration

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM Undergraduate Curriculum Committee will aggregate data collected from ESM Faculty at large.

Action 2.3.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Establish list of ESC and EMCH courses with current modeling, computation, and statistics and % of course hours	Months 1-6	Final list of current offerings per course
Establish list of ESC and EMCH courses in which modeling, computation, and statistics topics are not currently included but are amenable to such content (e.g., courses concerning data analysis and signal processing)	Months 6-12	Final list of potential courses for implementation

Assess whether to proceed to Action 2.3.2	Months 12	Final decision

Action 2.3.2: Implement new modeling, computation, and statistics topics in ESC and EMCH courses (OPTIONAL)

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: ESM Faculty

Action 2.3.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Faculty education on how to implement topics into their courses (e.g., guest speakers at faculty meetings) Topics may include: (1) emphasis on good programming practices and coding abstract skills: array manipulation, logic information flow, and modularity (functions); (2) integrating uncertainty in problem parameters: solution as a distribution and factors of safety, etc.	Once per year	Educational materials/resources
Update inventory of ESC and EMCH courses with modeling, computation, and statistics content	at end of months 24, 36, 48	Updated inventory

Objective 2.4: Facilitate transition to self-learning among graduate students.

Note: In a globally connected and rapidly changing society, where innovation in science and technology is faster than ever in human history, keys to success lie in the ability to adapt and learn quickly and effectively with and without the assistance of others. To achieve this objective, ESM seeks to:

1. Establish a comprehensive training/mentoring process that allows individual students to identify their learning needs, construct their learning goals.
2. Aid in filling the knowledge gap and skill gap.
3. Provide technological means to access information that accelerates students' ability to access knowledge.
4. Assist students in recognizing human and material resources available within the department, college, and the University to accomplish their stated goals.
5. Define the rubric and evaluate the outcomes of self-learning.

Key Performance Indicator: Student enrollment in Research Practices course, assessment of inclusion of structured learning modules across the graduate curriculum.

Objective 2.4 mapping:

- Foundations:
  - F1: Enabling Access to Education
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
- Supporting Elements:
  - OP2: Organizational Processes — Establish processes for continual institutional assessment, improvement, and innovation, including more systematic review of administrative and academic organizational performance and financial stewardship communication.

Objective 2.4 — Actions

Action 2.4.1: **Refine first-year course offerings (and associated faculty modules) instilling Research Practices needed for graduate students to transition to independent learning**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Select ESM Faculty, ESM Graduate Curriculum Committee

Action 2.4.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Make Research Practices course a permanent offering and propose to the faculty the course	F2022	Permanent Course Number established

be made a requirement for first-year graduate students		If approved by the faculty, modification to graduate course requirements completed
Create format for modules that provide structured learning experiences and revise graduate curriculum based on how students are credited with the structured learning experiences	S2023	Template for structured learning modules to distribute to faculty Strategy for credit scheme for learning modules
Develop strategy to assess the productivity of this kind of educational model (modular training)	F2023	Survey to assess students learning under this framework

Introduce 1-credit literature review workshop and/or open discussion forums on a wide variety of topics: determine if such a 1-credit course can replace a graduate seminar.	F2022	Initial course offering with enrollment >5 graduate students

Goal 3: Strengthen and expand our multidisciplinary and collaborative research activities in the next five years to pioneer innovative engineering solutions to society's complex challenges

Note: The ESM Department is a leader in multidisciplinary and collaborative research with multiple strengths including materials science and additive manufacturing, neural engineering, structural health monitoring, nanofabrication, and photonics. Both theoretical and applied mechanics also remain strong components of the department's research as is our presence in the field of sustainable engineering.

Use of artificial intelligence (AI) is becoming more and more pervasive in our society. More broadly, applications of AI should be viewed in the context of what The National Academies of Science, Engineering, and Medicine refer to as cyber-physical systems (CPS),[1] which the National Science Foundation define as[2]:

> *"engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components."*

The NSF recognizes that[2]

> *Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand the horizons of these critical systems. … CPS are becoming data-rich enabling new and higher degrees of automation and autonomy. Traditional ideas in CPS research are being challenged by new concepts emerging from artificial intelligence and machine learning. The integration of artificial intelligence with CPS especially for real-time operation creates new research opportunities with major societal implications.*

Such recognition is also evident in several other high-profile reports.[3]

The objectives identified under this Goal, are meant to consolidate the current strengths of the ESM department as well as expand our research efforts in fields such as CPS.

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[1] National Academies of Sciences, Engineering, and Medicine 2016. *A 21st Century Cyber-Physical Systems Education*. Washington, DC: The National Academies Press. https://doi.org/10.17226/23686

[2] NSF Program Solicitation NSF 21-551 (2021), https://www.nsf.gov/pubs/2021/nsf21551/nsf21551.htm.

[3] National Academies of Sciences, Engineering, and Medicine 2019. *Performance of Bridges That Received Funding Under the Innovative Bridge Research and Construction Program*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25358; also, National Academies of Sciences, Engineering, and Medicine 2019. *Toward New Naval Platforms: A Strategic View of the Future of Naval Engineering*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25601.

Objective 3.1: Science-guided machine learning (ML)

Note: The ESM Department aims to enhance and build departmental expertise in developing science-informed ML solutions for solving complex scientific and engineering problems in terms of new faculty/staff, computing and data management resources as well as graduate students.

Key Performance Indicators: Three new faculty hires. Infrastructure and support for high performance computing and effective data management. Increase the number of ESM graduate students doing related research.

Objective 3.1 mapping:

- Foundations:
  - F5: Driving Economic Development
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - EH1: Enhancing Health — Advance discovery in personalized and population health
  - SP1: Stewarding Our Planet's resources — Drive fundamental science relevant to critical problems
  - SP3: Stewarding Our Planet's resources — Improve modeling capability
  - DI3: Empowerment through Digital Innovation – Develop a more robust digital infrastructure and culture.
- Supporting Elements
  - IS3: Infrastructure & Support — Drive innovation and discovery

Objective 3.1 — Actions

Action 3.1.1: Hire three faculty with expertise in creating hybrid science-ML solutions.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: Department head/search committee

Action 3.1.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Faculty hire #1 in science-guided AI in medicine and neural engineering	2021-2022	Faculty hire #1
Faculty hire #2 in science-guided AI in SHM & transportation	2022-2023	Faculty hire #2
Faculty hire #3 in ML-assisted computational methods	2024-2025	Faculty hire #3

Action 3.1.2: Create and maintain infrastructure for effective data storage and management

Note: Having access to and maintaining a common and standardized Data Management System (DMS) is critical. Such a system needs to be flexible for all faculty group needs meaning scalable and easy to configure for each PI's needs, independent of their physical office location (EES, MSC, etc.). It should be

capable of linking data management to data processing at all scales. In addition, it is critical to hire and have an in-house IT professional capable of implementing and scaling the DMS for faculty and adapting it to their research needs and providing concierge service to University-wide data management services and hardware.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible party: Department head

Action 3.1.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Invest in the required hardware and software for high performance computing including the annual updates and maintenance	2021-2025	New faculty start-ups
Seek external funding to improve the computing and data storage infrastructure	2021-2025	No. of infrastructure support proposals
Create a department-wide secure data management system (DMS)	2021-2025	ESM DMS
Hire a support staff member to set up and maintain the DMS including managing the database, setting up and configuring the storage/backup system, and keeping track of PSU computing resources that ESM can leverage.	2024	IT staff hire #1

Action 3.1.3: Build a community with focus on science-informed ML (applied to problems in medical, neural engineering, SHM, transportation, etc.) to facilitate scientific exchange, advance research, increase research funding, train students and gain visibility in the broader scientific community.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: teams of faculty doing research on science-informed ML for advanced manufacturing of advanced materials.

Action 3.1.3 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Initiate and maintain an intellectually stimulating and supportive environment by connecting PIs and graduate students through organizing frequent gatherings	2021 - 2025	- seminar series - workshops - journal club
Submit internal and external seed grant applications	2021-2025	Proposals submitted in this area by ESM faculty
Seek DOE/NSF/NASA /NIH/… training fellowship grants to support graduate student research in science-informed ML	2021-2025	Fellowship applications submitted
Establish collaborations across the college and university for example with faculty in Computer Science and the college of IST	2021-2025	Collaborative papers and proposals

Develop multi-PI collaborative proposals	2022-2025	Multi-PI proposals submitted in this area by ESM faculty

Objective 3.2: Advanced manufacturing and materials

Note: Advanced manufacturing has an important place in the economy and national security of the United States. The ESM Department has a traditional strength in advanced manufacturing methods, advanced materials, and the merging of advanced manufacturing methods and materials. This traditional strength includes the mechanical testing of materials at multiple size scales. The objective of this task is to invest in new faculty, staff, and graduate students working in support of advanced manufacturing science and technology for advanced materials.

Key Performance Indicators: Hire three new faculty in the areas of (i) sustainable manufacturing of lightweight structural composites for transportation and urban mobility: (ii) fabrication-structure-property relationships of multifunctional materials with hierarchical/architectured structures; and (iii) biosynthetic and biomimetic materials. Hire a full-time technician to support laboratories participating in advanced manufacturing of advanced materials. Update manufacturing equipment. Increase the number of graduate students doing manufacturing related research.

Objective 3.2 mapping:

- Foundations:
  - F5: Driving Economic Development
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - SP1: Stewarding Our Planet's Resources — Drive fundamental science relevant to critical problems
  - SP2: Stewarding Our Planet's Resources — Develop technologies for implementation
  - SP4: Stewarding Our Planet's Resources — Fully engage our research infrastructure
- Supporting Elements
  - IS3: Infrastructure & Support — Drive innovation and discovery

Objective 3.2 — Actions

Action 3.2.1: **Hire three faculty members in advanced manufacturing of advanced materials and one technician with a high level of expertise in mechanical testing.**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible party: Department head and search committee

Action 3.2.1 Implementation Tasks Table.

Implementation Tasks	**Task Dates**	**Deliverables**
Hire a technician to support teaching and research related to multiscale, multifunctional	2021-2022	Hired technician

mechanical testing of materials. The technician will support and improve the ESM mechanical test facilities and foster broad utilization of test facilities from users in ESM and outside of ESM. The technician will have a PhD or equivalent laboratory experience.		
Hire a junior faculty member in the area of sustainable manufacturing of lightweight structural composites for transportation/urban mobility, which themselves are sustainable. The hire aligns well with recent hires in other COE/EMS departments, with continuing research interests in PSU's ARL, MRI, IEE, and with the NAE's grand challenges. It also aligns with trends in manufacturing funding coming from DOE, DOD, NASA aeronautics, NSF, and industry—particularly automotive and aircraft with their push for energy efficient future transportation, but also civil with its push for longer-lived infrastructure. A person at the forefront of advanced manufacturing and characterization methods would be best suited for this tenure track faculty position.	2021-2022	Hired faculty member
Hire a junior faculty member in the area of quantitative measurement of material behavior at micron to nanometer length scales with emphasis on developing fabrication-structure-property relationships for advanced manufacturing techniques; interrogating interactions of the deformation mechanism with microstructures of advanced materials; and tuning microstructure and geometrical length scales for customizing properties and performance. The hire aligns with interests in PSU's ARL, MCL, the recent ESM TEM hire, other hires in COE/EMS, and the relevant nanotechnology and nanomechanics oriented PSU center efforts. It also aligns with trends in NSF Designing Materials to Revolutionize and Engineer our Future (DMREF) and Materials Research Science and Engineering Center (MRSEC) programs and other materials genome initiative partners — DOD, NIST, AFRL, and ARL	2023-2024	Hired faculty member
Hire a junior faculty member in biosynthetic and biomimetic materials focusing on the development of responsive materials capable of sensing, reporting, and responding to external stimuli through the synthetic biology and	2024-2025	Hired faculty member

biological engineering. Natural evolution, over billions of years, has driven the design of constructive/protective interaction between biology and the environment. In the last two decades, the science of genomic and metabolomic modifications to biological systems has sufficiently matured to develop biosynthetic materials applications in responsive materials, such as for protection, self-healing, and communications. The hire aligns with interests in PSU's ARL, Huck Life Sciences, MRI, other hires in COE, and the relevant synthetic biology-oriented PSU center efforts. It also aligns with trends in DoD (ARO, AFOSR, DARPA, ONR) as well as NSF programs and synthetic biology initiatives (e.g., EBRC).		

Action 3.2.2 Modernize the research laboratory infrastructure in the ESM Department.

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible entity: teams of faculty doing research on advanced manufacturing of advanced materials

Action 3.2.2 Implementation Tasks Table.

Implementation Tasks	**Task Dates**	**Deliverables**
Identify and prioritize equipment needs	2021	List of prioritized equipment needs
Write proposals for obtaining external and internal funding to replace obsolete/nonfunctional equipment and procure new types of equipment that we currently do not have. Possible external sources of funding include DURIP, NIH S10 and NSF Major Research Instrumentation (MRI) grants . Matching funds from within PSU will be sought as well.	2021-2025	Successful infrastructure enhancement proposals

Action 3.2.3. Increase the visibility and prominence of advanced manufacturing of advanced materials in the ESM Department.

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible entity: teams of faculty doing research on advanced manufacturing of advanced materials

Action 3.2.3 Implementation Tasks Table.

Implementation Tasks	**Task Dates**	**Deliverables**
Add "Advanced Manufacturing" as a separate ESM "Research Area" on the ESM homepage to establish a clearer identity to our virtual visitors	2021-2022	New "Advanced Manufacturing" research area on ESM homepage

Seek additional funding opportunities for graduate students in advanced manufacturing and materials	2021-2025	Write at least one proposal for graduate traineeships in advanced manufacturing (e.g., NSF, DOE)
Seek collaborative opportunities between ARL and ESM in advanced manufacturing and materials	2021-2025	Co-advise graduate students, write collaborative proposals, participate in seed grants that are co-sponsored by ARL and the Institutes

Action 3.2.4. New Frontiers in complementary efforts in theory, computation, and experiment for advanced materials manufacturing.

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible entity: teams of faculty doing research on advanced manufacturing of advanced materials

Action 3.2.4 Implementation Tasks Table.

Implementation Tasks	**Task Dates**	**Deliverables**
Organize local symposium and or workshop, or with local and/or regional audiences	2021-2025	Write at least one proposal for workshops in advanced manufacturing and advanced materials design (e.g., NSF, DOE)
Organize conference symposia with national/international audiences	2021-2025	Faculty organize/co-organize at least three symposia
Funding for interdisciplinary and cross-cutting collaborative research efforts in theory, computation, and experiment	2021-2025	Multidisciplinary University Research Initiative (MURI)

Objective 3.3: Remote sensing innovations

Note: The ESM Department aims to enhance and build department expertise and multidisciplinary collaborations among faculty/staff, graduate, and undergraduate students for pioneering the development of next generations of smart, energy efficient, affordable, and secure sensors across length and time scales for deployment in engineering systems, as healthcare solutions, and for the emerging area of Internet of Things (IoT).

Key Performance Indicators: Two new faculty hires; expansion of the infrastructure for materials and device innovation and procuring new instrumentations for characterization across length and time scales; increased number of ESM graduate and undergraduate students doing related research; increased number of collaborative proposals; proposal for a Remote Sensing Center; increased number of patents, high-impact journal papers, conference presentations, invited talks, workshop, seminars and webinars.

Objective 3.3 mapping:

- Foundations:
  - F5: Driving Economic Development
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - SP1: Stewarding Our Planet's Resources — Drive fundamental science relevant to critical problems
  - SP2: Stewarding Our Planet's Resources — Develop technologies for implementation
  - SP4: Stewarding Our Planet's Resources — Fully engage our research infrastructure
- Supporting Elements
  - IS3: Infrastructure & Support — Drive innovation and discovery

Objective 3.2 — Actions

Action 3.3.1: Hire two faculty, one in the area of biosensors and another one in the area of IoT sensors.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible party: Department head/ search committee

Action 3.3.1 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Faculty hire #1 Biosensors	2021-2022	Faculty hire #1
Faculty hire #2 IoT Sensor solutions	2022-2023	Faculty hire #2

Action 3.3.2: Expand the infrastructure for materials and device innovation and procuring new instrumentations for characterization across length and time scales.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: Faculty and Department head

Action 3.3.2 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Invest in the required infrastructure for materials innovation	2021-2025	Procurement of advanced synthesis tools.
Invest in the required infrastructure for sensor development	2021-2025	Procurement of advanced fabrication (micron and nano), printing (3D, bio-, etc.) and manufacturing equipment
Invest in new equipment for sensor characterization and testing	2021-2025	Advanced characterization and testing tools
Remote Sensing Center	2024-2025	Proposal for a Remote Sensing Center

Action 3.3.3: Recruit and advise postdoctoral scholars, graduate, and undergraduate students to do research for developing next generations of smart sensors for engineering systems, healthcare, and IoT.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: ESM Faculty including the two new hires

Action 3.3.3 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Introducing ESM thrust area on remote sensing	2021-2026	Add Remote Sensing as a research area and list faculty
Recruit researchers	2021-2026	Recruit postdoctoral associates, graduate students, honors and REU undergraduate students

Action 3.3.4: Procure internal and external funding.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: ESM Faculty including the two new hires

Action 3.3.4 Implementation Tasks Table.

Implementation Tasks	Milestone / Date	Deliverables
Submit internal and external seed grant applications	2021-2026	Proposal submitted in this area by ESM faculty

Develop collaborative proposals	2022-2026	Multi-PI proposals submitted in this area by ESM faculty
Seek DOE/NSF/NASA /… fellowships to support graduate student research in remote sensing	2021-2026	Fellowship applications submitted
Seek IUCRC grants for Industry/University joint consortiums	2021-2026	Proposals submitted

Action 3.3.5: Dissemination of research results and seeding start-up ideas through innovation.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: ESM Faculty, staff, and students.

Action 3.3.5 Implementation Tasks Table.

Implementation Tasks	**Milestone / Date**	**Deliverables**
Dissemination of research results	2021-2026	High-impact journal papers, conference presentations, invited talks, workshop, seminars and webinars.
Seeding start-up ideas	2021-2026	File patents, write SBIR, STTR grants, I-CORPS

Objective 3.4: Quantum Computing and Information Science

Note: Quantum information science (QIS) applies the principles of quantum theory to generate novel knowledge and disruptive technologies. QIS related technologies involve communications (ensuring security in the digital world and building quantum-enabled internet); sensing and metrology (realizing quantum-limited sensitivity, resolution, performance and accuracy); simulations (developing advanced techniques and algorithms for understanding quantum dynamics, interactions and reaction mechanisms and for developing novel and complex materials beyond the capabilities of current supercomputer infrastructure); and computing (developing novel computing techniques and power to solve complex problems that are intractable or unsolvable with classical computing schemes). QIS related technologies are expected to create new jobs, improve industrial infrastructure and provide benefits to economy and national security. The physical platforms available to implement the QIS include semiconductors, photonics, cold atoms, ions, superconductors, phononics, etc. Despite the presence of theoretical and experimental research effort throughout PSU on quantum mechanics and quantum theory, PSU does not have a unified and centralized effort in QIS. Except a few (Weiss Physics: cold atoms, Hallgren EECS: Theory, Ozdemir ESM: Photonics/Plasmonics), none of the efforts directly addresses the challenges and needs of QIS. Recently, there are some efforts in the Materials Science community at PSU for research on quantum materials. ESM department is strong in additive manufacturing, acoustics, and material research which may provide fertile platforms to apply quantum theories.

Key Performance Indicators: Hire three new faculty in the areas of (i) Theory of hybrid quantum systems for modelling of materials and devices for quantum information technologies (quantum spin systems, circuit-QED, quantum sensors, 2D-layer systems, quantum dots, nanomechanical oscillators, systems that can bring together different devices, concepts and materials e.g., superconductors, mechanics, optics, quantum dots, condensed matter, liquid, soft, amorphous or crystalline materials, etc.); (ii) Quantum computing, AI, machine learning and algorithms; and (iii) circuit-QED and quantum microwave-photonics. Update facilities and lab spaces (controlled environment) and computational resources. Increase the number of graduate students doing quantum information science related research.

Objective 3.4 mapping:

- Foundations:
  - F5: Driving Economic Development
  - F6: Ensuring a Sustainable Future
- Thematic Priorities:
  - SP1: Stewarding Our Planet's Resources — Drive fundamental science relevant to critical problems
  - SP2: Stewarding Our Planet's Resources — Develop technologies for implementation
  - SP4: Stewarding Our Planet's Resources — Fully engage our research infrastructure

- Supporting Elements
    - IS3: Infrastructure & Support — Drive innovation and discovery

Objective 3.4 — Actions

Action 3.4.1 **Hire three new faculty in the areas of quantum information science and quantum technologies.**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: Department head and search committee

Action 3.4.1 Implementation Tasks Table.

Implementation Tasks	Task Dates	Deliverables
Hire a junior faculty member in the area of the theory of hybrid quantum systems for modelling of materials and devices for quantum information technologies (quantum spin systems, circuit-QED, quantum sensors, 2D-layer systems, quantum dots, nanomechanical oscillators, systems that can bring together different devices, concepts and materials e.g., superconductors, mechanics, optics, quantum dots, condensed matter, liquid, soft, amorphous or crystalline materials, etc.). The hire aligns well with the recent National Quantum Initiative and PSU Quantum Initiative (Joint faculty search of Physics and EECS). There is interest at PSU's ARL and MRI. It aligns with trends in funding opportunities from DOE, DOD, and NSF. A person at the forefront of quantum information science with an emphasis on hybrid quantum devices and systems, benchmarking and metrics for quantum devices would be best suited for this tenure track faculty position.	2021-2022	Hired faculty member
Hire a junior faculty member in the area of quantum computing, quantum algorithms, quantum artificial intelligence, and quantum machine learning for solving real-world problems and applications in data science and forecasting, optimization, scheduling, sensing, chemistry, biology and materials science. The hire aligns well with the recent National Quantum Initiative and PSU Quantum Initiative (Joint faculty search of Physics and EECS). There is interest at PSU's ARL and MRI. It aligns with trends in funding opportunities from DOE, DOD,	2022-2023	Hired faculty member

NSF and Industry (IBM, Google, Rigetti, D-Wave, Honeywell, etc). A person at the forefront of quantum computing and algorithms with an emphasis on development of general-purpose software tools for increasing the efficiency of quantum computers, quantum algorithms and techniques to address new application areas, and fault-tolerant computing would be best suited for this tenure track faculty position.		
Hire a junior level faculty member in circuit-QED and quantum microwave-photonics. Circuit-QED is based on superconducting circuits and relies on features of Josephson junctions (JJ) and their integration with other quantum systems (atoms, photons, phonons, etc) to build quantum bits and quantum information processors and computers. It is envisioned that future quantum computers will be utilizing superconductor architectures (e.g., Google, IBM Microsoft, Rigetti, etc) at local nodes whereas photons will be used to communicate information among these processing nodes. Cavity-QED relies on microwave photons whereas communication channels are efficient or less-lossy in the near-IR (so called communication band). This energy gap between microwave and optical photons makes it difficult to connect/interface circuit-QED based processors to communication links. Microwave-photonics will play a significant role here. Quantum microwave photonics will also serve to develop quantum microwave radars, remote sensing schemes etc. The hire aligns well with the recent National Quantum Initiative and PSU Quantum Initiative (Joint faculty search of Physics and EECS). There is interest at PSU's ARL and MRI. It aligns with trends in funding opportunities from DOE, DOD, NSF and Industry (IBM, Google, Rigetti, D-Wave, Honeywell, etc).	2023-2024	Hired faculty member

Action 3.4.2. Modernize the research laboratory and building infrastructure in the ESM Department.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: teams of faculty and the Department Head

Action 3.4.2 Implementation Tasks Table.

Implementation Tasks	**Task Dates**	**Deliverables**

Identify and prioritize computational resource and equipment needs	2021	List of prioritized needs
Write proposals for obtaining external and internal funding to modernize lab spaces (controlled atmosphere, temperature, humidity, air-flow control, dust/particle control, filtering, illumination).	2021-2023	Successful infrastructure enhancement proposals

Action 3.4.3. Increase the visibility and prominence of quantum information science and quantum computing related technologies in the ESM Department.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: teams of faculty doing research on advanced manufacturing of advanced materials.

Action 3.4.3 Implementation Tasks Table.

Implementation Tasks	Task Dates	Deliverables
Seek additional funding opportunities for graduate students in quantum information science and quantum technologies	2021-2025	Write proposals for undergraduate and graduate traineeships in quantum information sciences (e.g., NSF, DOE, DOD)
Seek collaborative opportunities with ARL and other departments (Physics, EECS, Materials Sci.) in quantum information science	2021-2025	Co-advise graduate students, write collaborative proposals
Develop new courses and core curriculum for quantum information sciences	2021-2025	Novel courses on theoretical and experimental foundations of quantum information sciences, quantum optics, quantum materials, and quantum computing.

Action 3.4.4. ESM-led symposiums and workshops on quantum sciences.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible entity: faculty doing research on quantum information sciences

Action 3.4.4 Implementation Tasks Table.

Implementation Tasks	Task Dates	Deliverables
Organize local symposium and or workshop, or with local and/or regional audiences	2022-2025	Write proposals for workshops in quantum information sciences (e.g., NSF, DOE)
Organize conference symposia with national/international audiences	2021-2025	Faculty organize/co-organize symposia

Funding for interdisciplinary and cross-cutting collaborative research efforts in quantum information sciences and quantum computing	2023-2025	Multidisciplinary University Research Initiative (MURI) or multiple-PI grants.

Goal 4: Over the next five years, augment the visibility of our program through increased outreach to international institutions, alumni, current and potential industry partners, and through increased targeted recruiting of undergraduate and graduate students.

Note: Outreach is vital to the ESM department's ability to fulfill its vision. The department's ability to continue its growth in research, education, and service depends on its ability to assert itself as a hub for innovation and excellence. Key factors in this growth are the department's ability to continue to attract competitive faculty, students, and staff. In turn, this is possible only with a continued growth of our reputation both in its quality and its reach. One opportunity to expand ESM's reach is in a broader engagement with the international academic community. While the ESM department maintains relations with its alumni, the ESM outreach can grow to involve alumni in its activities. This effort can also be coordinated in an expanded dialog with industrial partners. Paramount remains the effort to attract competitive students at both the undergraduate and graduate levels. In this regard, there are strong opportunities to grow in the recruitment of underserved and underrepresented groups.

Objective 4.1: Strengthen research and educational interactions with the international academic community

Note: The ESM faculty continuously identifies trusted and respected research partners to collaborate on high-impact research areas. Conferences, workshops, and sabbatical research visits are excellent opportunities to develop global partnerships with leading laboratories and research teams whose strengths of scientific research and technology development complement those of the ESM department. In addition, the ESM department is engaged in various joint education programs with well-known overseas institutes. One current focus is a 3+1+1 joint degree program, where an overseas college student is accepted to this "pathway program" following three years of undergraduate study at their parent university. Foreign students accepted to this Program attend Penn State for one year as non-degree undergraduate student and complete 24 credits of course work towards the completion of the requirements for a parent school undergraduate degree. Meanwhile, it is expected that the students enrolled in the Program apply to ESM one-year Masters of Engineering (MEng) or Master of Science (MS) degree during their year at Penn State, for admission following the completion of their undergraduate degree from their parent school, subject to all Penn State Graduate School requirements, tuition and fees.

Key Performance Indicator: A score of 70% or higher in survey of ESM faculty and students on the relevance, accessibility, and effectiveness of international collaborations.

Objective 4.1 mapping:

- Foundations:
  - F1: Enabling Access to Education
  - F4: Enhancing Global Engagement
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
  - SP5: Stewarding our Planet's Resources — Forge broad and relevant partnerships
- Supporting Elements
  - CO1: Constituent Outreach & Engagement — Focus on impact through partnerships
  - CO2: Constituent Outreach & Engagement — Provide expanded access to Penn State resources

Objective 4.1 — Actions

Action 4.1.1: **Establish research collaboration with overseas institutes under the Joint Innovation Partnership (JIP) initiative.**

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible Party: ESM faculty members and their overseas research collaborators with the assistance of the Strategic Interdisciplinary Research Office (SIRO).

Action 4.1.1 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables
Foster new collaborations between ESM research teams and external laboratories and scholars in overseas institutes	December 2022	Publish collaborative papers Hold joint symposium and/or workshop
Establish exchange programs for students, postdocs and faculties with overseas institutes	December 2023	student, postdoc, and faculty exchanges
Develop joint research projects and seek sponsorship from US and overseas funding agents	December 2023	collaborative proposals and joint grant awards
Progress assessment and plan revision.	May 2025	Evaluation results and revise implementation plan

Action 4.1.2: Joint education programs (e.g., 3+1+1 senior/MS program) in coalition with foreign institutes.

Metric: Achieving the deliverables in the Implementation Tasks Table.
Responsible Party: coordinator of Joint education program, graduate admission committee, undergraduate curriculum committee.

Action 4.1.2 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables
Advise the students enrolled in the joint education programs, and expand the program to more overseas universities;	December 2023	Recruiting 3-6 students/year
Progress assessment (to include number of students enrolled into the joint education program, and the percentage of them entering the graduate program) and plan revision.	May 2025	Evaluation results and revised implementation Plan

Objective 4.2: Create permanent opportunities for engagement of our alumni

Note: Alumni provide substantial support to the ESM department through committee participation, mentorship, and financial assistance. Our alumni have a wealth of life experiences and professional expertise to offer ESM students, staff, and faculty. The ESM department can stand to benefit from involving a larger pool of alumni serving in advisory capacities as well as in expanding its philanthropy base.

Key Performance Indicator: Increased levels of alumni engagement will be assessed though records of interactions at ESM events.

Objective 4.2 mapping:

- Foundations:
  - F1: Enabling Access to Education
  - F2: Engaging our Students
  - F4: Enhancing Global Engagement
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
- Supporting Elements
  - CO: Constituent Outreach & Engagement

Objective 4.2 — Actions

Action 4.2.1: Alumni participation at ESM today.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: The SES leadership team

Action 4.2.1 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables
Invite Alumni as Speakers and Judges for ESM Today	February 2021	Confirmed Alumni Speakers and Judges
Assess Alumni Involvement	F2021-S2023	Implementation plan
Execute Plan; Continue Assessments	F2023-S2026	Catalog Annual ESM Today Schedules Yearly Assessments
Review Improvements, Revise Plan	F2025-S2026	Revised Implementation Plan

Action 4.2.2: Communications with ESM staff and faculty on alumni activities.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Party: Marketing and communications staff

Action 4.2.2 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables

Present a summary of Alumni/Department activities at faculty meeting	September 2021	Confirmed Alumni Speakers and Judges
Assess Alumni Involvement	F2021-S2023	Collect information of attendance at Alumni events
Continue to assess and communicate level of alumni participation at ESM department events.	F2023-S2026	Catalog Annual ESM Today Schedules Yearly Assessments
Review Improvements, Revise Plan	F2025-S2026	Revised Implementation Plan

Objective 4.3: Develop a framework to establish collaborations with local, regional, and national industry partners.

Note: Engineering Science and Mechanics at Penn State is at a crossroads with respect to the future of engineering education and research. The university has world-class faculty and units in several strategic growth areas. There are excellent research capabilities available on the campus. An opportunity to grow is offered by innovative and translational collaboration with industry partners in the areas in which ESM can be a major player, especially where a natural research partner with industry and government ties already exists.

Key performance Indicator: Satisfaction in survey of ESM faculty and students on the relevance, accessibility, and effectiveness of industrial partnerships and translational collaborations.

Objective 4.3 mapping:

- Foundations:
  - F4: Enhancing Global Engagement
- Thematic Priorities:
  - SP5: Stewarding Our Planet's Resources — Forge broad and relevant partnerships
- Supporting Elements
  - CO1: Constituent Outreach & Engagement — Focus on impact through partnerships
  - CO2: Constituent Outreach & Engagement — Provide expanded access to Penn State resources

Objective 4.3 — Actions

Action 4.3.1: Promote collaboration between PSU Applied Research Laboratory (PSU/ARL) and ESM

Metric: Number of collaborative proposals submitted and amount of funding received, number of graduate students supported, number of affiliate appointments to PSU/ARL faculty.

Responsible Party: An ESM faculty member at PSU/ARL and a corresponding faculty member in ESM.

Action 4.3.2: Promote collaboration with industry partners.

Metric: Achieving the deliverables in the Implementation Tasks table.

Responsible Party: Department Head and Industry Engagement Committee.

Action 4.3.2 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables
Department Head establishes the Industry Engagement Committee	September 2021	Committee formation and charge

Identify key areas of immediately transitionable technology and industry partners.	F2021-S2023	Report to the faculty.
Identify ESM research areas that have high potential for future transition.	F2023-S2026	Report to the faculty.
Establish collaborations with industries and assess the program (including number of transitioned technologies, number of collaborative proposals submitted, funding received and graduate students supported).	F2025-S2026	Collaborations

Action 4.3.3: Increase industry investment in the department

Metric: Achieving the deliverables in the Implementation Tasks Table.
Responsible Party: Industry Engagement Committee.

Action 4.3.3 implementation Table.

Implementation Tasks	Milestones / Date	Deliverables
Identify potential donor companies and focal points	End of Spring 2021	Report to the faculty.
Work to establish Scholarships for students, professor endowments	F2021-S2025	Number of Scholarships and Growth of Endowments
Engage the IPAC for other potential investment opportunities.	F2021-S2025	Report to the faculty.

Objective 4.4: Establish pipeline and bridge programs for identifying, attracting, and recruiting competitive students and support their development.

Note: The lifeblood of any academic institution remains its students. The recruitment of competitive students will always remain a priority and the ESM department must remain engaged in a continual improvement of its ability to attract talent both at the undergraduate and graduate levels.

Key performance Indicator: We seek an increase in applications with a concurrent increase in the quality of applicants.

Objective 4.4 mapping:

- Foundations:
  - F1: Enabling Access to Education
  - F4: Enhancing Global Engagement
- Thematic Priorities:
  - TE4: Transforming Education — Prepare our students for success in their careers and in life
  - SP5: Stewarding Our Planet's Resources — Forge broad and relevant partnerships
- Supporting Elements
  - CO1: Constituent Outreach & Engagement — Focus on impact through partnerships
  - CO2: Constituent Outreach & Engagement — Provide expanded access to Penn State resources

Objective 4.4 — Actions

Action 4.4.1: **Establish pipeline and bridge programs for identifying, attracting, and recruiting competitive students and support their development.**

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Parties: Graduate and Undergraduate Committee.

Action 4.4.1 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables
Critically evaluate existing PSU and COE feeder programs/institutions for targeted recruiting	F2021–S2022	Report to the faculty.
Establish meaningful collaborative relationships with minority serving institutions (MSIs) and HBCUs, as well as programs at PWI's that align with ESM faculty interests. Identify faculty advocates at the institutions.	F2022–S2023	Report to the faculty.
Establish research collaborations at the above institutions: strengthen research and	F2023–S2024	Report to the faculty.

educational interactions through for example teaching exchanges.		
Establish faculty rewards for recruiting outreach activities.	F2024–S2025	Report to the faculty.
Ensure one faculty representative attends a national recruiting event per year at relevant conferences serving underrepresented minorities (e.g., NSBE, SHPE).	F2025–S2026	Report to the faculty.

Action 4.4.2: Create attractive research and educational initiatives for all students.

Metric: Achieving the deliverables in the Implementation Tasks table.
Responsible Parties: Graduate and Undergraduate Committee.

Action 4.4.2 Implementation Tasks Table.

Implementation Tasks	Milestones / Date	Deliverables
Identify funding opportunities for the improvement of teaching laboratories.	F2021–S2022	Report to the faculty.
Apply for federal initiatives for REU programs and ABET accreditation.	F2022–S2023	Report to the faculty.
Recruit industry support of student events, and industry involvement in Capstone projects.	F2023–S2024	Report to the faculty.
Engage with alumni in mentoring students, and raise the students' awareness of their professional responsibility in addressing societal challenges (such as sustainability) through social leadership talks.	F2024–S2026	Report to the faculty.