Design Reviews

The design review provides a forum in which questions can be answered, assumptions clarified and advice sought. They are a useful mechanism whereby the design of a product can be optimised through a systematic review of and feedback on design process outputs. Typically a number of formal and informal reviews are conducted during the duration of a design project. These reviews may last a few hours or a few days depending on the scope and the phase of the project.

Project activities in which design reviews are useful:

- Requirements definition
- Conceptual design
- Detail design
- Development and Qualification
- Production

Other tools that are useful in conjunction with design reviews:

- Effective Meetings
- Requirements Management

Introduction

In general, design reviews facilitate communication between the design team, management and the customer. Management and the customer are provided insight into the technical status of the product while the design team receives valuable feedback on issues involving the design. The objectives of a design review are to ensure that all contributory factors and reasonable design options have been considered, and that the design meets the requirements as outlined in the Product Development Specification. The design team are responsible for providing an accurate, concise overview of the design to-date and the facilitation of productive discussions. Reviewers are responsible for assessing the design to ensure that it can be produced, tested, installed, operated and maintained in a manner that is acceptable to the customer.

Types of Reviews

Reviews are classified as formal or informal depending on who participates in a review. An informal review involves those individuals directly involved in the design project. Formal reviews include applicable subject matter experts who are not directly involved in the design but can review and comment on the design. The "formality" of a review does not refer to the structure of the meeting and in fact, informal reviews often follow a similar structure as that used for formal design reviews.

Reviews can also be classified as technical or project reviews. Technical reviews involve subject matter experts and deal solely with technical issues. Project reviews will include

a summary of the technical review in addition to a survey of the status of budget, schedule and resources. A technical and project review can be combined into a single meeting however the agenda of the meeting should be such that subject matter experts are only required to be present when appropriate.

Timing of Design Reviews

There are numerous junctures during a design project at which a design review can be conducted. The number and timing of these design reviews is dependent on various considerations including the magnitude of the project, development schedule or the status of the market. The timing does need to be such that all relevant information can be provided to the reviewers. Too early of a review results in decisions being based on insufficient information while a review held to late may have little impact since commitments to the design have already been made and cannot be changed without significant alteration to schedule or budget.

Often, different types of reviews are combined into a single review. The following provides a sample of the different design reviews that can be conducted:

- ***Requirements Review.*** This review is conducted to ensure that all of the appropriate requirements and constraints have been clearly and completely identified. The requirements review is often conducted with the Preliminary Design Review.
- ***System Design Review (SDR).*** In the case of large systems being developed, a system design review examines the allocation of requirements to individual configuration items.
- ***Preliminary Design Review (PDR).*** Design concepts are evaluated for feasibility, technical adequacy and general compliance with requirements, and the relative merits/weaknesses of different concepts are presented. Assumptions and calculations that led to conclusions are provided, and whenever possible, preliminary prototypes, mock-ups or sketches are used to communicate the various concepts. The technical progress of the project is reviewed, as is the current and projected status of the budget and schedule. Potential risk items are highlighted and mitigation plans are evaluated.
- ***Critical Design Review (CDR).*** The CDR is an intermediate design review that occurs after the detail design is complete and prior to the fabrication of prototypes or pre-production models. This review is conducted to evaluate the design against the detailed requirements. It has many of the components as a PDR including the provision of assumptions and calculations used in the design, project progress and risk management. A production assessment is often included.

- ***Test Readiness Review (TRR).*** The TRR examines the test plans that will be applied to prototypes or pre-production units to verify the design against the requirements. These plans are reviewed for reliability and completeness.
- ***Final Design Review (FDR).*** A FDR is conducted after prototypes or pre-production units have been through verification testing. Problems encountered during this testing and the respective solutions are examined. Any necessary changes to the product with respect to performance, cost, reliability and manufacturing issues are agreed upon prior to the initiation of full-scale production
- ***Production Readiness Review (PRR).*** A number of PRRs are held through the development of a product and are not usually tied to other design reviews. In the early stages of the project, the PRR concerns itself with high level manufacturing concerns and become more detailed as the product design matures. PRRs are critical for products of which a large number will be produced.
- ***Ad Hoc Reviews.*** Problems may arise during the course of the project that may drastically change the direction of the design. In such situations, it may be appropriate to call a design review in order obtain multidisciplinary input before proceeding with critical decisions.

Preparing for the Design Review

The preparation for a design review should begin approximately a month prior to the review meeting. The first actions that should be completed are to set a meeting date and appoint a chairperson for the review (see "Participants" below). The following provides an example design review schedule:

Schedule design review	1 month. prior
Arrange for meeting facilities	1 month. prior
Assign areas of responsibility to design team members	
Publish agenda	3-4 wk. prior
Invite subject matter experts and customers (if applicable)	3-4 wk. prior
Distribute design review packages	2 wk. prior
Conduct dry runs	1 wk. prior
Distribute addendum to design review package	1 wk. to 2 days prior
Arrange layout of room and ensure availability of seating.	1 day prior
Confirm availability and functionality of equipment and supplies such as overheads (check for back-up bulbs), VCR, white board pens, etc.	1 day prior
Final dry run	1 day prior

Participants

One of the most crucial aspects to ensuring an effective design review is in the selection of the participants. For maximum effectiveness, the number of participants in a design review should be in the range of 5 to 10 people. To maintain this number when large systems are being reviewed, it is not uncommon for a few key people to participate in the entire review while others participate only during designated segments.

It is not uncommon that invited participants of a design review are not able to attend. In some instances, their absence is not known until the day of the review when it is too late to reschedule or backfill. Therefore, it is important to make alternate arrangements in advance, especially for key participants such as subject matter experts and customers, so that the productiveness of the review is not at risk.

The key participants at a design review include the Chairperson, the design team, subject matter experts and, if applicable, the customer.

- ***Chairperson***. The chairperson is responsible for co-ordinating the preparations for the design review and managing the conduct of the review meeting. This person also has the responsibility of monitoring the follow through of any actions resulting from the meeting. There are two common approaches to this position. In some companies, the chairperson for a design review is a senior person with an engineering background and a solid understanding of the design process. Typically, this individual is not directly involved in the design project itself and therefore can remain objective. When a product is being developed for a particular customer, ***co-chairpersons*** may be employed. The customer supplies one chairperson while the other is often the senior or principal engineer or the project manager for the project. This approach helps maintain balance and objectivity.
- ***Design Team.*** The design team participates in the design review by providing details regarding the design and the design process, and discussing and receiving feedback. It may not be practical to include the entire design team for large development projects therefore only the key persons involved in the preparation of the design review participate throughout the entire review, and other attend only when appropriate (e.g., reliability engineer attends when issues of reliability are being discussed). One member of the design team is appointed the ***lead engineer*** for the review. This person is often the principal engineer on the project and is responsible for introducing the details of the design project and leading technical discussions. Typically it is a member of the design team designated with the responsibility for recording the review meeting minutes. Often the quality engineer assumes the role of ***secretary***.
- ***Subject Matter Experts.*** The selection of subject matter experts is dependent on the appropriateness for any individual project. These experts are not directly involved in the development of the design and may include representatives from

manufacturing, test, quality, finance, marketing, reliability, safety, human factors, purchasing, maintenance, etc.

- ***Customer.*** In projects where development is being done for a specific customer, representatives from the customer's organisation will attend the design review. In some instances, only one or two representatives will attend while in other instances, the customer may mirror the subject matter experts with experts from their own organisation.

Design Review Package

The exact contents of a design review package depends on a number of items including the type of review being held as well as the magnitude of the project. The package reflects the current state of the design and project progress. Typical package contents may include:

- Current Product Development Specification (PDS)
- Applicable engineering data such as calculations, simulations, test/experimentation results, and any other analyses performed
- Competitive analysis of existing products
- Drawings, schematics, layouts, breadboards, mock-ups and prototypes
- Cost and schedule status and projections
- Project risk analysis
- Description of unusual requirements and design elements with associated high-risk

If any of the current reviewers did not participate in previous reviews, it may be beneficial to include a copy of the minutes from previous reviews to avoid revisiting settled issues.

Conducting the Design Review

The length of a design review can vary from a few hours to a few days, or in the case of extremely large systems, a few weeks. The length of the review depends on the scope of the project but also upon the resources available. If the budget or schedule does not support a comprehensive review, an abbreviated version is still more beneficial than no review at all.

Not every aspect of the design and the design process must be presented at the review. Only those items of significance or concern need to be reviewed. However, it is advisable to be prepared to address questions or present materials in areas not included in the agenda

Keep in mind that not all of the reviewers will have a full understanding of all of the aspects of the design background or technology. Therefore, be clear in descriptions and explanations and avoid using jargon that is not familiar to everyone. If there is uncertainty about reviewers' knowledge in a particular area, it is perfectly acceptable to ask the reviewers if they have sufficient understanding or if they would prefer added explanation.

Perhaps the hardest aspect of a design review for the design team is receiving negative, albeit constructive, feedback on their designs. It is important for the team to always keep in mind that the purpose of the review is to aid them in developing a superior product.

Agenda

Following a well-prepared agenda contributes to the smooth execution of a design review. The agenda should identify who is responsible and the allocated time for each agenda item with the majority of the time spent on a detailed *discussion* (i.e., not presentation) of the product. The following provides an overview of topics that could be included in an agenda. It is important that only those topics pertinent to the product and timing of the design review be included. Suggested time and responsibility allocations are provided in brackets.

Welcome & Introduction
(<5% of meeting; Responsibility: Chairperson)

- The chairperson welcomes the participants and allows people to introduce themselves. These introductions should include their organisation, position and area of expertise.

Design Review Purpose & Process
(<5% of meeting; Responsibility: Chairperson)

- The chairperson states the purpose and objectives of the review.
- Participants are asked to provide objective and constructive input.

Background
(~10% of meeting; Responsibility: Lead Engineer)

- Circumstances that led to the project including the "needs statement".
- Outline of the project objectives and significant requirements.
- Overview of design approach beginning with the overall design and function leading into more detail of the major components.
- Key assumptions made.
- Changes that have occurred since previous design review (e.g., requirements, design, project).
- Competitive analysis.

- Alternative concepts considered & rationale for selected design approach.
- Significant problems or risks encountered or expected.

Detailed Interactive Discussion of Product
(~60% of meeting; Responsibility: All with discussion facilitated by Lead Engineer)

- Presentation and discussion of each critical requirement and how it is satisfied by the design.
- Demonstration of the product or models (if available).
- Processes used to arrive at the design (e.g., testing, simulation, and calculations).
- Validation of assumptions used during design.
- Assessment and abatement of product risk.
- Highlighting of areas of concern and associated recommendations
- Clarification of areas of uncertainty and answers to outstanding questions.
- Any other issues that should be addressed during the review but have not been.

Discussion of Project
(<10% of time; Responsibility: Project Manager)

- Overview of schedule including significant milestones achieved and planned.
- Status of budget (financial and time) including spending versus planned to-date, and projected spending.
- Resources required versus resources currently available.
- Assessment and abatement of project risk.

Wrap-Up
(~10% of meeting; Responsibility: Chairperson with Lead Engineer and Secretary)

- Identification and discussion of issues that should have and have not been addressed.
- Discussion on recommendations whether to proceed with current design direction, pursue alternative design approaches or terminate the project.
- Review of action items.
- Present outline of post-review activities (e.g., schedule for distribution of Design Review Report).
- The chairperson thanks reviewers for their participation.

As an example of time allocation for a 90-minute design review, 5 minutes in total should be spent on introductory remarks (e.g., welcome, purpose, etc.) and another 10 to 15 minutes spent making a brief presentation mainly providing an overview of the details

forwarded in the design review package. The majority of the meeting time should be dedicated to an interactive discussion about the product with the aim of resolving any outstanding issues including obtaining answers to questions, confirming assumptions made, and receiving feedback regarding the design. If appropriate, a few minutes can be dedicated to project issues. The final 10 minutes of the review should be dedicated to the extremely important wrap-up portion of the agenda.

Responsibility of the Reviewers

As it is not feasible to invite specialists in all applicable areas of a product in order to conduct an extremely comprehensive review, it is important that reviewers examine the product in areas outside of their main area of expertise. Some of the general considerations reviewers should address are included in the following checklist (Ref. Burgess, pp. 176-177, 287-288) which can be provided to the reviewers with their design review package or at the start of the review meeting:

- Do the data and results support the conclusions drawn?
- Do the assumptions seem reasonable?
- Are there areas where the risks appear to be higher than normal?
- Are there items of significance that have not been addressed?
- Does the design satisfy the applicable requirements? Are there requirements that were intentionally not satisfied? Is that acceptable?
- Are the design methods used appropriate for this product and its intended application?
- What problems remain to be solved? Is there adequate assurance the problems can be solved in a reasonable manner and appropriate time frame?

- Does the design:
  - appear to be satisfactory to proceed to the next phase of development or production?
  - meet the performance requirements for the application?
  - meet the environmental requirements?
  - meet cost objectives?
  - have a high probability of meeting the reliability requirements for the application?
  - meet the producibility requirements?
  - satisfy applicable human factors and health/safety requirements?
  - meet applicable maintenance/serviceability requirements?
  - meet the aesthetic requirements?

(See Burgess, Appendix 2 for a more detailed checklist).

Design Review Meeting Minutes

The design review meeting minutes will form the basis of the Design Review Report. These minutes are used to record decisions that have been made, issues that require resolution, conclusions made and actions that have been identified during the course of the design review. They are not intended to be a detailed manuscript of the discussions that took place but rather capture crucial information that impacts the progress of the project. All items requiring follow-up should have an associated date for completion. The minutes should identify the participants of the meeting and the roles they played.

One member of the design team is assigned the responsibility to maintain the minutes, however, individual team members are advised to record in their personal log books any items that fall into their area of responsibility. This allows them to begin dealing with any issues or action items immediately instead of waiting for the formal documents.

It is useful to distribute the minutes within a day or two of the review to all of the participants to review. This provides an opportunity to highlight any errors or omissions prior to the completion of the Design Review Report.

Post-Design Review Follow-up

One person should be designated with the responsibility to co-ordinate the follow-up activities of the design review. The chairperson or the lead engineer can fill this role. Each and every issue that was identified for resolution and any other action items are monitored to completion. All item must be addressed objectively in a timely manner and resolutions documented for inclusion in the Design Review Report.

Design Review Report

The extent and content of the report will depend on the audience as well as what was agreed upon at the design review. Typically, this report should be issued within a month of the design review meeting. In addition to the meeting minutes, the report should contain the status of each issue or action item as well as the details on the resolution of these items. If further investigation, testing or other analyses have been completed, evidence of these should be furnished.

It is not uncommon for the outcome of a design review to lead to changes not only in direction but also schedule and budget. The impact of these changes should be determined and an updated project plan included in the report.

Post-Mortem

Reflecting on various aspects of the design process provides valuable information that can be used to improve processes in future projects. A brief post-mortem meeting should be conducted within a few days of the design review. One or two of the reviewers should be invited to provide their input at this meeting.

References

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