Rice University Collaborative Capstone Design
Documentation Instructions

Design Foundation Document: Design Context Review, Market Analysis, Customer Needs and Design Specifications

Why you do it

Prior to any engineering design, four questions must be addressed that will lay the foundation for successful product development:

- *What background knowledge or information do I need to know? (Design Context Review)*
- *Who is my customer? (Market Analysis)*
- *What are their needs? (Customer Needs)*
- *What will we, as engineers, deliver? (Design Specifications)*

Engineers are typically very skilled at designing to specifications or constraints given them. Without understanding where these specifications originate can result in unsuccessful products and even serious risks. Many products have failed due to lack of background knowledge, not selecting the appropriate customer, or misunderstanding their needs. The following steps are explained in greater detail in chapters five and six of your text (Ulrich and Eppinger). The steps outlined in chapters three (Opportunity Identification) and four (Product Planning) were already performed by your sponsors and professors prior to the beginning of the semester.

Upon completion of this process, you should have sufficient information to develop a strong, clear mission statement. Also, you will have focused, quantifiable target specifications to begin your concept generation and prototyping activities.

The Design Foundation Document

The Design Foundation Document should consist of the following four sections. Please use the Product Worksheet (found HERE) and include a printed copy at the end of your document. You may wish to use the tables in the worksheet throughout your final document. The design context review should be a maximum of 2,000 words. The entire design foundation document should not exceed 4,000 words.

Section 1: The Design Context Review

Every project requires very specific knowledge that you likely have not learned as a student. At the end of the semester, you will be the experts on your product. The design context review will start you on that path. The design context review in capstone design serves two primary purposes. First, it ensures that your team has educated itself thoroughly about the problem your project will solve and the status of other currently used or proposed solutions. Senior engineering students must become familiar with the terminology, technology, and economics associated with their projects. Writing a design context review requires your team to locate appropriate source material, sort through background information, and write a focused document that describes the specific problem you plan to solve.

Second, it improves your team's ability to communicate with its audiences—managers, sponsors, advisors, and others standing to benefit from your project—who don't need to know as much as you do. In academic and industry work, a design context review (also called a literature review) is an essential requirement in proposals. This review puts you—the student team—in the role of expert and educator. Your design context review will persuade your audience that a problem exists. The written review also demonstrates your team's understanding of the problem and factors associated with solving it.

How to prepare the design context review

The design context review process consists of four steps:

- Educate yourself about your project
- Analyze your aims
- Determine your problem statement
- Outline and write the design context review document

Six accelerators (examples, tips, and interactive forms) speed this process:

1. Examine how another team educated itself
2. Analyze your team's aims to generate a "Need to Know" List
3. Find the parts of problem statements
4. Learn to recognize a problem-focused outline
5. See how to lead with assertions
6. View poor and high quality versions of an argument

These accelerated techniques will assist you with this assignment. They will also help you organize complex information in other situations.

Step 1: Educating Yourself

Projects in Capstone Design require your team to become experts on complex technical and business issues. To fully understand your team's mission and begin to articulate a specific problem that will drive your project, your team will need to review literature in your project area.

Your self-education will be *more* extensive than the information you will ultimately provide to your readers. That's because your readers are interested *only* in the problem you plan to address and the reasons it should be addressed. To make your case, you will need to arm yourself with a broad range of information in your project area, including:

- Necessary background information about the environment of your design (e.g. BIOE projects, the physiology of the disease area or characteristics of the health application or process with which your project is associated)
- Identification of customers that will use, pay for, or authorize the use your design (More on this in the next section)

- References to applicable standards in the area of your project
- Descriptions of current technologies you might use in your design (e.g. for ELEC projects, existing or similar products and research demonstrations, or companies involved in the same general market space)
- Current competitive products or existing intellectual property (especially patents) in the area related to your product

Examine information that another team gathered to educate itself by consulting **Design Context Review Accelerator #1.**

Fill out the Product Worksheet with topics in each of these areas that you plan research.

Step 2: Analyzing Your Aims

The product of the first step in the design context review—references, notes, and amassed background information on your project—can be intimidating. An inefficient approach to the process is to dive immediately into writing. Drafts begun at this stage often focus too much on the background, telling readers everything you found out about your project. We have developed an accelerator to help your team explore the characteristics of your design opportunity. You will generate a Need to Know List that suggests issues you need to explain, given your aims. It also helps you pinpoint information you may not have collected or issues you haven't thought to explore.

Generate your Need to Know List by consulting **Design Context Review Accelerator #2**. NOTE: You must be ON Rice campus or on via VPN for this Accelerator to work.

Step 3: Determining the Problem Statement

The aims analysis performed in Step 2 provided your team with a list of evidence needed to explain your aims. This, in turn, offers a perspective on your collected background information. Your aims provide goals, but to effectively drive your project effectively, the goals must be specified in a motivating need or problem.. This problem often lies in the evidence you collected—in the "why" questions that arise when you explain the aim. If your aim is to modify or build on an existing design, the question is, "Why?" What about the existing design needs to be improved? Why not build an

entirely new design? Digging into these questions will help you determine your team's specific problem statement.

Problem statements define a problem and describe general points around which quantifiable design criteria can be established. They usually consist of:

- A statement of what is desired
- A statement of the contrary condition or problem with the status quo
- A statement of characteristics envisioned in potential solutions

The problem statement provides an organizing structure for your design context review. Knowing the problem statement at this stage in your work will enable you to identify appropriate background information to include in the design context review. Note, however, that in the written design context review, you will *place the problem statement at the end*. Introductions of research articles and design reports typically move from what is *known* about the topic to what is *not known* or *in question*, and end with the *problem statement*. While your design context review will cover substantially more information than the typical introduction, following this structure will help you when you ultimately condense your review into the introduction of your final design report in Phase 3.

Find the parts of problem statements by consulting this **Accelerator.**

Step 4: Preparing the Design Context Review

The process of researching your problem, determining your aims, developing a problem statement, and mapping your research will leave your team well prepared to develop a problem-focused design context review. You only have a maximum of 2,000 words to make your case, so you will need to choose the information to report carefully. A well written design context review will help your audience understand the motivation for your work. It will also help your team identify design criteria for successful solutions.

You will begin by preparing an outline from your design context review by transferring connections and ordering that you explored in the design context map to a traditional outline format. The process you have followed should result in a problem-focused outline. Design Context Review

Accelerator #1 contains more information on recognizing and creating this type of outline.

Once you have settled on your outline, you can begin drafting the design context review. Your team contract should outline a process for collaboratively writing the review. Follow this process in developing your draft. As this is the first major document you will produce in this course, you should evaluate how the process works and make adjustments if you see areas that are inefficient or need improvement. Design Context Review Accelerators #2 and #3 provide specific advice on how to structure scientific writing with assertions and evidence. Consider this advice to streamline your writing.

Learn to recognize a problem-focused outline by consulting this **Accelerator**.

See how to lead with assertions by consulting this **Accelerato**r.

View poor and high quality versions of an argument by consulting this **Accelerator*.***

Section 2: Market Analysis

Armed with the background knowledge of you design context review, you are prepared to develop a market strategy and determine who is your customer. A simple market analysis can be performed by the taking the following steps:

1) Identifying Market Segments
2) Estimating Market Sizes
3) Assessing Competitive Products/Solutions
4) Assessing Willingness/Ability to Pay
5) Selecting a Target Segment and Estimating the Market Opportunity
6) Write your Market Analysis document

While the text (U&E) doesn't cover market strategy, there are a number of online resources that are helpful, including the US Small Business Administration's website:

http://www.sba.gov/category/navigation-structure/starting-managing-business/managing-business/running-business/marketing

1) Identifying Market Segments

Market segments are groups of people that share similar needs. Segmentation can be performed along several different dimensions, including geography, age, gender, hobbies/interests, etc. One helpful way to think about a market segment is a group that has a common "job" that needs to be done (http://www.christenseninstitute.org/key-concepts/jobs-to-be-done/). Give some thought as to what key factors or dimensions you can use to segment your potential customers. Then, list at least five of these potential segments in the Product Worksheet. Be sure to be as specific as possible when identifying a segment.

2) Estimating Market Sizes

For each of the segments you've generated, estimate the number of people within the segment on the worksheet. Try to use as many reliable resources as you can find, but this may take some creativity. You may make assumptions, but list them with your reasoning. Market reports available online and volumes of competitive products may provide some good indicators of market size.

3) Assessing Competitive Products/Solutions

For each segment, list competitive products or solutions available to the customer that might fulfill the same need/job that you will address. The current product might be only partially fulfilling the need, or no product may exist. In situations where there is no product, what solutions (such as avoidance, etc.) might the customer pursue?

4) Assessing willingness/capability to pay

While it is hard to project what a customer might pay for a product, provide your best guess for each market segment. Consider carefully what customers are currently paying for competitive products, or what

alternatives the might pay to avoid. Keep in mind that in some circumstances, the user is not always the payer. For example, medical devices are used by physicians and/or patients, but are paid for by hospitals and ultimately, insurance companies.

5) Selecting a Target Segment and Estimating the Market Opportunity

Drawing from your market analysis, select one or two target segments that will be the focus for your product. Ideally, the segment you choose will have a large market size, few competitors, and willingness to pay a high amount for your product. In reality, it's rare that a segment will be the best in all dimensions. Give some thought as to what dimensions might matter most for you product. Estimate the financial market opportunity (in dollars) by multiplying your estimates of market size, market share, and price. Market share (or the percentage of the total market that buys your product) should be estimated considering competitors. Even if you product is meets the need better than all other products, you should never assume 100% market share. In many markets, top products may only reach 20-30% market share.

6) Write your Market Analysis Document

Your market analysis document should be no longer than 1000 words, and should begin by describing what segment you are targeting and the size of the financial market opportunity. The remainder of the document should describe how you arrived at this decision, including an explanation of your assumptions and reasoning. You should mention the other potential market segments. Be sure to include references where appropriate.

Section 3: Identifying Customer Needs

After identifying your target segment, the next step is to identify the needs of the customers in that segment. The research you performed in your design context review and discussions with your sponsor will give you a good

place to start; however, it is important not to assume that you know all your customer's needs, and the relative importance of those needs.

In addition, many times sponsors or professors (and your future managers) may provide solutions as customer needs. As engineers, we tend to jump into solutions as quickly as possible. This is dangerous because it can lead to unexplored design space, and products that don't address true needs. It is important during this process that you (and your mentors) take a step back to understand the underlying needs and suspend all problem-solving. This will set the stage for good design.

The steps for identifying customer needs are explained in detail in Chapter 5 of Ulrich & Eppinger. These are:

1) Gather raw data from Customers
2) Interpret raw data in terms of customer needs
3) Organize these needs into a hierarchy
4) Establish the relative importance of the needs

Follow the process outlined in the book to generate a table of prioritized customer needs in your Product Worksheet, such as the table found on p. 93 in the textbook. Importantly, include needs on the Product Worksheet that are from payers, regulators, and industry standards. Draw from the research you did in your Design Context Review. These needs are not mentioned in the text, but should be framed as customer needs in the worksheet.

Depending on your project, it may be difficult to gather raw data from customers. Do your best to interact with real customers to gather needs. Keep in mind, however, that formal surveys and interviews may need IRB approval. Please check with your professor prior to conducting any surveys or interviews.

In your customer needs document, explain the steps you took to gather, interpret, organize and prioritize your customer needs. This should not exceed 500 words. Also, share your customer needs table.

Section 4: Design Specifications

The last step prior to beginning concept generation and prototyping is to translate the needs (the language of the customer) into design specifications (the language of engineers). Specifications are quantitative, measurable characteristics of your product that satisfy a customer need. The specifications, when met by your final product, should fulfill all desired customer needs. Chapter 6 of the text explains the process of setting specifications, including:

1) Preparing the list of metrics
2) Collecting competitive benchmarking information
3) Set ideal and marginally acceptable target values

This year, students will use the House of Quality approach from the Quality Functional Deployment (QFD) toolbox. Follow the steps outlined in class to fill out you House of Quality. A couple of considerations:

- The book uses the terms "metrics" and "specifications" interchangeably in many sections
- Make sure that each customer need you have identified is addressed by a specification. Some needs may be difficult to measure, in which case provide a written explanation below the table on how you will fulfill the need.
- On the row at the bottom of your table, there are columns for "Ideal" and "Marginal" values. For now, provide your best guess on both. We recognize that these values will change as you learn more. As discussed in the text, at this point these are "target specifications" which will evolve into final specifications by the end of cycle three.

In your design specification document, describe the process of creating metrics, gathering benchmarking data, and establishing your ideal and marginal values. This should not exceed 500 words. Also, share your specification table.