

DESIGN PROPOSAL GUIDELINES

Written Documentation for Capstone Engineering Design Projects

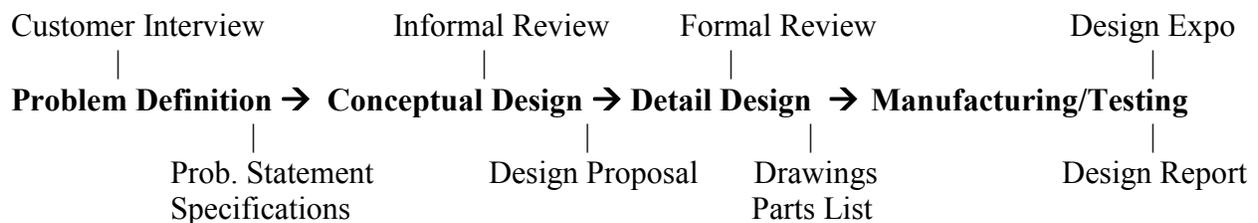
PURPOSE AND CONTENT

Formal written reports are essential communication media for engineering product design and development projects. Frequently, they augment oral presentations by providing the audience important supplemental information. Written reports typically contain information too exhaustive for inclusion in short oral presentations or content relevant to only a subset of the presentation audience. An effective written report will convince decision makers to authorize project continuation based on the compelling case presented.

In a four-stage product development cycle as depicted below, a critical decision point occurs before detailed design is initiated and after a conceptual design has been created. At this point, supervisor and client approval are required before engineers may continue the project into the detailed design stage. Typically, a design team makes an oral presentation to supervisors and/or clients to offer rationale and plans for development of a detailed design. A written report accompanies the oral presentation to elaborate on benefits anticipated from the project and give supporting data, sketches, and estimates of resources required for completion of the detailed design. The written conceptual design proposal (usually including a business plan or bid proposal) becomes the primary documentation from which analysts judge risks and benefits and advise decision makers on the future of the project.

Product Realization Process & Key Performance Tasks

(Oral Performances)



(Written Performances)

The conceptual design proposal is foremost a request seeking decision makers' approval to continue a design project. As such, the report must effectively communicate the credibility and value of a design concept to supervisors, clients, prospective investors, or other decision makers. A credible conceptual design proposal should document the extent of conceptual design efforts, processes used in concept selection and development, key features of the proposed product concept and their relationships to client needs and societal expectations, and evidence of product value to potential users and investors. The quality of the report's content and presentation will make a statement about the design team's professional competence, its attention to detail, and therefore, the credibility of the proposed conceptual design.

Conceptual design proposals are substantive formal written documents, the content of which may vary depending upon requirements of clients. Such reports are usually bound or packaged in a way that communicates professionalism and relevance to the intended audience. Guidelines provided below define elements commonly found in written reports prepared at the conceptual design stage of product development. As indicated in the guidelines, some elements receive greater attention than others. The order of different elements in the report will, in general, follow that of sections below, but order may be altered to achieve desired impact.

LETTER OF TRANSMITTAL

The conceptual design report is submitted to appropriate parties with a cover letter or letter of transmittal introducing the report. The letter is addressed to the proper decision maker(s), states the purpose of the report, and asks for specific actions. It also provides decision makers instructions for obtaining additional information and for communicating their response to the design team. This letter is an important entree to individuals who may not have benefited from an oral presentation on the conceptual design.

COVER PAGE

The cover identifies the report and its authors and creates an important first impression regarding its contents. The cover should include the name of the project, its purpose, names of key team members and/or their group/firm, audience, and date of preparation. Graphic identifiers (such as team/firm logo or a representation of the product) add interest and may communicate other values important to the project. An attractive, high quality cover page creates a positive impression about the team/firm and their project.

FRONT MATTER

The front matter in a formal report may include an *Executive Summary*, *Table of Contents*, and other relevant materials. Typically, the *Executive Summary* appears first to catch the reader's attention and to prepare the reader for the substance of the report. The *Table of Contents* presents an outline of the report and page numbers to guide the reader to sections of interest. These materials should be brief and should not distract the reader from the main body of the report.

Executive Summary (1/2 page)

The *Executive Summary* is intended to motivate readers to study the full conceptual design report. The executive summary should present a short, powerful synopsis of the report, highlighting important needs, presenting key features of the proposed solution, and delineating salient benefits of the solution. It should be less than one page in length and address issues of greatest interest to decision makers, including pivotal technical and business merits of the conceptual design, and it should recommend desired responses to the proposal.

REPORT BODY

The body of the report contains an organized presentation of the conceptual design, often arranged chronologically. The body provides the reader an understanding of the overall process and considerations that have yielded the conceptual design, giving credibility to the design team's understanding of the problem addressed and credence to the solution concept proposed. Content should be relatively inclusive yet brief enough for readability. The body should include selected background information, principal design processes and decisions, and noteworthy features of the conceptual design. However, extensive supporting documentation should be deferred to an appendix or separate volume.

The report body is organized, formatted, and written to meet professional standards of quality. Typical sections within the body include: *Background*, *Problem Definition*, *Concepts Considered*, *Concept Selection*, *System Architecture*, *Economic Analysis*, and *Future Work*.

Background (1/2 page)

The *Background* section explains the problem context and presents a justification for directing resources to the design problem. This section describes the source and scope of a need, identifies "clients" affected by the need and impacts of the need, and postulates opportunities and benefits expected from a viable design solution. It should present a review of relevant literature and patents, describe previous efforts to address the need, and explain adequacy of previous solutions. The strongest case for project continuation requires clearly documented needs and potential benefits from a solution.

Problem Definition (1 page)

The *Problem Definition* section states problem needs in terms that establish specific requirements (product attributes or performance expectations) for a high quality design solution. Frequently, this section begins with a goal statement that concisely defines the purpose of the product development effort, the deliverables to be produced, primary and secondary clients, and key business objectives. This is followed by a list of project requirements and metrics that will be used to demonstrate that these have been satisfied. It also identifies specific constraints and societal expectations that must be satisfied by the design solution. As appropriate, constraints should include: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political. Details of the problem definition process, such as development of an Objectives Tree, should be left to the appendix. The *Problem Definition* section summarizes the contractual obligations of the design team relative to the specified product development effort.

Concepts Considered (2 pages)

The *Concepts Considered* section describes the landscape explored by the design team in its search for creative solutions. It should address both original ideas and those derived from other sources. It should summarize the scope of ideas considered and highlight the most creative and relevant concepts for the overall solution and for its component parts. Because this section reflects the effort of the design team to identify relevant solution ideas, it communicates a message about the team's expertise and its effort invested in this project. Additional engineering analysis and test results may be reported in an appendix.

Concept Selection (1 page)

The *Concept Selection* section describes the processes and rationale used for selecting the “best” concepts for the overall product (the product architecture) and for the component parts of the design product. It may include summary tables comparing concepts against design criteria (e.g., screening matrices or selection matrices) or summary evaluations of specific concepts; however, more extensive details should be included in a section of the appendix.

System Architecture (2 pages)

The *System Architecture* section presents the conceptual design and asserts its potential to meet or exceed client expectations, those to be achieved after subsequent detailed design and development. This section describes the selected product concept with its overall architecture and component integration. It also explains how major components satisfy important design requirements. Novel features are highlighted to show their potential to outperform competing products. If available, results from component testing or analysis are presented to defend performance claims. DFMEA results should be used to support this discussion. Overall, this section must make a convincing case for the technical and functional merits of the design.

Economic Analysis (1/2 page)

The *Economic Analysis* section builds a financial case for continuing product development beyond the conceptual design phase. This case should include a detailed budget, outlining expenses incurred to date as well as anticipated expenditures through the end of the project. This should include estimates of student labor costs (\$20/hour) for the conceptual design, detail design, and fabrication phases. These estimates should be validated through consultation with your IEW mentor.

Future Work (1/2 page)

The *Future Work* section sets forth clear recommendations and rationale for project continuation. It summarizes principal technical and non-technical features of the product that satisfy important needs of clients. Any unresolved issues should be highlighted at this time. This section should provide details on the anticipated work schedule and milestones for the next phase of the project. If specific approvals or authorizations are needed for project continuation, this section should request these.

APPENDICES

Appendices are used to present supplemental materials that support the report body but are too lengthy or have less refinement than those contained in the body. These may be calculations, drawings, lists, computer programs, tables, figures, or narrative. Each appendix should be self-explanatory and be referenced in the report body as appropriate. One Appendix should contain a system-level DFMEA.

MEASURES OF PROPOSAL QUALITY

The quality of a conceptual design proposal is determined by its impact on the client and project supervisor. The document must build a compelling case for continuation of the product development effort and leave no doubts about the value of the product or the potential of the design team to deliver the contracted product within the allowed time and budget. The proposal must present a high quality interim product in a very professional manner. Specific criteria for assessing the proposal are defined below.

	Score = 1	Score = 3	Score = 5
<i>FACTOR</i>	Novice	Entry-Level Engineer	Professional
OVERALL REPORT QUALITY	Weak case for continued product development; conceptual design is incomplete or meets few design requirements; little or no evidence justifying product financially; report is incomplete, unattractive, can be misunderstood, has distracting errors	Credible case for continued product development; sound conceptual design meets most design requirements; some indication that product will be economically feasible; report is complete, understandable, attractive, nearly flawless	Excellent case made for product continuation; innovative and competitive conceptual design meets all design requirements; credible evidence that product will be financially successful; report is very complete, flawless, very clear, compelling, beautiful
BACKGROUND	Identifies basic client needs for product; acknowledges few existing products or resources that may influence the development of a solution	States problem context relative to clients and the state of technology within society; reviews most important literature, patents, competitive products	Describes and analyzes problem context in terms of clients' needs, societal and global issues; thoroughly analyzes literature, patents, competing products
DESIGN REQUIREMENTS	Few design requirements defined; most are loosely defined, performance-related, qualitative; few or none based on documented client needs; broader considerations* neglected	Defines important design requirements based on primary and secondary clients; addresses technical and non-technical requirements and constraints*; many measurable requirements	Skillfully defines comprehensive design requirements based on needs of clients and stakeholders; addresses system-level and life-cycle requirements and constraints*; all are measurable
CONCEPTS CONSIDERED	Limited number of useful concepts; do not reflect knowledge of state-of-art; little creativity	Useful concepts for components and overall; reflect knowledge of state-of-art for at least some parts; some show moderate creativity	Many useful concepts for components and overall; reflect knowledge of state-of-art for all components; significant creativity
CONCEPT SELECTION	Vague process to select concepts; little record of decision making process ; poorly-defined criteria	Rational, documented process to select concepts; clear measurable criteria in making design decisions	Quality client-focused process for selection; fully documented; clear quantitative, qualitative criteria
PRODUCT ARCHITECTURE	Product features lack client-focus; performance not linked to design requirements; no integration	Product evidences client-focus; meets key design requirements; some system integration	Product delights client; fully meets design requirements; components skillfully integrated into whole
ECONOMIC ANALYSIS	Vague estimates of product costs; does not consider other business issues	Reasonable estimates of costs and value to client; markets identified for product	Reliable estimates of life cycle costs and benefits to client; markets/business potential defined
CASE FOR CONTINUATION	Project strengths questionable; serious risks to project completion or to business viability	Project strengths, risks identified; reasonable potential for project success and for business value	Compelling case for success of project; risks managed; clear, strong business potential

* Incorporate engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.

ABET ASSESSMENT OF DESIGN SKILLS - DESIGN PROPOSAL

	Your Score	Scoring Scale		
		1	3	5
BACKGROUND COMMENTS:		Identifies most basic client needs for product; acknowledges few existing resources that may influence the development of a solution	States problem context relative to both client and the state of technology within society; aware of relevant literature, patents, and existing products	Describes and analyzes problem context in terms of clients' needs and societal/global issues; thoroughly analyzes relevant literature, patents, and products
DESIGN REQUIREMENTS COMMENTS:		Few design requirements defined; most are loosely defined, performance-related, qualitative; few or none based on documented client needs*; broader considerations* neglected	Defines important design requirements based on primary and secondary clients; addresses technical and non-technical requirements and constraints*; includes many measurable requirements	Skillfully defines comprehensive design requirements based on needs of clients and stakeholders; addresses system-level and life-cycle requirements and constraints*; all are measurable
CONCEPTS CONSIDERED COMMENTS:		Limited number of useful concepts; do not reflect knowledge of state-of-art; little creativity	Useful concepts for components and overall; reflect knowledge of state-of-art for at least some parts; moderate creativity	Many useful concepts for components and overall; reflect knowledge of state-of-art for all components; significant creativity
CONCEPT SELECTION COMMENTS:		Vague process to select concepts; little record of decision making process; poorly-defined criteria	Rational, documented process to select concepts; clear measurable criteria in making design decisions	Quality client-focused process for selection; fully documented; clear quantitative and qualitative criteria
PRODUCT ARCHITECTURE COMMENTS:		Product features lack client-focus; performance not linked to design requirements; no integration	Product evidences client-focus; meets key design requirements; some system integration	Product delights client; fully meets design requirements; components skillfully integrated into whole
ECONOMIC ANALYSIS COMMENTS:		Vague estimates of product costs; does not consider other business issues	Reasonable estimates of costs and value to client; markets identified for product	Reliable estimates of life cycle costs and benefits to client; business potential well-defined
CASE FOR CONTINUATION COMMENTS:		Project strengths unclear; serious risks to project completion or to business viability	Project strengths and risks identified; reasonable potential for project success and for business value	Compelling case for success of project; risks managed; clear, strong business potential
OVERALL REPORT QUALITY COMMENTS:		Conceptual design is incomplete or meets few design requirements; little or no evidence justifying product financially; report is incomplete, unattractive, can be misunderstood, has distracting errors	Sound conceptual design meets most design requirements; some indication that product will be economically feasible; report is complete, understandable, attractive, few flaws	Innovative and competitive conceptual design meets all design requirements; credible evidence that product will be financially successful; report is very complete, very clear, compelling
CONCEPT QUALITY COMMENTS:		Team partially understands needs of clients; concept not viable, does not address some important criteria*	Team understands main technical and nontechnical needs of clients; concept plausible, addresses most crucial requirements, constraints*	Team fully understands diverse needs of clients, society; concept innovative, viable, satisfies all requirements and constraints*

* Incorporate engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.