A GUIDE FOR SYSTEMS ENGINEERING GRADUATE WORK:
HOW TO WRITE WELL AND MAKE YOUR CRITICAL THINKING VISIBLE

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and the

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PREFACE

This guide is intended to provide the basis for learning to communicate effectively in writing. The guide is useful not just for your engineering project reports or thesis but for all the writing you will do as an engineering graduate student.

Technical and non-technical communication currently is perceived as an almost irrelevant and minor component of the engineering process and engineering education. The topic is given short shrift even though it is continually desired as a characteristic of a proficient engineer by professional societies and employers and required by accrediting bodies in the United States, such as the Accreditation Board for Engineering and Technology (ABET).

Specifically, the ABET Engineering Accreditation Commission’s (EAC) Criterion For Accrediting Engineering Programs lists several items required for successful engineering education:

   a) An ability to apply knowledge of mathematics, science, and engineering.
   b) An ability to design and conduct experiments, as well as to analyze and interpret data.
   c) An ability to design a system, component, or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
   d) An ability to function on multidisciplinary teams.
   e) An ability to identify, formulate, and solve engineering problems.
   f) An understanding of professional and ethical responsibility.
   g) An ability to communicate effectively.
   h) The broad education necessary to understand the impact of engineering solutions in a global, economic, societal and environmental context.
   i) A recognition of the need for, and an ability to engage in, life-long learning.
   j) A knowledge of contemporary issues.
   k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (ABET, “Criterion 3 Program Outcomes,” 2009.)

Outcomes (d), (f), and (g) indicate that a learner’s curriculum is required to address development of an understanding of professional responsibility, working on teams, and communication. These soft skills are given minimal space in already crowded
engineering education curricula because they are often the hardest to teach, to learn, and to assess. The skills related to these elements are not necessarily best learned through classroom lecture but through practice in authentic engineering contexts, such as capstone design projects. They are crucial nonetheless.

Communication is often cited as one of the most highly desired and important traits of a successful engineer in the US Defense workforce. Figure 1 shows the results of a 2010 survey of engineers from the US Department of Defense systems engineering 38,000-member workforce (Center for Naval Analyses 2011). Next to professional ethics, communication is the single competency that simultaneously requires the highest level of proficiency and is the most mission critical of any of the 29 engineering competencies surveyed.

Figure 1. Survey of the US Department of Defense (DoD) Systems Engineering Workforce.

Figure 1 displays mission criticality versus the proficiency desired for the 29 identified systems engineering competencies. The results show that of 29 engineering related competencies included in the survey, communication requires the highest level of proficiency and is one of the most mission critical skills required for conducting engineering for the DoD. These results mean that next to professional ethics, communication is the single competency that simultaneously requires the highest level of
A survey was conducted to determine levels of proficiency desired in the areas identified in this study and in the Conceive, Design, Implement and Operate (CDIO) syllabus that provides a state of goals for engineering education. CDIO is an international consortium of engineering educators. The results of the survey are shown in Figure 2.

The survey measured systems engineers’ responses to levels of desired proficiency for new hires and mid-career engineers with respect to categories of the identified by the DOD study and in the CDIO syllabus. Systems engineers (SE) were asked, “At what levels of proficiency is it expected that a hired SE perform?” The levels of proficiency defined ranged from a low of “contribute” to the process all the way through the ability to “lead and innovate.”

The importance of addressing the skills not necessarily related to any specific engineering discipline per se, for example, the ability to communicate, have professional skills (a sense of ethics, equity, and other responsibilities), personal skills (productive attitudes, the ability to think and learn), and to work on a team, are highly valued for new hire
engineers, and continue to be some of the most important skills for mid-career engineers. Notable as well is that by mid-career, engineers are expected to improve proficiency across the board in all areas.

I. OVERVIEW

This guide’s purpose is to help you become both a successful systems engineering student and a proficient systems engineer in that it provides guidelines for writing in a way that explicitly demonstrates critical thinking. Because of an increased interest in the professional engineering community in not only technical ability and mastery of engineering science, but in effective communication, the NPS Systems Engineering department would like to support your efforts in expressing yourself orally, in writing, and interpersonally when working on a team—to prepare you for success as a practicing systems engineer wherever your career may take you.

This guide should be used for preparing all systems engineering technical writing completed for graduate work at NPS (either for your coursework or the final report required for your degree.) Created from conversations among faculty members in the SE department and the wider NPS community (including the Dudley Knox Library, the Thesis Processing Office, and the Research Office), it builds on and works with previous versions of interdepartmental writing guidance.

The SE department is committed to helping you become a capable, articulate communicator by providing two dedicated faculty members, Barbara Berlitz and Mary Vizzini, to develop your writing and researching abilities. All graduate students are encouraged to pursue professional writing, editing, and formatting assistance. In addition, the Thesis Processing Office provides an outsourced staff of editors and formatters for hire. For information regarding editors or formatters, and for specific guidelines to use while developing your final report, see http://www.nps.edu/Research/research1.html.

A note about tone, examples used in the guide, and silent corrections

You will probably notice that this guide’s writing style is sometimes becomes less formal than is expected in your own written submissions. This is because we are hoping it will be a friendly explanation of some otherwise dry and colorless rules.

In contrast to this conversational style, writing for coursework and project reports is expected to have a formal tone, as it is often archived for further researchers in NPS’s library or the Defense Technical Information Center (DTIC). So while you may see the second person used in this guide, for example, when we say “we” or “you”, the tone for SE technical writing avoids the first and second person because it aims to be neutral,
objective, and de-personalized, an effect achieved most readily by using the third person (i.e., “this report contains” rather than “my report.”)

Finally, this guide includes student writing examples which have not been formally cited. Furthermore, variations in the use of punctuation or formatting styles have been silently corrected to prevent errors should this guide provide examples that may be imitated.

II. ENGINEERING REASONING: A CRITICAL THINKING PARADIGM

GET TO KNOW THIS BOOK: Elder, Niewoehner, and Paul’s The Thinker’s Guide to Engineering Reasoning

A key reference point for the Systems Engineering department is The Thinker’s Guide to Engineering Reasoning. This mini-textbook issued to all students by the department provides students and faculty alike with a common vocabulary for discussing critical thinking and reasoning within the engineering discipline.


The Thinker’s Guide to Engineering presents critical thinking as an ability that humans cultivate when they reflect on their own thinking. “A Model of Engineering Reasoning,” (Figure 3) provides a visual for the process of critical thinking. We learn to apply the standards of critical thought, such as “accuracy,” “precision,” “relevance,” and “breadth,” to elements of thought, which combine to produce traits of a mature thinker.


Figure 3. “A Model of Engineering Reasoning” (From Elder, Niewoehner, and Paul 2007).

**Engineering reasoning point of reference: The Thinker’s Guide**

Comments made to students about their writing will be based on evaluative language coming from Elder, Niewoehner, and Paul, as they describe the distinctions between the standards, elements, and traits of critical thought.

In Table 1, let’s imagine how this use of critical thinking vocabulary might appear. Column 1 displays a student’s claim, and Column 2 displays faculty feedback derived from *The Thinker’s Guide*. The feedback prompts the student to demonstrate his thinking more explicitly in later iterations.

<table>
<thead>
<tr>
<th>Student claim a draft technical argument</th>
<th>Faculty comment using the vocabulary of <em>The Thinker's Guide</em></th>
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<td>“The carbon footprint of the DDG51 should be mitigated.”</td>
<td>This claim isn’t <em>precise</em>. What <em>assumptions</em> are you making about why this is? This is an <em>incomplete</em> claim.</td>
</tr>
<tr>
<td>“It is important that the”</td>
<td>For whom is the carbon footprint <em>significant</em>? What are</td>
</tr>
<tr>
<td>carbon footprint of the DDG51 be mitigated.”</td>
<td>the implications to reducing it? If the means of accomplishing this were stated, this claim would be more informative, and more purposeful.</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>“The carbon footprint of the DDG51 class of ships would be mitigated by modifying shipboard lighting figures to reduce energy consumption.”</td>
<td>What points of view are involved in this? What is the purpose for making these modifications? If the people who are directly interested in this are pointed out, we could see the significance of this claim more clearly.</td>
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**Table 1.** A Draft Technical Argument. A dialogue between a student writer and an instructor providing feedback.

To address the concerns from Table 1, consider the following revision:

The carbon footprint in DDG51 class ships would be reduced if an off-the-shelf component were used to turn down shipboard lights during times of low activity. As a modification to existing systems, this could occur at a lower cost than replacing existing light fixtures, as it would not require modification to the ship itself, (i.e., replacing existing lights with newer, energy efficient versions.) Regulating shipboard light use with a timer would bring about the energy reduction in line with Secretary of the Navy Ray Mabus’ request for a “greener” fleet by 2012.

The writer is more precise in stating assumptions, (that modifications rather than structural change are preferred); more explicit in articulating points of view (people interested in the integrity of the ship and/or in cost-effective solutions), and more purposeful about why these modifications would be positive at this particular time (mentioning Secretary of the Navy Ray Mabus’s statement about a “greener” fleet by 2012).
TAKE AWAY

*The Thinker's Guide to Engineering Reasoning* should prepare you to start evaluating your own reasoning as it appears when writing for coursework or in a project report you write in partial fulfillment of your Master’s degree. Individual word choice itself requires precision, accuracy, clarity, and other standards of critical thinking, and this applies to all of your communications. You must study engineering reasoning and master its principles to be a successful SE student, and eventually, a proficient engineer.
GET TO KNOW THIS BOOK: Turabian’s *A Manual for Writers of Research Papers, Theses, and Dissertations*

Turabian’s book is a writing textbook that you can use to (1) augment your knowledge of academic writing and (2) understand what is meant by graduate level research. This manual for how to write using research is a simplification of what is contained in the *CMS (The Chicago Manual of Style)*. In addition to a chapter on assembling arguments, (Chapter 5: “Assemble the Elements of Your Argument”) Turabian has two particularly helpful chapters explaining how to write using the author-date style (also called the “Parenthetical Citations-Reference List Style”). The author-date style (as explained in the *CMS* and by Turabian) is the style of citing sources preferred by the SE department.


With a reference point for what is meant by critical thinking, we can focus on a sequence of steps used to construct an argument, as will be necessary for developing technical arguments in either your coursework or a project report. This next section is derived from Kate Turabian’s *A Manual for Writers of Research Papers, Theses, and Dissertations* (2007).

**Forming an argument**

Turabian describes an argument as something composed of three elements: a claim, reasons for accepting a claim, and the evidence that supports those reasons. Persuasive writing is built out of answers to the following questions:

- What is your claim?
- What reasons support it?
- What evidence supports those reasons?
- How do you respond to objections and alternative views?
- How are your reasons relevant to your claims?

Written arguments follow a particular pattern: you state your claim (“in a sentence or two”); you support your claim with reasons and evidence (as Turabian puts it, “we think up reasons, but we collect hard evidence; we don’t collect hard reasons and think up logical evidence.”) Next, we acknowledge and respond to readers’ points of view, whether implicitly or explicitly. As *A Manual* points out, our job as writers is to imagine...
and anticipate objections, where someone could say, for example, that the evidence we use is unreliable, out of date, inaccurate, insufficient, doesn’t adequately represent all available evidence, or is irrelevant (48–61). If this language sounds similar to The Thinker’s Guide, it should, as Turabian and the textbook on critical thinking are outlining basic patterns used by disciplined thinkers.

An argument in an abstract
Let’s examine a concrete example, to get a sense of how technical arguments look in a SE context. Figure 5 contains an abstract from a report recently submitted to the SE department.

The claims made here are that there is a material solution to “increase the survivability of the V-22 Osprey,” and the systems to do this are “a forward looking infrared (FLIR) camera,” an “infrared countermeasure (IRCM) system, the Joint and Allied Threat Assessment System (JATAS), and ramp and chin-mounted GAU-21s.”

This paper describes the development of a materiel solution to increase the survivability of the V-22 Osprey tiltrotor aircraft against man-portable projectile weapons during the vulnerable mission phases of approach, landing, takeoff, and departure. The project focused on defensive capability of the V-22 aircraft and application of a model-based system engineering (MBSE) approach to determine the highest ranking alternative after performance, cost, and risk analyses. The team performed a threat assessment to identify capability gaps in defense during four operational scenarios within urban and rural mission environments. Candidate system functions were chosen based on requirements derived from capability gaps. These functions were decomposed to form a physical architecture based on detection and mitigation components using ViTech© CORE system architecting software. A complex variation of Zwicky’s morphological box was created in Microsoft Excel to assess the performance of millions of component combinations based on relative comparisons of 43 quantifiable measures of performance (MOPs). Independent risk and cost analyses were conducted on the top 29 performing alternatives to make a final recommendation. The group of recommended systems included a forward looking infrared (FLIR) camera, an infrared countermeasure (IRCM) system, the Joint and Allied Threat Assessment System (JATAS), and ramp and chin-mounted GAU-21s.

Figure 5. Example of a Technical Argument in an Abstract.

Note the pattern: claims, followed by reasons, backed up by evidence, resulting in a conclusion directly related to their initial claim—that they wanted to improve the survivability of the V-22 Osprey by means of a particular set of systems suited to the complex SE context under consideration. They write persuasively as they indicate they used appropriate methods to analyze appropriate data, explaining their reasoning fully in
that they specified what they analyzed and the methods they used to do it (by naming the tools in question.)

An argument explaining a methodology
This next selection from a recent report shows how the writers decided on a process model which would organize their technical approach. Observe how the writers carefully explain their reasoning in how they developed a modified Vee model. Not only do they explain it, they show it by means of the graphics they include, and they situate their use of a common model in light of what others have done, as well as in relation to their own needs (Figure 6.)

To enable a rigorous technical approach, a Systems Engineering (SE) Process was designed to address the challenge of the MQ-8C development. With the identification of a materiel solution prior to the comprehensive development of detailed requirements, the SE Process needed to address a concurrent path that clarified the technical capabilities of the selected materiel solution, while quantifying and detailing the affected requirements associated with the JUONS.

The need to compare the capabilities of the materiel solution to the decomposed user requirements traced from the JUONS drove the development of a parallel assessment SE process. This strategy, followed by a gap analysis compels a need for concurrent, independent assessments, while preventing discoveries in one path from impacting, or skewing, the work of the other. The conceptual basis for the approach is shown in Figure 5, which established the working level concept for the Gap Analysis and Feasibility Assessment.

To accomplish these efforts, the traditional DoD Pre-Milestone A SE process and the DoD SE Vee model were modified (Defense Acquisition Univeristy 2011). This baseline was adapted to the specific, dual path approach for this project, depicted in Figure 6. The traditional SE Vee relies on a linear progression of tasks with concurrent feed-forward and feedback mechanisms to inform verification methodology and task iteration. For the FEU project, the SE process relied on two independent tracks focusing on requirements investigation and capabilities investigation. These tracks converged in an integration activity where the results of both tracks would be compared, evaluated, and integrated into a common baseline. Disconnects in this baseline would indicate likely gaps and feasibility risks, and these would be investigated and analyzed through the upward, integrated, leg of the “Vee.”
Figure 1: Technical Approach Development
As the project progressed through the parallel downward legs of the FEU SE Process model it became apparent that it was not adequately representative of the tasks necessary to complete the independent and integrated assessments. Additionally, the FEU SE Process Vee model included iteration and feedback linkages that were not representative of the fundamental strategy. To address this shortcoming and to refine the process model, the team developed an adaptation to the FEU SE Process Model Vee to clarify the unique tasks associated with the independent investigations, Figure 7. The updated process diagram specified the tasks associated with the individual process legs and clarified the integrated system tasks.
In the selection of a report wherein the writers explain how they tailor a common SE process to accomplish the demands of their specific analytical project, note that the writers identify each figure before it is presented, and they give guidance about how to read the data contained in it. (The reason for this is that the reader is encountering the information for the first time. Thus, a writer must explain how to read it and/or the logic behind its construction, as well as provide a legend, how any lines are obtained, the connections between data points, and so on as required by the particular graphic provided.)

Here, the writers explain how what is portrayed in the graphics connects to the main point of the section in which it appears: the writers *show* and *tell* the rationale behind their construction of a process model to structure their technical approach. In each figure they include, along with the discussion that describes what is portrayed in the figure, the writers assemble a technical argument, providing both reasons and evidence.

**An argument in a data analysis section**

This next example (Figure 7) comes from a recent thesis where the writers present evidence but have not yet arrived at an argument. The instructor’s response (in red font) asks for more complete explanation: as a reader, he indicates the writers need to provide more guidance for how to interpret the meaning of the graphic the thesis writers have
included. In the comments, the SE professor asks for the technical arguments to be developed, for the reasons (the written explanation) and evidence (the graphic itself) to be adequately articulated.

Figure 30, also generated by JMP data visualization software, illustrates the correlation of all 28 systems with respect to the eight key system attributes. From this chart, relationships can be inferred with respect to the solar irradiance, wind speed, and all eight key system attributes.

**Instructor comment 1:** Yes they can be inferred but what did YOU infer from these plots. You must be specific about how these were used to either modify, reinforce, etc. so your reader knows exactly why they are looking at this.

![Figure 1. Correlation table of all 28 energy systems and the 8 key system attributes](image)
Linear trend lines are included to aid in visualizing relationships that exist among the environmental data and attributes. The slope of the lines indicates data correlating either positively or negatively.

**Instructor comment 2**: You have not stated anywhere in this section why you show this plot, and specifically how it relates to the rubric, or anything else you found. Did you use this for any specific purpose – did it confirm or deny any outcomes, how was this useful, etc.?

Thinner lines indicate stronger relationships as the data points follow trends more closely. For example, the total O&M cost negatively correlates with PV energy production and positively correlates to wind production.

**Instructor comment 3**: It seems to me that many of the correlations have R-squared values that are very low (though some seem high) and that the shaded areas indicate on many that the linear fit can vary quite a bit based on the data and analysis. You should explain this in describing your results here.

**Figure 7.** An Argument in a Data Analysis Section in a Thesis.

While the writers have explained some of the elements of the correlation table they created, the instructor commentary indicates a few areas for improvement, pointing out that the students have not connected their observations to a main point, and noting that it is not yet evident how some of the ambiguities in the correlation table are to be understood. As the students revise their argument, it will be more fully developed as the instructor criticism helps them develop their critical thinking.

**TAKE AWAY**

When writing for a class assignment or in the context of a final report, remember this pattern of assembling an argumentative claim: claims, supported by reasons, borne out by evidence. Technical arguments are expository (in that they present explanations) and persuasive (in that they need to be compelling). They are based on reasons (that are abstract) and evidence (that is concrete.)
IV. DEVELOPING TECHNICAL ARGUMENTS WHILE CITING RESEARCH

GET TO KNOW THIS BOOK: The Chicago Manual of Style

This is 1026 page encyclopedic style manual contains anything you may need to know about formatting entries in a list of references and rules for English usage with respect to grammar, syntax, and punctuation.

When following the Chicago Manual of Style, do not create footnotes and develop a bibliography. Follow the “author-date” method of citing research and compile a list of references, as is common in SE.

This standardized point of reference to consult about all aspects of the writing process is available through the Dudley Knox Library, via the use of your NPS credentials: http://www.chicagomanualofstyle.org.libproxy.nps.edu/home.html.


This section shows you what your writing should look like when citing research, but it does not address the intellectual tasks involved in researching within the discipline of SE, an area you will address with your final report advisor(s), as well as other faculty you work with throughout your learning.

Including Citations: Summary, Paraphrase, and Quotation
Writing using research involves two aspects: signaling we are writing using other sources by means of using summary, paraphrase, or quotation, and by including citations which are presented in a codified and consistent way (the author-date branch of the Chicago Manual of Style).

Summary
A summary is a writer’s restatement of another’s contribution to knowledge but in a new context (that of your paper): this is indicated by means of a signal phrase, an identification of an original context and an in-text citation.

Summaries are often used to create a context for why a researcher is asking a particular question. In a recent article found in the journal Systems Engineering, we see a summary of various documents put out by several organizations that contributed to defining systems engineering:
The core of systems engineering standards and *de facto standards*— IEEE 1220 (Institute of Electrical and Electronics Engineers 1998), ANSI/EIA-632-1999 (American National Standards Institute and the Electronic Industries Alliance 1999), ISO/IEC 15288:2002 (International Organization for Standardization and the International Electrotechnical Commission 2002), and CMMI (Carnegie Mellon Software Engineering Institute 2002)— have been around for a decade, which makes the definition of systems engineering somewhat immature. MIL-STD 499A (U.S. Department of Defense 1969), and MIL-STD-490A (U.S. Department of Defense 1985) were the first standards that mentioned systems engineering, but define systems engineering in a much narrower way. (Valerdi and Davidz 2009, 176—177)

In this passage, note:

- how to use the author-date method of citing sources when the sources cited are not written by single authors but rather agencies or institutions
- how to include multiple citations in one paragraph
- how to refer to military standards
- how to format a “block quote” (passages longer than three lines of text are not enclosed in quotation marks; they are single-spaced, indented 0.5” from each margin, and the parenthetical citation for the quote itself is located outside of the quoted passage, not inside quotation marks, but after the final punctuation in the sentence.)

A summary like this one from *Systems Engineering* is a kind of context building that you might see in a literature review (for a thesis) or the background section where you need to explain the rationale behind the research conducted (for a project report written by a team.)

A note about style: this journal article example is not elegant from a writing perspective, but that is because it summarizing several documents in order to develop a frame of reference to present other ideas. Do not emulate this if you are trying to write smoothly, but note how the writers summarize key definitions in order to demonstrate where important ideas are coming from. Additionally, it gives you a good example of how to cite industry and technical standards and other items which are used in military writing.

An example from a summary written to build a context written in the field of economics is similarly unwieldy, but serves a definite purpose:

Recent literature has examined long-run price drifts following initial public offerings (Ritter 1991; Loughran and Ritter 1995), stock splits
(Ikenberry, Rankine and Stice 1996), seasoned equity offerings (Loughran and Ritter 1995), and equity repurchases (Ikenberry, Lakonishok, and Vermaelen 1995.) (CMS 2010)

Here, you may observe how to write a sentence which features summary, and how to write in-text citations where there are single, dual, and multiple authors. A final item to note is that when writing a citation for a block quote, it appears outside of the final punctuation mark of the sentence quoted. When the parenthetical citation appears within a normal sentence (not in a block quote), citations are placed just before the final mark of punctuation.

Paraphrase
To give you an example of what paraphrasing looks like, let’s look at an example of plagiarism, a writing problem which you can proactively avoid by learning writing habits appropriate to working with other researchers. Looking at a plagiarized passage will show you what not to do, so that you may move on to see how to use the writing gesture of paraphrase in a concrete way to avoid violations of academic integrity.

Plagiarism occurs when you do not give credit to other researchers or authors, and use words, phrases, the order of logic, or the order of presentation of ideas, without acknowledging they come from someone (or somewhere) else.

Here is an example of a plagiarized passage, which is taken from a lecture presented at the Naval Postgraduate School by Eric Dahl of the NSA department.

NPS Professor Simson Garfinkel wrote the following passage in an article appearing in an online journal:

Causes that employ Leaderless Resistance do not have these links because they are not organizations: they are ideologies. To survive, these ideologies require a constant stream of new violent actions to hold the interest of the adherents, create the impression of visible progress towards a goal, and allow individuals to take part in actions vicariously before they have the initiative to engage in their own direct actions. (“Leaderless Resistance Today” 2003)

In his 2009 book Leaderless Jihad: Terror Networks in the Twenty-first Century Marc Sageman wrote:

The leaderless social movement has other limitations. To survive, it requires a constant stream of new violent actions to hold the interest of potential newcomers to the movement, create the impression of visible progress toward a goal, and give potential recruits a vicarious experience
before they take the initiative to engage in their own terrorist activities.

(145)

This instance of plagiarism, coupled with others of a similar kind, had devastating consequences for Sageman’s professional reputation. But this instance of plagiarism could have been prevented, if Sageman had used paraphrase correctly.

You indicate that you are paraphrasing someone else with a signal phrase (i.e., “Garfinkel describes,” and/or a citation after the paraphrase appears (i.e., “Leaderless Resistance Today,” 2003). Here is what paraphrase should look like:

Garfinkel describes this concept of “leaderless resistance” movements by saying that they are not organizations, but ideologies. They require a stream of new violent energies to sustain the interests of followers, which also creates the impression that participants are moving toward a goal. Further, the “new stream of violent actions” allows adherents to imaginatively take part in the ideological movement, prior to their actual participation in terrorist activity. (“Leaderless Resistance Today,” 2003)

In paraphrasing, you may stick very closely to the line of argument presented in the original, the order of presentation, the syntax, the word choice, and the content. You do not need to add anything to the original to follow guidelines of academic integrity. However, you do need to indicate that you are paraphrasing someone else to show your reader where the original claims were made, giving credit where credit is due.

Quotation
Quotation is easy to understand because it is simply the direct inclusion of someone else’s work into the new setting of (your) researched writing. Any time a graphic, table, chart, or figure which is not the writer’s own is used, a writer must follow the rules of quotation, which are used to indicate that quoted material comes from someone else, and provide an in-text citation to locate it precisely. Complete rules for quoting are found in the CMS and in the formatting checklist in an appendix at the end of this guide and have been demonstrated throughout this guide.

Examples of Parenthetical Citation Use
Included here are some examples of how to write using the author-date style when you are citing sources within the body of a report. These examples are from “Documentation II: Author-Date References” in the CMS.

Two basic examples
As legal observers point out, much dispute resolution transpires outside of the courtroom but in the “shadow of the law” (Mnookin and Kornhauser 1979.)…Here we empirically
demonstrate that workers’ and regulatory agents’ understandings of discrimination and legality emerge not only in the shadows of the law but also, as Albinston (2005) suggests, in the “shadow of organizations.”

**Including a page number to precisely locate a quote**
(Pollan 2006, 99–100).

**For books with multiple authors**
(Ward and Burns 2007, 52).

**Clarifying information**
If you need to include an additional bit of information in your in-text citation to clarify something, add it after the author’s name and date, separated by a semi-colon:

(Mandolan 2009; *t*-tests are used here)

**Author’s name stated in sentence**
If you would like to mention the author’s name in your sentence, you do not need to repeat it in a parenthetical citation:

Tufte’s (2001) excellent book on chart design warns against a common error.

**Cross referencing other articles**
If you would like to tell your reader to consult other articles, write:

There are at least three works that satisfy the criteria outlined in Smith’s (1999) study: (see Rowan 2006; Bettelthorp 2004a; Choi 2008).

**A source by more than three authors**
To cite a source written by more than three authors:

(Shonen et al., 2009)

According to the data collected by Shonen et al. (2009).

**Multiple references in one citation**
If you need to cite multiple references in one citation:


**Adding a title in the reference citation for clarification**
If you need to add the title of the item you are citing because there might otherwise be confusion write:
Creating parenthetical citations when using citation management software

Citation management software will offer as an in-text citation something like (Navy 2001) if it can’t find a single author. But because (Navy 2001) could apply to thousands of different documents, write in the name of the agency within the Navy which published the document and/or the specific name of the item you are citing:


Multiple citations from one source in one paragraph

If you have a paragraph where you are pulling in a number of bits of information from the same source, you can have a citation appear at the end of the paragraph that applies to all the information you mention from the one source. Placing the parenthetical citation at the end of the section lets your reader know that all the information in the paragraph came from the one named source. The CMS explains these situations in this way:

When the same page (or page range) in the same source is cited more than once in one paragraph, the parenthetical citation can be placed after the last reference or at the end of the final paragraph (but preceding the final period.) When referring to different pages from the same source, however, include a full parenthetical citation at the first reference; subsequent citations need only include page numbers. (798)

By a similar logic, when you refer to a writer by name in the body of your paragraph, you do not have to repeat the person’s name/year in the in-text reference citation

Citing Informal or Unpublished Information

The purpose of citing sources is to show your reader how to trace a claim back to something outside of your personal experience or point of view. In addition, it is your way to get a reader to the same information you used to come to your conclusions, if your reader wanted to see the original context or recreate your experiment. For this reason, formal research rarely uses information from private conversations or coursework.

Part of the research process involves locating where information comes from and making sure it is available to someone else. Thus, if you are basing a claim in a paper off a lecture, look for the textbook used for the lecture so that it could be found by another researcher. Or, if you are basing a claim off a module in a course, find published readings where the same information is available to someone who was not also in that particular class.
To write about informally published material, you refer to it in the body of your paper and you do not include an entry in your list of references.

**A comment made in a lecture**

For example, to cite a comment made in a lecture, write:

An important distinction between design and architecture was made in a lecture on conducting a system upgrade delivered at the Naval Postgraduate School in Monterey, December 14, 2011: while architecture involves …, design is …

**A conversation or email**

To cite a comment from a subject matter expert (SME) or a professor, write:

William Smith, a civil engineer and professor at the Naval Postgraduate School, made this important distinction between architecting and design: … (personal communication.)

When using a parenthetical citation after including informally published material, you will need to write the name of the source of information, as well as an phrase which explains why it is unavailable to the reader, i.e., (Julie Cantor, personal communication) or (C.R. Brown and M.B. Brown, unpublished data.)

Write according to these modeled examples because this is how you lend credibility to otherwise informal material. By using a title or descriptor for the person cited, and/or stating the full name of the academic institution where the lecture was held, you provide authentication for the statement you are including and will make the tone of your paper suitable for the context of graduate work.

**Citing sources from the Internet**

Wikipedia and Google can be used to get basic ideas and to jumpstart research, but more thoroughly vetted material is usually required for graduate work. If you are including information from a Google search, Wikipedia, a personal website or a blog, you will have to be prepared to defend why you used an informal or unscholarly source.

When you refer to websites in the paper, identify them by a specific title, by the name of the sponsor or author, or by a descriptive phrase. In your list of references, be sure to provide a Digital Object Identifier (DOI) or a stable Uniform Reference Locator (URL) for every online source cited.

Turabian provides this example: “As indicated on the Federation of American Scientist’s Web site…” (264).
TAKE AWAY

As you write, cite information which is not already established or common knowledge in a codified and regularized way by using the author-date branch of *The Chicago Manual of Style*.

Follow the CMS guidance for the author-date method of formatting citations, and do not use footnotes, endnotes, or superscripts, or any alternate methods of citing sources. The “notes and bibliography” branch of Chicago-style referencing is used in the humanities and social sciences, not for SE technical writing. Do not use other methods even if you have a personal preference for them.

Be careful to use signal phrases, quotation marks for special words used, and in-text citations to credit the work of others and prevent academic integrity problems. Avoid plagiarism by the concrete actions of 1) using in-text citations and 2) maintaining a complete list of references at the end of the paper, where each cited passage used in the body of the paper has a corresponding entry in the list of references.
V. TECHNICAL WRITING STYLE

GET TO KNOW THIS BOOK: Shenk’s The Naval Institute’s Guide to Naval Writing

Although there are countless books to consult about writing style, only one book will be cited here for further reference on learning about technical writing.

Robert Shenk’s *The Naval Institute’s Guide to Naval Writing* explains how to write a technical report or an article for a scholarly journal, to audiences within the military and without. His book demonstrates the technical writing style appropriate for the kind of subject matter considered by SE students.


In this next section, we will discuss some features of technical writing style, in order to show you both *how* and *why* technical writing sounds the way it does.

**VOICE, PERSON, TENSE, AND TONE**

Language choices create the right sound in technical writing. The right tone for technical writing is created by selectively (not excessively) using the passive voice, the correct person, the right tense and by avoiding informality.

These stylistic choices all are made with one goal in mind: *technical writing creates a formal tone to elevate its subject matter and to deflect attention away from the writer and onto the information presented in the report.*

**Passive voice**

When a sentence is written using a form of the verb “to be,” it is known as the passive voice. Use the passive voice only when needed to emphasize what is said, rather than the person saying it. It also is used to avoid the first person (“I,” “we.”)

**Active voice**

Be an attentive writer with respect to removing the first and second person from your writing without relying on the passive voice to do this for you. Favor active verbs over passive constructions. Write “this thesis *examines* three case studies” rather than “the following case studies *were examined* in the thesis.”

A problem with the passive voice arises when a writer is avoiding taking responsibility for an action taken, when an entire paper is written in the passive voice, or when the passive and active voices are in the same sentence.
Use the active voice to enliven your work and to avoid unnecessary wordiness.

Be careful that your verb form clearly expresses your meaning. Consider the lack of accuracy in the following statement recently written in an SE abstract, "A solution was decided." Solutions can't simply be decided. Decisions can be made in regard to solutions, but solutions themselves can't be decided.

Here, the choice to use of the passive voice becomes more than a matter of taste. It indicates a critical thinking problem because the person’s use of that verb form created a sentence which cannot be true. “A solution was proposed” is more accurate. While it is still in the passive voice, it describes a situation which could actually take place. Better yet would be “the postulated solution is…,” with a description of what exactly has been decided!

Tense shift
Technical writing uses tense for a very specific purpose: writers use the present tense to talk about established information, i.e., “the data show,” and they write in the past tense to indicate that they are presenting their own and other’s research, which has not yet become definitive or universally accepted.

These examples from Aaron and Fowler (2007, 628) show how shifts in tense are used:

Lin (1999) has suggested that preschooling may significantly affect children’s academic performance through high school.

In an exhaustive survey of the literature published between 1990 and 2000, Walker (2001) found ‘no proof, merely a weak correlation, linking place of residence and rate of illness.’

A formal tone
Other ways to create the formal tone expected for SE writers:

• Do not use contractions or abbreviations. Spell out “it’s” or “can’t.” Write “according to” instead of “per.”
• Avoid jargon: Instead of “manning,” write “personnel requirements.” Instead of “vice” write “versus.”
• Avoid slang. Instead of casual expressions, like “by the book” or “24/7,” write “according to established procedures,” or “continuous surveillance.”

PUNCTUATION AND OTHER SENTENCE-LEVEL CHOICES

If the tone of technical writing tries to focus the reader’s attention on the research results, rather than the researcher, there are other sentence level choices which are used to organize ideas on paper, in a way that is almost invisible, to enable your reader to focus on your message rather than on the delivery of it.
Let’s observe some clarifying functions which can be accomplished by careful use of punctuation.

**Commas**
Commas separate elements in a sentence, items in a list, and in general, group ideas or steps in a sequence.

There are many rules for comma usage, but for the purposes of SE technical writing, your most important job is to make sure you use them to create clarity. Omitting commas (and putting them in where they do not belong) is very common in military and professional writing, but incorrectly used commas can really create confusion. To cite a well-loved example, there is a big difference between saying that *a panda eats shoots and leaves*, and *a panda eats, shoots, and leaves*. In one, we have a general, garden variety description of natural science [Pandas eat (bamboo) shoots and then move on]; in the second, a counterfactual tragedy.

Here are some examples of comma use to remember:

- Commas set off clauses in a sentence. ("The curves prove, as careful study will show, that Fourier’s theory is correct.")
- They separate coordinate adjectives modifying a noun. ("The large, reflective, white target.")
- They appear before and after a dependent clause in the middle of a sentence. ("The measurement, although it is in rough agreement with the theory, does not agree perfectly.")

Although common advice is that you can figure out that you need a comma by reading it out loud (and inserting a comma where you would pause for breath), this can actually prompt you to overuse commas. If you are uncertain about how they are used, learn and apply rules for comma use by consulting the CMS. Alternatively, write using shorter sentences, making two or three out of an original long one.

**Quotation marks**
The most obvious use of quotation marks is to quote someone in your writing. However, there are other lesser known uses of quotation marks which are useful and important (Table 2.)

<table>
<thead>
<tr>
<th>Use of Quotation Marks</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>To set off a word you know is colloquial</td>
<td>…the dependence on the type of “kill.”</td>
</tr>
</tbody>
</table>
To set off a word as special or when you are using a term for the first time

…this is an instance of a “system of systems.”

To pull in a word or phrase in from another source, as when you are paraphrasing a writer

…the term “autonomous” here is used in contrast to something which is “automatic.”

To link words into groups, especially stages in a process

…while the “Perform Localized Tracking” function is being carried out, the function “Fire HEL” is also performed.

Table 2. Uses of Quotation Marks and Examples.

**Capitalization**

In military writing, it is very common for writers to capitalize words that do not need to be capitalized. As a rule, capital letters are only used to signify proper names; they are not used for common nouns. For example, if you were talking about government agencies in general, you are should not capitalize it and write “Government Agency.” The reason why is that it is not a proper noun: there are many government agencies. However, if you were referring to the Federal Drug Administration, you would write “Federal Drug Administration” because there is only one government agency by that specific name.

In the next example, observe how the capitalization used where what is referred to is a specific thing, not just an important thing:

Crystal Ball was used to analyze the variables associated with the HEL and performed a technique known as Monte Carlo simulation to provided forecasts of the entire range estimate of the cost probability to outfit a HEL weapon system onto a Navy surface combatant.

Note that we know that Crystal Ball is a particular thing, a proper noun, because it has been capitalized. Although it is unlikely that we would have mistaken this Crystal Ball with a gypsy’s crystal ball, you can see how capitalization performs an important function. One other thing to note: the writers do not capitalize “surface combatant.” Why? There are numerous surface combatants, but only one U.S. Navy. Because of these reasons, write “Naval surface combatant,” not “NAVAL SURFACE COMBATANT” or “Naval Surface Combatant.”

**Apostrophes**

Apostrophes indicate possession and should not be confused with adding an “s,” which you do to indicate plurality.
An apostrophe is missing from this sentence: “Can MBSE help save Army programs time for acquiring system of systems?”

Since it is *the time* that the researcher wants to save is “owned” by the Army program, we revise it to: “Can MBSE help save Army programs’ time for acquiring system of systems?”

In contrast, when you want to say there is more than one of something, add an “s,” i.e., “MOPs” (not “MOP’s”) “1990s” (not “1990’s.”)

**Hyphens**

You can use hyphens to show how words, ideas, or processes are linked together.

- these simplifying assumptions enabled the rapid development of the back-of-the-envelope model
- commercial off-the-shelf solution
- system-of-systems
- kill-chain
- man-in-the-loop
- decision-maker
- twenty-four.

**Other specialized punctuation rules**

Here are some other punctuation rules to keep in mind.

- When writing about measured distances, temperatures, figures, percentages, etc., numerals are used (7 km, 90° F, Figure 4,)
- Numbers under 100 are written out, as are all rounded numbers
- Sentences do not start with variables or symbols
- Leading zeros are used in decimal values
- When dates are used, write the comma after the date, i.e., “May 10, 2009” or “10 May 2009,” but not “May, 2009”)
- If using a range of numbers, use an “en” dash to separate them, not a hyphen
- When you are writing a range of numbers, close up the spaces around the dashes (i.e., “1–100” not “1 – 100”)

**LANGUAGE USE: INTRODUCING WORDS AND TOPICS**

Good technical writing involves a balance where you define specialized terms as needed but also write freely using the “shorthand” vocabulary of technical language.
Using specialized terms
While SE writing involves technical language, the benefit of which is that it “allows specialists to communicate precisely and economically with other specialists who share their vocabulary,” it is nevertheless customary in formal writing to provide a brief definition of a specialized term the first time it is used (Aaron and Fowler 2007, 513).

In this example, observe how the SE term “system of systems” is used, briefly defined, and connected to the particular situation described in the report:

The FCS was envisioned to be the first of its kind; a system designed around an entire unit formation. The term “system of systems” emerged to describe the multiple platforms, supporting products, and peripheral systems that would be necessary to address the vast capabilities FCS would offer. The system was comprised of manned and unmanned systems, as well as a ubiquitous communications network.

The first time a technical term appears, a brief gloss of its meaning is needed. While nine times out of ten, the reader will know the meaning of system-of-systems, in the event that the reader is new to the field of SE, it is defined. In case the reader happens to be very conversant with SE terminology, the definition is not extensive. Importantly, the writer connects his use of the term system-of-systems to the context of his paper: the general concept system-of-systems in relation to FCS—one particular system-of-systems to be discussed in the thesis.

While defining terms is important, it is certainly possible to write in such a way that in providing context, you err on the side of excess. Examine this transition, where the writer is concluding an introductory chapter to a thesis: “This chapter outlined the background, purpose, research questions, benefit of study, and scope and methodology that has gone into the development of the thesis. The content of this section provided the focus areas necessary to direct the thesis research.” While this describes the structure of the report, it doesn’t describe the content. As a result, this passage is so generic that it could be true of any number of theses.

A better instance of providing a context for a technical argument comes in the following: this also summarizes the contents of one section before moving on to the next, but there is a high degree of specificity given here as to what is to be discussed.

Maintenance of Naval Aircraft occurs around the globe in a complex three-level maintenance system. Data is recorded tracking the maintenance steps involved from removal of a component from the aircraft all the way through its repair and reinstallation. Data available in the fleet 3M system for BCMs is closely mirrored by requisition data available in the supply
system. Data from the fleet 3M system will be used in this paper for analysis of the research questions posed by this thesis.

A good writer explains not only the material covered but gives a sense of how the material will be covered, why, and in what order. As is evident in the passage about aircraft maintenance, the writer uses the sentence structure to present the distinct topics and the order in which they will be presented in the subsequent chapter.

**WORD CHOICE: DISCUSSING YOUR SUBJECT MATTER**

Let’s examine four kinds of language use problems that might come up in SE report writing.

- Not realizing how words sound to someone else
- Picking the wrong word altogether
- Not realizing that the word you used has a specialized use in an SE context
- Making one word do the job of another type of speech

**Not hearing how a word might sound**

If you wrote a report where you said that of various posited solutions, you chose a “final solution,” you might not hear that it sounds like a special, specific, historical use of the phrase: “the Final Solution” of World War II and Nazi Germany. This would be where you are simply blind to what is known as a valence of a word—a connotation or denotation attached to a word (independent of your use of it.)

Not hearing how you sound occurs most frequently with jargon or slang. If you were describing a system to be fielded in a remote location, and wrote “there would be no reach back to CONUS,” while another person in the military would have no problem understanding your meaning, not all members of your audience would know what you meant by either reach back or CONUS. Instead, write: “there would be limited connectivity to the contiguous United States.”

**Picking the wrong word altogether**

Sometimes you just choose the wrong word through an honest mistake. This might happen if you were talking about a group of Native Americans and you inadvertently call them “Intuits” not “Inuits,” or when intending to describe a system as "material" when you really meant "materiel." These kinds of mistakes require someone else to catch you, hence the necessity of using a proofreader. This commonly occurs with homonyms (cite/site, or principle/principal, compliment/complement, its/it is.) Word processing software will not catch these errors, but good writing manuals will provide extensive lists. Check with the reference librarian for help locating one.
**Words that are special in SE contexts**
Part of learning the discipline of SE is learning to recognize which words are special to it. Pay attention to proper use of words that in the discipline of SE have special, unique meanings, such as *design, architecture, framework, limitations, scope, boundary, decomposition, allocation, measure of performance, measure of effectiveness, verification, validation, process, requirements*, and use of the word *shall*. You cannot use them without recognizing that these are specialized SE vocabulary words and have been used in certain ways within the conversations among people who work in or have defined the field.

**An example of a writer defining terms**
Here is an example from a recent SE report where the writers are unclear in their use of SE terms, in this case, “needs” versus “requirements” (Figure 8.) The red text are instructor comments in reference to their use of SE terminology.

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**Stakeholder requirements development** is accomplished by first identifying the stakeholders and their needs. Research is required to identify all those affected by energy system implementation and their respective energy system needs. The next step is to prioritize the relative importance of the stakeholders and their needs. Prioritizing the stakeholders is accomplished through pairwise comparisons and the analytic hierarchy process (AHP) (Satay, 1982). Pairwise comparisons involve comparing each stakeholder against one another and assigning quantitative values indicating their relative importance to each other with respect to energy system implementation. The AHP is used to capture the quantitative values in a matrix, where the values are reduced to vectors of weights that describe the relative importance of each stakeholder. Requirements are then extrapolated by analyzing and categorizing common stakeholder values. Requirements are also assigned weights based on individual stakeholder’s preferences; this step is also accomplished by pairwise comparisons and the AHP. The full analytical criteria method is used to establish the final requirement weightings by taking the product of the individual stakeholder preferences and the stakeholder weights.

**Instructor comment:** Stakeholders have needs that systems engineers turn into requirements. JCIDS was created to avoid using the term requirements for just this reason, so engineers could create proper requirements using requirement statements. The raw needs of stakeholders are to be transformed into requirements, so save the term ‘requirements’ for the situation where you have re-stated primitive needs into the correct format of a requirement.

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**Figure 8.** Systems Engineering Terms Being Defined in Student Writing.

The instructor commentary clarifies the special meanings which are assigned to the words “needs” and “requirements,” and further distinguishes between “primitive” and “effective” needs.
Another example occurs of ambiguity when writing about an SE term occurs when student writes: “A systemic concept is proposed.” What is really meant is “a concept of a system is proposed.” A systemic concept is one where a concept is overtaking a system, or is system wide: this is very different from “a concept of a system.” Such a mistake would be very egregious because of the weight the word “system” carries in this context.

**Making one word do the job of another part of speech**

Another other word choice problem comes when writers mix up or blur types of speech. For example, the use of nouns as verbs is common in military circles, i.e., “you need to maintenance your telework agreement.” Maintenance is a noun, whereas “maintain” is a verb. Or, “you need to evade to neutral territory.” Usually, you evade something, you don’t “evade” in a general way.

Mixing up and transposing word types is often neutral: it is not the end of the world to say, “You may need to reference it to locate your position,” when you really would be referring to it, or say “I inputted it” when you really entered data, thereby making an input.

However, trouble emerges when you ask a word to do a job in a sentence it cannot do. This occurs in infamous noun stacks. Sometimes writers put together too many nouns in a row, which can either make a noun do a verb’s job, or asks a noun to modify a word (perform the function of an adjective or adverb.)

In the phrase “the ship is stationary with contact movement radial inbound,” we do not know exactly what is moving. There is no clear verb in “contact movement radial inbound.” Those are all nouns. What is moving “radially?” Is it “inbound” to the ship? Is the “contact movement” what is “radial (ly) inbound”?

Although they are sometimes tempting to use (and there is a certain euphony to “the Taguchi design based DoE iteration sets.”) follow the advice in Shenk’s advice *The Naval Institute’s Guide to Naval Writing*, wherein he advises that you break up noun strings or stacks such as “aircraft carrier crack arrestor applications” and “Commander Navy Region Southwest San Diego Dockside Mail Center”) by inserting prepositional phrases, i.e., “crack arrestor applications in aircraft carriers” and “the San Diego Dockside Mail Center of Commander Navy Region Southwest” (2008, 230-231).

To conclude, we can end with a good example of SE technical writing: it is formal in tone, avoids jargon even though the writing is about an SE, military-specific topic, and is persuasive in that it clearly depicts a situation the writer has needed to explain in order make to an argument (in this case, in a Master’s thesis).

Additionally, within the Army, each level of bureaucracy has its own unstable process. Notably, the TRADOC Writing Guide series is re-
written with each revision of the JCIDS instruction and undergoes an iterative process as the TRADOC staff grapples with their interpretation of JROC and AROC publications, directives, and guidance. Occasionally, subordinate publications require documents to be written in a manner that is mutually exclusive of higher directives. Inevitably this leads to delays as documents loop through the review process attempting to please two masters.

Note that words are used as the types of speech they are; there is no use of the first person; commas are used correctly (most of the time); the present tense is used because the information described is established, and transitions are employed to move us from point to point (in “additionally,” “occasionally,” and “inevitably.”) When metaphor is used, i.e., “attempting to please two masters,” it is muted. What is noticeable about this style is that it is toned down: we hear the message that needs to be communicated and are not distracted by anything else.

**TAKE AWAY**

Seek a middle course between technical language and normal prose, using enough context to explain your points and the meaning of your terms, while avoiding fluffy “filler” language. In this way, you seek to retain relevant information and create concise writing, while not providing too much explanation of what your reader could probably figure out on his or her own.
VI. THE WRITING PROCESS

Good writing involves stages of production that happen in a sequence, and poor writing comes about when these distinct stages are collapsed into one, or when a stage is omitted entirely (Figure 9.) What should be very clear from this section is that there is more to writing than simply writing a final draft, and there is more to revision than correcting the format of a paper, which only involves aspects of ensuring that your paper meets expectations with respect to the appearance and layout of a document.

2. Drafting

1. Pre-writing: understanding the assignment and researching

5. Editing: reading to check writing

4. Revising: reading to check thinking

6. Proofreading: reading to check conformity to formatting standards

Figure 9. The Steps in the Writing Process. Image based on the writing process as described in Aaron and Fowler (2007).

1. Pre-writing: understanding the assignment and researching

Writing composition theory refers to this step in the writing process as understanding the rhetorical situation of a communication task. This is where you ask: “Who is the audience? What purpose is supposed to be achieved? What medium do I have to work with? What are the norms for language use in this context?”

When given a writing assignment for a systems engineering task, it is important not to start each task without first trying to understand the intent of the instructor in giving the assignment. Before beginning any written project, read the entire assignment or all the documents affiliated with the task. Then ask: “What is this assignment’s purpose, from a top-level point of view?”

In addition to determining the instructor’s motive for assigning a task, remember this description of the intended purpose motivating how technical writing is constructed: you
must include enough in your written submission so that “professional peers of the authors”
can “follow, assess, and replicate the presented experimental findings to test their
reliability and validity” (Goldbort 2006, 241).

If you are writing so that someone could “check your work,” this is accomplished in writing by:

- showing data and mental models used to arrive at any conclusions drawn
- the explicit identification of assumptions behind actions taken, and
- the use of citations to link the reader to an external and third party witness to the information.

An additional step that precedes actual drafting is where the writer uses various research methods to acquire sufficient background information. This involves 1) reading and evaluating material from Internet searches, publications, slides, notes, or articles provided by instructors, 2) independent research done in a library with the assistance of a subject matter librarian, and 3) the work of synthesizing newly discovered research with the writer’s previous experience as a professional, independent learner, and reader. The writing that takes place here is note-taking, writing in response to reading other writers’ work, and writing concept maps or outlines.

When a writer has used pre-writing to engage with topics and other researchers, a rough draft is the next step.

2. Drafting
Drafting is the stage of writing that is primarily for your own good (not your reader’s). The focus is on outlining subject matter, not on how it appears to another person. During the drafting stage, most of the product is created: ideas are now on paper, scraps of writing are now placed in a probable sequence, and notes are fleshed out into sentence and paragraph form.

3. Writing
After a rough draft is written, the writer can now turn from getting ideas onto paper in a logical sequence, to the action of paying attention to whether or not clear thinking is taking place. This stage in the writing process is purposeful and oriented toward accomplishing a goal—ensuring that the writer has presented an argument: an assertion, backed up by evidence, which bears out the truth of claims which are made in a particular context.

4. Revising: reading to check thinking
The writer examines claims which have been made, evaluates them, evaluates how well they are supported by reasons or evidence, and the writer tries to anticipate how an audience would respond to the claims made in the paper.
5. **Editing: reading to check writing**

Only after a document has been drafted and revised, can the stage known as editing fully take place. Editing is a secondary check to see if what is written is written in a correct way to communicate clearly so that a reader does not have to work to ferret out the intended message.

To contrast editing with revision: during the revision stage, a writer would compose a title for the paper, whereas in editing, it would be necessary to check that the title is the same in all places where it appears. In the revision stage, the goal would be to write a title which really captures the topic. You would ask: “Does this title summarize my article, providing enough detail to differentiate my paper from others which are similar to it, but give a general enough name so that a person could figure out what kind of paper it is?” When a writer is editing a report, however, is the time to check that title is always the same, in every place where it appears, i.e., on the title page, in any other affiliated documentation such as on a distribution statement or signature page.

6. **Proofreading: reading to check conformity to format standards**

In proofreading, it is important to verify that the written product is following the expected formatting requirements. It is also the occasion where a person removes grammar, punctuation, spelling, or usage errors. You might use the checklist at the end of this guide, as well as re-read the project assignment. Keeping with our example of a title, you would ensure that your title follows the correct method for how words are capitalized. You would make sure you have not accidentally written “material” when you really meant “materiel.” You would check to see if it is supposed to be on its own cover page, and whether or not it is appropriate to use acronyms in a title. Under the umbrella of proofreading comes copy-editing and formatting. This is when you scrub for surface errors (copy-editing) and you ensure publication standards are followed (formatting.)
VII. ORGANIZING A TECHNICAL REPORT

Overview of Key Writing Structures in Report Writing

Remember the old writing rule: “Tell ‘em what you are going to tell ‘em, tell ‘em and tell ‘em what you just told ‘em”? This is as true of a report in a SE context as it is for high school English. This is the basic argumentative arc you need to follow as you structure your engineering communications.

A report’s introduction is the moment where you present a summary of your argument: the body of the report is where you use evidence to back up the validity of your claim, by showing your evidence as well as how to interpret it, and in the conclusion, you show your reader how your argumentative claims are appropriate, based on the evidence you just showed.

1. An introduction
When you write a report, it is important to provide an introduction that presents an overview of the report, and explain how the report itself is organized. The introduction of a report introduces the report itself: it should have a thesis statement (a two to three-sentence synopsis of your argument or main points and the order in which you will address them.)

2. An abstract
While an abstract is similar to an introduction, it performs a very different organizational function. An abstract is used for researchers to find an article which addresses a set of topics. They are data-heavy and written in key words—as though to be used by search engines and are the briefest expression of the contents of a report. For project reports for class and the project report to be awarded the MS degree, you will need to write an abstract. While an abstract is the first thing you see in a report, it is not the first thing you write but rather the last. It has to be written last of all because it is not an introduction to the paper. Instead, it is an approximately three-sentence summary of your entire report. It does not provide background, or context, or explain how you are addressing, organizing, and approaching your report (which would occur in an introduction.) Rather, the abstract is a 200 word summary of 1) the problem you examine 2) the method of approaching the problem 3) the conclusions you arrived at in your analysis.

3. Executive summary
An executive summary, on the other hand, is written for the decision-maker: it is usually three pages long, where the recommendations resulting from research are presented first, the results, methodology, and data present afterwards. If you are asked for an executive summary of the thesis, it is an explanation of the motivation for the work and a more extensive discussion of the results and their significance. Most readers will carefully read
the executive summary, while few will read the entire report. Make sure your key points are presented effectively here.

4. **Frequent summaries and transitions**
   An important feature of report writing is that you move your reader from point to point, which is done by means of transitions and summaries. Transitions build a bridge from one paragraph to the next so that your reader understands how each section in the report connects to a previous one. For obvious reasons, your introduction and conclusion will not have transitions in them; however, between intermediary portions of the report, you will want to include *a topic sentence* (the first sentence of a paragraph, which encapsulates the main point of the body of the paragraph), and well as *concluding sentences* (the final sentences which articulate the end of one set of points and the transition on to a new set of ideas.)

5. **A conclusion**
   A conclusion of a report involves a final, summarizing restatement of the most important points you made in your paper. It is important to have a conclusion, because it is for the good of your reader—one final instance where you re-state the main points. Similar to an introduction in that you cover your main points, you also take a moment to explain any unanswered questions or mention unresolved ambiguity. Further, conclusions are where you indicate the problems which still remain to be solved. This is why reports end with authors clearly identifying 1) recommendations which emerge from the report and 2) areas for further researchers to examine.

**VIII. CRITICAL THINKING TASKS**

**Overview of Critical Thinking and the Logic of Report Writing**
If the abstract, executive summary, and body are places where your argument appears, the whole structure of a formal SE thesis or project report moves along based on the following critical thinking tasks which come out in your writing in this order:

1. **You define your problem**
   Writing an SE project’s problem definition uses a brief yet formal story as a way to explain and define a complex problem or an issue for your reader. It may rely on history and discovered but-as-yet-unresolved problems.

2. **You define your context**
   It is often necessary to give a short explanation of the theory, conceptual framework, model, or a body of knowledge that provides a foundation for what you have to say, or which is used to make sense of the paper’s area of inquiry.
This is where you describe the context for why you did what you did to solve a problem. If you approached a problem using a modified Vee mental model to help you think through the sequencing of the steps used in addressing an SE process, you would explain to your reader why a modified Vee model is suitable in your context (see example in the body of this guide.) You might show someone else using that same model, and what it did for his or her analysis, and then you would show how your use of it makes sense, given your particular circumstances.

3. **You present and explain your data**
Writers show why the data used in making claims is correct and relevant to the problem by explaining why it is the appropriate data for the context. When you provide data that you discovered by using a statistical analysis software suite, it is important to state why the data you presented in the paper is the right data for your purposes. If you show pages upon pages of the outputs of a modeling and simulation effort, but you do not tell your reader that the data you are showing him is the right data to be examined in this instance, it will not be persuasive writing.

4. **You analyze your data**
In the write-up of your analysis, explain why the methodology you use is appropriate for the data. If you are using discrete events simulation, part of the task you have as a persuasive writer is to explain why that is the right method to generate the necessary knowledge, as opposed to another kind of modeling and simulation.

5. **You explain your results**
When you write a report, in some way you will arrive at research findings, i.e., a recommendation, a new theory, a model, an important case study, a solution to a problem, or a design for a process. The body of your report is where you will have recorded this and made it visible for others, but you have to explain the results. You identify what the end product is, how you arrived at it (why it follows from and is supported by the analysis), and why the end product fits into or comes out of a particular situation.

**SE Report Writing Self-Assessment Questionnaire**
Ask yourself these questions to gauge how well you are demonstrating critical thinking and learning within the discipline of SE.

**Overall**
Overall, does my writing show the ability to

- Apply the SE process across the system’s lifecycle?
- Clearly define terms and symbols?
- Including sufficient important but not extraneous details for my audience?
- Write with economy?
• Conduct systems analysis, including deterministic and stochastic modeling of systems (including combat simulations and combat modeling)?
• Conduct decision analysis, risk analysis and management, economic modeling, or life-cycle supportability analysis, including basic optimization and trade-space management?
• Develop a Systems Engineering Plan, to manage schedule, cost performance and risk in a project?
• Demonstrate the ability to deliver and conduct technical reviews?

Introduction
Does my introduction

• Identify and formulate an operational, technical or engineering problem?
• Identify and define the techniques, skills, and tools needed to address it?
• Identify primary and secondary research questions?
• Provide an explanation of the organization of the report in a thesis statement (a two- to three-sentence synopsis of the report’s content and method of organization)?

Literature review or background and context section
Does my literature review section or background and context section

• More fully explain background research, in order to define the problem to be examined?
• Define the problem in relation to issues of research, design, development, procurement, operation, maintenance or disposal of systems, and processes for military applications?
• Identify key stakeholders, along with their interest in the project?
• Describe a tailored systems engineering process, along with its key products, in order to show how it will help solve the problem?
• Look at other views of the questions I address

Data analysis sections or body of the report
Does the body of my report (as needed)

• Define requirements?
• Conduct functional analysis? (define functions, decompose functions, show functional sequencing, analyze a functional architecture, generate alternative physical solutions, decompose physical entities, perform functional allocation)
• Explain a concept of operations?
• Develop scenarios and vignettes?
• Define metrics?
• Explain hardware, software, and human factors considerations?
• Discuss testing and verification?
• Describe a representative physical solution architecture?
• Offer a rationale for a selected concept?
• Describe the process to establish an effective need, along with the techniques used to support that process?
• Present the results of bounding and scoping the problem?
• Present the initial functional and non-functional requirements?
• Show the connection between mission threads (or similar) to a doctrine (or similar)?
• Present a value hierarchy (or Measures of Merit or objective hierarchy), and the connection between such measures to the problem statement and an objective alternative-evaluation in terms of solving the problem?
• Provide MOEs which clearly follow from MOPs and which are solution independent?
• Present functional architectures, and commonly accepted modeling tools (IDEF0, EFFBD, HPM, UML, etc.)?
• Explain the ideation process behind generating a generic physical architecture?
• Offer the results of generating a generic physical architecture, connected to the functional architecture?
• Describe the process of feasibility screening, along with life-cycle feasibility constraints?
• Present DoDAF products (or appropriate architecture description templates) used to describe the system from a functional, physical, and operational perspective?
• Present modeling and analysis efforts, and the connection between data extracted from a model, and the reason behind the value system used to analyze the data?
• Provide the model itself, described in words and pictures (with details provided in an appendix), where tables and graphs summarize key results?
• Provide information about the model, so that the reader can understand why it was used or so that analysis of alternatives can be conducted?
• Offer an explanation of limitations, assumptions, and factors used in analyzing model results?
• Generate alternative designs?
• Conduct sensitivity analysis?
• Offer ways to objectively compare alternatives?
• Explain the conversion of data from research and modeling to a decision matrix?
• Demonstrate that Life Cycle Cost was used as a decision variable?
• Show a clear connection between a decision matrix and a value hierarchy?
• Provide a solution that meets functional and non-functional requirements and objectively and quantitatively offers the best solution to the problem?

The conclusion
Does the conclusion of my report

• Explicitly revisit research questions or the initial problem statement?
• Make (a) recommendation(s) based on the research?
• Define areas for further research?
• Demonstrate that I answered or addressed significant questions and that my conclusions follow from the information laid out in the report?
• Present both positive and negative implications from my work?
• Explain implications that emerged from my analysis, which were not clear at the beginning of the research effort?
• Explain consequences if recommendations are not followed?
VIII. CONCLUSION

The goal of this writing guide has been to show you some ways in which critical thinking can be made evident in your writing, based on the premise that writing is a method to discover problems in one’s own thinking and to avoid what Elder, Niewoehner and Paul have identified as a block to critical thinking—thinking egotistically insofar as you only consider your own point of view. Transferring ideas from your mind out onto paper prevents this, as well as providing an antidote to the stereotypical failure to communicate pictured in Harris’s cartoon (Figure 10.)

Figure 10. Cartoon by Sidney Harris. (From Harris 2012).

As writers, our ultimate goal is to exchange ideas, while making reasoning visible. Figure 10 reminds us of what we are trying to avoid as SE communicators: presenting a solution, but no account of how we got there. To be clear writers, we must always recognize how we appear to others, as well as to ourselves.
APPENDIX A: FORMAT CHECKLIST

The Thesis Processing Office provides guidance for NPS publication standards for reports archived the Dudley Knox Library and elsewhere. Refer to their guidance at their website, which is updated quarterly, for formatting rules and requirements for the thesis, http://www.nps.edu/Research/research1.html.

This checklist is a set of standards for when you write reports for formal reports made for SE.

It should not contradict the Thesis Processing Office documents, and if it does, corrections will be made to future iterations of this guide.

<table>
<thead>
<tr>
<th>Order of appearance of the elements of a report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal published academic reports are divided into front matter, the text of the paper itself and back matter. The different pieces of a formal report are called elements, i.e., a title page, a cover page, an abstract, a table of contents, and so on.</td>
</tr>
<tr>
<td>Following is a list is of all the elements in an NPS thesis. Those marked with an asterisk (*) are required for all routine report submissions. Create the elements of your report in this order:</td>
</tr>
<tr>
<td>☐ Front Cover/ Title Page (*)</td>
</tr>
<tr>
<td>☐ Report documentation page (Standard Form 298)</td>
</tr>
<tr>
<td>☐ Signature Page</td>
</tr>
<tr>
<td>☐ Abstract Page</td>
</tr>
<tr>
<td>☐ Thesis Disclaimer</td>
</tr>
<tr>
<td>☐ Table of Contents (*)</td>
</tr>
<tr>
<td>☐ List of Figures (*) (if figures are used)</td>
</tr>
<tr>
<td>☐ List of Tables (*) (if tables are used)</td>
</tr>
<tr>
<td>☐ List of Acronyms and Abbreviations (*) (if there are at least 6)</td>
</tr>
<tr>
<td>☐ Executive Summary</td>
</tr>
<tr>
<td>☐ Acknowledgements</td>
</tr>
</tbody>
</table>
Title page

- Title page includes the project title, student name(s), completion date, Advisor and Reader names, distribution statement and the NPS logo.

- Titles of reports are descriptive, not suggestive. Report titles describe the contents of the report, not to seek to catch the attention or interest of the reader. (Instead of “Got Milk?” try “Self-Sustaining Goat Farms For Osteoporosis Prevention in Little Diomede, AK: A Systems Engineering Approach.”)

- Format for a title page: title (uppercase/bold/center) by (lowercase, center, separate with one line space above and one line space below) Name (center/upper and lowercase, no rank) Month/Year (upper and lowercase/center/ December 2012 (no comma), Advisor and Reader names, Distribution Statement (center/sentence case).

Abstract

- The word “abstract” appears centered, upper case, and in bold at the top of the page.

- As the abstract is used by researchers to find an article that addresses a limited set of topics, the abstract is “data-heavy” and is written using key words—as though to be used by a search engine.

- The abstract is limited to 200 words. It fits on one sheet of paper, and does not exceed 18 lines. The content of the abstract (the exact wording) is also placed in the Special Abstract document when the thesis is completed.

- As a summary of what is contained in your report, it follows this basic template: the first sentence explains the problem examined within the report; the second sentence explains the methodology used to conduct the research or to analyze the data in question, and third sentence explains the significance of those results, and indicates
for whom this is important.

- Abstracts do not use quotations in them or cite sources. They are written in the past or the present, but not the future. They are a standalone document (hence no quoted material) and they describe research that has already been completed (hence the past or the present tense.)

- The abstract makes sense on its own. It only describes the contents of the report, as it does not introduce the topic or give the background of the study.

- The abstract is not repeated word-for-word in an introduction, a conclusion, or an executive summary.

### Executive summary

- The words “executive summary” appear centered, upper case, and in bold at the top of the page.

- The three page limit is observed.

- The target audience is a decision-maker. It provides enough information about your report’s contents so that the decision-maker can decide whether to read the entire report.

- The recommendations that emerge from the research appear first, and the results, methodology, and data are presented afterwards. (A useful organizational tool for writing this is to use a five-paragraph paper model. Allot one paragraph to state any recommended actions that have emerged from your research. Present a succinct problem definition in the second paragraph. Use the following final paragraphs to explain the methods used to analyze the data presented in the body of the report.)

### Table of contents

- The words “table of contents” appear centered, upper case, and in bold at the top of the page.

- Numbering in the TOC starts with Chapter I, page 1 (i.e., the pages that are listed in the front matter, which are numbered with Roman numerals, are not included in the
TOC.) All chapters must begin on odd numbered pages; the TOC should display this structure.

☐ Dot leaders are used (Chapter I...........1.) to fill in the gap between the section headings and the page numbers listed on the right hand side of the page.

☐ TOC matches the body of the report, (i.e., the chapters, sections, subsections of the report are listed by headings and by the beginning page number.)

List of figures

☐ List of figures and list of tables do NOT appear in the TOC, but are included as separate sections of the paper.

☐ The LOF displays each figure identified by number and caption, plus the page number where the figure appears; figures in appendices are included.

☐ When a figure is taken from an outside source, the citation (From Jones 2011) appears in the LOF at the end of the caption.

☐ When a figure is taken from an outside source and modified, the citation (After Jones 2011) appears in the LOF at the end of the caption.

List of tables

☐ The LOT section displays each table identified by number, title, and page number where the table appears; tables in appendices are included.

☐ When a table is taken from an outside source, the citation (From Jones 2011) appears in the LOT at the end of the caption.

☐ When a table is taken from an outside source and modified, the citation (After Jones 2011) appears in the LOT at the end of the caption.

List of acronyms and abbreviations

☐ If the report contains at least 6 acronyms, abbreviations, or symbols, a List of Acronyms and Abbreviations is included as its own element in the report.

☐ This element of a report appears in the TOC.
### Body of the report

- Divided into chapters, sections, and subsections (as needed.)
- Chapter titles and all subsequent headings are consistent in spacing and font
- Any lists (i.e., numbered lists, bulleted lists, lists distinguished by “em” dashes) are indented 0.5” from the left margin (or indented appropriately beneath subsections.)
- Line spacing is 1.5 spacing, except for block quotes (containing three or more lines of quoted material).
- Footer is set at 1”; the gutter is 0, and gutter position left.
- Font is 12 pt. Times New Roman, Arial, or Courier (suggested for computer code only.)
- Font size used in figures, charts, graphs, and equations should be no smaller than 10 pt.
- Page margins include: 1” top and bottom, and 1.25” left and right margins.
- Paragraphs are fully justified (recommended) or left justified with the hyphenation turned off.
- Standard margins should apply to the entire report.
- Typically, portrait orientation is used for viewing images/tables. If an image or table exceeds the page margins, a landscape page can be created to accommodate the image/table. Follow the landscape page setup requirements found in the thesis processing formatting guidelines.
- All pages are numbered except for the cover page and blank page following the cover page.
- Front matter is numbered with lower-case Roman numerals (i, ii, iii ….).
- Body pages are numbered with Arabic numerals (1, 2, 3…).
- Page numbers are placed one inch from bottom and are centered, with nothing in the footer except the number. (The only exception would be FOUO, if applicable.)
- MathType is used to create and place equations. Microsoft Word Equation Editor is
not used because it does not provide automatic sequencing of the numbering of equations.

- Follows guidelines in the CMS when there is a question when writing about numbers.

- Numbers 0–9 are written out, while numbers 10 and above are displayed as digits. An exception to this would be metrics: all metrics are displayed as digits.

- Does not begin sentences with a variable, symbol, or number, unless the number is written out, i.e., “Seven cases were reported.”

- Uses leading zeros when displaying decimal values.

- When including dates, follows the correct date format consistently: i.e., “May 10, 2009” or “10 May 2009”

- If using a range of numbers, use an “en” dash to separate them, not a hyphen. When writing a range of numbers, close up the spaces around the dashes (i.e., “1–100” not “1 – 100”).

- Contractions are not used (i.e., “can’t,” “won’t”)

- Do not use exclamation points.

- Verify that all graphics and tables are checked for spelling.

- Commas and periods should be kept inside quotation marks: “The data is inconclusive,” the report stated.

- “Et al.” not “et, al” or “et al”

- Commas used after “i.e.” and “e.g.”

- “Master’s” degree has an apostrophe.

- “Postgraduate” is one word.

- Do not use the first or second person, i.e., “I,” “we,” or “you,” unless unavoidable.

- Active verb forms are preferred except when used to avoid the first person pronoun.

- “DoD,” not “DOD.”
<table>
<thead>
<tr>
<th><strong>Guideline</strong></th>
<th><strong>Description</strong></th>
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<tr>
<td>“U.S.,” not “US”</td>
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<tr>
<td>“It’s” means “it is.” “Its” is a possessive. (“It’s nice to see you.” “The dog hates its collar.”)</td>
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<td>When an acronym, abbreviation, symbol or technical term appears in a report, it is defined (spelled out) the first time it is used. Subsequent references can then use an acronym.</td>
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<tr>
<td>Italics are used to indicate emphasis, especially in a quote where someone else used italics.</td>
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<td>When the paper refers to the titles of books, they appear in italics and use “headline” style, i.e. <em>Systems Engineering Management</em> (not all caps or bolded.)</td>
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<tr>
<td>Bold font is used for section headings, the report title, and the titles of the elements of the report. It is not used for emphasis in the body of the report, or to indicate titles of cited works.</td>
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<tr>
<td>Capital letters are used to signify proper nouns, not for common nouns. They are not used simply for emphasis.</td>
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<td>Only one font is maintained throughout the paper (in graphics and tables also.)</td>
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<td>Indentation is used to signal a new set of ideas or paragraph, but not otherwise.</td>
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<tr>
<td>Single quotes are reserved for when citing a passage when someone else is using quotes. When citing a passage from someone else, switch their double quotes to single quotes. In this way, you can still preserve the author’s original meaning, in your own new setting: “Civil architecture schools have ‘crits,’ which are critical design reviews” (Valerdi and Davidz 2009, 178).</td>
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<tr>
<td>All figures, tables and equations are explained in the text preceding the display of the figure, table, or equation.</td>
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<tr>
<td>All figures and tables are numbered. They have explanatory captions if needed. For those copied from another source, the original title is retained. If no title is given, the report writer composes a title for the figure. If necessary, a sentence which explains what is depicted in the figure or table is included.</td>
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<td>When a figure is copied from another source, the source information is included at the end of the caption (From Jones 2011.) When a figure is used in a report where it</td>
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</tbody>
</table>
has been modified from another author’s original figure, the source information is added at the end of the caption (After Jones 2011).

| ☐ | Figures and tables are centered between the margins. |
| ☐ | Figures and tables are referred to by number, not location (i.e., not “See Figure 4 above” or “below.”) |
| ☐ | If your figures or tables are small, you can intersperse them throughout the body, but do not wrap text around them. Always insert images/tables as “Inline with text” to avoid wrapping text around them. |
| ☐ | If they are bigger than half a page, place them on a separate page, immediately following the first mention of them, with text following the table. If they are smaller than half a page, continue the text on the same page. |
| ☐ | Do not put titles, captions or amplifying text for figures or tables inside the figure or table itself (within the graphic.) In other words, do not use Microsoft Word’s built-in caption maker. |
| ☐ | Place table titles, captions, and amplifying text above or below the table: above is preferred if tables continue onto additional pages. |
| ☐ | A table can be on a page without any descriptive text, as long as it is centered vertically and horizontally. |
| ☐ | Equations need to be numbered in a sequence, either by chapter, or throughout the entire report. Use MathType equation numbering for sequential numbering. |
| ☐ | Pictures and images used in reports should be computer produced, not hand drawn. |
| ☐ | When photographs or images are used in reports, the file size to be used is: PNG, Windows Metafile, or Enhanced Metafile. |

**Appendices**

<p>| ☐ | Appendices are included in the table of contents by letter and title, i.e., “Appendix A: Results of Vitech’s CORE Simulations.” A short paragraph at the beginning of the appendix explains what the appendix contains. Appendices are used for the information that otherwise might be distracting from the central message of the report, i.e., derivations of formulas, detailed diagrams, computer code, or simulation results. |</p>
<table>
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<th>Appendices can appear before or after the list of references.</th>
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<td><strong>List of references</strong></td>
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<tr>
<td></td>
<td>The title “List of References” appears in bold, in upper case letters, centered at the top of the page.</td>
</tr>
<tr>
<td></td>
<td>Sources used in the paper appear on a separate sheet at the end of the main body of the text and are labeled “List of References.” For each in-text citation in the body of the report, there is a corresponding item in the list of references.</td>
</tr>
<tr>
<td></td>
<td>The CMS author-date method is used for formatting the list of references and there is <em>only</em> a list of references (not a bibliography, works cited, or works consulted page.) Endnotes, footnotes, and notations such as <em>ibid.</em> or <em>op. cit.</em> are not used.</td>
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<td></td>
<td>The first line is flush left. Subsequent lines are indented (called a hanging indent.) Each entry is single spaced within itself, and there is a double space between each entry.</td>
</tr>
<tr>
<td></td>
<td>Entries are arranged alphabetically by author’s name (not numbered). Elements in the list of references are separated by periods. Each entry ends with a period. Ampersands are not used when referring to more than one author. Instead, use “and” to separate multiple author names.</td>
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<tr>
<td></td>
<td>Book titles, journal, article, and public document titles appear in headline style (capitalize the first and last words of the title and subtitle and all other major words and proper nouns).</td>
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<tr>
<td></td>
<td>The titles of wholes (i.e., a book, a textbook, a manual) are italicized. If the item in question is a smaller part of a larger whole (i.e., an article in a journal, an entry in an encyclopedia), it appears in quotation marks.</td>
</tr>
<tr>
<td></td>
<td>Websites are referred to by a specific title, by the name of the sponsor or author, or by a descriptive phrase, not just a web link. A stable URL or DOI is used. URLs can be hyperlinked, but all must be consistent throughout the list of references and the document. “Last accessed” is no longer used by the SE Dept. or the Thesis Processing Office.</td>
</tr>
<tr>
<td></td>
<td>If citation management software is used, it is double checked to ensure accuracy in capturing bibliographic information and formatting.</td>
</tr>
</tbody>
</table>
APPENDIX B: FORMATTING ENTRIES IN A LIST OF REFERENCES

Included here are some examples of how to format entries on your list of references, with entries likely to appear in your report.

A dissertation

A technical report

(Note that the titles of unpublished works appear quotations, whereas the titles of published works are italicized.)

A conference paper

When writing about conference papers or meetings, include the sponsorship, location and date of the meeting or paper after the title.

An exhibition catalogue

When writing about something like a product specification or corporate brochure, you follow the format of a book, but you include a description of what the non-traditional source is, so as to identify the document (i.e. “exhibition catalogue”).

Journal article or periodical
Government documents


When writing about a public or government document, include as many of the following as possible: (1) name of the government, government body, and subsidiary divisions (2) title of the document (italicized and capitalized headline style), (3) name of individual author, editor, or compiler if given, (4) report number or other identifying information, (5) place of publication, publisher’s name, if different from the issuing body (use Washington, DC, GPO or other suitable variant forms for publications of Congress, executive departments, and government agencies), and date of publication, (6) page numbers or other locators, if relevant.

A website

Provide a Digital Object Identifier (DOI) or a stable URL for every online source cited. Include as much information as is possible, including the specific title of the website or webpage, the name of the author or sponsoring agency.
APPENDIX C: ASSESSMENT RUBRICS

Included in this guide are assessment rubrics for student Project Reports or Theses. These may be altered by instructors for use in other major course work. Two rubrics are provided to assist in evaluating writing.

An additional rubric, “Intellectual Standards for Engineering Reasoning: An Aid to Authors and Graders of USNTPS Student Deliverables,” reminds all that the standards and elements of critical thinking valued and endorsed by the SE department are similarly respected by other professional organizations—in this case, the United States Naval Test Pilot School.

Students should use these rubrics to define their tasks in all written and oral presentation work pursuing their Master’s degree. They can see exactly what is expected of them by the faculty in multiple areas of the projects rather than just receiving one overall, undefined grade. Individually scored sections of the rubric indicate strengths and weakness. Students can begin to focus on areas where their assessments show weakness. The rubrics provide specific guidance; however, not all strengths or weaknesses are identified in them.

Faculty members use the rubrics to structure their feedback to students. Having department-wide, multidimensional rubrics ensures consistency in grading. They keep the focus on course objectives.

While better than a simple letter grade, scores on rubrics are not entirely consistent with the totality of the work being evaluated because some parts of the work may flow well, be carefully drafted, consistent with rules and norms, while other parts within that same category may not be as successful but not mediocre or even poor. For evaluators and students alike inconsistency will exist within categories. Outstanding scores will be rare. Features in a work or writer’s talent may not be itemized on the rubric. Writing additional comments on the rubric will help the department refine them for future editions.
Writing Rubric 1 (Focus on Writing Style)

<table>
<thead>
<tr>
<th></th>
<th>1 = Not Attained</th>
<th>3 = Satisfactory</th>
<th>5 = Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Syntax and Structure</strong></td>
<td>Paragraphs, sentences or whole chapters are missing or are too brief.</td>
<td>Chapters and paragraphs are adequate</td>
<td>Well-developed chapters, paragraphs and sentences communicating priorities, relationships of dependence, cause and effect relationships, and time sequences.</td>
</tr>
<tr>
<td></td>
<td>Relationships among sentences, paragraphs or chapters are missing.</td>
<td>Relationships among sentences, paragraphs or chapters are mostly visible but require some extra work by the reader; missing smooth transitions.</td>
<td>Paragraphs flow from one to the other preparing the reader for what follows and summarizing key ideas before moving on to new ones.</td>
</tr>
<tr>
<td></td>
<td>Sentences are fragmented, confusing, circular, incomplete, simplistic or monotonous.</td>
<td>Sentences are clear but without variety or complexity.</td>
<td>Sentences have a variety of lengths and include complex and simple constructions.</td>
</tr>
<tr>
<td><strong>Mechanics</strong></td>
<td>Pervasive copyediting errors distort meaning and make reading difficult.</td>
<td>More than a few sentence-level errors every few pages, annoying but do not impact the substance of the message; may have errors such as too many capital letters or quote marks - deliberate but wrong.</td>
<td>The writing is near perfect with little to no spelling errors and conventions for punctuation, capitalization are followed.</td>
</tr>
<tr>
<td><strong>Tone and Language Use</strong></td>
<td>Frequent use of slang, excessive jargon, or nouns as verbs alienates reader or is confusing; ignorance of proper use of SE terminology (i.e. design, architecture, framework, limitations, scope, boundary,</td>
<td>Acceptable language use, occasional redundancy, rare if any use of slang, or jargon; uses SE terms adequately (i.e. design, architecture, framework, limitations, scope, boundary, decomposition,</td>
<td>Highly articulate academic tone employing professional language on an advanced level, using SE terms in sophisticated way (i.e. design, architecture, framework, limitations, scope, boundary, decomposition, allocation, measure of</td>
</tr>
<tr>
<td>decomposition, measure of performance, allocation, measure of effectiveness, verification, validation, process, requirements, shall)</td>
<td>allocation, measure of performance, measure of effectiveness, verification, validation, process, requirements, shall)</td>
<td>performance, measure of effectiveness, verification, validation, process, requirements, shall)</td>
<td></td>
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<td>---</td>
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<td></td>
</tr>
<tr>
<td>many problems with homonyms and/or uses first or second person; errors in subject-verb agreement; errors in verb tenses.</td>
<td>may have a few errors with homonyms; stays in third person; rare error in subject-verb agreement, and rare error in verb tenses.</td>
<td>no errors with homonyms: their/there; principal/principle; affect/effect; its/it’s, etc. Stays in third person; no errors in subject-verb agreement or use of verb tenses.</td>
<td></td>
</tr>
<tr>
<td>Exclusive or misuse of the passive voice creates confusion.</td>
<td>Some use of the passive voice is unnecessary and creates wordiness.</td>
<td>Uses the active voice when possible and passive voice when appropriate.</td>
<td></td>
</tr>
</tbody>
</table>
Writing Rubric 2 (Focus on Writing, Organization, and Argumentation)

<table>
<thead>
<tr>
<th></th>
<th>1 = Not Attained</th>
<th>3 = Satisfactory</th>
<th>5 = Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Contains vague or confused perspective on the topic, and goals are not developed or stated.</td>
<td>Contains clear perspective on the topic, and goals are stated.</td>
<td>Contains a new perspective on the topic, where goals are strongly developed and stated.</td>
</tr>
<tr>
<td>Literature Review or Background and Context</td>
<td>Content does not review and build on appropriate prior work; unreliable sources used or are not cited.</td>
<td>Content reviews and builds on appropriate prior work to a moderate extent; reliable sources are cited.</td>
<td>Content reviews and builds upon appropriate prior work to a significant extent; reliable sources cited correctly.</td>
</tr>
<tr>
<td>Explanation of Methodology</td>
<td>The research approach is unsound or inappropriate for the purpose of the paper.</td>
<td>Research approach is basic, appropriate for the purpose of the paper, suited to the perspective (i.e., quantitative, qualitative, mixed).</td>
<td>Research approach is sophisticated, appropriate to the purpose of the paper, suited to the perspective (i.e., quantitative, qualitative, mixed).</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>Data collection and assessment results need improvement or do not support the goals of the paper.</td>
<td>Data collection and assessment results are clear and logical, moderately supporting the goals of the paper.</td>
<td>Data collection and assessment results are very clear and logical, strongly supporting the goals of the paper.</td>
</tr>
<tr>
<td>Conclusion</td>
<td>The conclusions do not appear to be supported by the data, unformulated, or do not make a contribution to research.</td>
<td>The conclusions are formulated and are supported by the data, making a contribution to research.</td>
<td>The conclusions are very well formulated and are strongly supported by the data, making a significant contribution to research.</td>
</tr>
<tr>
<td>Mechanics</td>
<td>Pervasive copyediting errors distort meaning and make reading difficult.</td>
<td>Sentence-level errors are present, but they do not distort the substance of the paper.</td>
<td>The writing is near perfect, checked for spelling and other irregularities in punctuation, capitalization, etc.</td>
</tr>
<tr>
<td><strong>Language use</strong></td>
<td>Frequent use of slang, excessive jargon is alienating or confusing; ignorance of proper use of SE terminology. Uses first or second person. Many problems with homonyms or word choice.</td>
<td>Acceptable language use, occasionally redundant, using slang, or jargon, or SE terms without nuance. Written in the third person. May have a few errors with homonyms or word choice.</td>
<td>Highly articulate academic tone employing professional language on an advanced level, using SE terms in sophisticated way. Written in the third person. No errors with homonyms or word choice.</td>
</tr>
<tr>
<td><strong>Voice</strong></td>
<td>Exclusive use or misuse of the passive voice creates confusion.</td>
<td>Use of passive voice creates wordiness or ambiguity.</td>
<td>Uses the active voice when possible and passive voice when appropriate.</td>
</tr>
<tr>
<td><strong>Research</strong></td>
<td>Fails to meet research requirements. Sources are not quoted, are given with no discussion, quotations make up too large a percentage of the paper, or seem unreliable.</td>
<td>Incorporates reliable sources of a type suitable to the context and integrates them appropriately.</td>
<td>Meets or exceeds research requirements and integrates sources effectively, applying knowledge gained from research to the new setting of the paper with depth and precision.</td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
<td>In-text citations or items in list of references are incomplete. CMS author-date method not used or misused.)</td>
<td>Cites sources using CMS author-date method. Sources cited in the text clearly coordinated with items in list of references.</td>
<td>Cites sources using CMS author-date method smoothly: all items cited in the text are aligned with entries in list of references.</td>
</tr>
</tbody>
</table>
**USNTPS Assessment Rubric**
The rubric for assessing student deliverables for the Us Naval Test Pilot School specifically addresses the standards and elements of thought (figure 11.)

<table>
<thead>
<tr>
<th>Standard:</th>
<th>Definition:</th>
<th>Questions Targeting the Standard:</th>
</tr>
</thead>
</table>
| **Clarity** | Understandable; the meaning can be grasped. Clarity is a gateway standard. If a statement is unclear, we cannot determine whether it is accurate or relevant. In fact, we cannot tell anything about it because we do not yet know what it is saying. | - Could you elaborate further on that point?  
- Could you express that point more clearly in another way?  
- Could you give me an illustration or example?  
- Have the assumptions been clearly stated?  
- Have terms and symbols been clearly defined?  
- Do drawings/graphs/photos and supporting annotations clearly portray important relationships? |
| **Accuracy** | Free from errors or distortions; true. A statement can be clear but not accurate, as in “Most creatures with a spine are over 300 pounds in weight.” | - Is that really true?  
- How could we check that?  
- What is your confidence in that data?  
- Has the test equipment been calibrated? How or when?  
- How have simulation models been validated?  
- Have assumptions been challenged for legitimacy?  
- Are there hidden or unstated assumptions that should be challenged?  
- What if the environment is other than we had expected (e.g., hotter, colder, dusty, humid)? |
| **Precision** | Exact to the necessary level of detail. A statement can be both clear and accurate, but not precise, as in “The solution in the beaker is hot.” (We don’t know how hot it is.) | - Could you give me more details?  
- Could you be more specific?  
- What are acceptable tolerances for diverse pieces of information?  
- What are the error bars or confidence bounds on experimental, handbook or analytical data?  
- Does the readability of the measurement justify this level of precision?  
- At what threshold do details or additional features no longer add value? |
| **Relevance** | Relating to the matter at hand. A statement can be clear, accurate, and precise, but not relevant to the question at issue. A technical report might mention the time of day and phase of the moon at which the test was conducted. This would be relevant if the system under test were a night vision device. It would be irrelevant if it were a microwave oven. | - How is that connected to the question?  
- How does that bear on the issue?  
- Have all relevant factors been weighed?  
- Are there unnecessary details obscuring the dominant factors?  
- Has irrelevant information been included?  
- Have features and capabilities (and hence costs) been included which the customer neither needs nor wants? |
| **Significance** | Significant to the matter at hand. Our speech or writing can be clear, accurate, precise, and relevant, yet focus on insignificant conclusions or details rather than the most important features. | - Does one detail of many overwhelm the others in importance or influence?  
- Are insignificant details presented that obscure recognition of first-order factors or effects before working down to the more subtle?  
- Is that dealing with the most significant factors?  
- Are insignificant details presented that compromise the overall conclusion? |
<table>
<thead>
<tr>
<th>Standard:</th>
<th>Definition:</th>
<th>Questions Targeting the Standard:</th>
</tr>
</thead>
</table>
| Depth    | Containing complexities and multiple interrelationships  
* A statement can be clear, accurate, precise, and relevant, but superficial. For example, the statement, “Radioactive waste from nuclear reactors threatens the environment,” is clear, accurate, and relevant. Nevertheless, more details and further reasoning need to be added to transform the initial statement into the beginnings of a deep analysis. | • How does your analysis address the complexities in the question?  
• Have important interrelationships been fully identified and studied?  
• How are you taking into account the issues in the question?  
• Does this analytical model have adequate complexity and detail, given its counterpart in reality? |
| Breadth  | Encompassing multiple viewpoints  
* A line of reasoning may be clear, accurate, precise, relevant, and deep, but lack breadth (as in an argument from either of two conflicting theories, both consistent with available evidence). | • Do we need to consider another point of view?  
• Is there another way to look at this question?  
• What would this look like from the point of view of a conflicting theory, hypothesis, or conceptual scheme?  
• Have the full range of options been explored?  
• Have interactions with other systems been fully considered? |
| Logic    | The parts make sense together, no contradictions  
* When we think, we bring a variety of thoughts together into some order. The thinking is “logical” when the conclusion follows from the supporting data or propositions. The conclusion is “illogical” when it contradicts proffered evidence, or the arguments fail to cohere. | • Does this really make sense?  
• Does that follow from what you said? How does that follow?  
• But earlier you implied this and now you are saying that. I don’t see how both can be true.  
• Are the evaluation conclusions supported by logical analysis? |
| Fairness | Justifiable, not self-serving or one-sided  
* Fairness is particularly at play where more than one viewpoint is relevant to understanding and reasoning through an issue (conflicting conceptual systems), or where there are conflicting interests among stakeholders. Fairness gives all relevant perspectives a voice, while recognizing that not all perspectives may be equally valuable or important. | • Have other points of view been considered (contractor, program office, fleet user, maintenance, public citizens, etc.)?  
• Are vested interests inappropriately influencing the evaluation?  
• Are divergent views within the evaluation team given fair consideration?  
• Have the environmental/safety impacts been appropriately weighed?  
• Have we thought through the ethical implications in this decision? |
| Concision| Economy of thought, words, and images enhance clarity by preventing self-generated noise | • Would fewer words work?  
• Could all related graphs be overlaid or placed on one page to improve the insight into trends and encourage direct comparison?  
• Are relevant visual perspectives efficiently presented? |
| Suitability| Seeking to be fitting or appropriate by selecting the right tone and presentation for the intended audience | • Does this convey the appropriate tone?  
• Is the level of detail appropriate for the intended audience?  
• Is the language patronizing or condescending?  
• Is the language overly complex or specialized?  
• Are the elements appropriately placed to maximize communication? |
LIST OF REFERENCES


