Undergraduate Research
Spring 2022 opportunities

December 1, 2021
Agenda

• Research Projects for Spring 2022
  • Expectations of an Undergraduate Researcher
  • For Credit information

• How to get involved and next steps

• Hume Center Snapshot & Information
Hume Center
Spring 2022 opportunities
OSINT Framework Development for Countering Disinformation – PI: Dr. Aaron Brantly

**Project Description**

OSINT Framework for Development for Countering Disinformation

- Conduct research and literature review on OSINT Techniques
- Investigate Opensource OSINT platforms and develop tool database
- Establish human enabled disinformation framework with identified OSINT metrics for classification, tools for identification, and storage of findings
- Establish AI enabled disinformation framework with identified OSINT metrics for classification, tools for identification, and storage of findings
- Research report analyzing human vs AI enabled OSINT frameworks
- Help develop OSINT analysis platform

**Student Learning Objectives**

- Develop a more thorough understanding of human and and AI enabled disinformation
- Experience with OSINT Techniques

**Qualifications/Requirements**

- Computer Science or National Security and Foreign Affairs Students
- Programming experience **NOT** necessary – some Python or R would help

**Project Objectives/Deliverables**

- This is a funded project by the Commonwealth Cyber Initiative
- Monthly status reports to be delivered to faculty project team
- 2 student blog posts (1 per semester) examining OSINT from different perspectives
- Final analytical report and presentation due to faculty project team analyzing AI and Human enabled disinformation a framework of metrics, tools, data storage solutions to enable counter disinformation via OSINT.
- 10-15 positions available during the academic year

Students: X Volunteers Course Credit Wage

abrantly@vt.edu Tech4HumanityLab.org
Automated Cyber-Attack Detection and Mitigation under Non-Stationarity using Operating Envelopes
Faculty Mentor: Stephen Adams

Project Description
The objective of this project is to develop automated methods, e.g. AI, for detecting a cyber attack and then mitigating the consequences of the attack. However, systems are not stationary in time and changes to a system may influence the effectiveness of the automated methods. This project will explore transfer learning and operating envelopes as methods for responding to changes in the system.

Current team of 3 undergrads but looking for more.
Students: TBD Volunteers  2-4 Course Credit  2-4 Wage

Project Objectives/Deliverables
• Year 1 objectives
  • Construct quadcopter testbed
  • Design cyber attacks
  • Build/train detection AI
  • Build mitigation AI
  • Design operating envelopes
• Future objectives will include developing methods for changing the AI in response to a change in the system
• Primary deliverable for Year 1 is a completed testbed
• Ongoing potential/likelihood for conference / journal papers

Student Learning Objectives
• Experience constructing HW/SW testbeds
• Introduction to machine learning and AI concepts

Qualifications/Requirements
• Experience with HW and SW systems
• Interest in quadcopters
• Required experience - programming in Python
• Desired experience – exposure to artificial intelligence, machine learning, or data science

12/1/2021
MEEP: Materials & Advanced Manufacturing in Applied Electromagnetics
Faculty Mentors: Dr. Brad Davis

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**Project Description**

**Multidisciplinary – Need Students from all engineering and science disciplines**
- This project is designed to introduce you to the complex world of multifunctional structures for electromagnetic devices such as antennas and radomes and their construction using composites and materials with modern manufacturing techniques.
- This program aims to illustrate the design and test teams that you will encounter in industry where complex products are developed by teams of engineers that must understand the importance of requirements inside and outside of their own discipline.

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**Project Objectives/Deliverables**

- Students will have the opportunity to interact with industry and government sponsors and other interested parties: internships, jobs
- Students will work in teams various areas with faculty
- Potential work
  - Composite fabrication techniques and embedded RF systems – including composites, 3D Printing
  - Electronics, motion control,
  - RF design, test and measurement
- Weekly meetings with the project faculty mentor: progress and concepts.
- Oral poster presentation to undergraduate peers and faculty to showcase research findings and facilitate public speaking skills; potential conf. papers

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**Student Learning Objectives**

- Learn material properties typically used in applied electromagnetics
- Learn fabrication methods for tradition composites
- Explore applications of 3D printing in applied electromagnetics (e.g. antennas)
- Understand applications and considerations for modern communication, radar and sensor systems.

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**Qualifications/Requirements**

- Required – Restricted research training
- Preferred – Undergrad electromagnetics (ECE or Physics)
- Preferred: 3D Printing, Material Science experience (MSE, AOE, ME, CHE, CEE)

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12/1/2021
Project Description

Develop a multidisciplinary student team to compete in bi-annual Defend the Republic competition of helium balloon soccer

- Multi-university autonomous blimps playing “soccer”
- Multi-year program in applied autonomy, with research in:
  - Cybersecurity
  - Computer Vision
  - Robotics
  - Aerospace

- Work on with the goal to travel to and compete in 2 competitions each year
  - Latest was at Indiana University (November)
  - Following in April (location TBD, Florida?)

- Weekly and end-of-term interactions/presentations with VT faculty and grad students (show us what you're doing/did)

Project Objectives/Deliverables

- Three sub teams, each with different focus/objectives
  - Mechanical – make it fly, steer, capture
  - Software – robot operating system (C++), navigation, route planning
  - Communications – RF/optical jamming, jam resistant comms, deception techniques

- Work on with the goal to travel to and compete in 2 competitions each year
  - Latest was at Indiana University (November)
  - Following in April (location TBD, Florida?)

- Weekly and end-of-term interactions/presentations with VT faculty and grad students (show us what you're doing/did)

Student Learning Objectives

- Real-world, applied principals in a competition environment
  - Swarm autonomy – multi-vehicle capture/score – offense/defense/EW
  - Cybersecurity – both offensive and defensive RF and optical
  - Computer vision – need to find soccer ball somehow
  - Hardware/software – interaction between vehicle and autonomy S/W

Qualifications/Requirements

- Must have interest and passion for some aspect(s) of project
- Experience with vehicle design and dynamics
  - Design of vehicle – lift vs. payload, capture device design
  - Flight dynamics improvement
    - PID tuning for stable flight
    - Control system modeling, characterization, and simulation

Students: ?? Volunteers ?? Course Credit ?? 2 Wage
Use & Abuse of Personal Information: Michaels

**Project Description**

The Use & Abuse of Personal Information project is seeking to track and quantify how personally identifiable information is shared across the Internet. This is a heavily multi-disciplinary project (STEM and non-STEM) that has the opportunity to look into tangential questions related to foreign influence in elections, data collection methods by specific organizations, etc. Spring 2022 focuses are on (1) refining the organization list for a 50K-100K identity experiment, (2) automating data collection tools, and (3) seeking funding (professor’s job!).

Recent results were just briefed at Blackhat 2021 USA and the subject of a dozen news articles.

Students: 2-3 Volunteers 0 Course Credit 5-6 Wage

**Project Objectives/Deliverables**

- Strategic research questions: what can we answer with this type of dataset
- Organization list: need to develop a comprehensive organization list that will support answering questions posed about conditional PII sharing.
  - Assemble into a master list with company profiles / metadata
- Tool automation:
  - Establishing enterprise-level email and phone servers using FreePBX and related open source tools
  - Perform live experimentation with phone and email use cases
  - Define mechanism for SMS collection

**Student Learning Objectives**

- Team-based multi-disciplinary effort to answer data sharing questions

**Qualifications/Requirements**

- Meetings will be a mixture of in-person and remote, so must meet requirements for working in RB1311 (U.S. citizen).
- Restricted research training
- Students will be expected to dedicate 8-10 hours per week

**Spring 2022 MDE**

- For ECE students, there will also be a senior design (MDE) option under computer engineering starting Spring 2022 for this topic.
Radio Frequency Adversarial Machine Learning  
Faculty Mentor: Dr. William “Chris” Headley

Project Description

Recently, Radio Frequency Machine Learning (RFML) systems have been shown to solve hard wireless communication problems (such as spectrum sensing) that require less prior knowledge than traditional approaches. However, deep machine learning systems have also been shown to be vulnerable to attack vectors such as evasion attacks, poisoning attacks, etc.

In this multi-semester, multi-college, and multi-disciplinary project, students will learn about wireless communications, machine learning applied to these systems, and participate in red team / blue team research experiments to attack and defend these machine learning enabled systems.

Project Objectives/Deliverables

1. Learn to program Ettus software defined radios (USRPs) using the open source GNU Radio Framework
2. Set up an over-the-air communications systems within Hume’s RFML lab
3. Implement a deep learning based spectrum sensing within the communications system using GNU Radio custom programmable blocks
4. Splitting into teams, investigate adversarial machine learning algorithms and mitigations for implementation in spring semester

Student Learning Objectives

- Develop understanding of wireless communications concepts
- Learn to program and use software defined radios for over-the-air experimentation
- Learn to train and evaluate deep machine learning and adversarial machine learning algorithms for wireless communication applications

Qualifications/Requirements

- Required – Restricted research training
- Required – Programming Experience (preferably Python and/or C++)
- Required – Interest in learning about wireless communication and machine learning systems
- Required – Interest in working with a diverse team of student backgrounds and experiences

Students: 1-2 Volunteers  1-2 Course Credit  6-8 Wage

This project will require some in-lab tasks/setup but will be largely flexible for remote work.
Asset Tiger: National Security Institute’s Asset Management System Lab maintenance

**Project Description**
Help build, maintain and organize an asset management system for the National Security Institute and Hume Center. Help maintain NSI labs, offices and meeting areas.

- Enter students, employees, lab equipment and supplies into the Asset Tiger asset tracking database.
- Maintain a clean working environment (routine cleaning of white boards and machine shop).
- Assist with various tasks including - changing name plates, printing signage, producing instructional documentation and organizing lab spaces.

**Project Objectives/Deliverables**

- Spring Semester - Roll out Asset Tiger to Faculty, Staff and students.
- Implement a weekly routine for cleaning whiteboards and machine shop.
- Develop procedures for entering all equipment and supplies into Asset Tiger as they’re received.

**Student Learning Objectives**

- Asset management, inventory control and laboratory maintenance.
  - Gain knowledge of RF lab equipment and supplies.
  - Gain experience working with an asset tracking software.
  - Gain experience organizing parts and supplies in a stock room (Hokie Shack) and lab environment.

**Qualifications/Requirements**

- Required – Restricted research training
- Required – Basic computer knowledge.
- Required – Knowledge of electrical components (resistors/capacitors)
- Preferred – Mechanical aptitude (hanging pictures/building shelving)
Project Description

Develop a small payload (< 7 pounds) to ride on NASA High-altitude balloon to over 100,000 ft to test solar eclipse simulation devices and sensors in stratosphere. If not selected for HASP program, conduct high-altitude balloon (HAB) flight from VT.

- Hardware selection for eclipse characteristics that can show changes during eclipse
- Thermal, pressure considerations for parts selection
- Flight modeling simulations to show solar beta angle

Student Learning Objectives

- Build knowledge in HAB electronics, systems, and launches
- Show initial data results of eclipse simulation

Qualifications/Requirements

- Interest in electronics, ballooning
- No other experience or qualifications are necessary, we'll hope you learn along the way!

Semesters Available

- Starting in spring 2022, HASP will run through fall 2022.
- Students/knowledge for this project will transition to solar eclipse flights in fall 2023, spring 2024 with participation in National Eclipse Ballooning Project
Project Description

- This is a NASA funded program that seeks to develop a novel Ultraviolet CubeSat instrument, that uses a delta-doped electron multiplying CCD (EMCCD) camera system.
- The instrument will be designed to measure nighttime lower thermospheric nitric oxide at 215 nm and will operate in a Polar Orbit.
- A critical part of the next year is establishing a laboratory testbed, including a dewar (pressure vessel), optics, an EMCCD camera, and control software.
- Additionally, in the next year, a full environmental test plan will be conducted, including TVAC, vibration and radiation testing.

Students: TBD | Volunteers: YES | Course Credit: | Wage: ____

Project Objectives/Deliverables

- Help design and commission custom optical components (lenses, filters).
- Help design and commission the opto-mechanical testbed, including a dewar, optics and the camera. The dewar will make use of Liquid Nitrogen (LN2) to cool the camera.
- Attend biweekly meetings with partners at NASA Jet Propulsion Laboratory (JPL).

Student Learning Objectives

- Introduction to NASA space project life cycle.
- Introduction to environmental testing of flight hardware.
- Introduction to space instrumentation assembly and testing, including optics, cameras and opto-mechanical hardware.

Qualifications/Requirements

- EAR controlled – Hume TCP onboarding required.
- Required – Restricted research training.
- Required – Hume RB1311 AOSL laboratory training.
- Preferred – Experience with CAD; Experience with Zemax or CodeV.
Deploying an EMCCD camera in a CubeSat – PI: Dr. Leon Harding

**Project Description**
- This is a Canadian Space Agency (CSA) funded program that seeks to develop a space qualified electron multiplying CCD (EMCCD) camera system for use aboard a 6U CubeSat
- The CubeSat’s design will consider future exoplanet astronomy/astrophysics space-based applications
- Partners Nuvu Cameras Inc. (a Montreal-based company) are designing and building the camera electronics/controller
- VT are designing the CubeSat spacecraft

**Project Objectives/Deliverables**
- Help design a 6U CubeSat including:
  - Integration of an EMCCD controller and sensor
  - Design consideration of optics relevant to astrophysics science missions
  - Consideration of C&C / ADCS / Guidance etc.
  - Consideration of thermal / interfacing requirements
- Help complete a SWaP budget for the mission
- Attend weekly meetings with partners at Nuvu Cameras and take part in a milestone presentation to CSA in December 2021

**Student Learning Objectives**
- Introduction to flight hardware design & mission analysis/Ops
- Introduction to environmental testing of flight hardware
- Introduction to spacecraft design and NASA engineering practices

**Qualifications/Requirements**
- EAR controlled – Hume TCP onboarding required
- Required – Restricted research training
- Required – Hume RB1311 AOSL laboratory training
- Preferred – Experience with CAD
- Preferred – Experience in thermal design

**Students:** TBD  Volunteers YES  Course Credit ___  Wage ____
Project Description

- Collins Aerospace is seeking to advance the technological maturity of several components (ITAR controlled) for spaceflight
- The ultimate goal is to demonstrate operation in LEO (~500 km)
- Some parts of the component(s) may need to be modified to survive the harsh radiation environment on orbit, and also to survive launch loading
- VT is assessing pre- and post-environmental test performance of these components
- Testing will include TVAC, vibration, and radiation testing
- I&T with a small spacecraft (mass TBD) is also being considered

Students: TBD Volunteers YES Course Credit ____ Wage ____

Project Objectives/Deliverables

- Define mission requirements with Collins Aerospace
- Fully assess the (ITAR controlled) components
  - Assess performance in the laboratory pre-environmental test
  - Assess performance in the laboratory post-environmental test
- Conduct environmental and qualification testing of component(s)
- Define spacecraft form-factor relevant to mission and assess orbital details
- Attend biweekly meetings with sponsor (Collins Aerospace)
- Take part in all environmental testing listed above (in person if applicable)

Student Learning Objectives

- Introduction to radio components for space (specifically, RF and CubeSats)
- Introduction to environmental testing of flight hardware
- Introduction to thermal and mechanical analysis for spaceflight hardware
- Introduction to spacecraft design and NASA engineering practices

Qualifications/Requirements

- ITAR controlled – U.S. Citizenship required & Hume TCP onboarding required
- Required – Restricted research training
- Required – Hume RB1311 AOSL laboratory training
- Preferred – Experience with electronics
An Innovative Approach to Modular CubeSat Concept and Design – PI: Dr. Leon Harding

**Project Description**

- A major limitation of CubeSat implementation is the need to start at the beginning of the mission life cycle every time, instead of leveraging existing subsystems that could be used for many applications.
- This program aims to design a multi-mission capable, advanced modular CubeSat that will:
  - Leverage cutting edge technologies
  - Launch desired payload in a short amount of time
  - Optimize size, weight, and required power (SWaP)

**Project Objectives/Deliverables**

- Test and commission CubeSat hardware: OBC, spacecraft chassis with embedded wiring design, CubeSat protocol/standards testing
- Work with VT’s DREAMS Lab and ISE department to implement advanced additive manufacturing and 3D printing capabilities for embedded wiring concepts
- With partners Northrop Grumman, help to finalize mission type and concepts
- By end of semester, print a full 1U spacecraft with integrated OBC, embedded wiring, novel fastener/quick release mechanisms

**Student Learning Objectives**

- Introduction to NASA space project life cycle, concept through launch
- Introduction to spacecraft concept, requirements and design practices
- Introduction to space instrumentation including design

**Qualifications/Requirements**

- Required – Restricted research training
- Required – Hume RB1311 AOSL laboratory training
- Preferred – Proficiency in Python/Matlab, CAD
- Preferred – Introductory coursework that includes orbital dynamics
V&V of Astra Navigation magnetic-GPS (m-GPS) technology – PI: Dr. Leon Harding

Project Description

- VT technical lead: Gustavo Gargioni
- Astra Navigation has developed indoor and outdoor navigation and positioning systems
- These software-based, beacon-free systems can provide devices and vehicles with localization data at almost any point on the globe (regardless of time, weather conditions, environment, and in the absence of internet or cell signal)
- VT are working with Astra Navigation to help test and evaluate certain areas of their technology, including software and hardware development, and physical deployment and testing of autonomous platforms

Students: TBD  Volunteers: YES  Course Credit:  Wage: YES

Project Objectives/Deliverables

- Evaluate m-GPS boards for integration with autonomous vehicles at VT
- Calibrate vehicles in indoor and outdoor environments
- Demonstrate leader-follower capabilities
- Evaluate map-building capabilities of algorithms and demonstrate autonomous calibration
- Incorporate into new vehicles

Student Learning Objectives

- Introduction to GPS technology, including m-GPS
- Introduction to autonomous vehicles
- Mechanical and electrical design/modification of robotic platforms
- V&V of software, hardware and real-time in-person demonstrations

Qualifications/Requirements

- Required – Restricted research training
- Required – Hume RB1311 AOSL laboratory training
- Preferred – Experience with CAD
- Preferred – Programming experience (e.g. C/Python) / data science
- Preferred – Experience with electronics
Building up the SmallSat Cyber Testbed – PIs: Dr. Jonathan Black & Dr. Leon Harding

**Project Description**

- SmallSat manufacturers have almost no guidance, regulation, or testing, evaluation, and analysis on cybersecurity or cyber resiliency
- A need to establish, analyze, and publish cyber risk assessments best-practices
- In the Spring semester, Hume Center scholars completed an initial study to identify such risks in small satellites
- As a result of this study, key satellite hardware has been identified and procured, and will be used to build up the SmallSat Cyber Testbed
- The goal of this program is to assemble key Testbed components and to create a realistic ‘hacking’ environment to assess cyber risk of flight hardware

**Main goals:**
- Assemble and commission SmallSat Cyber Testbed hardware, e.g. on-board computers (OBCs), microcontrollers, radios/antennae, etc.
- Create a scenario where one team hacks and one team defends
- Complete a comprehensive cyber risk assessment that can be applied to flight hardware/assets

**Can also expect:**
- Weekly meetings to present results
- Collaboration with partners in the United Kingdom
- Presentation via poster and/or conference paper

**Student Learning Objectives**

- Develop understanding of cyber security and resiliency in SmallSats
- Experience assembling and commissioning potential flight hardware
- Experience designing hack/defend problems / cyber risk assessments

**Qualifications/Requirements**

- Required – Restricted research training
- Required – Hume RB1311 AOSL and Space@VT laboratory training
- Preferred – Proficiency in Python/Matlab
- Desired – Introductory coursework that includes cybersecurity

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**Project Objectives/Deliverables**

- Students: TBD Volunteers 2-4 Course Credit ___ Wage ______
Expectations of Undergraduate Research with the Hume Center

• Volunteers
  o General expectation is 3-5 hours per week in lab but not mandatory/required
  o No concrete deliverables, but should support a consistent learning objective

• Wage
  o Undergraduate researchers use Time Clock to record time
  o Need to be able to commit to 8-10 hours / week in lab (steady state)
  o Tasks are specific to a funded project and may vary through the semester

• Course Credit
  o General expectation is 3-4 hours/week per credit hour – similar to a lab class (~10 / wk)
  o For a 3-hour class:
    ▪ UGRAs should be able to meet as a team for 1-hour/week meeting with faculty lead
    ▪ UGRAs should be in the lab (CRC: 1311 Research Drive) a minimum of 5 hours / week
    ▪ Note that many of the key deliverables are documents – don’t slack off on those!

• Restricted vs. Unrestricted research
• Independent Study/Undergraduate Research paperwork must be submitted to the departmental advisor no later than the third day of the classes.

• College of Engineering
  • Form, Proposal, ABET Breakdown - https://eng.vt.edu/academics/undergraduate-students/undergraduate-research-independent-study.html

• College of Science
  • Form - https://www.science.vt.edu/resources/forms.html#vt-item-vtmultitab_1597764295201-11

• College of Liberal Arts and Human Sciences
  • Form - https://liberalarts.vt.edu/forms.html
How to Get Involved...
Follow link to application for research positions.


Questions?
Contact Colleen Bartos
cbartos@vt.edu
Timeline


**Wed, 12/1**  Review project slides

**Mon, 12/13**  APPLY!

**Tues, 12/14**  Hume PI Draft day

NLT **Fri, 12/17**  Offer letters sent via email (pay attention to details & deadlines)

**Fri, 12/31**  Signed & Accepted offers returned

Tentative **1/20/22**

Mandatory Kick Off & Restricted Research Training

**Questions?**  Contact Colleen Bartos **cbartos@vt.edu**
Hume Center Snapshot

**Research Laboratories**
- **Electronic Systems**
  - Assured and Secure Communications
  - Radar and Electronic Warfare
  - Resilient C4ISR Payloads
- **Aerospace and Ocean Systems**
  - Resilient Mission Platforms and Systems
  - Autonomy and Mission Orchestration
  - Space Situational Awareness
- **Intelligent Systems**
  - Machine Learning
  - Data Science
  - Cyber Operations

**Major Program Initiatives**
- **Space 2.0**
  - Satellite Supply Chain
  - Mission Autonomy, Disaggregation
  - Platform and Payload Resilience
- **Commonwealth Cyber**
  - Transportation, Energy Security
  - IoT and 5G Security
  - AI/ML and Security
- **Quantum**
  - Quantum Architectures
  - Quantum Information Science
  - Quantum Machine Learning

**National Centers**

**Centers of Excellence**

- Systems Engineering Research Center
- Security and Software Engineering Research Center
- National Security Agency
- National Institutes of Standards and Technology
- Department of Energy

**Key Metrics**
- **55** Faculty and Staff
- **675** Students Engaged Annually
- **$16.1M** Annual Program Revenue
- **$275M** Venture Investment in Spin-Offs
Facilities

New Blacksburg HQ
40,000 SQFT – CUI Offices/Labs
5,000 SQFT – Collateral/SCIF/SAPF

5,000 SQFT – Offices/Labs
Space @ VT

264,000 SQFT – CUI Offices/Labs

Unique Facilities

14.5ft Telescope Dome, 2.4m S-Band Dish

Industry-Grade Labs

Existing – 10m, 5m (x2), 3m (x2), 10m GEO belt
Planned – 5m dish, 71ft tower

“Big Dish Project”

“Satellite Tracking Station”

4.5m Dish
3m Dish
2m Yagi
6m Yagi

Cyber-Physical Security Lab

5,000 SQFT – Offices/Labs
6,000 SQFT – CUI – Fall 2019
3,000 SQFT – SCIF/SAPF

Arlington Research Center

5,000 SQFT – Offices/Labs

Wireless Lab

Satellite Control Center
Overall Approach

- Strategic Initiatives
- Hume Center Labs
- Academic Colleges

- Major Federal Programs
- Major Industry Partnerships
- Students
- Publications
- Cross-Cutting Applications
- Translational Research
- Basic Research

Industry/Government Technology Transition Spin-Off Companies