count and returns to the wall where the attacker awaits. The defender needs to defend, counter-attack, and escape five times.

To rotate, the defender becomes the pad holder, the attacker defends, and the previous pad holder becomes the attacker.

This kind of procedural writing, which does not involve tools, materials, or a formulation of some kind, can be difficult to write. It is often helpful to go through the steps of the procedure before, during, and after you write the first and subsequent drafts. I suggest having more than two people read and test the procedures after you have completed your own reviews.

6.3 Proposals

A proposal is a document that is submitted to a funding agency, an oversight committee, management, or some other entity that can provide permission, funding, or substantive support for some planned activity. The memo to my dean proposing the computers in film series (see Section 5.5) was an example of an informal proposal.

Formal proposals require much more information. Government agencies have elaborate requirements for their proposals. Space does not allow inclusion of a complete example of this proposal type, but here is a modified proposal template for a U.S. Government agency, which also can be adapted for use in situations when the funding agency does not require a specific proposal format.

- Title
- Problem Statement
- Hypotheses/Objective
- Scope and Limitations
- Definition of Terms
- Abbreviations
- Background
- Uniqueness of the Research
- Potential Contribution
- Direct Application
- Potential for Technology Transfer
- Methods and Procedures
- Success Criteria

- Qualifications of the Research Team
- Organizational Center Initiative History
- Deliverables/Schedule
- Estimated Cost
- Other Funding Sources

Many private foundations and corporations have simple proposal formats, while some offer none at all, thus leaving you to organize your proposal as a clear and well-structured document.

6.3.1 Vignette: Grant Proposal

As an extended case study, consider the following grant proposal for the study of software requirements and design that I submitted to a company a few years ago. I have left out some of the fields for brevity, and also I have omitted some of the identifying and budget information*.

Title: A Study of Software Requirements and Design

Specification Practices Problem Statement:
There is a wide range of techniques available for software requirements elicitation, specification, and design. It is currently not known which techniques are used across the many NASA internal and subcontractor software development groups, how these techniques are used, and whether they are perceived to be successful.

Hypotheses/Objective:
We plan to research how software requirements and designs are specified across NASA internal and subcontractor groups to uncover best practices and to disseminate this information. The purpose of this research is to improve the practice of software requirements and design specification, to seek to obtain a level of uniformity, and to improve the potential for software reuse and overall software quality.

Scope and Delimitation:
The study excludes non-NASA and non-NASA-affiliated entities and also excludes NASA entities specifically excluded at the request of NASA.

Definition of Terms:
Software Requirements Specification: The set of documents containing a complete, consistent, correct and verifiable functional and non-functional description of a software system.

* Permissions note: Because I wrote this proposal, and it was not funded, as the writer I own the copyright to this material. If the proposal had been funded, then the copyright would have reverted to the funding agency or company.

Software Design Specification: The set of documents that completely describe how a software system is to meet the requirements set out in the Software Requirements Specification.

Software Requirements Elicitation: The process and practice of determining the functional and non-functional requirements of a software system for the purposes of developing the Software Requirements Specification.

Best Practices: The collection of rules, procedures and behaviors that are known to lead to efficient production of software include the elicitation of requirements, followed by writing and validating the Software Requirements and Design Specifications.

Background:
Based on the experience of the principal investigator and of the project consultants, one of whom has been working with NASA for many years, it is clear that there is a wide range of software requirements and specifications techniques being used across the many NASA software development organizations, and by vendors providing contracted software to NASA. This wide variation is no different from what is found in the software development industry at large.

There are many reasons for the diversity of methodologies used in software specification and design. These include the background and education of the engineers, the application domain, the corporate culture, and the existence of prior documentation which is to be reused. In addition, wide variation in software requirements and design specification methodologies makes software reuse difficult and causes dramatic variation in the software product as well as in the productivity and versatility of software engineers.

Poor software specification and design combine to form the leading cause of software failure, delays in production, and cost overruns. Too often, new techniques are introduced for software requirements and design specification that are intended to mitigate these problems. Unfortunately, because of insufficient training, lack of desire, poor follow-through, and/or pressures to complete the project quickly, these techniques are often adopted incorrectly or half-heartedly. Yet the impression persists that the problems of poor specification and design have been solved.

Uniqueness of the Research:
There are virtually no published results of surveys of Software Requirements Specifications or of Design Specification practices. A recent search on ten of the most applicable abstract indexing services yielded only two related published works. The first was a survey of requirements methodologies used in the design of databases [Batra] and the other a survey of techniques for the design of software platforms [Johannson]. Further, we know of no survey data specifically covering NASA software project teams or for NASA external software vendors.

The consultants for this project have already conducted research on Software Requirements Specification practices for a broad base of more than one hundred companies in the Delaware Valley. The preliminary results indicate that there is a disconnect between mandated requirements specification practices, implementation of those mandates, and perceived benefits. We believe that this may also be the case for NASA software development groups.

We intend to adapt and apply the prior survey to assess the processes and perceptions of NASA internal and contracted software groups. We will further extend the study to include Software Design Specification practices. The data already collected for the Delaware Valley Companies will act as a "control group" with which to compare the results for NASA internal and external software development groups. We will also compare and contrast the practices for NASA internal groups versus NASA vendor software groups.

References:
[Batra] Dinish Batra, "Consulting Support During Conceptual Database Design in the Presence of Redundancy in Requirements Specification: An Empirical Study," *International Journal of Human-Computer Studies*, Vol. 54, 2001.

[Johansson] Enrico Johansson et al, "The Importance of Quality Requirements in Software Platform Development — A Survey," *Proceedings of 34th Hawaii International Conference on System Sciences*, 2001.

Potential Contribution:
This research will have a major impact on software reusability and consistency of documentation across the broad range of NASA centers and vendors and of flight software and support software. The research should lead to improved best practices for all NASA software organizations. Ultimately, it should lead to increased software reliability, maintainability, productivity, and cost savings.

Direct Application:
The proposed research will support all ongoing software development efforts and provide reference data and best practices for software project managers and practitioners. A pilot study has already been conducted by the project consultants for a group of more than 100 companies in the Delaware Valley.

Potential for Technology Transfer:
There is tremendous potential for technology transfer. Since there is little data available on prevailing practices in developing Software Requirements and Design Specifications, these results will be of great importance to software practitioners in all applications domains. There is a great likelihood that the results of this project would be applicable to a whole range of current NASA projects and contractor projects.

Methods and Procedures:
This research depends on intensive up front work and follow up in succeeding years. This work will involve visits to NASA and contractor sites and intensive telephone and email contacts. In the first year we will construct the Web based survey instrument. To do this we will assess existing survey instruments including the prior instrument used by the consultants for the Delaware Valley "control group." We will interview various NASA internal and external software development groups. We will construct an email list of survey participants. We will then invite the pool to participate in the survey and we will send various reminders to maximize participation. We will collect data and encourage participation for several months. Upon termination of the data collection phase we will commence data analysis. Finally, we will prepare a report and set of recommendations. Our recommendations will include next steps for the follow up research to be conducted in year two. We will present our findings to NASA and in various proceedings and journals as appropriate.

In the second year we will focus our investigation on the actual participants from the year one survey (those who provided survey data). We will study selected Software Requirements and Design Specifications documents, manuals and procedures. We will conduct focus groups and interviews (either in person, via telephone or via email). Our objective is to further understand and explain the results of the first year. We will match reported with actual practices and identify any disparities. We also intend to further quantify best practices and to intensively disseminate those findings throughout NASA. This will involve travel to NASA and contractor sites. We will also construct the final research focus for the third year. We will present our findings to NASA and in various conferences and journals as appropriate.

In the third year we will conduct additional focus groups and follow up studies. The purpose is to see if the findings and best practices disseminated in years one and two have begun to penetrate the behaviors of the software practice groups. The study methodology will be similar to that of year two. We will continue to work with those software groups that find our results beneficial. We will continue to disseminate our finding to NASA software groups. We will present our findings to NASA and in various proceedings and journals as appropriate, including recommendations for future work and initiatives.

Success Criteria:
Success will be measured by collection of statistically significant survey results and meaningful focus group results and by identification of best practices and areas for improvement. Furthermore, we expect to develop improved standards for Software Requirements and Design Practices, and signs of adoption of the best practices in those software practice groups that are identified as most needing improvement.

Unfortunately, this proposal was not funded—I think for reasons beyond the quality of the proposal. There is tremendous competition for grant monies, and political influence is often more important than persuasive writing.

6.3.2 Vignette: Proposal for Consulting Services

Sometimes a proposal to a company can be much more informal, as in consulting services. Here is a disguised sample proposal that I submitted to a company to deliver a course.

Proposal for Consulting Services
Agreement made this day February 6, 2009 between

MaggieTex Systems, the Client, and **Dr. Phillip Laplante**, the Consultant, for consulting work by Dr. Phillip Laplante, the Course Leader.

1. Preamble. The responsibilities of both the Consultant and Client are outlined in this Agreement. Each has obligations to one another, which when fulfilled in an atmosphere of mutual respect and cooperation, will yield benefits to all concerned.

2. Course Delivery. Real-Time Systems Design and Analysis, the Course, is a three-day lecture-style course. The Course will be delivered at the Client's site in Cambridge, Massachusetts on three consecutive days from March 17, 2009 to March 19, 2009.

3. Client Obligations. Client shall provide the following items for use by the Consultant in the delivery of the course:

- a lecture or meeting room capable of seating all course attendees,
- an overhead display projector and screen.

The Client will also pay the Consultant under the terms of section 5, Payment Terms.

4. Consultant Obligations. The Consultant will deliver the Course as described in section 2, Course Delivery, along with one copy of the course notes. The Client is authorized to photocopy the course notes, one set per attendee. The Consultant will ask attendees to participate in a course evaluation. The results of that evaluation will be shared with the Client. However, payment under section 5 is not contingent upon the results of the evaluation. Consultant will retain copies of all surveys and may use comments contained therein for promotional purposes.

5. Payment Terms. The Consultant shall be paid 400 shekels of gold for the delivery of the course. Payment will be due 30 working days after completion of the course. Late payments will incur an interest charge of 1.5% per month. Client is only authorized to copy Course notes, one copy each, for attendees of Course. Additional copies may be made at a cost of 1 shekel per set, or purchased from the author at 2 shekels per set.

6. Course Changes or Cancellation. Neither the Consultant nor the Client may reschedule or cancel the Course without the agreement of the other party except that:

In the event of serious illness on the part of the Course Leader, notice will be given to the Client and the course rescheduled at mutual convenience.

Client may completely cancel the Course up to 30 days prior to the start of the Course delivery without consequence upon simple notification of the Consultant.

Client may cancel the course 10 days prior the start of the Course delivery, but will be charged 40 shekels.

7. **Interpretation** The services described this Agreement constitute the entire agreement between the parties hereto, and supersede all prior verbal or written discussions and agreements. This Agreement shall be construed in accordance with the laws of the Commonwealth of Pennsylvania and shall be deemed to have been accepted in said state. It may not be changed orally. Any controversy arising out of or relating to this Agreement or the breach thereof shall be settled by arbitration in Pennsylvania in accordance with the rules of the American Arbitration Association, and the award rendered by the arbitrator may be entered in any court having jurisdiction thereof.

All proposals are legal documents—they constitute a commitment on the part of both parties, but this informal proposal really looks like a contract, and it is one. You should consult with an attorney before submitting any contract to a client.

Here is the cover letter to go with the proposal for technical services:

Dear Dr. Lee:

This is in reference to the Real-Time Systems Design and Analysis course that I will be delivering at your site on March 17–19, 2009.

First, thanks for sending the background information on MaggieTex Systems. I am sure that the course is very much aligned with your applications areas.

Please find enclosed one copy of the course notes to accompany my book, *Real-Time Systems Design and Analysis, fourth edition,* which I understand you are purchasing for course attendees, and a course evaluation form. You are hereby authorized to make one copy of the course notes and the course evaluation form for each person attending the course on March 17–19. Additional copies of the course notes may be made for non-attending personnel provided you notify me in advance of the number of copies to be made. I will then invoice MaggieTex Systems 1 shekel of gold per copy for the additional copies.

I am looking forward to our course and to meeting with you and the other people at MaggieTex Systems.

Please don't hesitate to contact me in the meantime if you have any questions.

Sincerely,
Phil Laplante

In submitting my proposal, I also included a summary of the course, which is included here for completeness.

REAL-TIME SYSTEMS DESIGN AND ANALYSIS (3½ hours)

Real-time and embedded systems, which are closely related, are so ubiquitous that they are impossible to avoid. The term real-time has even entered non-technical jargon. But real-time systems are special and require special considerations to design. Based on the second edition of the best selling text, *Real-Time Systems Design and Analysis: An Engineer's Handbook,* this course provides an introduction to real-time systems and the real-time problem.

BENEFITS/LEARNING OBJECTIVES

This course will enable you to:

- Identify the unique characteristics of real-time systems;
- Explain the general structure of a real-time system;
- Define the unique design problems and challenges of real-time systems;
- Apply real-time systems design techniques to various software programs.

INTENDED AUDIENCE

This course is ideal for newer software engineers or experienced software engineers who have never worked in real-time or embedded software environments. Managers of projects involving real-time systems will also benefit.

All proposals involve commitment; therefore, you must be extremely cautious in what you put in writing. There may be a temptation during the proposal phase to exaggerate your abilities or overreach your goals. You must curtail these urges lest you find yourself winning a proposal on which you can't deliver.

6.4 Panel Sessions

You may be asked to lead a technical panel discussion, forum, or roundtable. In many ways, leading a discussion panel is like leading a meeting. You need to control the pace of the meeting, keep participants on track, and stimulate discussion when needed. In preparing for these kinds of events,