Generic STM32 Sensor Board

Draper 2/2

ELECOMP Capstone Design Project 2026-2027

Sponsoring Company:

The Charles Stark Draper Laboratory, Inc.

555 Technology Sq
Cambridge, MA 02139
http://www.draper.com

Company Overview:

As a nonprofit engineering innovation company, Draper serves our nation's interests and security needs; advances technologies at the intersection of government, academia, and industry; cultivates the next generation of innovators; and solves the most complex challenges. Multidisciplinary teams drawn from a broad and deep pool of 1,300+ engineers and scientists collaborate to develop first-of-a-kind solutions. Our unbiased approach enables us to focus on our customers' needs and to deliver new capabilities.

Technical Director(s):

Steve Lawrence
Software Modeling, Analysis & Validation Group Leader
salawrence@draper.com
https://www.linkedin.com/in/stephen-lawrence-1b7514144

Brian Cotter
Senior Cyber SW Engineer
bcotter@draper.com
https://www.linkedin.com/brian-cotter1

Project Motivation:

We are a leader in the design, development, integration, and testing of algorithms and software for autonomous systems. We have developed reusable autonomy architectures that enable full mission autonomy for single- and multi-agent applications across many complex domains: underwater, terrestrial, aerial, and space. We are looking for a motivated student team to support the development of re-usable "black box" GPS module to help advance Draper's robotics capabilities.

Anticipated Best Outcome:

Goal is the complete design of a black box GPS module that can be plugged into any system to provide position data in some defined message format. Success will be evaluated by integrating the module with the Draper Jetson team.

Baseline

1. Define custom generic navigation message ICD
2. Black box module that streams navigation messages over UART
3. GPS receiver integration
4. Testing infrastructure to confirm meeting real time deadlines

Advanced

1. Simulated GPS drop out condition
2. IMU sensor integration
3. Additional sensor integration (magnetometer barometer)

Stretch

1. Custom PCD / Packaging

Draper will provide system level requirements needed to create the prototype system. The student team will have weekly correspondence (i.e., email, phone calls) with the Sponsor's Project POCs at a time that is mutually agreed upon. In addition to the technical directors, students will have access to additional subject matter experts from Draper as needed.

Project Details:

The project challenges your team to develop real time critical embedded software. Also forces students to apply clean architectures design of a generic module that could be plugged into any system

- Low level embedded programming concepts (RTOS, device drivers / communication protocols, etc.) in constrained environment
- Students will write C code using FreeRTOS kernel on STM32F439 development kits
- Students will define their own message format from scratch that Jetson team will need to adhere to
- STM team will be developing a generic device that can stream GPS (and other sensor data) to any device / platform that read serial and parse the format
- Both teams will be required to work together in order to both be successful

Project is designed to specifically give students experience with low level embedded programming concepts (RTOS, device drivers / communication protocols, etc.) to prepare them to work in Draper's software engineering division.

Students will write C code using FreeRTOS on STM32F4 development kits.

Students will define their own message format from scratch that Jetson team will need to adhere to. STM team will be developing a generic device that can stream GPS (+other sensor data) to any device / platform that read serial and parse the format. Potential to add other sensors as well. Both groups will be required to work together in order to both be successful.

Additionally, students will use Git version control for collaborating as well as issue tracking. Both to prepare for industry where school lacks.

<u>Milestones:</u>

- Baseline: Streaming custom messages over UART at some rate successfully integrated with Jetson Robot team.
- Advanced: Add IMU to sensor board assembly. This IMU could either replace or be secondary to the IMU already on the Jetson. Additional sensors could also be added.
- Stretch: Simulated GPS drop out condition. Artificially disable GPS to simulate GPS denied environment. In GPS drop out condition still stream messages to the Jetson

Robot but 0 filled data or flags to indicate GPS failure. Jetson team does analysis to show performance degradation after losing GPS.

+

[Hardware/Electrical Tasks:]

- Physical connection of all separate boards / components / sensors
- Power management to all boards / components / sensors
- System packaging (3D Printed housing, status LEDs)
- Logic analyzers to debug communication protocols
- System level test hardware (CI runner)

[Firmware/Software/Computer Tasks:]

- Defining message definitions
- Software architecture / system design
- Real-time software task implementation

- Test and implement device drivers
- System level test
- Passing GPS NMEA messages

Composition of Team:

2x Computer Engineers

US Citizenship Required

Skills Required:

Electrical Engineering Skills Required:

- Logic analyzers
- Soldering
- Debugging communication protocols at logic level
- Power
- GPS / GNSS fundamentals
- Basic understanding of antennas
- IMU fundamentals
- Magnetometer fundamentals
- Barometer fundamentals
- Git

Computer Engineering Skills Required:

- C/C++
- Rust
- RTOS
- Communication protocols
- SW architecture / design
- Device drivers
- Bootloaders
- Git

AI Usage:

The AI Use Policy for this project is defined in Appendix A at the end of this proposal. Technical Directors: complete the checklist in Appendix A to indicate which AI uses are permitted on this project. Any item left unchecked is not allowed.

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

Successful demonstration of edge computing with an autonomous system will increase Draper's edge computing capability which will enable Draper to pursue additional contracts for novel solutions in the area of national security.

Broader Implications of the Best Outcome on the Company's Industry:

Autonomy platforms and the ability to collaborate effectively help remove humans from harm. Autonomous systems scale at a fraction of the cost of a human and provide better situational awareness by collecting data at larger scales.

Appendix A: AI Use Policy – Generic STM32 Sensor Board (Draper project 2/2)

Allowed

- Students may use AI tools for

  ☒ brainstorming support

  ☒ concept development

  ☒ literature and publicly available documentation review

  ☒ software development

  ☒ debugging

  ☒ data analysis

  ☒ test development

  ☒ non-proprietary paragraph editing

  ☒ non-proprietary single-slide formatting

  ☒ preparation of project deliverables

  ☐ note taking or transcription of meetings

  ☐ Others: _____

Not Allowed

- Using AI in violation of university policies, applicable laws, or course-specific rules identified by capstone instruction team and project-specific rules identified by the technical directors.
- Entering proprietary, confidential, personally identifiable, security-sensitive, or otherwise restricted information into an AI system without authorization.

- Submitting AI-assisted work without understanding, reviewing, verifying, and appropriately disclosing its use.
- Submitting entire documents or presentations to an AI system for editing or formatting.
- Any unchecked items from the allowed list above.

Requirements

- If any use is allowed, AI tools may only be used to enhance, but not replace, students' technical reasoning, engineering judgment, and understanding. Students must be able to explain, justify, and defend all submitted designs, code, analyses, test results, documentation, and conclusions.
- During the first two weeks of the project, the student team shall work with the Technical Directors to: identify any proprietary or confidential information that may be involved in the project; determine what information may or may not be shared with AI systems; identify the AI tools, models, accounts, and configurations approved for project use; and document any project-specific restrictions or approval requirements.
- Students shall transparently document the uses of AI using the URI CYPHER AI Usage Marking guidelines (https://web.uri.edu/cypher/ai-marking/). A workshop is planned for September to familiarize students with these guidelines.
- Students retain full professional responsibility for all design decisions, analyses, implementations, testing, documentation, presentations, and final deliverables, regardless of whether AI tools contributed to the work.