
# Vertically Integrated Projects (VIP) Program

## Information Packet

Winter Quarter 2024-2025

Thank you for your interest in the Vertically Integrated Projects (VIP) Program at Drexel University!

VIP team members work as part of a multidisciplinary group of undergraduate students, graduate students, research staff, and faculty members to tackle novel research and design problems around a theme. Undergraduate students that join VIP teams earn academic credit for their participation in design/discovery efforts that assist faculty and graduate students with research and development issues in their areas of expertise.

VIP teams are:

- Multidisciplinary - drawing students from all disciplines on campus;
- Vertically-integrated - maintaining a mix of freshman through PhD students each academic term;
- Long-term - each undergraduate student may participate in a project for up to three years and each graduate student may participate for the duration of their graduate career.

The continuity, technical depth, and disciplinary breadth of these teams are intended to:

- Provide the time and context necessary for students to learn and practice many different professional skills, make substantial technical contributions to the team project(s), and experience many different roles on a large, multidisciplinary design/discovery team.
- Support long-term interaction between the graduate and undergraduate students on the team. The graduate students mentor the undergraduates as they work on the design/discovery projects embedded in the graduate students' research.
- Enable the completion of large-scale design/discovery projects that are of significant benefit to faculty members' research programs.

In the following pages you will find descriptions of the following VIP teams that are recruiting for the Winter Quarter of the 2024-2025 academic year:

- Astroparticle Physics in Extreme Locations
- Autonomous Soil Sampling System
- Circular Cities: Assessing, predicting, and tracking building material stocks and flows from urban areas
- Cognitive Neuroengineering for the Brain and Mind
- Consortium for Climate Risks in the Urban Northeast (CCRUN) Climate and Sustainability Research Team (CSRT)
- Coordination and Planning for Multi-Robot Systems
- Designing Smart and Healthy Transportation Systems
- Designing Sustainable Intelligent Transportation Systems
- Development of biomaterial-based nanofiber yarns and textiles for health applications
- Peace Engineering: Achieving the U.N Sustainable Development Goal #16
- Robust and Risk-aware Planning for Autonomous Vehicles in Smart Cities
- Wireless Systems for the Internet of Things

In order to participate in VIP, you must formally apply and be accepted to a specific team. To apply, please log into ForagerOne (www.drexel.edu/foragerone) and search for “VIP”. This will bring up all available open positions tagged as VIP projects. When submitting an application, please be sure to have uploaded an updated résumé to your ForagerOne profile and to include a statement regarding why you are interested in working on the team to which you are applying.

Please note that VIP team participation requires registration for the accompanying VIP course section. The number of credits required per quarter is flexible and will be determined on a case-by-case basis in consultation with the team's faculty mentor and a student's academic advisor; however, most VIP team members will register for a single credit per quarter. Long-term, sustained participation in the program (three or more quarters of working on a single team) is strongly encouraged and may be required in order for earned VIP credits to count towards degree requirements. More information will be provided to all applicants that are offered a position.

Should you have any questions about a particular team, please feel free to reach out to the team's faculty mentor(s). Any questions regarding the VIP program in general should be sent to Chad Morris via email at cam83@drexel.edu

We hope you'll take the time to consider this compelling new opportunity. We look forward to receiving your application!

# Astroparticle Physics in Extreme Locations

Dr. Christina Love (Physics) – Faculty Mentor

## GOALS

Particles like cosmic rays and astrophysical neutrinos are produced throughout our Universe. This Astroparticle VIP team explores two main ways of detecting these particles: the IceCube Neutrino Observatory at the South Pole and the HERA collaboration using High Altitude Balloons (HAB). IceCube detects neutrinos using a massive array of detectors embedded in the Antarctic ice. Team members working on IceCube will specifically work with the citizen science project called Name that Neutrino. This project allows volunteers (members of the general public) to aid in data classification of events for IceCube. The HERA collaboration studies particles produced by cosmic ray air showers by using HAB to carry scientific instruments into the stratosphere.

Team members participating in Name that Neutrino will work on analyzing data, visualizing data for the next iteration, exploring ways to reach more volunteers, and actively participating in the forum talk pages to help volunteers.

Team members participating in the HERA HAB experiment will engage in all the stages of real-life research projects: literature searches, theory calculations and predictions, equipment design, prototype testing and development, logistics and deployment, data analysis, and project reporting. There should be a few opportunities to participate in the field deployment of devices on balloons.

The entire Astroparticle VIP team will focus on improving the experimental design for these two distinct detection methods to better understand the origins and properties of these elusive and astronomical particles.

## METHODS & TECHNOLOGIES

Computer programming, citizen science, web development, hardware with particle detectors, literature searches, communication, surveys, social media

## MAJORS & AREAS OF INTEREST

The Astroparticle VIP team needs a variety of skills:

- Physics and Math – astronomy, particle physics, data analysis, data visualization
- Computer Science – microprocessors for data collection for HAB, data analysis, data visualization
- Engineering – engineering payload design for HAB, data analysis, data visualization
- Education, Communication, and Sociology – design, assess, or deliver high school lessons
- Design Majors and English – explore ways to recruit volunteers through graphic design, animation, blog posts, etc
- Other students with a variety of interests are welcome to apply – this is a multidisciplinary project.

## MENTOR CONTACT INFORMATION

Dr. Christina Love
Email: love@drexel.edu

## PARTNERS & SPONSORS

Collaborators: Richard Cairncross (Chemical and Biological Engineering); Alissa Sperling (Springside Chestnut Hill Academy); Naoko Kurahashi Neilson (Physics)

Funding received from:

- NSF IceCube: https://www.nsf.gov/awardsearch/showAward?AWD_ID=2209445&HistoricalAwards=false
- Nationwide Eclipse Ballooning Project (NEPB): https://eclipse.montana.edu/
- Pennsylvania Space Grant Consortium: https://sites.psu.edu/paspacegrant/support/statewide-support/competitive-mini-grant-program/
- Drexel: College of Arts and Sciences Undergraduate Research Support (ASURS) Fund

# Autonomous Soil Sampling System

Dr. Lifeng Zhou (ECE) – Faculty Mentor

## GOALS

This project aims to develop an autonomous robotic system for precise soil sampling from agricultural fields to enable accurate soil health monitoring. The robotic system will autonomously navigate fields and collect geo-referenced soil samples at predefined depths for further analysis. The autonomous robotic system should perform automatic, consistent, efficient, and precise soil sampling across large agricultural fields, which will lead to large-scale soil sampling and accurate soil health assessments. VIP team members will work with professors and doctoral students and have regular meetings to discuss progress. There will be opportunities for publications at top robotics and AI venues.

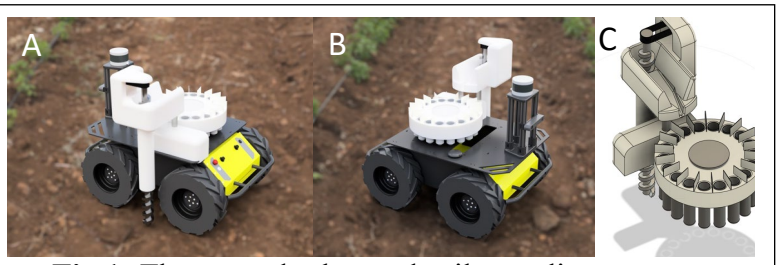


**Fig 1:** The ground robot and soil sampling system.

## METHODS & TECHNOLOGIES

Robotics system design, path planning, motor control, sensing techniques (RTK-GPS, LiDAR, camera)

## RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Build an autonomous soling sampling system.
2. Equip the ground robot (HUSKY) with RTK-GPS for precise geo-localization.
3. Equip the system with a soil sampling drill, a slice coated with Teflon, a shaker motor, a motorized sampling wheel with absolute position encoders, etc.
4. Develop autonomous navigation algorithms via GPS or LiDAR/camera and precise sampling/planning/control algorithms.

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering – path planning, motor control, RTK-GPS, robot communication, system design, autonomous navigation, localization and mapping
- Computer Science - motion planning, perception, autonomous navigation, reinforcement learning
- Mechanical Engineering – sampling system design, structure design, computer aid design (CAD) software experience

## APPLICATION PREREQUISITES ()

This team is looking for team members with some background in Arduino, embedded programming, DSP, circuit design, and CAD.

If interested in working on the autonomous navigation portion of this system: Prior to applying for a position on this team, prospective team members are asked to please install the Linux-Ubuntu & Robot Operating System (ROS) on their computer and go through the ROS tutorials (ROS1: http://wiki.ros.org/noetic or ROS2: https://docs.ros.org/en/humble/index.html). Prospective team members should prepare a video of the velocity control of a turtlebot in the ROS-Gazebo simulator and provide a link to this video when reaching out on ForagerOne to apply for the team.

If needed, a docker package with all the instructions for both ROS 1/2 which allows using Rviz, Gazebo, etc. is available at: https://github.com/Zhourobotics/ros2-docker-dev Alternatively, this software can also be utilized using a virtual machine to install Linux and ROS.

Please note that participation on this VIP team requires use of many robot hardware and software tools, which can take significant time to learn and build familiarity with; therefore, it is NOT recommended to apply for this team if one doesn't have enough time to commit to this effort (such as having a heavy courseload or participating in co-op in the same quarter). Prospective team members should indicate how much time they can commit to the team when reaching out on ForagerOne to apply for the team.

## MENTOR CONTACT INFORMATION

Dr. Lifeng Zhou
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Drexel Zhou Robotics Lab

## PARTNERS & SPONSORS

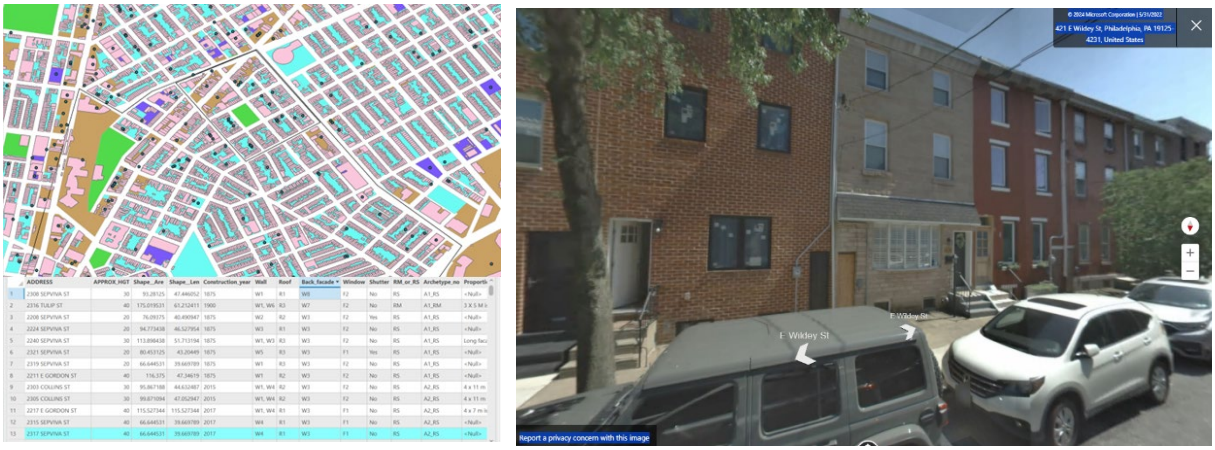
Potential for funding from USDA-NIFA

# Circular Cities: Assessing, predicting, and tracking building material stocks and flows from urban areas

Dr. Fernanda Cruz Rios (CAEE) – Faculty Mentor

## GOALS

Cities are responsible for 75% of natural resource consumption and 70% of global greenhouse emissions. The circular economy has been increasingly discussed as a potential solution to climate change, resource scarcity, and pollution – problems that have been exacerbated by growing urbanization trends. In circular economy systems, products and services are traded in closed loops, and resources are recirculated into the Technosphere through sustainable strategies such as reuse, refurbishment, remanufacture, or recycling. “Circular cities” apply circular economy concepts in infrastructure, resources, goods, and




*1. ArcGIS and Google Street View - Fishtown, Philadelphia*

services.

This VIP team will focus on circular economy for city infrastructure; specifically, building envelope materials from buildings that have been demolished or will be demolished (or deconstructed) in the future. To reuse or recycle building materials, first we need to understand the quantity and types of materials that are and will be available in a city. Materials that are currently being used in a building are called “material stocks”, while materials that are arriving at the construction site or leaving the demolition site are called “material flows”. Assessing, predicting, and tracking building material stocks and flows is key to creating economic opportunities and public policy to incentivize the recirculation of building materials. **Team members will assist in the creation of an urban database for building material stocks and flows in Philadelphia, including quantity and type of materials and their respective environmental impacts for manufacturing and end-of-life treatment (e.g., reuse, recycling, incineration, disposal in landfills).** Throughout AY 24-25, teams will focus on residential buildings in the Fishtown neighborhood.

## METHODS & TECHNOLOGIES

1. Spatial data collection (e.g., ArcGIS), photogrammetry (e.g., analysis and interpretation of photographic images from different sources)
2. Life cycle inventory data collection (collecting data on environmental impacts from different building materials)
3. Statistical data analysis
4. Machine learning algorithms (e.g., for predicting future material flows based on demolition trends)
5. Qualitative data collection and analysis (interviews and surveys with demolition and deconstruction contractors and experts)

## RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP team will focus on collecting and preprocessing quantitative data from ArcGIS, City databases, building codes, life cycle inventory databases, and stakeholder surveys. Team members may also participate in collecting and analyzing qualitative data from stakeholder interviews. Undergraduate team members will work with graduate students and professors biweekly to work on developing the building material stocks database for Philadelphia and predicting current material flows in the City.

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate students from the following majors or areas of interest:

- Civil, Architectural, and Environmental Engineering – sustainable buildings and cities, circular economy, building envelope design, life cycle assessment, material flow analysis, urban metabolism, material reuse or recycling.
- Computer Engineering – big data, machine learning
- Architecture and urban studies – circular building design, circular cities
- Construction management – deconstruction and material reuse

Other students with a variety of interests are welcome to apply!

## MENTOR CONTACT INFORMATION

Dr. Fernanda Cruz Rios
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Civil, Architectural, and Environmental Engineering

## PARTNERS & SPONSORS

None

# Cognitive Neuroengineering for the Brain and Mind

Drs. John Medaglia (PSY) & Gary Friedman (ECE) – Faculty Mentors

## GOALS

Just like any other part of the body, brains are unique to the individual and change over time. Anatomical MRIs (magnetic resonance imaging) show very clear differences in the shape and position of different landmarks, lobes, etc. in different peoples' brains. But there are also many differences that are not evident from visual inspection of anatomical images. Using fMRI (functional MRI), we are able to see which areas become more or less activated during a certain task. This allows us to make a functional connection between a behavior or performance and regions of the brain. For example, fMRI has allowed us to associate the frontal areas of the brain with executive control, which is the ability to choose between options and make plans. Like anatomy, the location of these functional areas varies across individuals. Even more, functional areas are part of greater networks throughout the brain. These networks connect and exchange information in order to execute tasks. For example, the "frontoparietal control network" (FPCN) is a network that links frontal and posterior areas of the brain and is especially important in helping us to switch between different tasks based on the context of our environment or rules. Networks vary across individuals in the same way that functional areas do.

As described above, there are individual differences at many levels within the brain. i.e. at the anatomical, functional, and network levels. Our lab uses a combination of MRI, functional MRI, diffusion MRI (which maps brain connectivity), EEG, graph theory, and network control theory to create individual-level functional maps of a person's brain. We pair these maps with TMS (transcranial magnetic stimulation) and tDCS (transcranial direct current stimulation) to stimulate the brain in order to learn about how functional networks connect and to develop and inform treatments for brain disorders. TMS and tCDS are non-invasive brain stimulation technologies, meaning that they can influence how neurons fire, harmlessly, from outside the body. TMS achieves this through the application of strong magnetic fields and tCDS achieves this through direct low-intensity electrical currents. A unique advantage of brain stimulation allows us to make causal connections between brain activation and behavioral outcomes, which was previously only possible using invasive techniques or by studying those with brain damage due to injury.

However, TMS and tCDS are often used in treatments without any information about underlying neural circuits and network organization, i.e. using anatomical landmarks. Our lab uses the fMRI methods described above to create detailed and personalized functional networks to guide stimulation to test whether we can induce improved behavioral responses. Another aspect of targeting neural stimulation is synchronizing it to the activity in the relevant networks. Our lab uses Electroencephalography (EEG) to measure what happens in subjects' brains while they complete tasks. We use extremely fast "closed-loop" systems to deliver neural stimulation that can enhance or suppress brainwaves in the targeted networks. Together, personalized targeting in space ("where" in the brain) and in time (synchronizing with ongoing brain waves from functional networks) can help us to identify optimal stimulation strategies that lead to better treatment plans and better patient outcomes.

## METHODS & TECHNOLOGIES

Many different methods and technologies are used at each step of our research. Our typical process is to design appropriate MRI tasks and scan sequences; bring the subject into the scanner; process their imaging data and create personalized stimulation targets; create cognitive/behavioral tasks that test the function of interest; noninvasively stimulate the subject at their personalized target and analyze their results. Some steps are more design-focused with an emphasis on cognitive psychology, some are more technically focused such as creating tasks and setting up equipment, some are more subject-focused, i.e. running sessions, and some are more programming-focused, such as neuroimaging data processing and analysis. In general, most of our time is spent doing processing and analysis on computers, and the rest is spent in-person running sessions. Experience with and interest in any of the following will be relevant to our research.

- Computer-guided behavioral testing of humans
- EEG (electroencephalography)
- MRI (magnetic resonance imaging)
- Transcranial magnetic stimulation (TMS)
- Transcranial direct current stimulation (tDCS)
- Statistical data analysis (Matlab, Python, R, etc.)
- Neural network models
- Any EEG or MRI preprocessing suite (FreeSurfer, SPSS, FSL, fMRI prep, EEGLab, ERPLab, FieldTrip, etc.)
- Using the Command Line
- Signal Processing
- Cloud Computing, Supercluster computing, Supercomputer computing (Azur, AWS, Google Cloud, University Clusters, regional sites) and knowledge of computing resources for research beyond Drexel
- Windows, Mac, and Linux operating systems
- Computer Hardware/Design, including adding hard drives, expansion cards, memory, etc., upgrading internal components, RAID configuration, and technical specifications such as cable shielding, data transfer rates and certifications, Monitor metrics such as ppi, refresh rate, viewing angle, motion artifacts, etc.

## RESEARCH, DESIGN, & TECHNICAL ISSUES

In general, VIP team members will be involved in both running in-person research sessions and in analysis, processing, and design. The lab will work closely with incoming VIP students to understand their interests and goals and align their time and efforts with appropriate projects. At any given time, the lab has multiple ongoing projects in various stages of development.

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical Engineering - EEG and MRI signal detection and processing, modeling of field penetration into the brain, neural network models, statistical signal processing
- Computer Engineering - software for behavioral tests, implementation of testing protocols over internet, neural network modeling, statistical signal processing
- Psychology - development of behavioral tests, interpretation of EEG data, development of TMS and TDCS protocols, neural network modeling
- Biomedical Engineering - EEG and MRI signal detection and processing, modeling of field penetration into the brain, neural network models, statistical signal processing
- Computer Science - software for behavioral tests, implementation of testing protocols over internet, neural network modeling, statistical signal processing

## MENTOR CONTACT INFORMATION

Dr. John Medaglia
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Cognitive Neuroengineering & Wellbeing Laboratory

Dr. Gary Friedman
Email: gf29@drexel.edu
Phone: 215.895.2108
Professional Profile

## PARTNERS & SPONSORS

None

# Consortium for Climate Risks in the Urban Northeast (CCRUN)
# Climate and Sustainability Research Team (CSRT)

Drs. Franco Montalto (CAEE) & Patrick Gurian (CAEE)– Faculty Mentors

## GOALS

We invite students interested in Resource Stewardship and Sustainability, Climate Change, Climate Resilience, and related topics to join the VIP Climate and Sustainability Research Team (CSRT). As part of the Consortium for Climate Risks in the Urban Northeast (CCRUN), Drexel undertakes stakeholder-driven, applied research that helps our external partners cope with and plan for climate change. Working under the supervision of a research team directed by Dr. Franco Montalto and Dr. Patrick Gurian, CSRT students will be involved in all aspects of this work, including data collection, data analysis, planning studies, modeling and simulation efforts, literature reviews, interviews, surveys, and planning and organization of meetings and convenings.

Climate resilient development simultaneously addresses human well-being, sustainability, and climate action goals. Our team is developing planning, policy, and infrastructure strategies that align the various sustainability, adaptation, and emissions reduction goals of our stakeholders. This work requires that engineers work with natural, social, and applied scientists, and public health experts. The objective is to explore the various intersections between sustainability, mitigation, adaptation, and equity goals, addressing topics such as the: 1) Emissions implications of various adaptation projects (e.g., low carbon adaptation); 2) Ecological implications of adaptation strategies; 3) Social/cultural/regional implications of coastal retreat; 4) Relationship between nature-based solutions and green gentrification; and 5) Enhancement of urban land-based ecosystem services through decentralization.

## METHODS & TECHNOLOGIES

Team members will have the opportunity to tackle real-world projects and create deliverables for these real-world projects, including communication & outreach plans; data tools, maps, information; decision support tools; publications (book, peer-reviewed publication, and/or technical report); presentations; white papers; academic theses/dissertations; and methodologies/approaches.

## RESEARCH, DESIGN, & TECHNICAL ISSUES

The faculty mentors and research coordinator for this team are looking for team members interested in:

1. Public Engagement with Philadelphia's Adaptations to Climate Change. Drexel led a collaborative effort that developed a Climate Resilience Research Agenda for Philadelphia. There is a need for follow up efforts that engage community networks in Philadelphia and surrounding communities to understand information needs for climate change adaptation. This project will engage with community members' understanding of climate change through semi-structured interviews that identify a) current understanding, b) information sources, and c) opinion leaders. The project will pilot test different strategies for engaging with the participants, including understanding participants' sense of identity, information sources, and position in social networks, as well as their technical understanding of climate change. These efforts will be assessed through follow-up surveys and interviews with the participants.
2. Camden Floodnet sensor installation and analysis – Urban flooding is difficult to manage because of the difficulty in knowing precisely where, when, and how much flooding occurs. Team members will assist Drexel researchers collecting flood data in Camden, NJ using IoT sensors
3. Stafford, New Jersey flood mitigation project – Low-lying developments are exposed to increasing flood risk due to the convergence of accelerated sea level rise, and the increased frequency and intensity of extreme precipitation and runoff events. To address these concerns, local communities are turning increasingly to Nature based Solutions (NbS), with the goal of using the restoration of natural ecosystems to mitigate flood risk while providing other benefits in terms of biodiversity, carbon sequestration, and enjoyment of green spaces and natural areas. Team members will assist in collecting tidal data and writing up results of modeling of the effectiveness of different flood adaptation options in this NJ coastal community

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the following areas:

- Infrastructure and the built environment
- Nature-based strategies / green infrastructure
- Water, energy, waste
- Computer simulations
- Planning and urban design
- Other related topics

## MENTOR CONTACT INFORMATION

Dr. Franco Montalto
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Dr. Patrick Gurian
Email: pgurian@drexel.edu

## PARTNERS & SPONSORS

This work is sponsored by the Consortium for Climate Risks in the Urban Northeast (CCRUN) and the National Oceanic and Atmospheric Administration (NOAA) Climate Adaptation Partnerships (CAP) / Regional Integrated Sciences and Assessments (RISA) program

# Coordination and Planning for Multi-Robot Systems

Dr. Lifeng Zhou (ECE) – Faculty Mentor

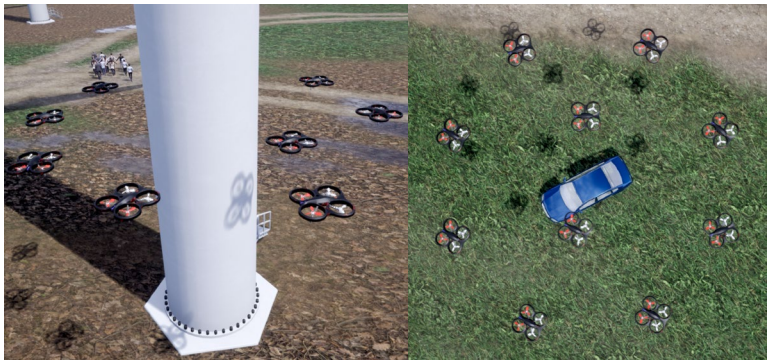
## GOALS

Robots continue to get smaller, faster, and cheaper. Robots today are equipped with sophisticated computing, communication, and sensing resources. It is becoming increasingly essential to advance robotics systems and algorithms that make full use of the robots' capabilities. The goal of this VIP team is to develop novel robotics systems and advanced coordination and planning algorithms for the resilient and long-term operation of robots in tasks such as environmental monitoring, search and recuse, target tracking, surveillance, and reconnaissance. VIP team members will work with professors and Ph.D. students and have regular meetings to discuss progress. There will be opportunities for publications at top robotics venues.

## CURRENT PROJECTS

### PROJECT 1: DECENTRALIZED AND SCALABLE MULTI-ROBOT COORDINATION

This project aims to apply graph neural networks (GNNs) and large language models (LLMs) for decentralized and scalable multi-robot coordination.



### RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Design GNN-based learning frameworks for decentralized multi-robot coordination.
2. Apply or fine-tune LLMs for decentralized and scalable multi-robot coordination.
3. LLMs in the loop of coordination, planning and control.
4. Develop a high-fidelity simulator based on Unreal Engine for testing multi-robot coordination.
5. Implement the algorithms into a team of drones.

## PROJECT 2: COORDINATION OF HETEROGENEOUS ROBOTICS SYSTEMS

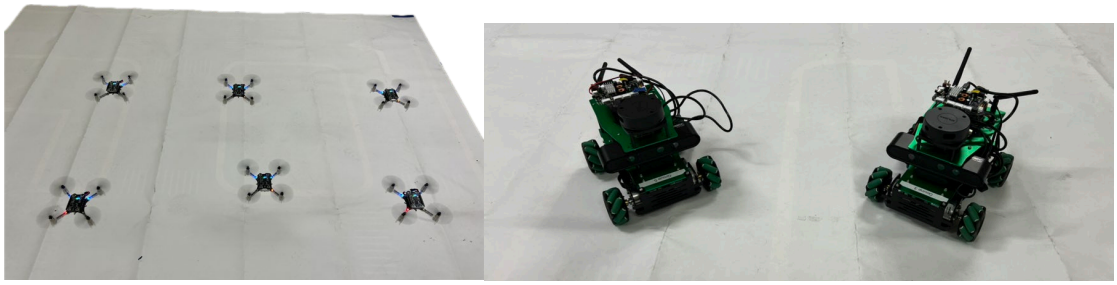
This project focuses on the coordination between a drone and a rover for outdoor information gathering. The perceptions of the drone and rover can complement each other for better data collection. In addition, when the battery of the drone is out of power, the rover should rendezvous with the drone to charge the drone.

### RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Developing a heterogeneous robotics system composed of a drone and a rover
2. Autonomous landing of the drone on the rover (the drone can be ferried by the rover)
3. Autonomous drone charging by the rover
4. Autonomous navigation of the rover using a Lidar, a camera, etc.
5. Area monitoring, coverage, exploration, target tracking of the drone using a downward facing camera
6. Real-time communication and information sharing between the drone and the rover
7. Joint perception of the drone and rover

## PROJECT 3: MULTI-ROBOT MULTI-TARGET TRACKING

This project aims to develop a multi-robot target tracking system and design coordination algorithms for the robots (drones) to actively track dynamic targets (ground robots).



### RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Develop a multi-robot target tracking system composed of multiple drones as trackers and multiple ground robots as targets
2. Equip each drone with an AI camera to detect and track the target
3. Implement neural networks to recognize and classify the targets
4. Design coordination algorithms that enable drones to share perceptions and assign them to track targets

## METHODS & TECHNOLOGIES

Robotics system design, unmanned aerial and ground vehicles, multi-robot coordination and communication, planning and control, perception and deep learning, reinforcement learning, GNNs, LLMs, robotics algorithm design, sensing techniques (Lidar, camera, radar, etc.).

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering - coordination and control, motion planning, perception (Lidar, camera, radar, etc.), computer vision, deep learning, reinforcement learning, robot communication, system design
- Computer Science - motion planning, perception, computer vision, deep learning, reinforcement learning, GNNs, LLMs, algorithm design and analysis
- Mechanical Engineering - sensor design, system design, structure design, computer aid design (CAD) software experience
- Civil, Architectural & Environmental Engineering – environmental monitoring, data collection and analysis

## APPLICATION PREREQUISITES

Prior to applying for a position on this team, prospective team members are asked to please install the Linux-Ubuntu & Robot Operating System (ROS) on their computer and go through the ROS tutorials (ROS1: http://wiki.ros.org/noetic or ROS2: https://docs.ros.org/en/humble/index.html). Prospective team members should prepare a video of the velocity control of a turtlebot in the ROS-Gazebo simulator and provide a link to this video when reaching out on ForagerOne to apply for the team.

If needed, a docker package with all the instructions for both ROS 1/2 which allows using Rviz, Gazebo, etc. is available at: https://github.com/Zhourobotics/ros2-docker-dev Alternatively, this software can also be utilized using a virtual machine to install Linux and ROS.

Please note that participation on this VIP team requires use of many robot hardware and software tools, which can take significant time to learn and build familiarity with; therefore, it is NOT recommended to apply for this team if one doesn't have enough time to commit to this effort (such as having a heavy courseload or participating in co-op in the same quarter). Prospective team members should indicate how much time they can commit to the team when reaching out on ForagerOne to apply for the team.

## MENTOR CONTACT INFORMATION

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Drexel Zhou Robotics Lab

## PARTNERS & SPONSORS

Distributed and Collaborative Intelligent Systems and Technology Collaborative Research Alliance (CRA)

Assure - THE FAA's Center of Excellence for UAS Research

# Designing Smart and Healthy Transportation Systems

Drs. Zhiwei Chen (CAEE), Shannon Capps (CAEE), Gina Lovasi (Epidemiology and Biostatistics) – Faculty Mentors
Benjamin Gruswitz, Amy Verbofsky, Sean Greene – Industry Mentors

## GOALS

The goals of this team are: (1) to develop a systematic health impact assessment model for transportation systems that can directly be used by our community partner, Delaware Valley Regional Planning Commission (DVRPC), in their regional planning activities and (2) to build an eco-driving testbed using robot cars and eco-driving algorithms. Together, these activities will produce actionable information that communities can leverage to design smart and healthy transportation systems.

## METHODS & TECHNOLOGIES

Team members interested in health impact modeling for transportation systems will utilize a number of methods and technologies, including literature research, expert interviews, data analytics, and computer programming (R, Python, or more complex atmospheric models) and will build domain knowledge in transportation engineering, atmospheric chemistry, and public health. Team members interested in eco-driving will utilize a number of methods and technologies, including basic hardware skills (e.g., assembling sensors on a robot car), ROS programming, Autoware software platform, motion planning and control for autonomous vehicles, and computer programming (Python).

## RESEARCH, DESIGN, & TECHNICAL ISSUES

For the team's health impact modeling goal, specific technical challenges include identifying transportation-related health impact metrics and health impact modeling frameworks (e.g., ITHIM); for each framework, specifying the modeling details, assumptions, advantages, disadvantages, implementation requirements (e.g., data, computation resources), and current usage in practice; presenting the results to DVRPC; developing a roadmap to a systematic health impact assessment framework for transportation systems based on DVRPC's inputs; and preparing a technical memorandum to implement the roadmap. For the team's eco-driving testbed development goal, specific technical challenges include hardware development (assembling the robot cars, infrared distance sensor, Wi-Fi chips), wireless communication (data loss is a critical issue), software development (connecting the testbed to the Autoware framework), algorithm implementation (implementing simple vehicle trajectory controllers), and feasibility testing (testing the performance of the build testbed under various circumstances).

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate and graduate students from a variety of majors including but are not limited to:

- Civil Engineering – transportation systems, infrastructure, GIS
- Environmental Engineering, Environmental Science – air pollution, geospatial data analysis
- Electrical and Computer Engineering – hardware, control, wireless communication, optimization
- Mechanical Engineering – hardware, control, optimization
- Public Health – health impacts of transportation, health policy
- Public Policy – transportation and health policies, planning
- Computer Science – big data, machine learning
- Sociology – societal impacts of transportation systems
- Other students with a variety of interests are welcome to apply – this is a multidisciplinary project!

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## PARTNERS & SPONSORS

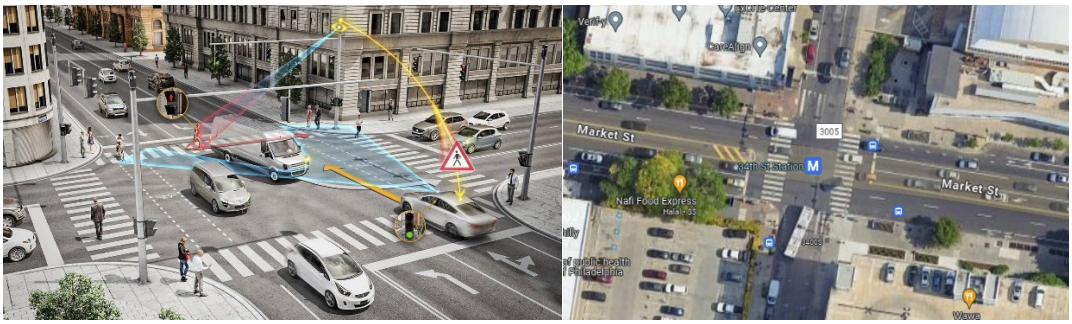
Delaware Valley Regional Planning Commission

# Designing Sustainable Intelligent Transportation Systems

Dr. Liang Zhang (ELS) – Faculty Mentor

## GOALS

An Intelligent Transportation System (ITS) is a system in which real-time data is gathered and used to inform automated decisions regarding the function of traffic-related infrastructure and hardware. Although traffic communications have traditionally been hardwired, cities are increasingly looking to wireless networks for such communications. Challenges, however, could arise when adapting these sectors to smart cities. For instance, the traffic signal system could enter a failsafe mode (a blinking red light) if the communication between sensors and traffic signals fails. Natural events or malicious human actions (e.g., extreme weather or cyber-attacks) could create unsafe driving conditions or system congestion, trapping people in an affected area. Consequently, stability and reliability should be addressed when developing such systems. In addition, the rising number of vehicles and congestion have highlighted environmental impacts. Sustainability, as a result, should also be considered.




Our team will focus on designing a self-organizing traffic signal control system to increase the stability and reliability of smart cities. This system operates as a self-organizing system which aims to automatically adapt and optimize signal control based on real-time traffic conditions despite system failure and human intervention. In addition, vehicle emissions due to vehicle delays during traffic operations will also be addressed. Team members will have the opportunity for publications at top systems engineering, engineering management and transportation engineering venues, such as INFORMS, ASEM, and TRB.

## METHODS & TECHNOLOGIES

1. Basic traffic flow theory, traffic control methods, and vehicle emission measures.
2. Machine learning algorithms (deep learning, reinforcement learning, classification methods, etc.).
3. Resource allocation problems.
4. Fairness index and equity measures.
5. Traffic simulation software (SUMO and VISSIM), operations research software (Arena), programming language (Python and MATLAB).

## RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP team will mainly focus on hands on experiments, field research at signalized intersections, and writing research papers. Undergraduate students will work with graduate students and professors biweekly to participate in the following activities: 1) literature review; 2) conduct field research at signalized intersections; 3) establish simulation environments using SUMO or VISSIM and Python; and 4) data analytics.

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate students from the following majors and/or with a background and interest in the areas listed below.

- Civil, Architectural and Environmental Engineering – transportation systems, infrastructure, GIS, air pollution, data analysis.
- Systems Engineering – optimization, operations research, queue theory, game theory, graph theory.
- Computer Engineering – big data, machine learning.
- Sociology – societal impacts of smart cities.

Other students with a variety of interests are welcome to apply to this multidisciplinary project!

## MENTOR CONTACT INFORMATION

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## PARTNERS & SPONSORS

None

# Development of biomaterial-based nanofiber yarns and textiles for health applications

Dr. Caroline Schauer (MSE), Dr. Christopher Rodell (BME), Genevieve Dion (Westphal) – Faculty Mentors

## GOALS

Functional textiles are knitted materials with capabilities such as energy storage, biosensing, tissue engineering, implantable devices, or drug delivery. Traditional textiles have garnered interest for broader applications in recent years due to their hierarchical structure and flexibility. Nanofibers in textiles are enticing for functional textiles as the functionality and properties of the fibers can be controlled from the nanoscale to the macroscale level through the incorporation of active materials within the nanofibers. The Natural Materials and Polymer Processing lab led by Dr. Caroline Schauer has developed a nanoyarn machine that can produce continuous yarns from nanofibers from diverse materials. The nanofibers provide increased surface area that is advantageous to improve sensitivity for biosensing and increase the number of conductive pathways for energy storage applications. In addition to material properties and functionality, mechanical properties are important in transforming nanoyarns into 3D structures. The current goals of this VIP project are to standardize and qualify a modified ASTM method for traditional textiles, to apply this method to nanoyarns, and, lastly, to transform these nanoyarns into a 3D structure for biomedical applications.

## METHODS & TECHNOLOGIES

This VIP team will be utilizing a uniaxial tensile tester to establish a modified ASTM standard for measuring the mechanical properties of commercial yarns and nanofiber yarns. Additionally, the team will utilize traditional textile manufacturing methods such as plying, twisting, weaving, and knitting to transform biomaterial-based nanoyarns into 3D structures for heart patch applications.

## RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP will address the following challenges:

- Development of a standard procedure for mechanical testing of commercial yarns, which can be applied to any material type or fineness.
- Application of established standard procedure for mechanical testing on biobased nanoyarns.
- Investigation of transforming the nanoyarns into a 3D structure for biomedical heart patch applications.

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate students from the following majors and/or with a background and interest in the areas listed below:

- Material Science & Engineering- Electrospinning, polymer science, mechanical testing
- Textile Engineering/Manufacturing- commercial textile manufacturing methods, 3D printing
- Biomedical Engineering- tissue engineering scaffolds, cardiovascular patches

## MENTOR CONTACT INFORMATION

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Center for Functional Fabrics
Prof. Genevieve Dion
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## PARTNERS & SPONSORS

None

# Peace Engineering: Achieving the U.N Sustainable Development Goal #16

Drs. Joseph Hughes (CAEE/ELS), Mira Olson (CAEE/ELS), and James Tangorra (MEM/ELS) – Faculty Mentors

## GOALS

The research theme of this VIP is focused on challenges presented by the *U.N. Sustainable Development Goal (SDG) # 16*:

*Promote peaceful and inclusive societies for sustainable development,*
*provide access to justice for all, and*
*build effective, accountable, and inclusive institutions at all levels.*

A number of significant underlying challenges present roadblocks to achieving SDG 16. War, direct violence, structural violence, and cultural violence all represent barriers to sustainability. They are destructive forces (180° opposite of efforts to be constructive and advance sustainability) and are recognizable to anyone. Peace, however, does not possess a shared understanding and creating peaceful societies becomes a complicated and elusive social aspiration. SDG #16 aims at challenges that are least the understood of all the SDGs and known to be fundamental to achieving sustainability.

The U.N, has identified a number of structural roadblocks to achieving SDG #16 including: Conflict and Insecurity, Weak Institutions and Governance, Inequality and Exclusion, and Access to Justice. Tackling these underlying issues is critical for creating the foundation for peace – locally, in conflict regions, and globally. The long-term focus of our research efforts is the development of decision support tools using emerging technologies (i.e., machine learning, AI, and Geo-AI, remote and/or autonomous systems, and visualization) to aid peace practitioners and community organizations in addressing these, and other, structural challenges more effectively.

## METHODS & TECHNOLOGIES

As a topic to provide real world context in AY 24-25, we will leverage ongoing work led by Professor Hughes with A) the U.S.-Ukraine Foundation Task Force on Reimagining and Reconstruction of Ukraine and B) Jumpstarting Hope in Gaza with the Arava Institute. These challenges present a number of complex research questions all directed at a better future for recovery after unthinkable destruction and loss of life. The Fall Term of AY 24-25 will be the inaugural term for VIP Group. Early efforts will focus on developing research capacity, building technological skills, and establishing a Peace Engineering team culture that will be foundational for teams to build on for in future terms. hroughout AY 24-25, teams will follow developments in Ukraine/Gaza while building IT and systems modeling capability that provides for enhanced decision support towards both a durable and an enduring peace.

## RESEARCH, DESIGN, & TECHNICAL ISSUES

Foundational computational tools that will be used in this VIP program will be Geospatial Information Systems (GIS) and Systems Modeling. Specifically, we will develop ArcGIS (a cloud-based mapping and analysis software used to map information in a geospatial layered data system that allows for analysis and collaboration) and Stella Online (a web-based modeling tool for dynamic modeling, policy analysis, and strategy development) as platforms to develop skills in AY 24-25.

Beginning on Day 1 of the Fall term, teams will engage in the development of Peace Data Ontology[1] (PDO). Of particular interest will be the ability to link information obtained in community-based research (e.g., interviews, surveys, etc.) with sensor-based (remote sensing, IoT, arial/satellite imagery, etc.) approaches. No accepted approaches currently exist to combine digital-derived data with survey-based information to create large scale “peace outcomes” data sets. Engaging in the development of PDO is highly interdisciplinary and presents a significant challenge including fields of peace and diplomacy, peace studies, peace engineering, peacebuilding, and in some cases spirituality. Adding complexity and nuance

[1] An ontology provides the map that links together data and meaning by defining what is meaningful.

to PDO is needed for both objective terms used in SDG #16 “peace” and “inclusivity” since both have local and/or cultural variation.

## MAJORS & AREAS OF INTEREST

Peace, inclusivity, and sustainability can be advanced by all interested students. This VIP team will promote convergence across disciplines and welcomes students ranging from freshman to doctoral candidates, in any major, and with/without other learned skills (i.e., Coop, independent research, etc.). Examples of personal interest related to this effort include, but are not limited to:

- Sustainability
- Peace
- Justice
- Health
- Environment
- Computing
- Data Science
- Psychology, sociology, anthropology
- Economics and business
- Religion and/or Peace Studies

## MENTOR CONTACT INFORMATION

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## PARTNERS & SPONSORS

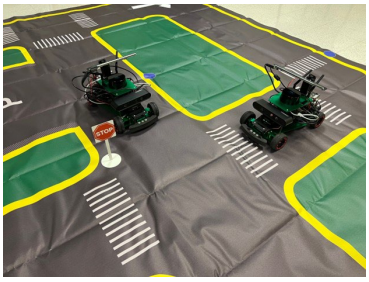
None

# Robust and Risk-aware Planning for Autonomous Vehicles in Smart Cities

Dr. Lifeng Zhou (ECE) – Faculty Mentor

## GOALS

Through major advances in technology, autonomous driving is already revolutionizing modern travel, navigation, and safety; however, there are major concerns with the robustness of perceptions and motion planning for autonomous vehicles. For instance, consider a motion planning scenario involving multiple autonomous vehicles (AVs) at an intersection. The AVs use various sensors (Lidar, depth camera, sonar, etc.) along with a neural network to process sensor observations. In a normal situation, the AV is trained to perform core functionalities such as waiting at a red light and avoiding collisions with other vehicles at an intersection; however, the AV's neural networks could be easily misled by perturbations. These perturbations are primarily in two forms: natural/environmental (rain, snow, and fog) and adversarial (deceptive attackers). The perturbations can cause major issues in autonomous driving which adds uncertainty to their performance. This project is particularly relevant to "smart intersections" that are powered by AI to evaluate how pedestrians, bicyclists, and other vehicles interact and intelligently manage traffic. VIP team members will work with professors and Ph.D. students and have regular meetings to discuss progress. There will be opportunities for publications at top robotics and AI venues.




## METHODS & TECHNOLOGIES

Robust deep learning, motion planning and control for AVs, perception with neural nets, sensing techniques (Lidar, camera, radar, etc.), sensor fusion, and vehicle-to-vehicle and vehicle-to-infrastructure communication.

## RESEARCH, DESIGN, & TECHNICAL ISSUES

5. Build a mock smart city with drivable lanes, AVs, traffic lights, traffic signs, buildings, pedestrians, etc.
6. Evaluate how perturbations mislead/spoof the perceptions of AVs.
7. Design robust neural networks to denoise observations and improve perceptions of AVs.
8. Utilize advanced machine learning models such as diffusion models to predict the trajectories of moving entities.
9. Design risk-aware motion planning algorithms to handle uncertainties from perceptions.
10. Address the issue of perturbations and uncertainties though vehicle-to-vehicle and vehicle-to-infrastructure communications.

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering and Mechanical Engineering – motion planning and control, robot perception (Lidar, camera, radar, etc.), deep learning, vehicle communication
- Computer Science - motion planning, computer vision, robust deep learning
- Civil, Architectural & Environmental Engineering – traffic monitoring and management, intelligent transportation

## APPLICATION PREREQUISITES (for work with Avs)

Prior to applying for a position on this team, prospective team members are asked to please install the Linux-Ubuntu & Robot Operating System (ROS) on their computer and go through the ROS tutorials (ROS1: http://wiki.ros.org/noetic or ROS2: https://docs.ros.org/en/humble/index.html). Prospective team members should prepare a video of the velocity control of a turtlebot in the ROS-Gazebo simulator and provide a link to this video when reaching out on ForagerOne to apply for the team.

If needed, a docker package with all the instructions for both ROS 1/2 which allows using Rviz, Gazebo, etc. is available at: https://github.com/Zhourobotics/ros2-docker-dev Alternatively, this software can also be utilized using a virtual machine to install Linux and ROS.

Please note that participation on this VIP team requires use of many robot hardware and software tools, which can take significant time to learn and build familiarity with; therefore, it is NOT recommended to apply for this team if one doesn't have enough time to commit to this effort (such as having a heavy courseload or participating in co-op in the same quarter). Prospective team members should indicate how much time they can commit to the team when reaching out on ForagerOne to apply for the team.

## MENTOR CONTACT INFORMATION

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## PARTNERS & SPONSORS

Potential for funding from NSF

# Wireless Systems for the Internet of Things

Dr. Kapil Dandekar (ECE) – Faculty Mentor

## GOALS

The future Internet of Things (IoT) will consist of a large number of wireless devices and sensors with profound implications for the economy and society. The Drexel Wireless Systems Lab (DWSL) is focused on developing new experimental wireless transceivers and sensors for future IoT networks. These systems require a wide variety of protocols (wireless local area networks, radio frequency identification, Zigbee, Low-power wide area networks, real-time localization systems, etc.) which can be implemented using flexible software defined radios (SDR) in DWSL. Target applications include: applications of radio frequency identification (RFID), wearable transceivers for biomedical sensing, smart grid and smart city infrastructure, effective omni-channel retailing, real-time localization, collaborative intelligent radio networks.

## METHODS & TECHNOLOGIES

Software defined radio, wireless communications and networking, signal processing, machine learning, antenna and wireless transceiver design, augmented reality, cybersecurity, unmanned aerial vehicles

## RESEARCH, DESIGN, & TECHNICAL ISSUES

Using RFID and sensors for biomedical sensing and real-time localization, wireless networks and sensors for smart infrastructure applications enabling a smart and connected omni-channel approach in retail environments, software defined radio for collaborative intelligent radio design, research and education with competition-based radio networks, cybersecurity for wireless networks, unmanned aerial vehicle communications and sensing

## MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering - wireless communications and networks, signal processing, machine learning
- Computer Science - software defined radio, machine learning, game design and visualization, cybersecurity
- Sociology - human factors and technology adoption
- Business - business analytics, marketing, decision sciences
- Economics - smart CRM; customer experience; and optimization of employee, inventory, and store layouts

## MENTOR CONTACT INFORMATION

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## PARTNERS & SPONSORS

Currently in discussions with Comcast machineQ, Impinj, and Centrak