Capstone Project Proposal Template

Use this "template" to organize your project proposal. You are welcome to change formatting or add sub-headings.

Project Overview (< 0.5 page)

This is a quick introduction to your project. What are your ***deliverables***? What problem does it solve or what audience does it serve? What does it do? Do not include every detail here. Rather, convince the reader it is worth their time to keep reading to learn more!

If you have a picture that clearly explains what your device will look like or do without needing much explanation, include it here. Otherwise, save more complicated system block diagrams for a later section.

Here is a simple example:

> This project centers on the creation of a robot designed to weave baskets underwater. While basket weaving has long been considered a traditional craft, performing it underwater introduces unique challenges in dexterity, material handling, and environmental adaptation that make it an exciting problem for robotics. The primary audience includes students learning about robotics, researchers exploring underwater manipulation, and general audiences intrigued by the novelty of seeing a robot perform a traditionally human craft.
>
> The deliverable is a robotic system that can weave small baskets built from grass. The robot will accept user input to determine precise basket dimensions and shape, given a list of options. The robot will then build the basket while in a submerged environment.

Background (typically 1 page or less)

Here you should lay the groundwork for your project. Why you chose it, what similar projects have been done in the past, and what differentiates your project from past work by others. Include references in IEEE style.

Example (references not included):

> The AutoBleedr project builds on the proven success of the RedSide BleedPro Syringe Holder,which gained significant traction in the bicycle maintenance industry at $35-$50 since 2022 [1]. The BleedPro solved stability issues by providing a secure, hands-free mounting system for bleeding syringes. However, several major pain points persisted: repetitive manual plunger operation, inconsistent flow rates leading to incomplete air evacuation, and mechanic fatigue during extended bleeding sessions. This project was chosen to address these remaining challenges by layering automation onto the already successful BleedPro foundation. Hydraulic brake bleeding represents one of the most technically demanding procedures in bicycle service. SRAM's DOT-based systems

require precise dual-syringe operations with controlled push-pull cycles, while Shimano's mineral oil systems demand consistent vertical positioning and flow rates [2]. Current practice depends entirely on manual skill, with mechanics juggling syringe positioning while managing fluid flow and lever operation simultaneously. This creates unreliable results that can compromise brake performance.

The bicycle brake bleeding market consists almost entirely of mechanical solutions. Park Tool's BKD-1.2 and BKM-1.2 systems represent the industry standard but require complete manual control. SRAM's Pro Disc Brake Bleed Kit follows a similar approach. RedSide's BleedPro was the first innovation, solving positioning challenges through frame-mounted systems. The automotive industry has adopted automation through pneumatic systems from companies like Harbor Freight [3] and AGM Products, but these are incompatible for bicycle applications due to differences in pressure requirements and access constraints.

The AutoBleedr differentiates itself through targeted automation that addresses specific bicycle brake bleeding workflows while maintaining the BleedPro's established stability. It focuses on stepper motor-driven syringe plungers for consistent fluid manipulation, sensors for real-time bubble detection, and small actuators for brake lever operation. The design accommodates standard brake lever positions without requiring specialized mounting adjustments or positioning procedures. This approach provides the strongest value for SRAM's full-flush routines where repeatable cycles and sensor-guided purges eliminate manual effort while preserving mechanical reliability.

Project Description

If needed, you can include text before any subheaders that better defines what your project is. This might be needed if your project is relatively complicated. For most groups, the project overview section above should be sufficient and you should delete this text and jump right into the first sub-section of the project description.

Performance objectives and specifications (typically 1 page)

What must your project do in measurable and, preferably, quantitative terms? Include features geared specifically for your end-user.

Objectives are typically broad statements of desired outcomes, while specifications are detailed descriptions of how those outcomes will be achieved and assessed. You may use a table (suggested) or describe this entirely in text. If you use a table, make sure it is concise and use the text space for explanations and further detail.

Example:

The SCI PCB must collect temperature and pressure data during flight, retain at least one minute of history, expose calibration and self-test over a simple USB text interface for bench use, and deliver science housekeeping data to the OBC on request. These objectives and specifications come directly from the SCI requirements, further detailed in the table below.

	Objectives
Functional requirements	The SCI PCB shall be capable of collecting science data from at least four temperature thermocouples and four pressure transducers at least two times per second.
	SCI shall be capable of buffering at least one minute of collected science data.
	SCI shall transfer the science data to the OBC periodically when enabled
	SCI shall respond to commands from the OBC.
	SCI shall collect housekeeping data –consisting of at least one temperature, one voltage, and one current reading for each major component – once per second. Major components include microcontrollers, voltage regulation and conversion circuits, ADC circuits, communications circuits, and sensors.
	SCI shall be capable of buffering at least one minute of housekeeping data.
	SCI shall transmit the housekeeping data to the OBC periodically when enabled.
Operational requirement	SCI shall implement calibration functions for the temperature thermocouples and pressure transducers. These functions shall be accessible through a simple text-based interface on the USB port.
	SCI shall implement a self-test routine accessible through the USB port and on command from the OBC.
Technical requirements	SCI shall include a USB-C port easily accessible when the avionics stack is integrated.
	SCI shall make the BOOTSEL button easily available when the avionics stack is integrated.
	SCI shall include one power LED and one status LED easily visible when the avionics stack is integrated.
	SCI shall be powered by 5 VDC supplied by the EPS on the spacecraft bus pin PWR-3.
	SCI shall provide any other voltage required via voltage conversion at Point-of-Load (POL)
	SCI shall transfer data to the OBC via spacecraft bus pins UART_E_TX (RS-485 “A”) and UART_E_RX (RS-485 “B”). The data rate shall be 115200 baud

Technical Details and Challenges (typically 1-3 pages)

How it works, including block diagrams. It should explain in sufficient detail that would allow another 4th year undergrad to follow your design.

As relevant, technical details that justify your design decisions, including mathematical analysis and references that show the project is viable. This should include 10 to 15 references to journal papers, parts specs, and technical documents.

Identify any major challenges you will need to overcome to implement the project.

We will have an in-class activity to work through block diagram examples. See the full final report for an example of the writing in this section, but recognize that the proposal will be less detailed than the final report since you have not yet discovered all challenges and you certainly have not solved them all yet.

Test plan (1-2 pages)

A test plan for verifying the project functionality via testing **all** your project objectives. You should detail any sub-system tests that you will complete before testing your final system. Whenever possible, tests should be quantitative and specify all project conditions.

<u>Past projects tend to not be sufficiently detailed in this section and thus lose points, spend time here!</u>

External Constraints, Parts List, and Cost (0.5-1 page of text plus a table)

As needed, you should consider and discuss how any relevant constraints will impact the development of your project such as:

- Part availability
- Manufacturability
- Resources and equipment required, and where you expect to get them if they are outside of your budget
- Software tools you will use

Then include a table of parts for your project. Include non-tangible costs such as software licenses or fees to access data sets. You should only price relatively pricey items (>$20). You are welcome to have a line such as "assorted resistors and capacitors" with a rough estimate cost at the proposal stage. Make sure to budget for iterations if you are designing a PCB!

Table 2. Parts list. The total cost for the prototype development is ….

Item	Supplier	Unit Price	Quantity	Total Price

Societal Impact (typically 0.5 page)

Considerations for the most relevant stakeholders with relation to public health, safety, cultural factors, environmental concerns (e.g., recyclability), and economic factors as appropriate. You will not have room to discuss every possible societal impact in half a page; prioritize discussing the 1-2 largest or most relevant impacts rather than paying lip service to every possible impact.

Example:

> Given that the primary motivation for the development of Cell Seeker is for search-and-rescue teams, the largest stakeholders are private and public SAR teams such as the U.S. Military, U.S. National Park Service, and independent firms deployed on ski mountains, state-owned forests, and other remote areas. A positive impact of this device would be to

aid in the rescue of lost, abandoned, and/or injured persons in remote areas. Safety of the public and of military personnel, especially given the large number of SAR operations annually, is the driving principle behind this project.

However, the development of a tracking device for such a common item as a cell phone raises questions about the ethics of Cell Seeker, seeing as how such a product could be maliciously used - specifically, stalking of unknowing individuals using their cell phone's pings is a major concern. This problem can be mitigated through design of the RF frontend and SDR parameters. If the RF frontend does not provide significant signal amplification and the SDR does not perform advanced signal tracking, the Cell Seeker will be less effective in densely populated buildings with more signal noise and a higher number of objects attenuating RF signals, such as buildings. Through these and other targeted design choices, the Cell Seeker will only be able to operate effectively in remote areas with lower population density where stalking is less likely to occur.

Project Management

Expectations (0.5 - 1 page)

How will you define success for your project? List your deliverables (no need for full sentences). What will you have produced by the end of the semester? This is a detailed description of the prototype, including major components like the PCB, power supplies, user interfaces, etc. Write the group member(s) who are taking primary and secondary responsibility for each sub-system.

Timeline and Group Responsibilities (1-2 pages of figures, 1-2 pages of bullets)

This section may be more informal, but the content is important. Feel free to use bullet points.

- Your Gantt chart and discussion of it. The chart should identify tasks that can be done in parallel, and those tasks that must be done sequentially.
    - You can do your Gantt chart in a spreadsheet, or you can use a Gantt chart tool. Some options (but certainly not the only ones) are: https://templatelab.com/gantt-chart-templates/, https://www.ganttproject.biz/, and https://www.officetimeline.com/online/gantt-chart-maker.
    - Make sure your Gantt chart is legible! You may need to alter the format or break the Gantt chart up into sections so that when it is presented in the report, the text will still be large enough to be read. You may also include a landscape page for the Gantt chart.

Individual Milestones: Enter name here (1-2 pages per group member)

Start each of these sections on a new page for easy printing. You can create a forced page break in Word using Ctrl+Enter.

Each group member should take responsibility for some portion of the project design. Oftentimes groups will divide work by sub-systems. Sometimes multiple students will work on a sub-system; that is good, but ***you should clearly assign individual responsibility for tasks***.

Each group member should have three sub-sections (responsibilities and background, milestone 1, and milestone 2). This will define your individual responsibility, milestones for your design work, and a rubric of how your advisor will grade you at each milestone. The rubric will serve as a guide; advisors may adjust your grade to account for unforeseen technical challenges and time spent helping team members with other tasks.

Note: while you take primary responsibility for some portion of the work, your team must still function as a team. You should expect to ask for and receive help from your team members throughout the semester, and you may have to redistribute tasks as you continue in the semester.

Responsibilities and background

Briefly list your primary and secondary responsibilities, which should include current expertise, skills/knowledge that you will need to develop to finish the project, any major challenges you anticipate, and any dependencies your work has on other group members.

Example:

> I am primarily in charge of the PCB design. I am secondarily in charge of building the case.
>
> Current expertise:
>
> - I took the PCB design class.
> - Basic exposure to CAD
>
> What I need to learn:
>
> - 3D printing
> - How to design a motor driver
> - Power management systems
>
> Anticipated challenges and
>
> - Limited space on the PCB
> - Thermal management
>
> Team dependencies

- Group member must select a specific motor in time to have the motor driver design completed

Milestone 1 (mid-October):

What will you accomplish by milestone 1? Be specific. Follow the principles of setting a SMART (specific, measurable, actionable, realistic, and timely) goal.

How should your advisor grade you at this milestone? Given the difficulty of designing a good rubric, we suggest you follow the examples and give a few anchor points (what does a 100%, 80%, and 50% look like). If you would prefer, you can set a point system for meeting different sub-tasks to further clarify grading expectations.

Ask yourself, *"When I sit down with my advisor for 30 minutes at Milestone 1, can I easily show proof of this outcome?"* If the answer is no, revise your goals and rubric.

Here are some examples. Feel free to start with one of these and modify it based on your role.

1. **PCB-focused example**: By the date of Milestone 1, I will finalize the schematic capture, verify all component footprints against physical datasheets, and complete the 4-layer compact PCB for the wearable sensor sub-system in KiCad. Success will be measured by a passed Design Rule Check (DRC) with zero errors and submission of the manufacturing Gerber files to the fabrication vendor. Rubric:
    a. **Meets Expectations (100%):** Design includes all components and a working schematic. Gerber files are submitted to the vendor; schematic and PCB layout files are completely clean with zero DRC errors and pushed to the project repository.
    b. **Close (80%):** Schematic is locked and the layout is 90% complete, but may need refinement, delaying manufacturing submission.
    c. **Below Expectations (50% or less):** The schematic is incomplete, missing critical component footprints, or contains multiple unrouted nets/DRC errors that prevent manufacturing.
2. **Firmware-focused example:** By Milestone 1, I will develop a firmware prototype on a microcontroller dev-board that configures a hardware timer to sample a dummy data array at 50 Hz and broadcast this data over BLE. Success will be verified by connecting a smartphone utility app to the MCU, subscribing to the custom GATT characteristic, and confirming the data arrives smoothly without polling. Rubric:
    a. **Meets Expectations (100%):** Firmware successfully broadcasts custom GATT characteristics triggered by a stable 50 Hz hardware timer. A mobile device can connect and receive data notifications reliably. Code is commented and pushed to GitHub.
    b. **Close (80%):** The BLE service is discoverable, but data transmission is unstable or relies on manual delays in the main software loop rather than a dedicated hardware timer interrupt.
    c. **Below Expectations (50% or less):** The MCU cannot be discovered over BLE, or the firmware fails to compile due to unresolved protocol stack errors.

3. **Coding-focused example**: By Milestone 1, I will set up a local Conda virtual environment on the Raspberry Pi 5, successfully run an open-source PyTorch keypoint model, and execute a Python script that outputs classification text to the terminal. I will demonstrate a live webcam test correctly identifying at least 4 discrete hand gestures with >85% confidence. Rubric:
    a. **Meets Expectations (100%):** The environment runs smoothly on the Pi 5 ARM architecture. The script processes live camera frames in real time and prints accurate gesture definitions for 4 or more classes.
    b. **Close (80%):** The gesture model runs on a PC/laptop architecture but fails to run on the Pi 5 due to unoptimized dependencies, or the frame rate is too slow to be usable (< 5 FPS).
    c. **Below Expectations (50% or less):** The script fails to run entirely, or dependency conflicts prevent the model from loading into memory.
4. **Circuit-design example**: By Milestone 1, I will research MURS band FCC regulations to ensure compliance, design the audio transmitter interface schematic, and construct a functional breadboard prototype of our input amplifier. I will verify performance by injecting a 1 kHz test signal and proving clean, unclipped microphone passthrough audio across an oscilloscope. Rubric:
    a. **Meets Expectations (100%):** The breadboard audio stage operates cleanly with measurable gain, zero unexpected clipping, and a completely documented compliance report for MURS operations.
    b. **Close (80%):** The schematic is drawn and the breadboard passes audio, but significant clipping or noise coupling occurs at typical operating voltages, requiring design revision.
    c. **Below Expectations (50% or less):** The circuit does not pass audio on the breadboard, or the design relies on illegal radio modifications that violate FCC guidelines.
5. **Mechanical-focused example:** By Milestone 1, I will print the V1 structural chassis containing custom battery slots and PCB mounting points, and assemble the linear actuator claw subsystem. I will verify mechanical tolerances by fitting dummy components into the chassis and demonstrating that the actuator securely clamps onto the two target hydraulic syringe models. Rubric:
    a. **Meets Expectations (100%):** Chassis V1 is printed and houses the batteries and mounts cleanly. The claw mechanism successfully holds both target syringe types without slipping under simulated mechanical load.
    b. **Close (80%):** The chassis and claw are fabricated, but structural tolerances are slightly off—requiring a dremel or manual sanding to get components to fit cleanly together.
    c. **Below Expectations (50% or less):** The parts have not been printed, or the mechanical design fails to lock the linear actuator/syringes in place, preventing system live testing.
6. **ML data cleaning example:** By the date of Milestone 1, I will build and execute a Python data preprocessing pipeline that ingests raw scraped dataset fields, isolates unique topical categories, and groups them into a clearly defined 3-tier parent-child hierarchy. I will measure success by running a custom cosine similarity script to automatically flag

and deduplicate at least 95% of semantic duplicates (e.g., case sensitivity variations, acronyms, and synonyms), outputting clean `node.csv` and `edge.csv` files that conform to our team's locked schema diagram. Rubric:

a. **Meets Expectations (100%):** The data cleaning and deduplication scripts are complete and run without errors. The hierarchical topic data is fully mapped into separate node and edge CSV files that accurately represent the 3-tier hierarchy. Edge connections are structurally sound with zero orphan nodes, and the pipeline code is fully documented and pushed to GitHub.
b. **Close (80%):** The script successfully processes the data and creates a hierarchy, but the string deduplication threshold requires significant manual correction for semantic edge cases (e.g., missed acronyms or minor syntax variations). The resulting CSV files require format tweaking before they can be ingested by the team's graph platform.
c. **Below Expectations (50% or less):** The data remains flat or unstructured because the script fails to handle syntax variations. No distinct node/edge hierarchy maps are produced, stalling the team's ability to begin building vector embeddings or setting up the graph database.

Milestone 2 (week before Thanksgiving break):

Same as above, but for the second milestone. During your milestone 1 meeting, you can discuss changes to this section given that many teams often find your project and thus your individual tasks will shift.

In addition to the technical accomplishments, list which section of the final report you will draft by this time.

Statement on Artificial Intelligence

If you do not use generative AI (GAI) tools beyond simple copyediting (e.g., Grammarly, Word grammar checkers), then include the statement: *"We have not used generative artificial intelligence in this manuscript beyond simple copyediting."*

If you use generative AI tools are used, authors must disclose how and to what extent they were applied (e.g., data analysis, manuscript drafting or revision). Disclosures should include prompts provided to the AI when possible, and relevant details must also appear in a methods section if AI contributed to the research itself.

References

These should be done in IEEE reference format [1]. An example is shown below. A great tool for doing this is found at Zotero.org [2]. You should have 10 to 15 solid references for a good proposal, e.g., publications, manufacturers' websites, and .edu. At least 2 sources should come from IEEE or ACM databases. Additionally cite any 'popular science' sources or hobby site that you reference.

[1] C. Freid, "Are required courses meeting industry demands?," *IEEE Potentials,* vol. 20, no. 3, pp. 39-40, 2001.

[2] "Zotero: Your personal research assistant," [Online]. Available: www.zotero.org. [Accessed 02 Sep 2020].

Grading

Your submission should be delivered as a pdf, and have a file name format:
CapstoneProposal_*YourTeamName*.pdf

View the full rubric on the assignment on Canvas.