National Security Scholars Summer Internship Program 2025

The University of Maryland (UMD) is offering approximately 45 paid intern positions for the summer of 2025 as part of its National Security Scholars Summer Internship Program (NSSSIP) which is supported through a Cooperative Agreement with the Army Research Laboratory (ARL). Interns will work in teams on real-world, Army-relevant problems, be mentored by ARL and / or UMD researchers, and will work on site at ARL and / or UMD facilities (details given in each topic described below). Interns must be U.S. citizens and full-time university students. Interns will be paid a fixed stipend of $12,000 for undergraduate students and $14,000 for graduate students for completing the 10-week internship program. No additional funding for travel or lodging is available. Students who have previously participated in the NSSSIP are welcome to reapply and should submit an application for the 2025 program.

ARL is the Army's fundamental research laboratory focused on cutting-edge scientific discovery, technological innovation, and transition of knowledge products that offer incredible potential to improve the Army's chances of success. Topic areas have been selected based on the Army's needs and the promise of the technical areas to help address those needs. Internship opportunities are offered in the 9 topics described below. Specific projects are listed under each topic – each project will be staffed with a team of approximately three interns. Some topics and projects may not be supported if there is insufficient interest from applicants.

Both undergraduate and graduate engineering and science students are encouraged to apply including Freshmen, Sophomores, Juniors, Seniors, Masters, and PhD candidates. Applicants should submit a resume (1 page) and a cover letter (1-2 pages) that describe relevant education, projects, work experience, interests, affirms US citizenship, provides cumulative GPA, includes a statement of their goals for the internship, and identifies up to 3 projects of interest from the list of topics and projects below. A GPA of 3.0 or greater is preferred. Applicants that do not provide the requested information will be considered non-responsive and dropped from consideration for internships.

The internships are full-time and in-person for the 10-week period beginning on June 2 and ending on August 8, 2025. Interns must be able to commit to on-site work for the entire 10-week period (there is no remote work option). No schedule modifications to the 10-week internship period will be permitted. Interns must have their own transportation to the listed work location(s).

Applicants should submit resumes and cover letters as soon as possible but no later than November 29, 2024 via http://go.umd.edu/nsssipsu25. Applications will be shared with ARL and UMD mentors for review and the highest ranked applicants will be contacted to schedule a short virtual interview. We expect that conditional offers will be made to successful applicants in late January or early February. Applicants with conditional offers will need to be fingerprinted and successfully complete a background check prior to obtaining a final offer.

Topics

- 2025A – Autonomy for Air & Ground Unmanned Systems
- 2025B – Biocomputing and Synthetic Biology
- 2025C – Computing with Living Neural Networks
- 2025D – Data Analytics
- 2025E – Radioisotopes for Energy Conversion
- 2025F – Large Language Models
- 2025G – Additive Manufacturing
- 2025H – Hypersonics
- 2025I – Data Analysis for Machine Learning on the Edge

Topic 2025A – Autonomy for Air & Ground Unmanned Systems

Topic Description: While state-of-the-art autonomous vehicle navigation techniques can enable autonomous vehicles to navigate in environments of varying complexity, they are typically only able to do so after a time-consuming process of experimentation and manual tuning by skilled roboticists. These existing approaches may not scale to situations where environments and desirable navigation styles may not be known in advance and skilled roboticists and/or tuning time may not be available. The research aims to fill a broad set of knowledge gaps to move air and ground autonomy towards more robust, less brittle, autonomy.

Skills Desired: Students with interest and some experience with coding in C/C++ and/or Python. Experience with Linux is helpful, but not required.

Locations: University of Maryland, College Park, MD; ARL, Adelphi, MD; and the Robotics Research Collaboration Campus in Graces Quarters, Middle River, MD

Potential Specific Research Areas:

- Aerial Autonomy: The Army is actively exploring the use of unmanned aerial vehicles (UAVs) for aerial perception, with a focus on enhancing AI/ML capabilities for scene perception, image understanding, and real-time object recognition. Interns will work on developing vision-based algorithms for scene understanding with an emphasis on integrating these algorithms on embedded computing devices for onboard UAV implementation. The project will leverage the PX4 flight stack and the Robot Operating System (ROS2) framework, aiming to advance techniques for feeding aerial perception back into mobility, trajectory planning, and obstacle avoidance. Additionally, interns will explore innovative autonomous behavior using virtual flight simulators, which can reduce the need for time-consuming and risky flight experiments. Beyond single agent autonomy, it is envisioned that interns will develop methods for multi-agent collaborative systems, exploring planning and group behaviors that balance resource allocation, costs, and goal states.
- Ground Autonomy: The Army is deeply invested in advancing ground autonomy, particularly in areas that enhance the performance of unmanned ground vehicles (UGVs). This summer program aims to develop artificial intelligence and machine learning (AI/ML) capabilities for scene perception from these vehicles. Interns will focus on

creating image understanding algorithms that enable UGVs to gather information about moving objects within their sensor range, as well as perform object recognition while simultaneously tracking and determining the geospatial coordinates of these objects. Students will participate in field experiments and data collection, develop language pipelines and vision-based algorithms for object detection and activity recognition using both real and synthetic data, and implement these algorithms on embedded computing devices for UGV integration. The program will begin with classical techniques and progress to novel approaches, with specific outcomes including the integration of custom-trained object detection classifiers and visual language models onboard wheeled and limbed UGV platforms and the development of algorithms to inform vehicle maneuvers for better information gathering.

Topic 2025B –Biocomputing and Synthetic Biology

Topic Description: With the advent of synthetic biology, it becomes possible to not only harness the natural world but evolve and reprogram biological systems ushering a new wave of biotechnological advances. In this intern research experience, teams of interns will undertake multidisciplinary research to impact a variety of Army materials. This work will require interns to customize and optimize natural biological systems for material applications by developing strategies to access, understand, and tailor biological components from the environment. Through this work, interns will learn how to apply diverse skillsets in microbiology, neurobiology, biomolecular, chemical, material and engineering sciences, integrated with bioinformatics, modeling, and a creative mentality toward designing and engineering biology across molecular, organismal, and biosystem levels for the advancement Army material technologies.

Skills Desired: Students with bioengineering interest. Chemical or biomolecular lab experience will be helpful. Bioinformatics experience or programming experience will be helpful.

Location: University of Maryland, College Park, MD; ARL, Adelphi, MD

Potential Specific Research Areas:

- Biocomputing: A thumb drive is memory device that receives information from microelectronic devices, stores the information, and because of its small size and standardized I/O modalities, it can provide a means for site-to-site transmission and retrieval. This project will enable the first biological thumb drive wherein the unit is made of biological parts and stores molecular information and can be transported to distant sites and completely erased.
- Self-Assembling Biofilms: To detect compounds of biological origin, cells can be genetically modified to produce a signal detected by an electrode. Our lab seeks to engineer self-assembling synthetic biofilms able to increase signal transmission from biosensing cells to electrodes, while also reducing the manufacturing time and costs of biohybrid devices. We will achieve the deposition of synthetic biofilms on the electrode

by engineering cell-electrode and cell-cell interactions. Specifically, we will genetically modify the external surface of bacterial cells to display heterologous proteins able to mediate the specific interactions with other cells and with the electrode.

Topic 2025C – Computing with Living Neural Networks

Topic Description: The living neural networks of brains can rapidly adapt to new contexts, learn from limited data, and achieve all this with low power consumption. This research seeks to establish a novel biocomputing paradigm for information processing and learning by living neural networks. Our specific focus is on harnessing the characteristics of living neural networks that we believe are critical for context dependent information processing and learning.

Skills Desired: Students with an interest in working at the convergence of machine learning, neuroscience, and biology.

Locations: University of Maryland, College Park, MD; ARL, Aberdeen, MD

Potential Specific Research Areas:

- LNN Technologies: This project will involve experimental and computational studies on living neural networks that are engineered for specific network architectures. The work will require interns to customize biological systems and implement approaches to interrogate neural networks and to link experimental observations to AI algorithms. Through this work, interns will learn how to integrate diverse skillsets in cell biology, neurotechnology, and computer science. Research may include experimentally test new biocomputing algorithms with a living neural networks platform; and exploring the effects of external physical perturbations, including mechanical, optical, and electromagnetic, on biocomputing performance of living neural networks.

Topic 2025D – Data Analytics

Topic Description: Visualizing the real-time movements of a single truck, plane, or car on a map is fairly simple. Typically, an icon representing the vehicle is placed on a map, and the location of that vehicle then gets updated at some regular frequency (like every X-seconds or X-minutes.) While this works reasonably well for the visualization of just a few vehicles at a time, there are significant drawbacks to this approach when dozens, hundreds, or millions of individual vehicles need to be tracked and visualized.

Skills Desired: Creativity and some background with data analysis, or information visualization, or human factors are preferred.

Location: ARL, Adelphi, MD; University of Maryland, College Park, MD

Potential Specific Research Areas:

- Natural Language Information Gathering: Most analytics tools give users an interface that helps them develop queries on one or more datasets. These interfaces typically have many buttons and filter options that may require training or special knowledge about the data for them to work properly. Geospatial data with temporal and categorical variables can be even more complex to work with. In this research project, the team develop methods to reduce the learning curve on data analytics UIs by attempting to create a natural language query capability. Using existing databases and APIs, the team will attempt to create a "natural language UI" that will allow users to ask questions through a text input—like an AI chatbot. The team will need to find ways to convert the question to a real query and/or automatically ask follow-up questions and engage the user to provide additional details to help finish the query.

- The Human Factors of Focus: Digital maps with overlays of real-time information are often used to present information to users—whether they be soldiers in the field or intel analysts in an operations center. However, the information presented on those maps can vary depending on the situation. Information overload is a threat to decision-making—especially in an emergency. When dozens of data variables are all overlaid on a map, how does a user know what information is important and relevant? This project will connect the research team with users of the system to better understand how they react in times of crisis when decisions need to be made, and then determine how to best handle the visualization and presentation of massive amounts of data. This may include the building of intelligence into the display system to hide/fade less relevant data and provide additional focus for faster decision-making with fewer errors when important events are occurring. This would include intelligence to link data sets and determine what information is or is not relevant to a particular situation.

- Predictive Analytics: Massive data sets describe the movement of people and things around the country and the world. A significant amount of effort has gone into the creation of look-back analytics that help analysts understand what has happened in the past with these datasets. However, far less has been done to look forward in time to predict the future and/or risks. With this project, researchers will investigate the creation of ML models and other algorithms for use in the prediction of things like:
    - The location and type of disruptive incidents (like crashes or disturbances on transportation facilities)
    - The duration of a crash (e.g. the amount of time it will take for the crash to be resolved and for traffic to return to normal)
    - The movements of aircraft and marine vessels. E.g. the route and/or destination of a plane or ship.

- People movement. Given certain environmental conditions, where might people travel to.
- Travel times and/or queues on different types of transportation facilities

- Correlation of Movements to Events: A string of convenience store robberies occurred last night all within a few miles of one another. You are in possession of a dataset that allows you to look at the historic movements of vehicles over a period of time. Your job is to see if you can identify a vehicle (or vehicles) that visited each of the convenience stores—trying to determine if there's a correlation between each of the robberies. Will you be able to identify a vehicle that visited all of the stores? Will you be able to track that vehicle to other destinations? The goal of this research project is to develop algorithms to correlate mobile device movements with specific events.

Topic 2025E – Radioisotopes for Energy Conversion

Topic Description: Investigate the radiation tolerance of ultra-wide bandgap (UWBG) semiconductor materials to increase the power density of both betavoltaic and alphavoltaic persistent power sources

Skills Desired: Interest or some experience in chemistry, physics, material science & engineering, mechanical or electronics engineering, interest in electrical power generation

Location: ARL, Adelphi, MD; University of Maryland, College Park, MD

Potential Specific Research Areas:

- Radioisotope Technologies: Unattended sensor networks support persistent surveillance in locations where direct observations are difficult. In remote locations, battery life is essential in sensor element lifetime and may determine the feasibility and utility. Radioisotope power sources open the opportunity for long-lived operation of electronics. For example, the 13 year half-life of tritium and the ~100 year half-life of ^{63}Ni radioisotopes, make them attractive for unique power sources for small sensors/communications nodes and GPS, in a distributed power architecture. Research related to nuclear scattering simulation with alpha and beta particle scattering, generating electrons, simulating electron transport in materials, characterizing energy conversion materials for radiation tolerance, designing device packaging for micro-robotics, as well as device packaging are involved in this project area. Investigating issues of extended power source lifetime is the primary outcome of this program.

Topic 2025F – Large Language Models

Topic Description: The recent rise of the transformer in LLMs has proven a very useful tool in generative AI settings. Intrigued by this success, mathematicians have begun analyzing the transformer as an interactive particle system in high dimensional space. Here particles represent embedded tokens, and their interaction is driven by the attention block inside the transformer. Using tools from differential equations a "cluttering behavior" has been observed, where tokens seem to gather at the boundary of shapes whose geometry is governed by parameters in the attention block. However, there are many open questions, even for low-dimensional embedding of tokens. Previous work has relied on a few key assumptions. First, matrices in the attention block are a subset of "nice matrices"; second, there is no feed-forward layer; and third, the generation of new tokens is not modeled. We are interested in understanding if these assumptions are needed, and if not how to formulate new results for a wider class of models.

Skills Desired: Students with an interest in machine learning theory. Some programming and data visualization experience. Knowledge of some linear algebra and have taken calculus courses.

Location: University of Maryland, College Park, MD; ARL, Adelphi, MD

Potential Specific Research Areas:

- LLM Technologies: Potential research directions include:
  - Investigate the role of non-linear feed forward layers on clustering in low dimensions.
  - Write code to visualize the evolution of tokens in low-dimensional space.
  - Experiment with matrices that lie outside the scope of previous work.
  - Generate new tokens in a way consistent with the transformer ODE.

Topic 2025G – Additive Manufacturing

Topic Description: The US Army has a strong interest in additive manufacturing, also known as 3D printing, to create durable parts, address design changes, solve supply chain issues, modernize systems, produce personal protective equipment, and many other possibilities.

Skills Desired: Background in Mechanical, Aerospace, and/or Electrical Engineering, with experience in computer-aided design (CAD) (SolidWorks preferred), 3D printing, finite element analysis (FEA), and/or experimental research.

Location: University of Maryland, College Park, MD; ARL, Adelphi, MD

Potential Specific Research Areas:

- Shape Memory Alloys: Characterize the thermal properties of additively manufactured solid-solid phase change materials (PCM) using Raman thermometry/spectroscopy and experimentally investigate two-phase cooling in a metal microchannel evaporator with porous PCM coating.
- Miniature Sensors: Leverage an additive micro / nanomanufacturing approach, Two-Photon Direct Laser Writing, to develop new classes of miniature sensors with designs informed by Machine Learning (ML). Interns will use ML techniques to inform the sensor design and use 3D micro / nanomanufacturing to fabricate devices.

Topic 2025H – Hypersonics

Topic Description: The development of turbulent flow within the boundary layers over high-speed vehicles can have a significant effect on performance, leading to enhanced levels of heating, viscous drag, and mechanical loading. In this project, we will employ experimental techniques in a hypersonic wind tunnel to understand various aspects of high-speed turbulence and the influence it has on high-speed vehicles and projectiles. Interns will gain a direct exposure to high-speed ground testing facilities and diagnostics, and associated analysis techniques.

Skills desired: Background in aerospace engineering, including experience with experimental techniques and/or application of machine-learning algorithms

Location: University of Maryland, College Park, MD; ARL, Aberdeen Proving Ground, MD

Potential Specific Research Areas:

- Hypersonics Technologies: A potentially useful application of machine-learning techniques in high-speed ground testing is the analysis of high-speed images to identify important flow features. In this project, we will train machine-learning algorithms to identify laminar, transitional, and turbulent features within images of high-speed boundary layers and shock-wave / boundary-layer interactions acquired in wind-tunnel tests and potentially ballistic-range experiments; this identification will then be combined with other analysis techniques to determine important properties such as propagation speed and turbulence intermittency.

Topic 2025I – Data Analysis for Machine learning at the Edge

Topic Description: The Department of Defense has an abundance of historical data and real-time sensor systems feeding in new data, measuring power systems as well as vehicle signatures. When it comes to areas such as vehicle tracking and power-system quality, much of the analysis is done with the aid of soldiers / engineers to sift through the large amounts of data for actionable information. While this works reasonably well for visualizing a few events every day, there are significant drawbacks to this approach when data needs to be continuously monitored.

This topic will explore the ability to develop algorithms to compress vehicle data and power-systems data into much smaller sizes, then use machine-learning techniques with the compressed data to develop algorithms that look for specific events/activity. The intern team will then code the algorithm in C and/or Python so that it can be ported to microcontrollers, system on chips (SOCs), etc.

Skills desired: Creativity and some background with data analysis, linear algebra, or machine learning is preferred. Students with interest and some experience with coding in C or Python is required. Experience with Linux or MATLAB is helpful, but not required.

Location: ARL, Adelphi, MD; University of Maryland, College Park, MD

Potential Specific Research Areas:

- Machine Learning in Restricted Environments: In internet-of-things-class sensor systems, sensor networks are often performance constrained due to the size and power of the platforms. With multi-modal sensing modalities, some level of processing is required to understand the various sensor signals and to characterize events. This project aims to address this need for miniature and low-power processing capabilities by developing AI / ML algorithms to be implemented on a smartwatch-class microprocessor. The intern team will implement and test basic signal processing and AI / ML algorithms on commercial, low-power MCUs. The goal will be to quantify the performance of well-established algorithms (CNN, Random Forest, KNN, etc.) on 32-bit processors, then integrate the 'best' AI / ML algorithm for demonstration on current sensor system(s).
- Predictive Analytics of Power: There is an abundance of historical data on the electrical activity of power systems across the USA, renewable energy sources, and electric cars. Many sensors are forwarding new data in real time to research current trends! Modern energy systems not only need to accurately report current power-usage data, but also need to have the ability to predict future electrical activities to ensure power is always readily available. Interns will write software to analyze electrical power data for magnitude, phase angle, harmonic distortion, etc. to recognize patterns in power data. Once patterns of interest have been recognized, the interns will then write real-time statistical or machine-learning algorithms to spot those patterns before they occur.