Senior Design Handbook

2022

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Electrical and Computer Engineering
Data Analytics and Systems Engineering
University of Colorado at Colorado Springs

Based on the MAE Senior Design Handbook
which was kindly provided by Drs Gorder and George

Contents

Course Syllabus

ECE 4890/91 *Senior Seminar,* and ECE 4898/4899 *Senior Design Project*

Class Times:	Friday, 0800-0915 (ECE 4890/4891) Friday 0925-1040 (ECE 4898/4899)
Class Location:	ENGR 107 or 109
Instructors:	William Michael bmichael@uccs.edu 719-321-9615 (mobile)
Office hours:	Regular meetings will be set up for each group once projects are allocated.
Textbook:	System Analysis and Design, Dennis, Wixom and Roth. (available from the Kraemer Family Library as an e-book)
Prerequisites:	ECE 3110, ECE 3205, ECE 3220, ECE 3430, ECE 3610, ECE 3611, or consent of instructor.
Attendance:	Students are expected to attend class.

Course Description:
The ECE Senior Design Capstone two-course sequence is the pinnacle event for electrical engineers, computer engineers, and DASE engineers. To be admitted to the sequence, you have completed a substantial number of courses in electrical engineering, computer engineering, and data analytics and systems engineering. During this course, you and your team will complete a project for an external company, private entrepreneur, not-for-profit organization, or internal professor. The entity or person for whom you are completing your project is referred to as the *sponsor*. You will apply your engineering knowledge to meet engineering requirements while interfacing with the needs of your real-world sponsor. You will learn and apply design processes, as well as organizational and managerial skills and processes. Your team will be assessed through your written work (engineering specification documents, management documents, and final reports) as well as the final product and deliverables specified by your sponsor. Your professionalism in the workplace is also an important factor in final grades.

Learning Objectives:
At the end of this course, students will be able to:

1. Explain the role of systems engineering for a structured engineering design process and describe the systems engineering approach of the engineering design process.
   a. Explain the roles and responsibilities for project *stakeholders,* including sponsors, faculty, teaching assistants, and fellow group members
2. Develop a comprehensive project plan for a typical engineering design project.
3. Identify and manage customer requirements, associate these requirements with engineering specifications and set targets for these specifications using the Quality Function Deployment technique.
4. Perform a systematic process of generating, evaluating, selecting and prototyping design concepts for an engineering design project.
5. Develop a prototype product using the development process based on systems engineering artifacts developed in Objectives 2-4.
6. Analyze the economic aspects and impact of a proposed engineering design.
7. Analyze the social impact of a proposed engineering design.
8. Consider the ethical and sustainability aspects during engineering design.
9. Work as a productive member of a diverse design team.
10. Recognize the value of modeling and employ modeling during the design process.
11. Communicate individually and as part of an engineering design team in a professional manner.

Grading:

Throughout the course, students will be demonstrating their abilities to work as engineers. This includes academic/technical abilities and the ability to function satisfactorily as a member of an engineering team. Appropriate behavior working within the team and with other stakeholders is expected. Interactions with sponsors, faculty, teaching assistants, and fellow group members should meet the standards of a professional environment. Any student deemed not ready to take on the responsibilities of an engineer or to contribute meaningfully to their group will be removed from the program.

Teams will produce several documents and reports during this two-course sequence. These are detailed in the remainder of this document. Each document and report should be viewed as essential to the design process and, accordingly, to your progress and grade. You will be assessed on the quality of your work, as well as the professionalism of your interactions with both faculty and your sponsor. Your final semester grades will be based on your instructor's overall evaluation of your work throughout the semester. Numerical grades will be given only for Engineering Specification Report and the Final Report. A formal grade breakdown for the course will not be used.

Exams:

There are no exams for this course.

Disability Policy:

If you are a student with a disability and believe you will need accommodations for this class, it is your responsibility to register with Disability Services and provide them with documentation of your disability. They will work with you to determine what accommodations are appropriate for your situation. To avoid any delay, you should contact Disability Services as soon as possible. Please note that accommodations are not retroactive and disability accommodations cannot be provided until a Faculty Accommodation Letter has been given to me. Please contact Disability Services for more information at Main Hall room 105, 719-255-3354 or dservice@uccs.edu.

Military Policy:

Military students who have the potential to participate in military activities including training and deployment should consu lt with faculty prior to registration for any course, but no later than the end of the first week of classes. At this time, the student should provide the instructor with a schedule of planned absences, preferably signed by the student's commander, in order to allow the instructor to evaluate and advise the student on the possible impact of absences.

In this course, absences due to participation in verified military activities to be excused absences, on par with those due to other unavoidable circumstances such as illness. If, however, it appears that military obligations will prevent adequate attendance or performance in the course, the instructor may advise the student to register for the course at another time.

Institutional Equality:

UCCS does not discriminate on the basis of sex in employment or in its education programs and activities, and is committed to providing an environment where all individuals can achieve their academic and professional aspirations free from sex discrimination. UCCS prohibits sex discrimination, including "sexual misconduct," as defined in CU policy. "Sexual misconduct" includes sexual assault, sexual exploitation, intimate partner abuse, gender/sex -based stalking, sexual harassment, and any related retaliation. UCCS does not tolerate acts of discrimination or harassment on the basis of race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender express ion, veteran status, political affiliation or political philosophy in admission and access to, and treatment and employment in, its educational programs and activities. Faculty, staff and students may report allegations of sexual misconduct, discrimination or harassment to the UCCS Title IX Coordinator. Additional information can be found at www.uccs.edu/equity

Course Deadlines

Course deadlines are listed in the tables below. The design documents will be turned into the team's assigned faculty instructor. Sponsor signatures must be obtained showing that the team and sponsor have completed the required design reviews. These signature pages must also be submitted to the team's faculty instructor. Descriptions of each deliverable are given in the remainder of this document.

Document	Deadline	Sponsor signature required?
Problem Specification Documents	April 15 (recommended)	No
Engineering Specification Report and Presentation	May 6	No
Conceptual Design Report	September 2	No
Critical Design Documents	October 14 (recommended)	No
Final Report	December 2	No

Design Review	Deadline	Sponsor signature required?
Preliminary Design Review	April 15 (recommended)	Yes
Conceptual Design Review	September 2	Yes
Critical Design Review	October 14 (recommended)	Yes

Engineering Design Final Presentation and Exposition: December TBD

Course Structure

The Senior Seminar and Senior Design program is a two-semester capstone culminating in the Engineering Design Exposition in December, 2022 (date TBD).

Senior Seminar Semester: TBD

Lecture and Discussion Topics will include some or all the following:

Systems engineering
Requirements definition
Specifications
Project management

Senior Design Semester:

The class will meet weekly during the Fall semester. During this meeting, teams will present an informal update, listing progress to date, setbacks, and other items of interest. The intention is to bring the teams together during class time and allow teams to have time for design activities.

Teams are expected to meet weekly with their faculty instructor/advisor through the Senior Design semester.

The Digital Engineering Notebook

Each team will create a Digital Engineering Notebook (DEN) using Github (or a similar service). The basic format of the DEN will be provided with design teams having the flexibility to add or modify the DEN to meet their needs. Access to the DEN shall be given to team members, the ECE Senior Design Capstone Coordinator, sponsors, and others, as appropriate. Teams are free to set access permissions for the DEN as they deem appropriate.

The DEN is the central repository of information and knowledge about your project. In model-based systems engineering, this information would be incorporated into a system model and would serve as the "Authoritative Source of Truth" or ASoT for the entire project. Any stakeholder could go to the DEN and have questions answered about the project, including design documents, schedules, budgets, specifications, etc.

More information will be provided about the DEN and expectations for this critical repository of information.

Project Plan

The Project Plan is a management document used to manage project activities. For the Project plan, you will create a project schedule that includes allocation of project resources, such as personnel, labs, and test equipment or environments. The Project Plan can be in the form of a table with each row corresponding to a different task which must be addressed throughout the course of the project, but in any case, the following detail should be included in the description of all tasks and subtasks. Subtasks are often useful to map out individual components of the major tasks. Tasks and subtasks are numbered and should also be reflected in the Gantt chart using the same numbering (see Gantt Chart section below).

Task Label:

Each task should be clearly labelled using either a number or letter. Subtasks can be labelled using a nested numbering scheme with either letters (1a, 1b, 1c, etc.) or numbers (1.1, 1.2, 1.3, etc.).

Task Action:

The task action contains a brief description of the task or subtask.

Inputs:

Inputs shows the predecessor tasks required for the task; that is, tasks that must be completed prior to starting the task in question. For example, prior to executing the task of creating a PCB, the tasks of creating the schematic and (possibly) modeling the design must be completed. Inputs are usually specified using the number labels of the predecessor tasks. Some tasks, particularly those early in the process, may not have any predecessor tasks. In this event, leave this field blank.

Resources:

The Resources field lists that which is needed to accomplish the task or subtask. Potential resources include a variety of items such as: Engineering-hours, equipment, turnaround time, physical resources such as metals, chemicals, computers, and more. Use your engineering judgement to add to this short list of resources. Small or common items such as paper, pencils, etc, are not appropriate to be included unless there is something unusual about them. For example, if your design photo-senstive paper and pencils, consider listing these as Resources. Additionally, Resources are those objects or items that need to be identified ahead of time to make sure that they are acquired and available when needed by the project.

Outputs:

The outputs define the end product of a task. Outputs from a task or subtask must be, unambiguous, detailed and measurable. For outputs which are inputs to future tasks, the number labels of the future tasks can be listed. For example, if the task is to Create a Schematic for Thermocouple Interface, the input would be the completed schematic itself.

Gantt Chart

The Gantt Chart will thoroughly present the project's schedule. This chart translates the Project Plan into a schedule that provides a graphical depiction of the path to successful completion of the project. All tasks and subtasks contained in the Project Plan are shown on the Gantt Chart with beginning and end dates consistent with precedence relationships and known due dates. Tasks and subtasks must be numbered and correspond exactly to those used in the Project Plan (see Project Plan section above).

The Gantt Chart is a roadmap or guide that teams use to accomplish their projects over the year. This improves the groups' organization and allows a broader view of the project scope. Additionally, the Gantt Chart helps faculty follow each group's work. The chart will begin as an approximation and will need to be routinely updated as the timeline becomes clearer. All modifications must be documents and justified, and all previous versions must be kept on file so that changes can be easily tracked.

Gantt Charts for the course must be created electronically, but any software that the teams prefer can be used. There are a variety of free Gantt Chart creation programs available online. Additionally, Gantt Charts can be created using Microsoft Project or Microsoft Excel. The project's Gantt Chart is created at the beginning of the project and must be included in the Final Report.

Problem Specification Documents

The purpose of the Problem Specification process is to come to a quantified definition of success in meeting the customer's needs, where, in this context, the word "customer" refers to all of the different stakeholders who would have a stake in design decisions. The culmination of this effort is called the Engineering Specification, but the Problem Specification Documents include the build up to that culmination as well.

This can be a difficult step in the process, or it can be straightforward, but it is a critical – and frequently, the most critical – step. While the desire will be to jump past this as quickly as possible, it is important that sufficient attention be paid such that an appropriate specification is created. It is important to note that, while there is a suggested due date for the completion of this phase of the design process, there is no imposed hard date. Teams should aim to satisfactorily complete the Problem Specification as quickly as possible. The conclusion of this phase of the design process is the Preliminary Design Review, where teams will discuss the quantified, measurable definition of success with their sponsor.

Teams may use any number of approaches to accomplish this phase of the project. Some sponsors may prefer a particular approach. Teams who do not receive specific direction from their sponsor may wish to use either or both of the Quality Functional Deployment (QFD) methods described in the sections below. These are known as the Developed Method and the House of Quality.

Overall, the QFD is a set of documents that identifies and fully characterizes a sponsor's problem, and provides a systematic approach to the generation of an Engineering Specification. It does not contain any design work, and it is vital to not consider possible designs at all when creating the document because that could lead to a problem statement that fits a solution rather than a solution that fits a problem statement. Rather, the QFD is used only to fully define the problem and clearly identify the requirements which need to be accomplished for a successful project. All QFD documents contain the same sets of information which are described in the sections below.

Customer Requirements:

Customer requirements are compiled and prioritized as the first component of the Quality Function Deployment. These requirements can take many different forms. Each requirement should be able to be written in the form "the device must…". Examples of good requirements are "the device must be lightweight", "the device must be portable", "the device must be inexpensive", etc. Requirements which only make sense in the context of a specific type of design are heavily discouraged since satisfying these requirements can force a team into using that specific design approach instead of considering all possibilities. To ensure that the specification is comprehensive, requirements from a variety of sources should be included.

Sponsor Requirements:

Requirements which are directly given by the sponsor are obviously important to include. The relative importance of each requirement should be determined from the sponsor (mandatory, important, or unimportant). Additionally, a justification for why the requirement exists should be understood. If a justification for the requirement cannot be found, that requirement should be eliminated.

Additional Voices Requirements:

Requirements from other constituencies who would have a stake in design decisions must also be included. These sources can include the customers who will buy the product, the manufacturers who will produce the product, or the sales and marketing people who will sell and market the product. These additional sources provide different perspectives which can help make sure important requirements are not overlooked.

Engineering Parameters:

Engineering parameters are the measurable quantities and/or objective quantities that define what it means to satisfy the customer requirements. Where customer requirements are, themselves, measurable, they would appear in both lists. Effort should be made nonetheless to think about other measurable quantities that could have an impact on a given requirement.

Competitor Analysis:

The QFD also compiles information related to how competitive solutions to the same or similar problems have dealt with requirements of the given problem. Note that “competitive solutions” could imply solutions derived by your sponsor’s competitors, but it could just as easily mean current solutions of your sponsor that they would like improved upon, or solutions to only tangentially related problems. This process involves evaluating how well the competitive solutions satisfy the customer requirements that you have just established. Much can be learned from a competitive solution that does a good job of meeting requirements. Analyzing these solutions can provide insight into possible other solutions. Conversely, knowledge of what to avoid can be gained by analyzing competitive solutions which fail to meet requirements. A competitor analysis can also be used to determine target engineering values for requirements by evaluating what the various competitive solutions do well and what they do not, and then determining if specific measures can explain that result.

The competitor analysis section of the QFD should first list the competitor and which of the sponsor and additional voice requirements are satisfied by that competitor. Next, the specific feature(s) which satisfy those requirements should be listed. Finally, any risks that the competitor assumes with their solution should be noted. These risks are typically ways in which the competitor’s design could fail to satisfy the requirements and are noted since they demonstrate shortcomings of the competitor’s design.

The objective of the QFD is to identify as many different measurable quantities as possible that are associated with each of the customer requirements. This is a particularly difficult part of the process when dealing with a customer requirement that is not directly measurable. For example, a requirement of “the sensor shall detect any obstacle within 3m” presents a challenge. The idea is to come up with as many different measurable quantities associated with this requirement and then set appropriate target values for each. There may be many parameters associated with detecting an obstacle (how large an obstacle, detected and localized, does the velocity vector of the obstacle need to be determined, etc) may be found, but setting the target values for these parameters to quantify “detected” is a challenge. Competitor analysis can help in this regard. By analyzing the values of these parameters for various competitive solutions and considering obstacle detection, the proper target values for the engineering parameters can be chosen.

Developed Method:

The Developed Method document is a simple, tabular approach to generating the customer requirements, engineering parameters, and competitor analysis. A simple template can be found in which this information can be recorded.

House of Quality:

The House of Quality is the tabular synthesis of the customer requirements, engineering parameters, and competitor analysis. The central matrix on the table indicates the correlation between each of the engineering parameters and the corresponding customer requirements. During the design phase, teams may discover that they cannot meet every specification. It is often the case that two requirements are contradictory; it is impossible to meet both. In this event, the correlation matrix presents a way to relate the offending parameters back to the customer requirements that would be at risk of not being met, and those requirements’ relative importance can help guide the give and take in the design process.

Engineering Specification Document:

The list of engineering parameters along with their associated target values constitute the Engineering Specification Document (ESD). The ESD forms the basis for the contract between the client and the design team, whether that is an external company-to-company contract or an internal agreement. The ESD completely defines the objectives of the design effort. In other words, when the design team delivers a product that has been demonstrated to meet the specification, the design would be a complete success. This is important because the last thing the design team wants to hear is that it failed to identify a requirement into consideration when it thought the design was complete. It’s important that the ESD be comprehensive in its list of measurable parameters and justifiable in its target values for each.

Engineering Specification Report

This report is the major piece of work to be graded for the Senior Seminar Semester. It presents the complete Engineering Specification Document and explains how the requirements and engineering parameters were determined and why they correctly capture the project and the characteristics of its solution. You are free to customize by adding sections to the Engineering Specification Report (ESR) but it must contain the following:

Introduction:
A thorough description of the sponsor, the problem, and the engineering importance of the problem is required.

Methodology:
A description of the process used to determine customer requirements and engineering parameters should be given. This includes a description of the QFD methods presented during the Preliminary Design Review. The QFD itself must also be included in the document either in the main text or as appendices. A description of the voices used and any research into competitors should also be discussed.

Customer Requirements:
The customer requirements should be included, along with detailed justifications for why each requirement is important to the success of the project. The relative importance/priority of each requirement should be discussed and justified.

Engineering Specifications:
Engineering parameters which are used to evaluate the success of a given project requirement should be described. These parameters must be objective and/or measurable, and the reasoning behind choosing specific values of the parameters must be fully justified. The relationship between individual parameters and individual requirements should be fully explained.

Conceptual Design Report

The Conceptual Design Report presents a variety of conceptual designs which could satisfy the sponsor's problem and discusses the advantages and disadvantages of each. This document should conclude with a suggestion for one solution that will be pursued for the remainder of the project. This document is presented and discussed with sponsors during the Conceptual Design Review. The Conceptual Design Report should contain (at a minimum):

Description of Solution Concepts:
A brief description of each solution concept should be given. These concepts do not each need to fulfil the entire problem requirements; parts of the problem can be addressed by each concept and combined into a full solution concept if necessary. Conceptual solutions should be distinct from one another and should not just be minor variations of one main concept. Specific details such as dimensions, masses, brands, etc. do not need to be given at this stage. The document should "paint a picture" of the overall idea of each concept.

Comparison of Solution Concepts to Problem Requirements:
Each solution must be compared against the problem requirements to determine how that solution concept will meet the requirement. The specific manner in which the requirement is met by the concept must be discussed. If a concept does not meet a requirement then this should also be mentioned.

Decision Matrix:

A decision matrix which compares the concepts should be included and used to determine a best solution. A decision matrix lists the main project requirements as separate rows. Each column in the decision matrix represents one of the solution concepts. At each row/column intersection, a number is placed which represents how well the concept satisfies the requirement. The sum of the numbers in each column indicates how well the concept satisfies all requirements. Weighting can also be applied so that some requirements affect the total sum more heavily. A comparative"+/-" technique can also be used rather than numbers to simplify the process.

Concept Recommendation:
The decision matrix should be used to recommend a concept to pursue. This concept does not necessarily need to be the top-scoring solution from the decision matrix. If the concept is not the top-scoring solution from the decision matrix then an explanation for why this solution was chosen should be given.

Plan to Complete the Design:
The Conceptual Design Report must include a plan to complete the design. This does not need to include every detail but should have most of the scheduling mapped out to the end of the project. Time should be allotted for finalizing the design, ordering parts, prototyping, construction, testing, and making final adjustments to the design. Project milestones should be highlighted. The Gantt Chart and Project Plan should be updated until the end of the project at this point. It may be helpful to include these charts in the conceptual design document in a summarized form.

Testing Documents

After a design has been approved, construction may begin (if required). Prototypes may need to be tested to ensure the product functions in a way that satisfies the design requirements. The testing process must be well planned, carefully performed, and the data properly analyzed and reported. Testing here could include physical testing and/or computational modelling.

Test Plan

A Detailed Test Plan must be presented to your faculty advisor before testing begins. In it, teams should present the following sections (at a minimum):

1. Introduction
2. Methodology and Procedure
3. Results and Analysis

Introduction
The reason that the test is required needs to be documented. Particularly, clarification needs to be given on which aspect of the device or product is addressed by the testing. This section mainly deals with describing the need for the testing and the specific information that needs to be obtained.

Methodology and Procedure
The testing methodology must be described. Any equipment to be used should be discussed, and the test setup should be described in sufficient detail such that another researcher could reproduce the setup. The testing procedure should also be sufficiently described (in report format) such that the procedure could be duplicated.

Results and Analysis
Teams should describe what data will be taken, why this data was chosen, and how it will be analyzed.

Testing Report

Once testing has been approved and completed, a final Testing Report should be written. The Testing Report will appear in the final report, either in full or as an Appendix if it is summarized in the main text. It should include, at a minimum, the following sections.

1. Introduction
2. Methodology and Procedure
3. Results and Analysis
4. Discussion and Conclusions

Introduction

This section contains the same info as the Introduction from the Test Plan.

Methodology and Procedure

This section contains the same info as the Methodology and Procedure from the Test Plan.

Results and Analysis

Data should be presented appropriately, as tables or graphs, whichever is best. All figures and tables must be introduced, captioned, and referenced in the section text. A brief description of the trends should also be given when introducing each figure and/or table. Results should be interpreted in the context of the reason for testing. Averages, standard deviations, confidence intervals etc. should be provided where appropriate. A single result with no uncertainty does not represent thorough testing and will not fill the sponsor with confidence in the product.

Discussion

Broader conclusions can be drawn about the results, and potential reasons for these results can be discussed. Issues in consistency, the testing procedure, accuracy and uncertainty should be discu ssed in detail.

Conclusions

Discuss how the results affect the product design. Additionally, discuss any changes that may need be made to accommodate the testing results. If testing was inconclusive, mention the ways in which the testing can be improved.

Critical Design Documents

The Critical Design Documents detail the implementation of your chosen conceptual design. There are four main components of the Critical Design Documents:

1. Detailed Description of Design
2. User Manuals and Instructions
3. Detailed Drawings of Parts and Assembly
4. Bill of Materials

These documents are discussed with the sponsor during the Critical Design Review and are the final step before product manufacturing, assembly, and final testing.

Detailed Description of Design:
A description of the design should be given, and design decisions should be explained in report format. The function of all parts should be explained in detail, and the manner in which the individual parts work together should be discussed.

User Manuals and Instructions:
User manuals should be given for the design. These manuals should be appropriate for use by either the sponsor or the end user (if the design is a product marketed by the sponsor). These should be given in the form of a step-by-step guide to using the product. A troubleshooting and common-problems section can also be included if necessary.

Detailed Drawings of Parts, Schematics, Software Descriptions:
All parts needing to be manufactured must be modelled in a solid-modelling program such as SolidWorks and appropriately dimensioned such that sponsors can fabricate more parts in the future. Isometric views and orthographic projections of each part should be produced. Assembly drawings should also be included. Standard engineering practices for labelling and dimensioning drawings should be followed, including a logical part and assembly numbering system. For ECE only groups, this requirement can be relaxed or we can ask for assistance from the MAE Department.

As appropriate, circuitry should be modeled using an appropriate modeling tool. Schematics shall be included with appropriate documentation so that sponsors can modify the part in the future.

Bill of Materials:
A bill of materials for all parts (whether manufactured in-house, supplied by the sponsor, or purchased) shall be included. The bill of materials should include a part number, description, vendor, quantity, and price of part for each part. The bill of materials should be in table form and should follow conventional engineering standards.

Final Report

Two versions of the final report are required for the course: a version to be given to the sponsor and a version to be submitted to UCCS faculty. The versions are similar, but the UCCS version contains additional information for use by the ECE Department. The sponsor version will be discussed first and any additional content required for the UCCS version will be conclusion of this section.

Final Reports from previous semesters are available to help guide students in writing. These can be found at T:\Faculty\jadams3\Public\Final_Reports

The sponsor version of the Final Report explains in detail every part of the design throughout the entire project lifetime. It is a culmination of the project and will include information from all previous documents. Most teams will prefer to reformat information from previous documents into this report. However, the final report cannot simply be a direct copy of these documents; edits must be made to ensure that each aspect of the document flows logically and forms a cohesive whole. This report is written after the design has been finalized, prototyped, and tested.

The sponsor report should include (at a minimum):

1. Executive Summary
2. Introduction
3. Problem Description
4. Conceptual Design
5. Finalized Design
6. Testing and Analysis Summary
7. Conclusion
8. Final Design Package

Keep in mind that this is not an exhaustive list of what might be included; more information can be included if necessary. The manner these topics are presented should justify why the chosen solution best satisfies the sponsor requirements.

Executive Summary:

A brief executive summary of the complete design must be given. This should be a short (approximately one page) description of the problem and your chosen design solution. It should be thought of as an extended abstract and should summarize the entire project. Small details do not need to be included in this section. Rather, the executive summary should address the project more broadly. The problem, chosen solution, and method of implementing the solution should be discussed briefly. A summary of data proving that a solution to the problem was obtained should also be included.

Introduction

The project should be introduced. Basic information about the sponsor and their need for the solution should be explained. Information should be presented so that any technically minded person can understand the concepts. Depending on the nature of the problem, a significant portion of this section may include explaining key concepts and terms necessary to understand the technical details of the project.

Problem Description

The problem should be outlined, and all problem requirements and engineering parameters should be discussed. This portion of the report includes summarized information from the Engineering Specification Report.

Conceptual Design:

A variety of conceptual designs should be discussed. Particularly, the way each possible design satisfies or does not satisfy the problem requirements should be detailed. This portion of the report includes all information from the Conceptual Design Report and should conclude with the choice of a single design to pursue. This portion of the report includes all information from the Conceptual Design Report.

Testing and Analysis Summary:

The entire testing procedure should be documented. The complete Testing Report or a summary of the methods and results should be included. The full Testing Report should be included as an Appendix if putting it in the main text disrupts the flow of the document. Additionally, all analysis performed to finalize the design parameters or validate the design must be included. **This section should document which engineering specifications have been met and which specifications have not been met.**

Final Design Description:

The design chosen for implementation must be fully detailed. The interactions between all parts should be discussed. Instructions for using the system and/or product must also be given (in report format). The method in which the parts are produced and assembled should also be given. This portion of the report includes all information from the Critical Design Report.

Conclusion:

A summary of the final design should be given to conclude the document. Testing data showing that the design meets the problem requirements can be reiterated in this section. Possible improvements to the design should be mentioned if they were not implemented. This section serves to conclude the document and convince the reader that the design successfully meets all problem requirements.

Final Design Package:

The chosen design must be fully detailed. The interactions between all parts should be discussed. Instructions for using the system and/or product must also be given (in report format). The method in which the parts are produced and assembled should also be given. The software system, if applicable, should be fully described so that any future design effort can quickly understand the software design approach. A complete set of part and assembly drawings is essential, as is a complete bill of materials. For any commercial off the shelf (COTS) parts in your design, vendors and part numbers should be included.

Additional UCCS Requirements:

The UCCS version of the final report will contain the same information as the sponsor version but will also include some additional information about the design process. Particularly, three new topic areas should be addressed:

1. Project Planning & Project Management
2. Sponsor Interactions
3. Team Interactions

It is recommended to include new sections in the final report to address these topics. In these sections, the teams should address the aspects of the project that went well, but also those that did not go so well. What did the team learn by working through those struggles?

Project Planning & Project Management:

This section discusses the issues of project scheduling and resource allocation. The project plan and Gantt chart should be discussed. Any issues or unforeseen difficulties in the scheduling should also be discussed.

Sponsor Interactions:

Communication with the sponsor should be addressed. This includes information on the team's communication frequency, type (email, in-person, video conferencing, etc.), and dynamic (formal or informal) with the sponsor. Any issues with communicating with the sponsor should also be discussed.

Team Interactions:

Finally, communication between team members should be addressed. This section is similar to the Sponsor Interactions section and contains information on the team's communication with each other. Issues or areas of improvement in team communication should be discussed. However, this section is not meant to cal lout individual team members and should instead be used to describe the general team dynamic.

Design Reviews

The design reviews are required meetings between the teams and the sponsor which must be completed before moving onto the next phase of the project. These reviews help ensure that the team and sponsor are on the same page with the overall project ideas. Teams must present documents to their sponsors at each design review and obtain sponsor signatures to show that the design review was completed.

The format of the design reviews is decided by the team and sponsors. Some teams may prefer informal discussions while others may require formal presentations. This is dependent on the sponsor/team dynamic. For ECE projects, we will do semi-formal reviews with slides created from your engineering documentation. Presentations will be to ECE faculty, your fellow students, and sponsors with the objective of simulating a "real-world" environment in which most of you will find yourselves after graduation.

The three main design reviews are discussed below. Note that the first of these design reviews involves little to no actual design. Though the naming is unfortunate, the reason for this is important – teams need to make sure that the problem is well-defined and that the sponsor and team are in agreement before any design work can be accomplished.

Preliminary Design Review:
The Engineering Specification Document and the problem requirements are discussed with the sponsor. An agreement signifying that the Engineering Specification Document has been reviewed should be signed by the sponsor and the group if the requirements are accepted by the sponsor. The Engineering Specification Document itself should be stapled to this agreement. If the Engineering Specification Document is not accepted, the problem specification process must continue.

At the completion of the PDR, requirements and specifications must be agreed to and understood by all stakeholders. Budgets, schedules and related project management activities are also important, of course, but requirements and specifications are critical.

Conceptual Design Review:
The Conceptual Design Report and the group's chosen design are presented to the sponsor. Documents supporting and justifying all design decisions should also be presented. An agreement signifying that the Conceptual Design Report has been reviewed should be signed by the sponsor if the chosen design is accepted by the sponsor. The Conceptual Design Report itself should be stapled to this agreement. If the chosen design is not accepted, the conceptual design process must continue.

Critical Design Review:
The Critical Design Documents and the final product design are discussed with the sponsor. An agreement signifying that the Critical Design Documents has been reviewed if the final product design is accepted by the sponsor. The Critical Design Documents themselves should be stapled to this agreement. This is the sponsor's final chance to suggest minor changes or alterations to the design before prototyping. These modifications must be made before beginning the Final Report. If the final product design is not accepted, the critical design process must continue.

Engineering Design Exposition

The Engineering Design Exposition is the teams' chance to display their project to other students, UCCS faculty, and industry professionals. This is the culminating event of the project and is a great opportunity to invite family and friends to show off the projects. Teams must invite their sponsors to the event. The event consists of a short oral presentation followed by a poster session.

Oral Presentation:

Teams will give an extremely brief (approximately 2 to 3 minute) PowerPoint presentation introducing their project. This should be viewed as a teaser to entice audience members to visit the team during the Poster Session. This presentation can be created from your Final Presentation slides.

Poster Session:

Teams will present a poster and any additional material they would like to show off their design. Each team will have a station that includes a table and an easel for a poster. To produce the posters, teams will have access to the MAE machine shop's large format printer (42'' wide paper). Most teams will prefer to utilize PowerPoint to build their posters, but any method of creating a professional-quality poster is acceptable. Any additional team requirements for their stations can be discussed with the instructors.