V - WRITTEN COMMUNICATIONS

Importance

Engineers are rarely judged solely by the quality of their technical knowledge or work. People also form opinions by what one says and writes. When an engineer writes a memo or report, talks to members of a group, deals with vendors on the phone, or attends meetings, the image others get is largely formed by how a person communicates. Even if an engineer works for a large company and does not see high-level managers very often, upper management can still gain an impression of an engineer by the quality of written reports as well as by what the immediate supervisor tells them. Richard C. Levine, Manager of Hardware Planning at Bell Northern Research, recently told a group of engineering students the following:

> *Another fundamental is the ability to read with comprehension and to write clearly and correctly....I can't emphasize enough that both of these skills are extremely important. I am not a picky person when it comes to spelling and grammar, but when I see a report or memo that has repeated errors, I immediately question the ability and dedication of the person who wrote it. Why didn't they take the time and effort to do it right? Most of the successful engineers I know write clear, well-organized memos and reports. Engineers who can't write well are definitely held back from career advancement.*

Many engineers spend nearly half of their time writing and usually find that the time devoted to writing increases as they move up the corporate ladder. It does not matter that some writing is now sent through electronic mail (e-mail); the need for clear and efficient prose is the same whether it appears on a computer screen or sheet of paper. Much written material first read on a screen ends up being printed out on paper anyway, and the possibility of a paperless office seems pretty remote.

Engineers interact throughout their career with a variety of other engineering and nonengineering colleagues, officials, and members of the public. Even if an individual does not do the actual engineering work, they may have to explain how something was done, should be done, has to be changed, needs to be investigated, and so on. The list of all the possible engineering situations and contexts in which communication skills are needed is unending. The following list identifies just some of the documents that engineers are responsible for writing:

Memos	Contracts	Articles
Abstracts	Specifications	Executive Summaries
Weekly Reports	Progress Reports	Investigation Reports
Policy Manuals	Training Aids	Maintenance Manuals
Annual Reports	Lab Reports	Repair Manuals
User's Manuals	Newsletters	Safety Instructions
Proposals	Tutorials	Letters
Patents	Procedures	Standards

Many public and private organizations have style-guides and procedural manuals for writing reports and other documents. That is exactly the purpose of this document: to present a standard for typical writing assignments for engineering students at Arkansas State University. These helpful guidelines address topics such as abbreviation, capitalization, citation of references, gender-neutral writing, punctuation, typestyles, graphics, common mistakes, and overall report format. Inasmuch as technical reports are often written as a team effort, style-guides and procedure manuals help achieve internal consistency within any given report. They also contribute to inter-report consistency for the organization. Finally, writing guides save time and minimize frustration by reducing the need to make decisions about the mechanics of a report and the specifics required by a particular engineering professor at ASU. At minimum, refer to these guidelines and other available guides such as those of Beer and McMurrey (3) and *The Chicago Manual of Style* (4).

The type of engineering documents addressed here will only be those that will be required by the Engineering Program coursework. These documents can be classified as letters, memoranda, and e-mail; laboratory and informal reports; formal technical reports; and log books and notebooks. The format, examples, and some rules for each type are presented in later chapters.

Planning and Implementation

This document has been developed as if it were a formal technical report. The objectives are to present and demonstrate the techniques of effective communications for ASU engineering students. As with most worthy endeavors, the planning and implementation stages are important in order to produce high quality work. The following sections on this topic are taken directly from Martin (5).

Very simply stated, the purpose of written or oral communications is to present *specific* information to *specific* audiences for *specific* purposes. To accomplish this, the development of all communication methods requires two phases: exploratory and implementation. When these two phases are completed, a third, improvement, is needed to ensure the best quality product. The usual steps are gathering information, planning the report/speech, writing, and then revising. The first two steps, gathering and planning, constitute the exploratory phase; the last two, writing and revising, are (respectively) the implementation and the improvement.

Exploratory Phase: MAPS. The acronym MAPS helps define the exploratory phase. The letters stand for message, audience, purpose, and scope. These words serve as guides in this creative phase of gathering information and planning. The message directs the selection of information from three major sources: personal and professional experience, library/internet sources, and original research/experiments/tests performed. For example, the message of a progress report will be the progress made on a project. The audience will be higher management, maybe the course instructor,

or possibly a client. The purpose of a progress report is to keep management/your client informed, a very important part of project management. The scope of a progress report should include a brief introduction, summary of work completed, work in progress and work yet to be done, any problems (technical, costs, or timing), and attachments like manhour summaries and a Gantt Chart.

Procedures: PWRR. The procedures for the implementation phase are correlated with the acronym PWRR which stands for plan, write, relax, and revise. One of the most important aspects of any project is to prepare a plan to serve as a guide and to prevent wondering what to do next. So, the first step in preparing a report or talk should be to make a plan or an outline. The initial outline may only be simple phrases that are expanded and revised as the work develops. In the case of a written report, it eventually becomes the table of contents.

When preparing a written report, the next step is to write a rough draft of each section using the topical outline. The idea is to get information on paper as quickly as possible without worrying about spelling, grammar, and punctuation. Ideas easily slip away when distracted by the few seconds needed to check punctuation or synonyms. These aspects can always be corrected later, and with modern word processing software, this is not a problem. This approach is easier said than done, but when engineers finally learn to write in this manner productivity increases dramatically. After the rough draft is finished, the manuscript should be put aside for a day or a week, if possible. Relaxing after completing a task is satisfying and motivating, but of greater importance is that a more objective, critical review can be made of a written report at a later time.

The last implementation step is revise, revise, revise. Revising is the most important aspect in producing top-quality reports. Conciseness in writing is an outstanding virtue, greatly appreciated by the busy engineer and manager. But, writing that is too terse can cause problems for the reader. It can require extra time to analyze and supply what was left out in an attempt to save reader's time. In revising, check the rough draft for technical accuracy. Check closely for misleading statements; truthfulness is the soul of science and engineering, the essence of professionalism. Strive for clarity; write so that statements are not misunderstood. Make sentences as simple and concrete as possible; avoid implications and jargon not generally known to the intended readers. Avoid writing sentences which have more than 20 words. Revise for good organization and logical development. Liberal use of headings and subheadings can lead the reader through the thought processes desired. To achieve conciseness, delete unnecessary words that do not affect the reader's understanding, needs, or ease of assimilation. Correct errors in grammar, punctuation, and spelling. There is no excuse for these errors. Finally, have a competent colleague review the report and suggest improvements.

Manuscript Mechanics

Accuracy and clarity are of vital importance for technical reports, but first impressions often depend on appearance. Some people that review technical reports, particularly those in upper management, may have little technical background, and their overall evaluation can be influenced by how well the report is written and its appearance. Thus, it is advantageous to produce a report that is free of typographical mistakes, grammatical errors, and misspelled words and is also professional-looking. There are no set rules for manuscript mechanics, but the following recommendations are good practice and assure a professional look.

Spelling and Punctuation. The effect of poor spelling is a sense of annoyance for the reader, and it distracts their attention from the topic that is being communicated. Spelling errors can bring

readers to a stop and cause them to seriously question the writer's ability to write. They may even suspect that a person who is careless with spelling could also be inept in more critical technical matters. To reduce or eliminate any noise in writing caused by incorrect spelling, use a spell checker and also have a standard dictionary nearby. Also, it is good practice to have others read your work to check for spelling mistakes and misuse of words.

The flow of meaning in written sentences is controlled by punctuation marks much the same as in spoken language by means of pitch, pauses, and emphasis. When punctuating written sentences, speak the sentences aloud as in normal conversation. Pay careful attention to where natural pauses occur within the sentence; that is likely where some punctuation is needed. Many detailed books on proper punctuation exist, and they should be used if a lot of queries exist in this area. The following suggestions taken from Beer and McMurrey (3) and Martin (5) are often the most common problems many engineers tend to have with punctuation.

Commas. Confusion sometimes exists about commas because their use is frequently optional. To decide if a comma is important, determine if adding or omitting a comma in a given sentence creates noise. In general, if no possible confusion or strain results, the tendency in technical writing is to omit unessential commas. Often, omitting a comma after introductory words (such as the first word of this sentence) or phrases in a sentence will cause the reader momentary confusion. One more point about commas: most technical editors prefer what is called a "serial comma" when a list of words or phrases is presented in a sentence. For example, *the serial comma has become practically mandatory in most scientific, technical, and legal writing*. Some believe that the *and* joining the last two terms replaces the need for a comma, but this is not the case in standard, technical writing.

Parentheses. Parentheses are used to set off facts or references within a sentence. An example is given in the paragraph above. If the words within the parentheses are not a complete sentence, put any required comma or period outside the parentheses. If the parenthetical material forms a complete sentence, put the period inside the parentheses. It is best not to use parenthetical material too frequently since these marks force the reader to pause, and are likely to distract them from the main intent of the writing.

Dash. A dash makes a sentence seem more emphatic by calling attention to the words set aside or after it: *Staying up all night to finish a lab report is not so terrible—once in a while.* Since the dash is considered less formal than other parenthetical punctuation marks, try to avoid using it in formal writing. Also, overuse of dashes will cause a loss of their effect. Notice that the dash discussed here is the "em" dash—the dash used between words that practically touches the letters at each end of it.

Colon. Colons are used to separate the hour and minute in a time notation and to divide parts of the title of a book or article. The most common use of the colon within a sentence, however, is to introduce an informal list. For example, several items will be needed for the final exam: a pencil, a calculator, and three sheets of graph paper. A colon can also be used to introduce an illustration or example, but in both cases, an independent phrase comes before the colon.

Hyphens. Hyphens have been called the most underused punctuation marks in technical writing. Unfortunately, apart from the general rule that hyphens should be used to divide a word at the end of a line or to join pairs of words acting as a single descriptor, there is no clear consensus on when to use them. Here are some suggestions:

1. Do not hyphenate prefixes such as *pre-*, *re-*, *semi-*,and *sub-* unless leaving out a hyphen causes an eyesore or possible confusion. For example, distinguishing between recover (regain) and re-cover (to put a new cover on) is good.

2. Do not hyphenate compound words before a noun when the first one ends in *ly*. For instance, *early warning system* needs no hyphen since it is clear that *early* modifies *warning*, not *system*.

3. With really complex technical terms, such as *direct-axis transient open-circuit time constant*, there may be very little to go on, and the best solution may only be found in a technical dictionary.

Quotation Marks. Use quotation marks to set off direct quotations in the text, and put a needed period or comma within them, even if the quoted item is only one word. British publishers use different guidelines, but the American practice is to always put commas and periods inside quotes, and semicolons and colons outside. For example: "The correct answer is 18.2 Joules," he told me. If the quoted material takes up more than two lines, set it off from the text by a space and indent it from both right and left margins. Some other distinction, such as italics or font size, might be used, and the quotation marks should be omitted in this case.

Semicolon. The semicolon seems to be disappearing from much engineering writing. Often it is replaced by a comma, which is an error according to traditional punctuation rules. More frequently, a period is used and a new sentence is started, but the psychological closeness implied by a semicolon is lost. For example, examine the correctly punctuated sentence: *We wanted to finish the computer program yesterday; however, the network was down all afternoon.* There are plenty of examples of similar sentences where the semicolon has been replaced incorrectly with a comma. Semicolons should also be used to separate a series of short statements listed in a sentence if any one of the statements contains internal punctuation. The semicolon will then divide the larger elements.

Punctuation of Lists. If the lead-in to a list ends with a verb, no colon is necessary. For example, *The five priorities established are* would not require a colon after *are* since the list is needed to logically and grammatically complete the sentence. A lead-in like *We have established the following five priorities* would be followed by a colon. If the items in the list are complete sentences, each item should conclude with a period. If the items are parallel phrases, they should be concluded with a comma, or if internal commas exist, then use a semicolon. The *and* should be placed after the comma/semicolon prior to the last item in the list. The first letter of the first word in each item should be capitalized. For lists of phrases, some prefer that the first letter of each word be capitalized, but either way is acceptable as long as the text is consistent. Another concern when writing lists is to maintain grammatical parallelism between entries. This means if some entries begin with a verb, all entries should do so.

Sentence Length. When dealing with highly technical subjects, sentences should rarely be over 20 words long. Technical material can be difficult enough to follow without being presented in long, complex sentences, particularly if the audience is not familiar with the topic. Nobody wants to be left breathless at the end of a mile-long sentence. If sentences tend to be lengthy, look for ways to break them into two or more separate ones. The readability of text is determined partly by the length of the sentences; however, too many short sentences may leave the reader feeling like a first grader.

Abbreviations. Abbreviations are necessary in technical communication; they refer to concepts that would take a great deal of time to spell out fully. It would be time-consuming and boring for an engineer to read *Computer-Aided Design/Computer-Aided Manufacturing* several times when CAD/CAM would do. However, confusion may occur when abbreviations are used that the reader does not understand. Always spell abbreviated words the first time unless this would insult the intelligence of the reader. Once the abbreviation has been defined, the reader can be expected to

remember it. Occasionally, some highly complicated or unusual abbreviations may need to be defined more than once to remind the reader, or a glossary can be provided as a reference for the reader.

Abbreviations can be subdivided into initialisms and acronyms. Initialisms (sometimes called initializations) are formed by taking the first letters from each word of an expression and pronouncing them as initials: GPA, IBM, ASU. Acronyms are also created from the first letters or sounds of several words, but are pronounced as words: FORTRAN, NASA, ROM. Some acronyms become so well-known that they are thought of as ordinary words and are written in lowercase: *bit, laser, radar*.

Use the correct form of *a/an* before an initialism. No mater what the first letter is, if it is pronounced with an initial vowel sound (for example the letter M is pronounced "em"), use *an* before the initialism. Form the plural of acronyms and initializations by adding a lowercase *s*: for example, CRTs. Only put an apostrophe between the abbreviation and the *s* if indicating a possessive form.

Numbers. Engineering reports usually involve a great deal of numbers which can result in a lot of confusion due to typographical errors, incorrect or inexact numbers, and inconsistencies. This type of noise can be avoided by making certain any number is written correctly. The way that numbers are presented is an indication of the degree of precision: know that 53.235235 implies an accuracy of 0.000001 and that 53.2 may be more representative of the accuracy of the value presented. Numbers can be expressed as words (twelve) or numerals (12). The ordinary practice is to present numbers from one to ten in word form and to present all other numbers as figures. Use numerals rather than words when citing time, money, or measurements: 1 AM, $43.45, 14 feet. Spell out ordinal numbers only if they are single words. Write the rest as numerals plus the last two letters of the ordinal: second verse, fifteenth time, 21st attempt. If a number begins a sentence, it is good practice to spell it out regardless of any other rule or rewrite the sentence so that the number does not begin the sentence. Form the plural of a numeral by adding an *s* with no apostrophe such as 1960s. Place a zero before the decimal point for numbers less than one, and omit all trailing zeros unless they are needed to indicate precision. Write fractions as numerals when they are joined by a whole number, and connect the number and the fraction by a hyphen: 2-½ gallons. When expressing large or small numbers, use scientific notation such as 4.35E-06.

Units. The general public in the United States is still not committed to the metric system, but the engineering profession is generally committed and prefers the SI system (from French *Systeme International*). Be consistent by not mixing the English and metric units unless it is required. Depending on who the readers might be, it may be necessary to show both types of units. In this case, use one of the unit systems (primary) in the text following by the other (explanatory units) in parentheses. Sometimes similar symbols can stand for more than one thing, and confusion can result unless an explanation is given. For example, consider G (gauss, measure of magnetic induction), G (gravity), and G (giga-). Units of measurement derived from a person's name usually are not capitalized, even if the abbreviation for the unit is. For example, consider newtons, N. Refer to a recent dictionary of scientific terms to determine the correct spelling/symbol for the units.

Equations. At times, equations can communicate ideas far more efficiently than words. However, formulas and equations slow down the reader, so use them only when necessary and when certain the audience can follow them. Most word-processing programs now make it easy to write equations in text, but make sure the equations are noise free and easily understood. Equations should be centered on the page and numbered sequentially in parentheses to the right for reference. Leave several spaces between the text and any equation, and leave a space between lines of equations. Also,

space on both sides of operators such as =, +, or −. For text with several equations, try to keep the equal signs and reference numbers parallel throughout the text. Every symbol used in equations should be defined in the text or below the equation as illustrated below.

$$P = I * E \qquad (1)$$

where:

P = Power, measured in watts
E = EMF (electromotive force) in volts
I = Current in amperes

Spacing and Indenting. Generally, the text of a technical report should be double-spaced, but sometimes exceptions do occur. Consistent spacing and indentation make for a professional-looking report. Some guidelines are

1. Triple-space above and below centered headings, quotations, listings, and equations. Double-space above and below subheadings set at the margins.
2. Single-space inset or center listings, such as definitions of the terms of equations, and number them if they are numerous.
3. Single-space long quotations (more than three lines).
4. Single-space individual footnotes, entries in a bibliography, or items in a list of references; double-space between the individual items. For items in a bibliography or list of references, indent the second and succeeding lines three spaces.
5. Single-space the summary and abstract sections of a formal report. Limit the length of a summary to one page if possible; otherwise, double-space the summary.
6. The beginning of a paragraph should be indented five spaces when using double-spacing. If text is single-spaced, no paragraph indentation is necessary, but double-space between paragraphs.

7. Single-space material in an appendix.

Paper and Margins. Reports should be printed on one side of good-quality white sheets, 8-½ by 11 inches. Company policy might require colored or boarder sheets for some reports; however, black print on white paper generally gives a neater appearance. Use of colored sheets is good practice for long reports to separate major sections such as appendices.

The left margin should always be either one or 1-½ inches; all others should be one inch. The greater left margin ensures that the reader will not have difficulty reading the report after it is bound. Different word lengths will cause the right margin to vary, but it should not be less than ¾ inches. Some people prefer to use full justification for margins for a neater appearance, but this sometimes crowds words and makes reading difficult with small fonts. Where quotations or other insets are included in the text, an additional ½ inch should be used on both the left and right sides.

Page Numbering. The general rule is to locate page numbers at the bottom center of the page, but some exceptions do occur. Use Arabic numerals for the main body of the text, and use lower-case Roman numerals for prefatory pages (transmittal letter, title page, table of contents, list of figures, list of tables, and abstract). The transmittal letter and title page are counted, but the page numbers are omitted for these sheets so that the table of contents would be iii. Pages of appendices should be numbered using different notation to distinguish them from the main body. For example, for Appendix A, use page numbers of A-1, A-2, and so on.

Headings and Subheadings. Use of major section headings and subheadings will help organization of the report and will help the reader follow ideas and retrieve information. Headings signal the main points of the report and should have the same wording as the topical entries in the table of contents. The main headings name the major divisions, sections, or chapters of a report. These

main headings should always be centered at the top of a new page, all-capital letters, and either underlined or placed in bold lettering. Main headings and subheadings can be numbered; for example, **1.0 INTRODUCTION** is a main section heading, **1.1 Background** is a second-order subheading, and **1.1.1 Prior Studies** is a third-order subheading. Use of numerals is optional, but the format should be consistent throughout the report.

Two levels of subheadings (second- and third-order) are usually adequate. Second-order subheadings should be placed flush with the left margin; the words are in lowercase letters with the first letter of each word capitalized; and the subheading is either underlined or placed in bold lettering. Double-space above and below second-order subheadings, but put no text on the same line and no punctuation after the subheading. The third-order subheading is treated exactly as the second-order except for three details: indent it five spaces (½ inch) or same as paragraph indentation, put a period after it, and start the text on the same line after the subheading. Again, an alternative is to use numerals along with the subheadings as illustrated in the previous paragraph.

General Guidelines

A basic rule of technical communications is to give the reader the most information of value while requiring the minimum time and effort. Probably the most important step in meeting this objective is to revise, revise, revise. The following guidelines should be kept in mind while doing these revisions:

1. Engineering reports are generally written in the third-person which means an observer rather than the doer of the work. Also, past-tense is preferred since the writing is usually about something done in the past. For example, a report

is prepared about some experiment or investigation that was done. However, using present-tense makes more sense for describing such things as designs which are proposed. Mixing of past- and present-tense is acceptable in some instances, but the writer should take care to minimize this practice.

2. Most people reading written documents are likely to be in a hurry. Just as the sentences need to be concise and direct, the document needs to have the most important information at the beginning. For example, a long report should give the main points through an informative title followed by a summary section.

3. Even the clearest writing is useless when the information it conveys is wrong. If the report text refers to Appendix B when the information is in Appendix C, the error may confuse the reader and cause them to lose confidence in the report. Inaccurate statements and references will cause the reader to be suspicious of the reliability of the entire report.

4. Not only should it be easy to access the document's essential message, but all information should be in the right place. This means the report should be organized so that each idea, point, and section is clearly and logically laid out within an appropriate overall pattern. Use headings and subheadings liberally.

5. The word *ambiguous* comes from a Latin word meaning to be undecided. Ambiguity primarily results from permitting words like *they* or *it* to point to more than one possible referent in a sentence, or from using short descriptive phrases that could refer to two or more parts of a sentence. In either case, the reader becomes confused and may interpret a sentence differently than intended. Strive to be so clear that sentences cannot be misunderstood.

6. Abstract or subjective words are not inherently wrong, but they fail to provide the precision needed for effective technical writing. Avoid abstract words and phrases like *pretty soon*, *substantial amount*, and *corrective action*, and replace them with concrete, objective terms that have exact meaning, preferably numerical or "either/or" descriptors.

7. Coherence in paragraphs can be achieved by making sure that each sentence clearly relates to the one before it and after it. This means opening with the main point or topic sentence, repeating key words where needed, and using transitional words and pronouns to link sentences as they build up the paragraph.

8. Using an unnecessarily pompous word instead of a straightforward one can cause the reader to slow down. Choose the simplest and plainest word whenever possible. Readers can be distracted or even confused by words that call attention to themselves without contributing to meaning. Check the

writing for phrases and words that can be removed without reducing the reader's understanding, and delete them. Never use big words to impress the reader, or five words when two would be better.