# AI-Augmented Finite Element Analysis: Accelerating Composite Failure Prediction Using JAX

**About AFRL:**

Air Force Research Laboratory (AFRL) is a scientific research organization operated by the United States Air Force Materiel Command. AFRL is dedicated to leading the discovery, development, and integration of aerospace warfighting technologies, planning, and executing the Air Force science and technology program, and providing warfighting capabilities to United States air, space, and cyberspace forces.

**RESEARCH LOCATION:** Wright-Patterson AFB, OH

**PROJECT DESCRIPTION:**

The JAX Python library, developed primarily by Google, provides building blocks for high-performance AI/ML, including JIT compilation, automatic differentiation, and GPU acceleration. AFRL/RX, supported by the DoD HPCMP and in collaboration with external partners, is utilizing this framework to construct novel physics-based modeling tools that leverage heterogeneous computing. This project will utilize an existing JAX-based codebase to accelerate performance prediction for materials of high interest to the Air and Space Force, utilizing a fusion of generative AI and traditional numerical methods.

This project employs a GPU-accelerated, JAX-based finite element framework to implement high-performance progressive damage simulations for Carbon Fiber Reinforced Polymers (CFRP). An established CPU-based simulation code will serve as the ground truth for verification. Phase one focuses on porting a representative microscale simulation to JAX, validating numerical precision against the CPU reference, and profiling performance on DoD HPC GPU resources, such as Flyer. Phase two integrates a generative AI framework to predict optimized initial solution and damage fields, thereby accelerating convergence for nonlinear iterations. The final participation on the project will be an AI-augmented physics solver that maintains the predictive fidelity of the reference model while achieving the computational throughput required for parametric studies and uncertainty quantification. To achieve the goals of the project, the intern will:

Week 1: Complete in-processing, obtain access to a DoD HPC system, and learn how schedule simulations on an HPC system.

Week 2: Install and test an existing CPU finite element solver that will be used as a reference for verification. Run simulations using the CPU solver for benchmark speed and solutions.

Weeks 3-4: Implement governing equations underpinning the reference CPU solver into the JAX-based finite element framework, verify numerical agreement, and establish baseline performance on HPC computing resources.

Week 5: Implement hooks to allow non-zero guesses for nonlinear iterations.

Weeks 6-8. Connect an existing generative AI framework to supply an initial guess for the solution and damage fields. Demonstrate AI-augmented simulation framework using a simulation of a composite material of interest to RX.

Weeks 9-10: Author a report summarizing the research, document all code and results, give a research presentation to research team, and present at the HIP symposium.

In addition to the activities related to the project directly, the intern will have the opportunity to attend seminars focused on computing, machine learning, and material science; attend technical meetings across a variety of disciplines; participate in tours in the computing and material labs; and network with experts across disciplines.

These activities will give the intern the opportunity to learn how to lead a research project typical to those in government labs, develop an understanding of a variety of computational tools and computing environments, and show how findings can impact a broader community of researchers in the lab. If desired, the intern can choose to pursue authoring a DoD technical report.

**ANTICIPATED START DATE:**

May/June 2026 – Exact start dates will be determined at the time of selection and in coordination with the selected candidate.

**QUALIFICATIONS:**

The ideal candidate will be currently pursuing or received a master's or doctoral degree in Computer, Information & Data Science or related field. Knowledge in the following is preferred:

- Machine Learning and Materials Science
- Running ML and related frameworks on High Performance Computing Resources
- FEM related tools and their integration with ML frameworks
- Python for Pre-/Post- Processing of Data

**ACADEMIC LEVEL:**

Degree received within the last 60 months or currently pursuing:

- Master's
- Doctoral

**DISCIPLINE NEEDED:**

- Computer, Information, and Data Sciences
- Engineering