Grants for Applications in Industry and Networking (GAIN)

SC EPSCoR Solicitation Number 09-GAIN2025

A. Introduction

The goal of the Grants for Applications in Industry and Networking (GAIN) Program is to encourage early career faculty researchers at South Carolina's Comprehensive Research Universities (CRUs) (Clemson University, Medical University of South Carolina, and University of South Carolina Columbia campus to compete effectively for research funding to support the U.S. NSF EPSCoR ADAPT in SC (AI-Enabled Devices for the Advancement for Personalized and Transformative Health Care in South Carolina) award.

The vision of ADAPT in SC is to build research capacity at the nexus of Artificial Intelligence (AI), life and social sciences, and bioengineering through fundamental research, education, workforce development, and industry engagement.

Proposals submitted in response to this solicitation can be submitted by single investigators (targeting early-career faculty pursuing high-risk/high-reward research) from South Carolina's three comprehensive research universities (Clemson University, the Medical University of South Carolina, and the University of South Carolina Columbia). **(NEW) Although not required, applicants are encouraged to include a clinical or an industry collaborator as appropriate for the success of the project.**

B. ADAPT in SC Research Priorities

For the ADAPT in SC project, biomedical devices are broadly defined to include conventional mechanoelectrical apparatus (e.g., X-ray machines, pacemakers) and biomedical digital systems such as computer-based biomedical information analyzing systems and predictive models and tissue-engineered implantable biological constructs. The following are major themes of research in ADAPT in SC. Proposals may be submitted to address any of the following four themes:

Theme 1 - Biomedical AI

Biomedical AI is an emerging interdisciplinary field where innovations sprout new theories, models, and algorithms in AI and data science and in synergistic integration of AI with targeted biomedical devices and their downstream applications in complex biomedical settings. Proposals on this topic will conduct research related to the development of theoretical foundations of biomedical AI, AI-ready data acquisition and preprocessing, multimodal data fusion technologies, deep learning algorithms, physics-informed ML models, and software tools to facilitate the use of mechanistic and AI models, sometimes

with limited amounts of data.

Proposals on this theme may address one or more of the following:

1. Tackle three key research challenges in biomedical AI: small data size; multimodal data; and unannotated data.
2. Develop new data-enrichment methods for given small datasets.
3. Develop techniques for generating AI-ready data.
4. Adapt current post hoc XAI techniques to achieve interpretable and trustworthy outcomes in biomedical devices.
5. Build a comprehensive data-driven modeling framework, integrating physics, mechanistic modeling, and machine learning.
6. Explore new AI methods for biomedical device developments with integrated security measures.
7. Develop new uncertainty quantification methods to test the robustness of the AI tools integrated with the proposed biomedical devices.
8. Apply latent variable space and/or inductive logic programming approaches to data fusion.
9. Create new statistical approaches to analyze transparency and trust in AI modeling.

Theme 2 - XAI-enabled Biomedical Devices for Diagnostic and Planning Applications

Explainability is crucial to rationalizing and cross-checking model outcomes to ensure that the AI-informed decisions made are reliable and trustworthy. The major challenge to implementing AI in biomedical devices is a tradeoff between the explainability and accuracy of the AI models. Highly accurate, complex models like deep neural networks (DNNs) trained by significant amounts of data tend to be less explainable, but explainable algorithms like decision trees usually lead to low accuracy for complex tasks. As an emerging field in trustworthy AI, XAI (Explainable AI) endeavors to find explanations for complex models using ante hoc or post hoc methods. Ante hoc methods address explainability from the beginning, whereas post hoc methods rely on an external explainer of an already trained model. Proposals on this topic will use XAI to improve the explainability of the diagnostic or treatment decisions made from multimodal clinical data to provide insights into important causal factors and to obtain domain experts' trust, high prediction accuracy, and safe, continuous workflows from initial diagnosis to treatment end.

Proposals on this theme may address one or more of the following:

1. Explore the degree to which XAI approaches improve understanding of diagnostic outcomes.
2. Develop strategies for classification of bioimages from small data sets.

3. Use XAI approaches to accommodate multi-modal data (images and biosensor data) in biomedical classification.
4. Develop AI tools to accelerate the identification of biochemical compounds from complex biological samples.
5. Use XAI to assist decision-making for drug dosage control.

Theme 3 - DL-Imaging Model-Enabled Biomedical Devices for Personalized Prognostic and Treatment Applications.

Novel DL (Deep Learning) techniques are needed to actualize high-performance biomedical devices for prognosis and/or treatment. Current devices for these purposes depend on multiple data sources to make the final treatment decision, directly guide the treatment, or implement the treatment. Constructing a model that can effectively integrate multimodal data remains a challenge. Moreover, in many applications, there are limited human samples (e.g., patients) from whom the data can be collected, not to mention the limited number of samples that clinical experts can effectively annotate. Building high-performance DL models from a limited amount of data is critical for the successful development of AI-enabled biomedical devices. Furthermore, the data collected by different investigators, labs, and instruments have an inherent bias. The ability to generalize DL models constructed from limited data sources to many application scenarios determines whether the AI-enabled medical devices can be effectively applied to a general group. Additionally, current clinical practice seeks to leverage big data repositories collected over many years while still tailoring treatment for individual patients. Therefore, developing DL models for medical devices is different from training DL models in general image or text classification, where a large amount of training data is available. The ADAPT in SC will focus on innovation in the DL models and training data processing.

Proposals in this area will conduct fundamental research on creating DL models for AI-enabled biomedical devices for prognosis and/or treatment from limited data. This research thrust aims to advance the field of AI-enabled medical devices for prognosis and/or treatment. The primary outcome of this research thrust will be fundamental knowledge that governs generating high- performance, generalizable DL algorithms from limited data.

Proposals on this theme may address one or more of the following:

1. Improve ML algorithms for unannotated, incomplete, and limited available biomedical data.
2. Develop novel strategies for integrating multimodal data with imaging data.
3. Explore new methods for integrating clinically relevant data.
4. Translate XAI techniques to address the “black box” issue in DNNs.
5. Implement AI-enabled image analysis and multimodal data fusion into a risk stratification and decision-making tool for prognosis and treatment.

Theme 4 - DT-Enabled Biomedical Devices for Rehabilitation and Therapy

Rehabilitation is an important process for patients to optimize recovery following medical treatment. Today, for a given medical problem, there is a host of rehabilitation procedures and methods. However, determining the best or most suitable rehabilitation method for a given patient is difficult. Likewise, medical treatment of chronic diseases such as diabetes and cancer or rapidly developing ones such as sepsis requires physicians and patients to navigate through a sea of treatment pathways to identify the one suitable for the individual patient. An overarching scientific challenge is developing a system for an individual patient so that various available rehabilitation treatment regimens or active medical treatment pathways can be monitored and analyzed, and the outcome inferenced. The use of AI-enabled digital twins (DTs) can be a viable solution. A DT is a virtual representation of an object or system that spans its lifecycle; it synchronized with the real system in real-time and uses simulation to analyze and forecast the future state, ML, and causal analysis to aid decision-making and design of the patient-specific treatment pathway. An AI- enabled rehabilitation DT would be an ideal platform for clinicians to design an optimal rehabilitation strategy for a specific patient to realize a personalized treatment pathway. For diabetes, cancer, or septic patients, a DT can provide an intelligent assistant for the physician and patient to develop and optimize the treatment pathway dynamically. For the elderly and less serviced communities, DTs would provide additional AI-enabled, user-friendly instructional materials and devices.

DT is a concept derived from the aerospace industry, where aircraft or spacecraft need to be evaluated virtually under potentially challenging or hazardous conditions to determine the need for replacement or reinforcement procedures. This concept perfectly fits the healthcare industry, but a fully functional DT platform in the healthcare industry has yet to be developed. Proposals in this area should address the development of such a platform that can be used for patients in various medical categories and communities.

Proposals on this theme may address one or more of the following:

1. Develop methods for identifying foundational characteristics of a biomedical device to predict outcomes and infer causality.
2. Establish a DT framework consisting of multiple data types and model types (e.g., data- driven vs. mechanistic model-driven platform).
3. Identify and implement a digital twin module that optimally addresses the needs of a biomedical device.
4. Implement a developed DT model with a biomedical device for rehabilitation or a specific disease.
5. Create DT-enabled biological cell-based implantable biomedical devices.
6. Establish DT-based multiscale, mechanistic models for biomedical device developments.

7. Develop fundamental theories and technologies for time series modeling and causal analysis.

C. Award Information

Maximum Funding Amount Per Award: $60,000.00 (an additional $15,000 may be requested for the inclusion of a clinical or industry collaborator).

Maximum Award Duration: 18 months

Number of Awards: Depends on quality of proposals and available funds

Anticipated Project Start Date: Projects can start as early as May 1, 2026.

D. Eligibility and Conditions

- The PI must be a faculty member at Clemson University, the Medical University of South Carolina, or the University of South Carolina - Columbia.
- The Principal Investigator must be a faculty member who has been in a tenured or a tenure-track appointment for no more than 10 years, or in a full-time research faculty position for no more than 10 years.
- If a clinical or an industry collaborator is included, the home institution of the PI will serve as the fiscal agent and will establish either a sub-award for the collaborator's institution or a consulting agreement.
- Current GAIN and GAIN CRP PIs/co-PIs are not eligible to serve as PI or co-PI on this solicitation unless their awards have ended, and final reports submitted before the submission deadline of this solicitation.
- Former investigators who have defaulted on a SC EPSCoR award (e.g., did not submit final project reports) are not eligible to apply.

E. Deadline

Full Proposals are due by 5:00 PM on September 11, 2025.

F. Proposal Content

The sections below represent the body of the proposal. Failure to submit the required sections will result in the proposal not being accepted or being returned without review. *Note: Where indicated, the number of pages refers to the maximum number of pages allowed and must not be exceeded*.

1. **Proposal Cover (2 Pages)**

Use the Cover Page form in Appendix A.

2. **Project Summary (1 Page)**

   Proposals must contain an NSF compliant project summary not to exceed one page in length. The Project Summary should be informative to others working in the same or related fields, and, insofar as possible, understandable to a broad audience within the scientific domain. It should not be an abstract of the proposal. The Project Summary must include the following three sections:

   Overview. The overview section must include a description of the activity that would result if the proposal were funded and a statement of objectives and methods to be employed.

   Intellectual Merit. The statement on intellectual merit must describe the potential of the proposed activity to advance knowledge.

   Broader Impacts. The statement on broader impacts must describe the potential of the proposed activity to benefit society and contribute to the achievement of specific, desired societal outcomes.

3. **Project Description (Not to exceed 10 Pages)**

   The Project Description should provide a clear statement of the work to be undertaken and must include the best scientific and strategic (long-term) objectives of the proposed work and expected significance, the relationship of this work to the present state of knowledge in the field, and the work plan. The Project Description section must include at least the following sections:

   a. **Objectives of the Proposed Work and Relevance**

      - State the objectives of the proposed work
      - Explain how the proposed research and potential outcomes contribute to the goals and Themes of the ADAPT in SC project outlined in Section B. Identify the Theme(s) in Section B above, and one or more of the items in the numbered list under the theme(s) with which the proposed work best identifies.

   b. **Prior Relevant Research**

      Describe the proposed research project including significance of research and a review of relevant literature related to the proposed work.

   c. **Research Plan**

      Describe the research framework, hypothesis, research questions, methods and procedures, potential outcomes, etc. Describe the broad design of activities to be undertaken (e.g., experimental methods and procedures). The

proposed activities must be well justified, and the PIs should address:

- what they want to do,
- why they want to do it,
- how they plan to do it,
- how they will know if they succeed, and
- what benefits could accrue if the project is successful.
- if a clinical or industry collaborator is included in the project, their role must be integral to the proposal and reflected in the proposal narrative, to easily delineate their role and contributions to the project.

This section must also include a timeline for implementing major proposal activities and the names of the team members who are responsible for each activity. The template below (or a similar table) may be used for this purpose.

Activity (name of responsible party)	Year 1				Year 2	
	Q1	Q2	Q3	Q4	Q1	Q2

Finally, proposers should explain how the expected research results can extend and supports ADAPT in SC. Also, briefly describe the facilities/equipment that will be used, and which institution hosts these.

d. Broader Impacts

Proposers must clearly identify the broader impacts of the proposed work and accomplishments to be expected at the end of the project. Specific milestones must be carefully stated to aid in proposal evaluation.

4. References Cited

Reference information is required. Each reference must include the full citation with the name of all authors (in same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication.

5. Clinical or Industry Collaborator Information (1 Page)

Explain the special contributions that will be provided by the clinician or industry collaborator without which the proposed work will not be successful. Include any special qualifications, facilities, resources, etc. that are vital for the successful completion of the proposed work.

6. **Plans to Leverage GAIN Funding (1 Page)**

   The GAIN program is a seed funding program whose aim is to assist faculty in using the work done in a GAIN award to target other opportunities for future research and project funding. Therefore, it is of utmost importance that GAIN awards be used to propel the research forward to larger research programs to sustain the effort. Proposers should outline a plan for submitting proposals for extramural research funding and include the names of potential funding sources and the programs and dates (if known) that will be targeted.

7. **Results from Prior SC EPSCoR Support (1 Page per Award)**

   Note*: If the senior personnel have not received support from SC EPSCoR, this section should include a statement to that effect.* The purpose of this section is to assist reviewers in assessing the quality of prior work conducted with prior SC EPSCoR Program funding. If any senior personnel identified on the proposal has received a SC EPSCoR Program award as a PI since January 1, 2020, the following information must be provided:

   - Title of the project, start date, date completed, and award amount.
   - A summary of the results of the work completed.
   - A list of the publications (full citations) or funding awards resulting from the SC EPSCoR award.

8. **Biographical Sketch(es)**

   A biographical sketch is required for the PI in NSF format. ***Please note*** the new NSF Biographical Sketch format effective May 20, 2024. For more information on NSF format, visit https://new.nsf.gov/funding/senior-personnel-documents#biographical-sketch-0bd. Biographical Sketch must be created and certified in SciENcv (Science Experts Network Curriculum Vitae).

9. **Budget**

   Use the Budget form in Appendix B.

10. **Budget Justification**

    The budget justification must be composed of no more than two pages and must include an explanation of each budget item, such as personnel, other personnel, fringe benefits, materials and supplies, equipment, domestic travel support, publication costs, other direct costs.

    The budget justification must be composed of no more than two pages for each institution and must include the following: an explanation of each budget item, such as personnel, other personnel, fringe benefits, materials and supplies,

equipment, domestic travel support, publication costs, other direct costs.

11. Current and Pending Support

All senior personnel must submit Current and Pending Support in NSF format. Current and Pending Support must be created and certified in SciENcv (Science Experts Network Curriculum Vitae). For more information, visit https://new.nsf.gov/funding/senior-personnel-documents#current-and-pending-other-support-5db

12. Synergistic Activities

A one-page Synergistic Activities document is required for all senior personnel in NSF format. For more information on the Synergistic Activity format, visit https://new.nsf.gov/funding/senior- personnel-documents#synergistic-activities-ec2

G. Budget Information

- A maximum of one month of summer salary for the PI is allowed.
- Salary support is allowed for a clinical or industry collaborator.
- Salary support is allowed for post-docs, graduate and undergraduate student researchers, and other technical support staff.
- Indirect costs and tuition are not allowed.
- Cost-sharing is not required but encouraged.
- Awardees should ensure that the costs claimed are allowable, allocable, and reasonable.

H. Submission Instructions

Submit proposals using: https://scepscor.inforeadv4.com/.

I. Proposal Review Process

Proposals that meet the eligibility requirements and the guidelines of this solicitation will be evaluated by external reviewers (outside South Carolina) based upon the extent to which they meet specific criteria including but not limited to:

- Intellectual Merit and Broader Impacts.
- Whether the plan for carrying out the proposed activities is well-reasoned, well-organized, and based on a sound rationale, and whether it incorporates a mechanism to assess success.
- Alignment with ADAPT in SC research themes.

- Whether the collaboration is reasonable and builds on the team members complementary expertise to the benefit of all involved including students.
- Qualifications of the PI as it relates to the ability to successfully conduct the proposed activities including the clinical/industry collaborator, and the adequacy of available resources to carry out the proposed activities.
- The likelihood that the research will lead to extramural funding.

J. Award and Reporting Requirements

- All GAIN PIs will be considered part of the ADAPT in SC Project and are expected to participate in ADAPT in SC activities which include attending meetings and contributing to the annual report submitted to the U.S. National Science Foundation (NSF).
- All publications and presentations resulting from the GAIN CRP must include an acknowledgement of SC EPSCoR Program support and a disclaimer: "*Research reported in this [publication, press release, presentation] was supported in part by the U.S. NSF and SC EPSCoR Program under award number (U.S. NSF Award # OIA-2242812 and specific SC EPSCoR grant number). The views, perspective, and content do not necessarily represent the official views of the SC EPSCoR Program nor those of the U.S. NSF.*"
- Awardees are expected to provide required information and documentation to the SC EPSCoR Program staff and External Evaluator as needed. SC EPSCoR Program reserves the right to conduct site visits during the project period for evaluation and reporting purposes.
- Reassurance of Responsible Conduct of Research (e.g., CITI Certification) are required for student researchers and postdocs to be submitted to SC EPSCoR Program State Office.
- Progress reports are due every six months after the start date of the award. A template will be provided to the PIs.
- A final report will be due 60 days after the end of the award.

K. Contact Information

General inquiries regarding this program should be made to:

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SC EPSCoR Grants and Contracts Manager
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Columbia, South Carolina
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