Capstone Project Proposals

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A project proposal is the document that describes the what, why, how, and when of creating a product or service. It's really three different documents combined:

1. **Background and Research:** ramping your reader up on your project’s domain.
2. **Product Design Specification:** a description of what product or service you're going to build.
3. **Project Management Plan:** a description of how and when you're going to build it.

## Formatting

You should do all the things you should already know to do for a formal document:

* Sane margins and a cohesive font choice.
* Title, author, date, version number.
* Number the pages. Best is a format like "i/j" pages so the reader knows where they are.
* I strongly suggest a table of contents (automatically generated, of course) if there are more than about ~4 pages, or there are a lot of sections.

## Writing Style

Please don't use the passive voice. Your document should be written in a direct and *concise* fashion. Some of the best PDS are just a few pages long. There's no reason to sound "fancy" or "scientific", which are code words for convoluted, passive, hard to read sentences which people think makes you sound smart. They don't. People who write this way often actually don't know what they're trying to say, and are hiding it with poor writing. Use direct, short, active sentences. Use "we" and "our". Does that sentence sound weird? Take a step back, and say it more simply.

## Collaborative Process with your Sponsor

This is **not** a document your team writes and hands to the industry sponsor as a finished product. Your project proposal **must be reviewed** by your industry sponsor and **must be signed off.** So send your industry sponsor a rough draft early and often, so that they’re in the loop and there are no last minute surprises. This document will literally be a contract between you and your sponsor.

Below is what we’re going to expect in the project proposal. Customize to your project; not every bullet point will apply!

# 1. Executive Summary

This is the "30 second elevator pitch". It's the 100 km view of the *project*, not just the product. It should answer the quick "who, what, why, and when." It should use as little technical jargon as possible, and clearly describe to a technically competent reader what you're going to do for the next 6 months. They should understand in broad terms what you're going to make and what you’re going to do after reading this. It should be 2 to 5 (at most) paragraphs. Sometimes, the executive summary is the hardest part of a proposal to write, so you might keep it to the last section to write!

# 2. Background and Research

In order for you and your reader to understand your capstone, you need to provide all of the relevant background information. This is a critically important section; it describes everything the reader needs to understand about your project up to the point that it was handed off to you. Here are some of the things it should include:

* Describe the sponsor (who, what they do, how large, etc.) and what their business is (if they have one).
* Describe / explain the project’s technology domain or context if it’s not obvious. Include why these systems exist, what they do, and briefly how they work. If your project fits in a larger system, briefly describe the larger system that it fits in.
* Describe HOW these kinds of systems work, if it’s not obvious and if it’s relevant
* **Describe exactly what has been done on this particular project (if anything), and how your project fits in**. Is this a revision of an existing system? An addition to the system? Both? Describe the existing system, possibly even with pictures or a block diagram to make it clear what it is, and how it operates.
  + If nothing has been done on this project yet, are there comparable products or projects that exist? Similar technologies or direct competitors? Include them if they’re relevant or help describe your project.
* Include pictures! Sketches! Figures! Graphs! Whatever you can to try and make this more real. Try and capture the current state of what you’re about to dive into.

## Research

You’re going to become domain experts in this field/project/area. You’ll need to do research to be that! Do your research and write it up in detail. Don’t just list your findings, discuss and analyze each one. How is it relevant? What features are good or bad? You’re going to to all of the Googling and research and write up in your proposal at least three areas:

#### Commercial Off-the-Shelf Products

Are there any commercial off-the-shelf projects that can help with your project? Can your industry sponsor buy these? List them here, *with a discussion of if/how they’re applicable*.

#### Open Source Projects

Are there any appropriately licensed open source projects out there that can help with your capstone? This could mean schematic and PCB designs, Python libraries, C libraries, MATLAB examples, etc etc. Can you use these open source designs? That depends on your project’s IP requirements and the IP license of the open source project. What’s good/bad about them?

#### Patents, Papers, White Papers, Articles, Conference Proceedings

Google All the Things. Look up patents, look at commercial white papers, look up scholarly articles including conference proceedings. Can you find things that are directly applicable to your project? Put them here, with a short writeup of what’s applicable about each one.

# 3. Product Design Specification

This section is your "standard" PDS. The important thing to remember is that it's a contract between you and your industry sponsor (and faculty advisor) that codifies what you're going to design and build. After reading the PDS, a reader should be crystal clear on what your product/service is, what parts of it you're going to deliver, and how you're going to approach the problem.

## Product Overview

OK, we have the background, now describe what you propose to make for your industry sponsor. This section is a general description of what the industry sponsor is asking for, the general terms of what you’re going to build, **how it works**, who is going to use it, and how they're going to use it. The Concept of Operations (often called "conops") and user stories can help describe to your reader in a concise format *exactly* what you're being asked to create. You should be answering questions like:

* What does this thing/service do?
* How does it work?
* Who uses it?
* Why would they want it? What does it do for them?
* How does the sponsor get it to the users?
* How do the users use it? What does the user need to use it?
* What’s its lifecycle? What’s its timeline?

Again, bonus points if you can use sketches or CAD drawings or even competitors pictures to paint a picture of the thing you’re going to design/build/test. It might even make sense to include an L0 or L1 block diagram for clarity, although you should still put it in the PDS below.

## Stakeholders

This is a formal list of the stakeholders in the project. Often this is the industry sponsor, the users of the project, and feel free to list yourselves as the project team. Stakeholders may be more than you think; is the purchaser of this system the same as the users? I.e., who makes the decision to purchase the system? Who uses it? Who has to service it? Who determines when it's at the end of its useful life? Most importantly, does anything about your stakeholders affect how you do this project, or emphasize certain parts of it?

## Requirements

These are the requirements of your product. Often called "User Requirements" or "Marketing requirements". Don't forget that requirements are abstract, verifiable, unambiguous and written as a concise statement, traced to a user need, and realistic. You can list requirements you must meet, or you can break them into "must", "should", and "may", especially if it’s possible you might not hit all the requirements in the next 5 months.

REMEMBER: Unless the user is specifically requiring the "how", this is *not* the "how" section. The requirements are about what requirements your project must deliver on, in an abstract way. "Must last 3 hours when on battery power" is a good example requirement, "Uses 2.5 Ah LiPo battery" is *not*.

## Specifications (optional)

Specifications and requirements are often mixed up. Specifications are the hard numbers that you have to hit. Sometimes you won't need a specification section, the requirements are good enough. If you have a lot of hard requirements, however, it might be a good idea to have the requirements be your abstract, user-centered requirements list and then add a specification section that lists the hard specifications. Also, sometimes your industry sponsor throws some very specific technical requirements here (e.g., “Must use an STM32 processor”), you can put them here in specifications.

## Initial product design

OK, NOW, FINALLY, describe what you think you're going to make. Remember, this is a *proposal*. You literally don't know all the answers, so make sure your product design section is chock full of questions and discussions. Remember, *you don't have to know all of the answers!* This is a learning process. Even in industry, there should be questions and discussions in the design section.

Things to include here:

* Hardware architecture
  + **Block diagrams (L0, L1, maybe even L2)**
* Software architecture
  + Languages and development environments
  + Data flow diagrams
* User interface / experience
  + How is the user going to use this thing? E.g., User stories of how the end-user actually uses your product
* Other considerations
  + Security (physical, electronic, and software)
  + Regulatory compliance

Some important notes:

* If you’re doing a revision of an existing system, you MUST call out what already exists and what parts you’re adding/modifying so it’s crystal clear what part your team is doing.

While we encourage you to use MS Visio or Inkscape or LucidCharts to draw diagrams, do *not* be afraid to include some hand sketches here! Photos of whiteboard drawings, for example, are worth a thousand words and are much, much faster than, say, a full SolidWorks drawing. Crop them down and try to make them as presentable as possible.

## Verification plans

Once you've built your Thing™, how do you know that it works, or it fulfills the requirements? It might be as easy as filling out a bullet point of features, but usually this involves a test where you formally record the results. This way you have proof that the system met its "must" requirements (or not) before hand off to the industry sponsor.

**At the very least, write out a testing strategy that will prove that your system works.** At the most, include detailed test plans here. You probably can’t do a detailed test plan here, and that’s OK, but you can say “we’re going to [insert description system test here] and the system will [insert description of what the system should do if it works]”. Maybe even include a series of critical pass/fail criteria that will show that your system works and meets requirements. Including this in your PDS will help the sponsor understand what you're going to deliver in more detail. Also, it might not be possible to create a *detailed* test plan right now, because you might not yet know how you're really going to solve this. But a short section on what and how to test your final product should be possible.

## Risks

Discuss some risks, both technical and existential.

* What are the big risks? How are you going to answer them quickly?
* What are critical questions you still need to answer?
* What maybe can’t be answered, but you have to move on anyway?
* Back up plans: What if things go wrong? What can you fall back to? What can you deliver if nothing else?

## Deliverables

This critical section specs out what you're going to deliver to the industry sponsor by the end of your capstone. This **must** include:

* Project proposal
* Weekly Progress Reports
* Final report
* ECE Capstone Poster Session poster
* Any other documentation or activities (presentations) your *faculty advisor* requires

And, *oh*, *right*, you should probably also deliver the project you're building for the industry sponsor. This is very different for each capstones, so here's an example listing of some of the things you might be expected to deliver:

* Detailed design documentation, explaining how your what your design does, how your design works, and why you made the decisions you did
* Simulations, including both the simulation inputs and outputs
* Electrical CAD: Schematics and board layouts, including output files (Gerbers, PDFs, etc)
* Mechanical CAD: enclosures, mechanisms, including output files (STLs, PDFs, etc)
* Bill of materials and pricing
* Discussion on manufacturing, servicing, updates, upgrades, etc.
* Short user manuals documenting how to use your creation
* Version control, including checked in previous revisions of your design (e.g., a Git repo).
* A working prototype
* A manufacturable design

Finally, include how you’re going to deliver them. In a Github repo? In a Google Drive? Be specific about your deliverables.

# 4. Project Management Plan

Now describe, in detail, *how* you're going to actually do this.

## Timeline, with milestones

Use a Gantt chart. It can be simple (Word table or Excel spreadsheet) or it can be fancy (MS Project, ProjectLibre, or some online Gannt program like Asanna and InstaGantt).

Emphasize quick prototypes, iterating on prototypes, testing prototypes, getting user feedback. We’ve taught you agile methods - try to deliver value as soon as possible by paralleling development as much as you can. Lots of bad prototypes that work are WAY BETTER than a great thing that doesn’t work in the end.

However you do it, you'll need carefully think about how much time things are going to take, multiply it by a factor of 3 for the fact it's *way* more complicated and harder than you think, and then by a factor of 4 because you theoretically only have 10 hours a week to work on Capstone so you're 0.25 FTE (full time equivalent), and *now* you should be panicking about getting your project done and handed off before the end of May. Your timeline should be realistic: it's going to take time to get PCBs, components, and development boards. Things are going to go wrong, and you've underestimated how much time some parts of your capstone will take. Try to factor that in by providing wiggle room in your schedule for unexpected delays.

Milestones to include will depend on your capstone, but might include: research phase done, initial design done, first schematic, development tools up and running, board layout, first working prototype code, first integrated prototype, second prototype, third prototype, etc.

DO NOT FORGET TO INCLUDE TIME FOR:

* Writing the project proposal
* Writing the final report
* Writing / presenting other documents
* Creating the final poster

Please include a readable timeline. If you have to, link to another document, or include an appendix, or something so everyone can see, and read, your timeline.

And finally, try to think carefully and put some effort into your timeline. An artificial timeline that is a bunch of artificial tasks that you don’t understand or can’t quantify is a waste of everyone’s time.

## Budget and Resources

What's your budget? What do you need to buy? And when? And what other resources do you need that your industry sponsor has told you they would provide? List it here.

This section should also include resources *you* are bringing to the table. For example, are you using the EPL? List that as a resource. Where are you going to set up and build your project? Do you need a locker to store your capstone in? A work area at PSU?

## Intellectual Property Discussion

Who owns the IP? Is it under a license? You should already know this from the sponsor, but it’s absolutely required to say it here so that everyone agrees.

## Team

A short section on your team. Try to include:

* Who are the team members and what are their skills? Just some bullet points are fine, no need to include full resumes.
* What are each of the team members going to do? You might not know yet, of course.
* Who is going to be the point person to be communicating with your industry sponsor and faculty advisor?
* Is there a team leader for your group? Who is that?

## Development Tools and Process

Tools and processes you’re going to use to get this done.

* Are you going to follow a method, like Agile, or spiral, or ? Discuss what you plan to do.
* What collaboration tools are you going to use?
* What technical tools / languages / etc are you using? CAD, CAM, etc? Be specific if you can.